13th Edition

THIRTEENTH EDITION

PRACTICAL WIRELESS ENCYCLOPÆDIA

F. J. CAMM

PRACTICAL WIRELESS ENCYCLOPÆDIA

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THE "PRACTICAL TELEVISION" RECEIVER

PRACTICAL WIRELESS ENCYCLOPAEDIA

DEFINITIONS · TERMS · UNITS
PRINCIPLES CONSTRUCTION

By

F. J. CAMM

EDITOR OF
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AND
"PRACTICAL TELEVISION"

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PREFACE TO THIRTEENTH EDITION

A CONSIDERABLE amount of new matter has been added to the present edition, and the text has been entirely reread, amended and where necessary brought up to date.

F. J. CAMM

PREFACE TO TWELFTH EDITION

THE first edition of this book was published in 1932 and its appearance coincided with the first issue of *Practical Wireless*. In founding that journal I felt that the large public for which it was intended to cater should at the same time have at hand a really comprehensive volume arranged in encyclopædic form which would serve the dual purposes of an instruction manual and a work of reference. The reader encountering new terms, or wishing to consult a not easily-remembered formula was thus able, with equal facility, to refer to this encyclopædia; and, if he desired, for example, to trace a fault in a receiver, to wind a coil, make a transformer, erect an aerial or study short-wave technique, he found upon consulting the subject that those aspects of radio were included in expanded sections. This book was then, and it remains, the only work of its type, and I am naturally gratified to know that it has become the standard work of reference.

The justification of the idea which prompted its preparation is provided by its remarkable sales, for in the past eighteen years, during which the market has avidly absorbed eleven editions, over 300,000 copies have been sold. They have journeyed all over the world. Copies can be found on board ship, in radio laboratories, in the radio dens of the Bush, in public libraries, and the libraries of colleges and scientific institutions; in fact, copies are almost as widely broadcast as the radio waves with which the volume treats. The sales have exceeded by tens of thousands those of a best seller in fiction.

In a new industry such as radio, changes are rapid. New branches of the science are introduced, and the nomenclature expands with the developments. The task of revising each edition so that it reflected these changes to keep readers' knowledge up to date was a heavy one, but as edition succeeded edition I made great efforts faithfully to record every fact, every figure, every new term and every change in technique which had arisen after the previous edition had gone to press.

There is a practical limit to which such expansion can go without entirely upsetting the pagination, reducing existing matter, and resetting the whole book. That limit was reached with the eleventh edition, and it was upon the publisher's request for a twelfth that it was decided to reset and to prepare an entirely new volume but with the same underlying idea as the previous editions.

Since the eleventh edition was published, a great deal has happened in the world of radio, and in this twelfth edition, upon which I have been engaged for the past two years, I have packed information on all of these new aspects, and included the unchanging data such as Ohm's Law, and all of the standard terms and definitions, at the same time deleting matter which had become obsolete.

It was not found possible further to compress the previous volume to include the mass of new matter which it was my duty to include. A book, like a boot, must comfortably accommodate what it is intended to contain, without undue compression. The practical information on the making of various components has been retained. The constructor, for example, will find herein information on the building of intermediate frequency transformers, oscillator coils, mains transformers, coils and chokes, etc.

New sections deal with Radar, Television, Remote Control, Oscillators, Kirchoff's Laws, Photo-electric Cells, an entirely new series of modern circuits for receivers and amplifiers, Automatic Station Selection, Car Radio, Electron Multipliers, Quartz Crystals, Amateur Transmission, Fault Finding, Building a Television Receiver, the New Colour Code, Aerials, Meters, Table of International Call Signs, New Valves and all of the officially approved Service Terms, etc., etc. The opportunity has been taken to amend, and to amplify where necessary, such information as has been included from the previous edition. The book has been re-illustrated throughout. It is a work which indexes itself and it incorporates the accumulated knowledge of radio science.

The opportunity is here provided for me to express my gratitude to the many thousands of my readers who have written to me making suggestions for future editions, and also expressing their gratitude for the instruction they have received at my hands.

F. J. CAMM

ABBREVIATIONS

A.—Ampere; also Anode, or plate.
A.A.—Artificial aerial.
A.C.—Alternating current.
A.E.—Aerial.
A.F.—Audio frequency (same as Low frequency).
A.F.C.—Automatic frequency control.
A.G.C.—Automatic gain control.
A/h.—Ampere-hour.
A.M.—Amplitude modulation.
A.P.C.—Automatic picture control.
A.T.C.—Aerial tuning condenser.
A.T.I.—Aerial tuning inductance.
A.V.C.—Automatic volume control.
A.V.E.—Automatic volume expansion.
B.A.—British Association.
B.C.L.—Broadcast listener.
B.E.M.F.—Back electromotive force.
B.F.O.—Beat frequency oscillator.
B.T.U.—Board of Trade unit = 1,000 watt-hours, or 1 kilowatt-hour.
B.Th.U.—British thermal unit.
B.W.G.—Birmingham wire gauge.
C.C.C.—Closed circuit or secondary condenser or S.T.C.
C.C.I.—Closed circuit or secondary tuning inductance or S.T.I.
C.G.S.—Centimetre-gramme-second system of units.
cm.—centimetre.
C.P.—Candle power.
C.W.—Continuous waves.
D.A.V.C.—Delayed A.V.C.
db.—decibel.
D.C.—Direct current.
D.C.C.—Double cotton covered.
D.E.—Dull emitter.
Det.—Detector.
D.F.—Direction finding, or direction finder.
D.P.—Difference of potential.
D.P.D.T.—Double pole double throw.
D.P.S.T.—Double pole single throw.
D.S.C.—Double silk covered.
D.X.—Long distance.
E.—Earth.
E.M.F.—Electro-motive force.
F.—Filament.
F.M.—Frequency modulation.
F.P.S.—Foot-pound-second.
G.—Grid.
G.B.—Grid battery or grid bias.
G.C.—Grid condenser.
G.L.—Grid leak.
H.F.—High frequency (same as radio frequency).
H.F.C.—High frequency choke.
H.P.—Horse power.
H.P.I.—Height position indicator.
H.R.—High resistance.
H.T.—High tension.
I.C.—Intermittent current.
I.C.W.—Interrupted continuous waves.
I.F.—Intermediate frequency.
I.F.F.—Identification, Friend or Foe.
I.P.—In primary (of transformer); start of primary.
I.S.—In secondary (of transformer); start of secondary.
Kw.—Kilowatt = 1,000 watts.
Kw/h.—Kilowatt hour.
L.F.—Low frequency (same as Audio frequency).
L.F.C.—Low-frequency choke or low-frequency coupling.
L.P.R.—Long-playing record ($33\frac{1}{3}$ and 45 r.p.m.).
L.R.—Low resistance.
L.S.—Loudspeaker.
L.T.—Low tension.
mA.—milliampere.
M.C.—Moving coil.
mfd.—microfarad (μF).
mhy.—microhenry.
M.K.S.—Metre-kilogramme system of units.
mm.—millimetre.
mmfd.—micro-microfarad ($\mu\mu$F).
M.U.F.—Maximum usable frequency.
μF.—Microfarad.
$\mu\mu$F.—Micro-microfarad.
N.B.F.M.—Narrow band frequency modulation.
O.F.—Outside foil.
O.L.—Output load.
O.P.—Out primary (of transformer); end of primary. Also output.
O.S.—Out secondary (of transformer); end of secondary.
P.—Plate, or anode.
P.A.—Public address.
P.D.—Potential difference, same as D.P.
pF.—Picafarad.
P.M.—Permanent magnet.
Pot.—Potentiometer.
P.V.—Power valve.
Q.A.V.C.—Quiet automatic volume control.
Q Code.—See page ix.
Q.M.B.—Quick make and break.
Q.P.-P.—Quiescent push-pull.
Rd.—Dynamic Impedance.
R.F.—Radio frequency (same as high frequency).
R.M.S. Value.—Root-mean-square value.

R/T.—Radio telephony.
Rx.—Receiver.
S.C.C.—Single cotton covered.
S.G.—Screen grid.
S.H.M.—Simple harmonic motion.
S.I.C.—Specific inductive capacity.
S.P.—Series parallel.
S.P.D.T.—Single pole double throw.
S.P.S.T.—Single pole single throw.
S.R.—Specific resistance.
S.S.C.—Single silk covered.
S.T.C.—Secondary tuning condenser.
S.T.I.—Secondary tuning inductance.
S.W.G.—Standard wire gauge.
S.W.L.—Short-wave listener.
T.R.F.—Tuned radio frequency.
T.S.F.—French abbreviation for wireless : "Telegraphie sans Fils" (telegraphy without wires).
T.T.—Tonic train.
TV.—Television.
Tx.—Transmitter.
U.H.F.—Ultra high frequency.
V.F.O.—Variable frequency oscillator.
V.H.F.—Very high frequency.
V.M.—Velocity modulation.
W/T.—Wireless Telegraphy.

SYMBOLS

Absorption Factor	α
Admittance	Y
Ampere	A
Ampere-hour	Ah
Amplification Factor	μ
Anode A.C. Resistance (Impedance	Ra, Ro
Anode Circuit Inductance	la
Anode Current	Ia
Anode Potential	Va
Capacity	C
Conductance	G
Current	I
Current (Instantaneous)	i
Current (R.M.S.)	I
Dielectric Constant	ϵ
Efficiency	η
Electrostatic Flux Density	D
E.M.F. (voltage)	E
Energy	W
Frequency	f
Grid Current and Potential	Ig, Vg
Impedance	Z
Magnetic Field	H
Magnetic Flux	Φ
Magnetic Flux Density	B
Period Time	T
Permittivity	κ
Phase Angle	Ø
Power	P
Quantity	Q
Reactance	X
Reluctance	S
Resistance.	R
Resistivity.	ρ
Self-inductance	L

UNITS

Ampere	A
Ampere-hour	A/h
B.O.T. Unit = 1,000 watt-hours, or 1 kilowatt-hour	
Coulomb	C
Farad	F
Henry	H
Joule	J
Kilovolt-ampere	kVA
Ohm	Ω
Volt	V
Volt-ampere	VA
Watt	W
Watt-hour.	Wh

PREFIXES

Kilo	k
Mega	M
Micro	μ
Milli	m
Pica	$\mu\mu$

LETTER SYMBOLS

The symbols given below are the most important and the most firmly established of those recommended by the International Radio Propagation Conference, held in Washington in 1944, and endorsed by the General Assembly of the International Scientific and Radio Union in 1946.

foE.—Critical frequency, E layer, ordinary wave.
foF1.—Critical frequency, F1 layer, ordinary wave.
foF2.—Critical frequency, F2 layer, ordinary wave.
fxE.—Critical frequency, E layer, extraordinary wave.
fxF1.—Critical frequency, F1 layer, extraordinary wave.
fxF2.—Critical frequency, F2 l ayer, extraordinary wave.
Es.—Highest frequency of sporadic-E reflections at vertical incidence, ordinary wave.
bEs.—Blanketing frequency, sporadic-E ionisation, ordinary wave.
h'E.—Minimum virtual height of E layer.
h'F1.—Minimum virtual height of F1 layer.
h'F2.—Minimum virtual height of F2 layer.
h'Es.—Minimum virtual height of sporadic-E ionisation.
(Md)E, (Md)F1, (Md)F2.—Maximum usable frequency factor for d km. transmission by the layer indicated.

THE INTERNATIONAL CODE OF ABBREVIATIONS

The chief Abbreviations used by Amateurs to form a rapid means of communicating information in code

INTERNATIONAL Q CODE

Abbrev.	Question	Answer for Advice
QRA	What is the name of your station?	The name of my station is . . .
QRB	How far approximately are you from my station?	The approximate distance is . . . miles.
QRD	Where are you bound and where are you from?	I am bound for . . . from . . .
QRG	Will you tell me my exact frequency in kilocycles?	Your exact frequency is . . . kc.
QRH	Does my frequency vary?	Your frequency varies.
QRI	Is my note good?	Your note varies.
QRJ	Do you receive me badly?	I cannot receive you.
	Are my signals weak?	Your signals are too weak.
QRK	Do you receive me well?	I receive you well.
	Are my signals good?	Your signals are good.
QRL	Are you busy?	I am busy. Please do not interfere.
QRM	Are you being interfered with?	I am being interfered with.
QRN	Are you troubled by atmospherics?	I am troubled by atmospherics.
QRO	Shall I increase power?	Increase power.
QRP	Shall I decrease power?	Decrease power.
QRQ	Shall I send faster?	Send faster (. . . words per minute).
QRS	Shall I send more slowly?	Send more slowly (. . . words per minute).
QRT	Shall I stop sending?	Stop sending.
QRU	Have you anything for me?	I have nothing for you.
QRV	Are you ready?	I am ready.
QRX	Shall I wait? When will you call me again?	Wait (or wait until I have finished communicating with . . .). I will call you at . . . G.M.T.
QRZ	Who is calling me?	You are being called by . . .
QSA	What is the strength of my signals? (1 to 5).	The strength of your signals is . . . (1 to 5).
QSB	Does the strength of my signals vary?	The strength of your signals varies.
QSD	Is my keying correct? Are my signals distinct?	Your keying is indistinct. Your signals are bad.
QSL	Can you give me acknowledgment of receipt?	I give you acknowledgment of receipt.
QSM	Shall I repeat the last telegram (message) I sent you?	Repeat the last telegram (message) you have sent me.
QSO	Can you communicate with . . . direct (or through the medium of)?	I can communicate with . . . direct (or through the medium of . . .).
QSP	Will you retransmit to . . .?	I will retransmit to . . .
QSV	Shall I send a series of V's?	Send a series of V's.
QSX	Will you listen for . . . (call sign) on . . . kc.?	I am listening for . . . (call sign) on . . . kc.
QSZ	Shall I send each word or group twice?	Send each word or group twice.
QTH	What is your position in latitude and longitude?	My position is . . . latitude . . . longitude.
QTR	What is the exact time?	The exact time is . . .

AMATEUR ABBREVIATIONS

Abbrev.	Meaning	Abbrev.	Meaning
ABT	About.	CO	Crystal oscillator.
AGN	Again.	CUD	Could.
ANI	Any.	CUL	See you later.
BA	Buffer amplifier.	DX	Long distance.
BCL	Broadcast listener.	ECO	Electron-coupled oscillator.
BD	Bad.	ES	And.
BI	By.	FB	Fine business (good work).
BK	Break in.	FD	Frequency doubler.
BN	Been.	FM	From.
CK	Check.	GA	Go ahead, or Good afternoon.
CKT	Circuit.	GB	Good-bye.
CLD	Called.	GE	Good evening.

AMATEUR ABBREVIATIONS—*contd.*

Abbrev.	Meaning	Abbrev.	Meaning
GM	Good morning.	SA	Say.
GN	Good night.	SED	Said.
HAM	Radio amateur.	SIGN	Signature.
HI	Laughter.	SIGS	Signals.
HR	Hear, or here.	SKD	Schedule.
HRD	Heard.	SSS	Single superheterodyne receiver.
HV	Have.	TKS	Thanks.
LTR	Later.	TMN	Tomorrow.
MILS	Milliamperes.	TNX	Thanks.
MO	Meter oscillator.	TPTG	Tuned plate tuned grid.
ND	Nothing doing.	TX	Transmitter.
NIL	Nothing.	U	You.
NM	No more.	UR	You are.
NR	Number.	VY	Very.
NW	Now.	WDS	Words.
OB	Old boy.	WKG	Working.
OM	Old man.	WL	Will.
OT	Old timer.	WUD	Would.
PA	Power amplifier.	WX	Weather.
PSE	Please.	YF	Wife.
R	Received all sent.	YL	Young lady.
RAC	Rectified A.C.	YR	Your.
RCD	Received.	73	Kind regards.
RX	Receiver.	88	Love and kisses.

MISCELLANEOUS INTERNATIONAL ABBREVIATIONS

Abbrev.	Meaning	Abbrev.	Meaning
AA	All after . . .	OK	Agreed.
AB	All before . . .	UA	Are we agreed?
AL	All that has just been sent.	WA	Word after . . .
BN	All between.	WB	Word before . . .
CL	I am closing my station.	XS	Atmospherics.
C	Yes.	GA	Resume sending.
N	No.	MN	Minute/minutes.
W	Word.	NW	I resume transmission

QSA CODE (Signal Strength)

QSA1	Hardly perceptible; unreadable.	QSA4	Good; readable.
QSA2	Weak, readable now and then.		
QSA3	Fairly good; readable, but with difficulty.	QSA5	Very good; perfectly readable.

QRK CODE (Audibility)

R1	Faint signals; just readable.	R6	Good signals.
R2	Weak signals; barely readable.	R7	Good strong signals.
R3	Weak signals; but can be copied.	R8	Very strong signals.
R4	Fair signals; easily readable.	R9	Extremely strong signals.
R5	Moderately strong signals.		

RST CODE (Readability)

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

SIGNAL STRENGTH

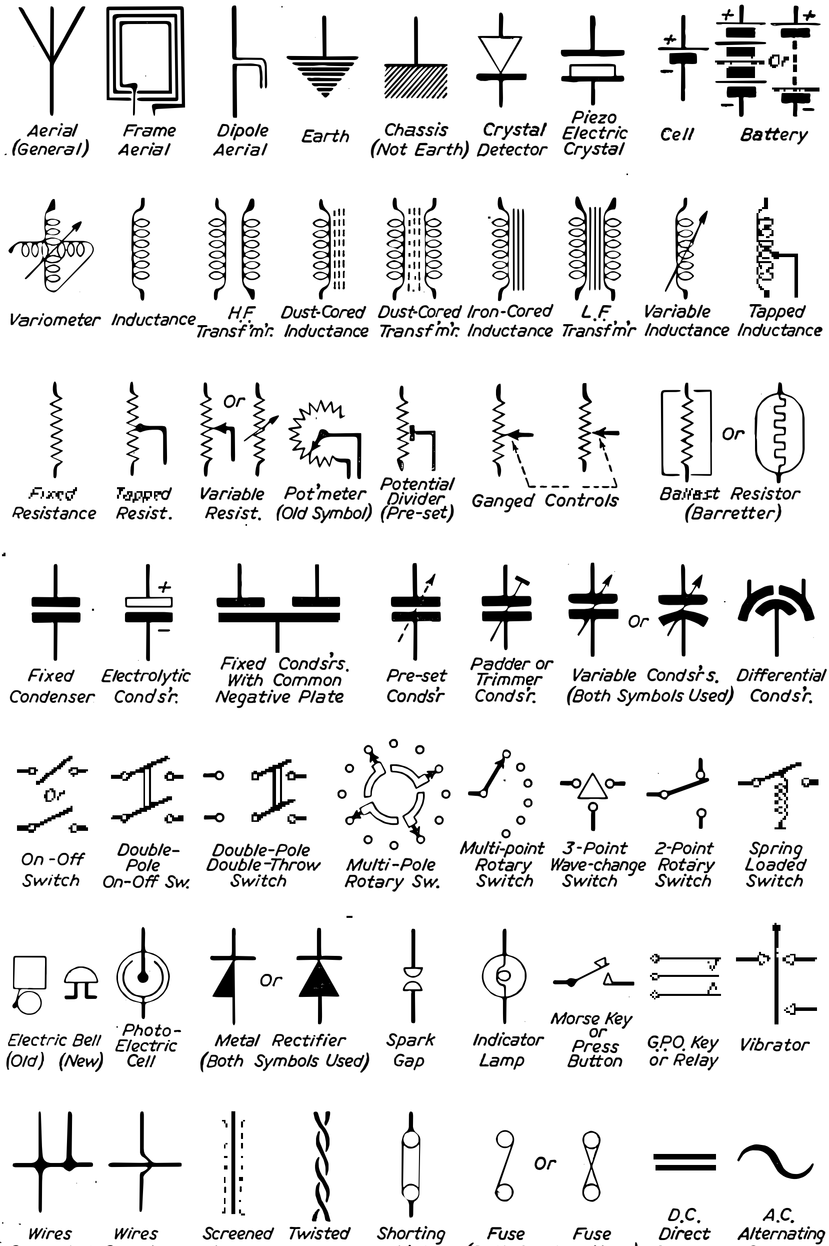
1	Faint, signals barely perceptible.	6	Good signals.
2	Very weak signals.	7	Moderately strong signals.
3	Weak signals.	8	Strong signals.
4	Fair signals.	9	Extremely strong signals.
5	Fairly good signals.		

TONE

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

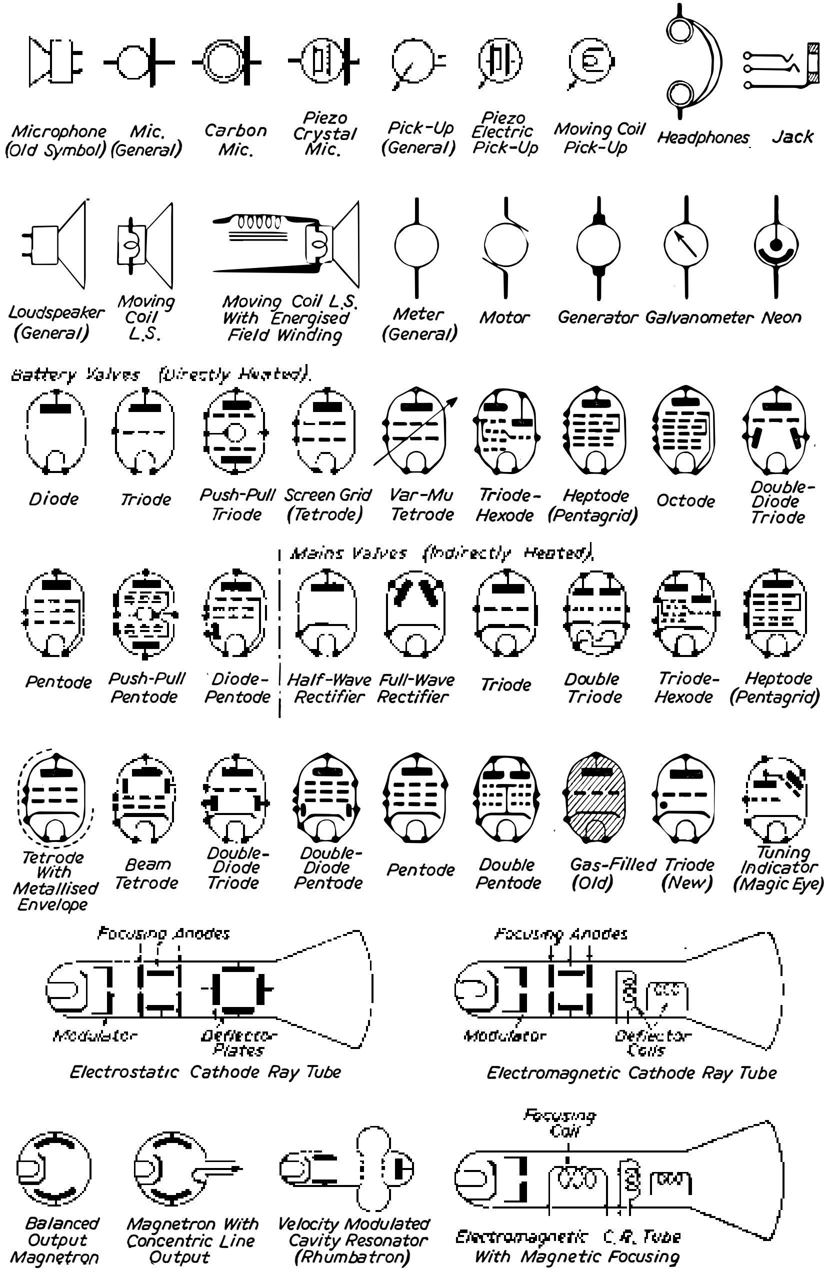
(If the note appears to be crystal-controlled add an X after the appropriate number.)

STANDARD THEORETICAL SYMBOLS



Conventional signs used in drawing a wireless circuit, which merely consists of a number of these signs joined together. Pictorial diagrams showing the actual components represented are given in the book in their correct alphabetical order.

STANDARD THEORETICAL SYMBOLS (*continued*)



A further selection of conventional signs.

PRACTICAL WIRELESS ENCYCLOPAEDIA

ABAC. A graphical diagram constructed from any standard formula, enabling results of that formula to be obtained without calculation by using a rule. The most complicated formulæ may thus be used by the non-mathematical constructor. The basis of the Abac system is d'Ocagne's theorem, published in France in 1899. A monogram

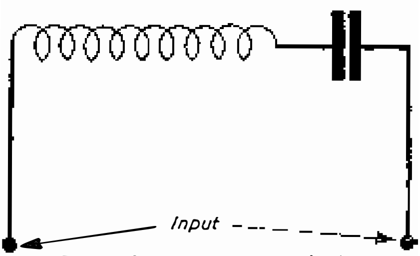


FIG. 1. *Acceptor or wave-trap circuit.*

ABAMPERE. The absolute electromagnetic unit of current—that current which, passing along a wire of 1 cm. length, bent into an arc of 1 cm. radius, will exert a force of one dyne on a unit magnetic pole placed at the centre. One abampere equals 10 amperes; one ampere equals one-tenth of an absolute unit of current. 1 ampere $= 3 \times 10^9$ statamperes, or 0·1 abampere; 1 abampere $= 3 \times 10^{10}$ statamperes. (See *Statampere*, *Unit Magnetic Pole*, and *Weber*.)

ABBREVIATIONS. See page vii.

ABCOULOMB. See *Coulomb.*

ABFARAD. See *Farad.*

ABHENRY. See *Henry.*

ABMHO. See *Mho.*

ABOHM. See *Ohm.*

ABSCISSA. The horizontal distance of any ordinate from the axis of a graph. Plural, *abscissæ*. Refer to *Ordinate.*

ABSOLUTE UNIT OF CURRENT. The current which, flowing in a circular conductor of radius 1 cm., will produce at the centre a magnetic field of strength 2π gauss. The ampere is equal to one-tenth of an absolute unit of current. (See *Abampere.*)

ABSOLUTE UNITS. The units of the centimetre-gramme-second system of measurement, in which the unit of length is the centimetre, the unit of mass the gramme, and the unit of time 1 second. Thus the C.G.S. unit of force is the force that can so move a body weighing a gramme that at the end of 1 second it will have a velocity of 1 cm. per second.

ABSORPTION FACTOR. Symbol *a*. The ratio of luminous flux in lumens absorbed by a body to that incident upon it. A lumen is that luminous flux emitted per unit solid angle by a point source (uniform) of a luminous intensity of one International Candle or 0·98 of the English Standard Candle. (See *Lumen.*)

In radio, reduction in the intensity of an electromagnetic wave, due to eddy currents and dielectric losses in the earth. Also called *Attenuation Factor* (*which see*).

ABSORPTION POINT. A frequency at which stray coupling between two or more circuits gives rise to noticeable loss of energy from one of them.

ABVOLT. See *Volt.*

A.C. Abbreviation for alternating current (*which see*).

ACCEPTOR CIRCUIT. A tuned circuit consisting of inductance and capacity so designed that a certain band of frequencies is accepted in preference to all other frequencies (Fig. 1). An instance is given in the Acceptor Wave-trap, where a coil with series condenser is arranged in series with the aerial lead to the receiver. When the acceptor circuit is tuned to the frequency of an interfering station that frequency is accepted, or absorbed, and therefore is received by the wireless receiver. (See *Rejector Circuit.*)

ACCUMULATOR. A device for storing electricity (see Fig. 2). It consists of a container of either glass or celluloid, in which are fitted two sets of plates. These

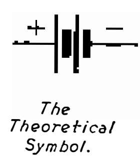


FIG. 2. *Theoretical diagram of an Accumulator. Note that the thick line is always the negative in a theoretical diagram.*

plates are made up of pastes (see under *Accumulator Paste*, p. 15) immersed in a solution known as the electrolyte. This consists of dilute sulphuric acid in either liquid, paste, or jelly form. (See *Jelly Electrolyte.*) It was Galvani who, in 1793, whilst conducting some experiments, observed that the legs of a frog began to twitch when they were used as a conductor for the discharge of this well-known form of condenser. Later on, Volta discovered that by using two different metals to touch the leg of the frog an increased twitching effect resulted. A *primary* cell is one which gives an electric current by the immersion of two dissimilar plates (usually carbon and zinc) in a chemical solution. An accumulator, or secondary cell, must have an electric current passed through it, a proportion of which it stores. An accumulator is rated according to its voltage, and its capacity for storing is known as its ampere-hour capacity.

Cells in Series. Most single-cell accumulators have a voltage between one and two or perhaps a fraction over two, but to obtain a higher voltage one may connect any number of cells in series (see Fig. 3), that is to say, by joining the negative terminal of one cell to the positive terminal of its neighbour. By this means the voltages of the cells are added together to give any value desired. In high-tension batteries, for instance, about seventy dry cells may be connected in series to give about 100 volts.

The number of the cells will govern the voltage, whilst the size of the individual cells will decide the extent of the total capacity.

Cells in Parallel. A large accumulator possesses greater storage capacity than a small one and, although size does not affect the voltage, the larger battery will have a larger ampere-hour capacity. The equivalent of a large battery may also be obtained by connecting a number of smaller ones in parallel, this being accomplished when all the positive terminals are connected together and also all the negative terminals, as shown in Fig. 4. The voltage will not be increased, however, so that series connection (referred to earlier) gives increased voltage, but parallel connection gives lower resistance and consequently greater capacity.

ACCUMULATOR ACID. (See also *Jelly Electrolyte.*) The acid solution consists of pure brimstone sulphuric acid diluted with distilled water to the required specific gravity; acid of the correct specific gravity can be purchased. Instructions regarding the correct specific gravity are usually attached to the battery, and should be carefully followed. The density specified has a direct bearing on the battery condition, and acid of too low a density will reduce the capacity, whilst too high a density decreases conductivity and sets up heating and local action in the plates. The specific gravity is affected by a rise or fall in the temperature of the acid solution, and an appropriate correction must be made before using the acid (see tables below).

USING ACID OF 1·840 SPECIFIC GRAVITY

Required Specific Gravity at 70° F.	*Water*	*Acid, 1·840 Specific Gravity*
	Parts by Volume	*Parts by Volume*
1·400	14	10
1·350	18	10
1·300	21	10
1·250	27	10
1·225	29	10

USING ACID OF 1·400 SPECIFIC GRAVITY

Required Specific Gravity at 70° F.	*Water*	*Acid, 1·400 Specific Gravity*
	Parts by Volume	*Parts by Volume*
1·300	4·5	10
1·280	5·5	10
1·275	6·25	10
1·265	6·4	10
1·255	6·65	10
1·250	6·75	10

Density is normally stated as at 60° F. To correct for temperatures above 60° F. add ·002 to the specific gravity for every 5° F. For temperatures below 60° F. deduct ·002 for every 5° F. to obtain the requisite equivalent at 60° F.

For cells in which the separators are wood, it is necessary to make an allowance for the moisture content of the wood, this type of separator being stored in a wet condition.

How to dilute Acid. Pure brimstone sulphuric acid is supplied in carboys, and can be obtained broken down to any specified density required for battery electrolyte, but as this density may alter owing to evaporation, it is preferable to dilute the acid as and when required. In mixing the solution, glass, glazed earthenware, or lead vessels should be used. The water must be poured in first, and the acid added gradually, stirring meanwhile with a glass rod. *Violent and dangerous splashing of the acid is liable to occur if water is poured into acid.*

A new battery should not be filled with solution until ready for charging, and before filling the acid should be cooled to atmospheric temperature. After filling, the battery should be allowed to stand for twelve hours before charging. The acid should be tested periodically, as impurities in it may lead to self-discharge, heating, and other battery troubles.

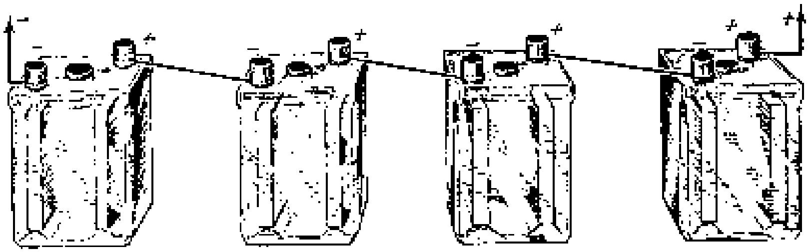


FIG. 3. *Accumulators connected in series.*

ACCUMULATOR CHARGING FROM A.C. AND D.C.

First Charge. The first charge is of critical importance to the life of a battery, and the manufacturers' instructions should be followed implicitly. The usual period is thirty-six hours, and the charging rate approximately half of this period. The period and rate vary with different makes of cell, and depend on the formation of the plates and the density of the solution used. During the charge the temperature of the electrolyte should be kept below 100° F., and if this figure is exceeded the charging rate should be reduced or the charge suspended until normal temperature is regained. High temperatures cause the active material in the grids to expand and to loosen, resulting in flaking, loss of capacity, and shorting of the plates.

Batteries will give much better service and last longer if the temperature during charge or discharge periods is kept within the limits of 70° F. and 90° F. At the end of the charging period the cells should be gassing freely and the density of the acid have attained a maximum value. The vent plugs should be removed during the first charge to allow the gas generated to disperse. *This gas is highly inflammable and explosive, and on no account should a naked flame be brought near to the cells.*

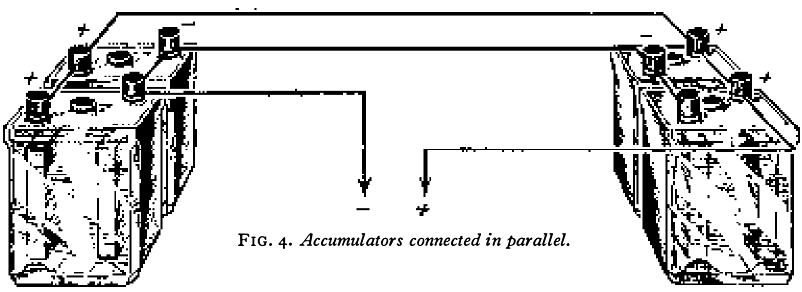


FIG. 4. *Accumulators connected in parallel.*

The fact that so many electrical undertakings are changing over from direct current to alternating current renders necessary information on charging accumulators from this source of supply. It is impossible to charge an accumulator from alternating current until it has been rectified or converted into unidirectional or direct current by one of the methods now to be described.

Fig. 5 illustrates the difference between direct and alternating current (*which see*). The usual means adopted for rectifying alternating current is by means of a chemical rectifier, a rotary converter, a vibrating reed rectifier, the Tungar rectifier, a motor generator, the mercury-vapour rectifier, the valve rectifier, the copper-oxide rectifier and the selenium rectifier. For amateur purposes, the metal or selenium rectifier is the most suitable.

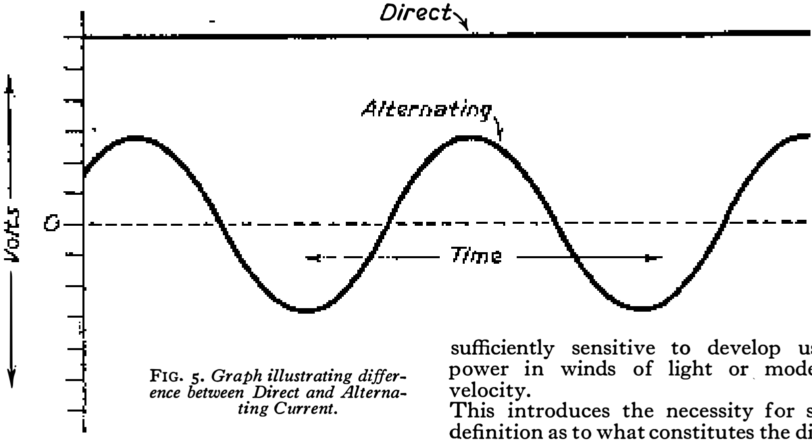


FIG. 5. *Graph illustrating difference between Direct and Alternating Current.*

The Motor Generator. There are on the market a number of motor generators consisting of an induction motor driven from the alternating-current mains, and coupled to a direct-current dynamo. This system has much to recommend it, but unfortunately it is expensive. There are other motor generators somewhat similar but differing in principle, having rotary transformers incorporated in the frame of the motor. The mechanically driven rectifier makes use of an A.C. motor (synchronous) coupled to a commutator fed by the alternating current, and from it is delivered the direct current (see Fig. 6). The chief defect of this type is sparking at the commutator, necessitating frequent renewal.

Wind-Chargers. A method of charging which may be used in open districts without mains supply consists of driving a dynamo or generator by means of wind sails. Although wind power in this country is apt to be rather erratic, far too much of it at times and not enough of it at others to provide any useful results, it is a notable fact that, taken over a long period, careful observations have proved that serviceable wind power is available for an average of eight hours per day in the majority of localities, if the site is carefully chosen.

The problem with wind motors is, of course, to control the variations in speed arising from extreme weather conditions, such as periods of calm, on the one hand, and tempests on the other. A wind motor to be successful must be so constructed as to resist disaster in a gale and yet be sufficiently sensitive to develop useful power in winds of light or moderate velocity.

This introduces the necessity for some definition as to what constitutes the difference between a breeze and a hurricane. The Meteorological Office has compiled a table known as "Beaufort Scale Numbers" which are attributed to winds of varying force according to their characteristics as below :

Beaufort Scale	*Corresponding Wind*	*Velocities in Miles per Hour*
0	Calm	Under 2
1 to 3	Light Breeze	2 to 12
4 to 5	Moderate Wind	13 to 23
6 to 7	Strong Wind	24 to 37
8 to 9	Gale	38 to 55
10 to 11	Storm	56 to 75
12	Hurricane	Above 75

The indispensable parts in any such outfit comprise (1) the constant-voltage dynamo, (2) the propeller, (3) a tailpiece to keep the propeller in the wind, (4) the collector rings for conveying current from the movable head to fixed terminal points, and (5) the mast upon which the whole is mounted.

So far as the generator is concerned there are plenty of good secondhand car lighting dynamos to be picked up cheaply, of a type illustrated in Fig. 7. This is one of the most popular models, and makes a very serviceable unit, cutting in for charging at 850 r.p.m. and giving its full output of 12 volts 13 or 14 amps. at about 1,350 r.p.m. If larger models happen to be available they can, of course, be used, and the lower the cutting-in speed the more serviceable will they be in light winds.

The Propeller. Item (2), the propeller, will no doubt demand some little patience and several modifications before a satisfactory home-made article is arrived at. Lightness and strength is, of course, essential, as the centrifugal effect and thrust will be considerable at high speeds. A well-seasoned piece of straight grained pine or cedar will be required, in one piece 6 ft. long and 1½ in. thick, tapering from 6½ in. wide at the hub to 3½ in. or 4 in. at the tips, fashioned on the lines shown in Figs. 9 and 11, the pitch of the blades being about 35° measured from the plane of rotation. The boss needs strengthening by a flanged double-arm casting, keyed to the dynamo shaft and retained by an end lock nut.

The design and proportions of the sheet-metal tailpiece are obtainable from Fig. 9, the extension arm carrying it consisting of a length of seamless steel conduit about 1 in. diameter, such as is used in electric wiring, attached to the revolving head by saddles at each extremity.

The Rotatable Head. The rotatable head with the collector rings needs planning out with a view to utilising whatever material happens to be available in the workshop, and dimensions are of secondary importance, so long as the collector is not too small, say, 3 in. in diameter. The main idea is sketched out in Fig. 12, but is not to scale, for reasons stated above. As shown in this figure, the wood mast A terminates in four angle pieces of 1½ in. by 1½ in. mild steel B, not less than 12 in. long, which are arranged to grip the mast with four straps and bolts S. These angle pieces stand up 6 in. beyond the end of the mast, and a flanged steel plate C is screwed to them to form a rigid metal top. Above this is the rotatable table E to which the dynamo is fixed, and from the underside of which extends a central tube G carrying the two insulated sliprings H. From these rings current can be collected, whatever may be the position in which the dynamo is pointing, by means of two insulated cartridge-type carbon brush-holders K. An outer casting L which serves for their mounting is fixed to C and forms a protection from wet or dust, and is drawn in section to expose the collector rings.

Connections from the dynamo terminals are brought down through the hollow stem G, one being attached to each slipring. Between the underside of the slipring assembly and the fixed head C may be placed a ball thrust washer D to carry the whole weight of the dynamo and propeller. The extremity of the stem at N is guided and supported by passing through a cross strap riveted to the angles B, with a nut P to prevent it from rising.

The design of the head is to be taken as a suggestion, and subject to variation according to means and experience. It forms a workable basis for building up a practicable wind-driven lighting installation capable of providing a good light to four or five bulbs of 25-watt size, when working in conjunction with a 12-volt car accumulator.

A Mechanical Governor. Some attempts have certainly been made to steady the charging current by the addition of a mechanical governor or wind-diverter, or even a small wind vane attached to the tail to move the propeller into less effective positions with increasing force of the wind. One example is given in Fig. 10,

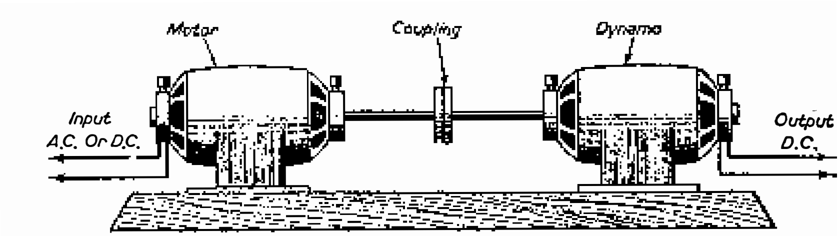


FIG. 6. *Diagram showing the principle of the Rotary Converter and Rotary Transformer. A motor, either A.C. or D.C. is driven from the mains and coupled to a D.C. generator which charges the accumulators. In practice one machine acts both as motor and dynamo.*

showing an addition to the 2-blade main propeller in the form of small blades hinged at one end which open out at excess speeds by centrifugal effect and cause the wind stream to diverge before reaching the main blades (see also Fig. 8). This device is used in the windcharger outfits manufactured by an American company. In these the natural regulation of the constant-voltage dynamo is augmented by the action of the air-brake, seen at right angles to the propeller, when a critical speed is exceeded. An English set is illustrated in Fig. 11, which relies principally on the self-governing properties of the dynamo, aided by a furling action of the wind-motor tail. The operation of this device, as supplied by the makers, is as follows, the parts referred to being illustrated in Fig. 11. When the furling handle is moved downwards to bring the set into operation, a metal collar is slid down the shaft against the tension of a spring. The whole of the head gear is free to rotate within the metal collar. A forked member is engaged with the collar and is moved downwards about its pivot by the collar. A lever arm attached to the forked member engages the tail bracket, causing it to be moved outwards against the tension of another spring. When furling, the reverse takes place. Release of the furling handle relieves the spring and allows the metal collar to slide up the headgear. This lifts the forked member, the lever arm is disengaged from the tail bracket, and the tail is thus returned to the furled position by the spring. In the event of very strong winds likely to cause excess speeds the tail is swung back and out of the wind with a consequent regulation of the dynamo speed.

The Electrical Circuit. Apart from details of design, such as are shown in the foregoing illustrations, the electrical circuit is similar in all such outfits, and in its simplest form without any switches, instruments, or other complications, consists of placing dynamo and battery in parallel. But there must be some automatic means of preventing current from the battery discharging back through the dynamo when the latter is not running fast enough to charge. Also, switches are required to control individual lamps, and an ammeter to measure the charge or discharge current in the accumulator circuit.

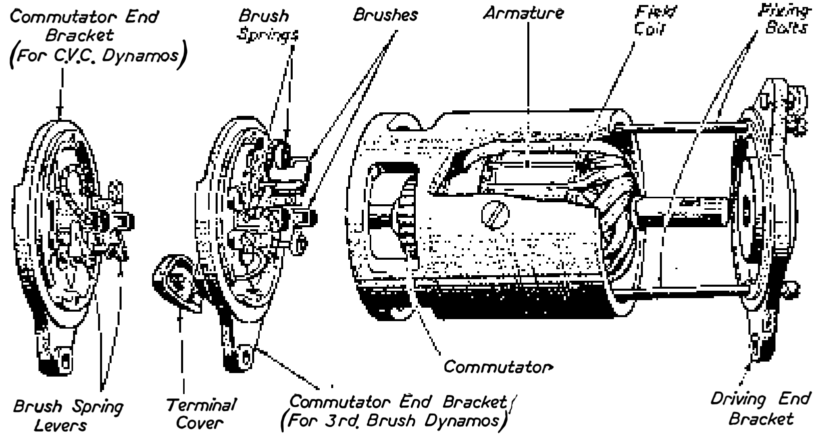


FIG. 7. *A car lighting dynamo, showing construction.*

Constant Voltage Generator. The "constant voltage" generator permits of a fairly constant voltage being obtained from its terminals at widely different driving speeds by a special construction, and by the use of a "floating battery" used in conjunction with it.

There are, in fact, a good many different devices for obtaining constant voltage at varying speeds, but the most popular is the one known as "third-brush control." In the case of the ordinary shunt-wound 2-pole dynamo, engine-driven at a closely governed speed, there are two brushes only at opposite positions on the commutator (see Fig. 13). The windings form

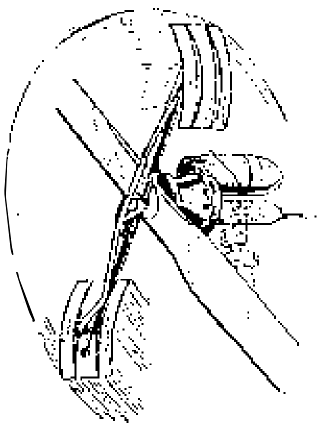


FIG. 8.

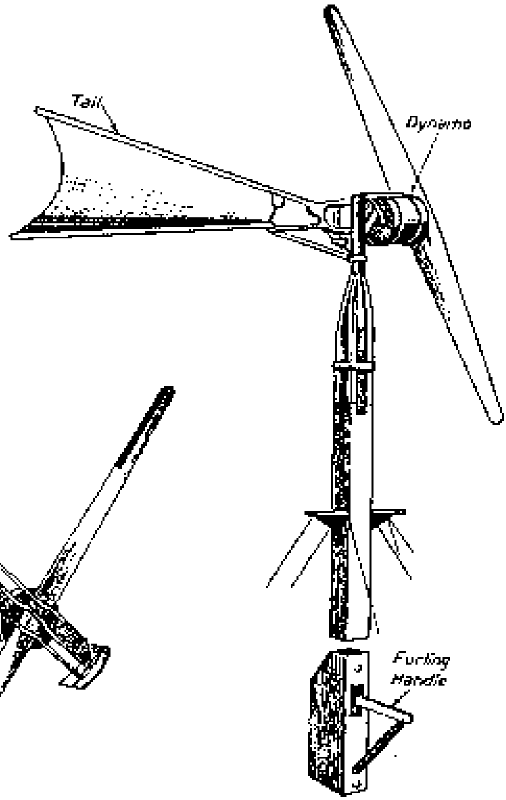


FIG. 11. *A commercial wind-charger, with furling tail.*

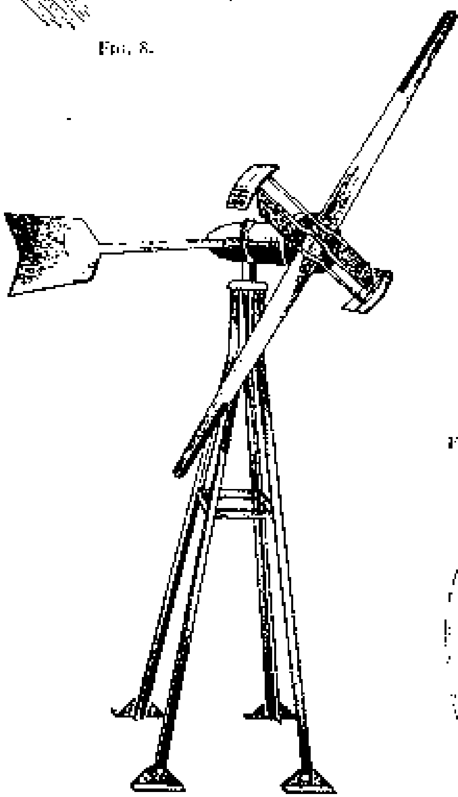


FIG. 9.

FIGS. 8 TO 10. *An addition to the 2-blade main propeller in the form of small blades hinged at one end, which open out at excess speeds.*

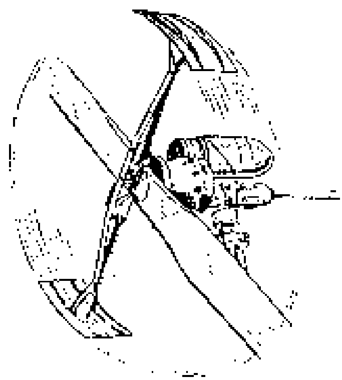


FIG. 10.

two distinct circuits, one through the armature A and brushes to the main terminals B and so direct to the lamps or battery; the other is an independent and

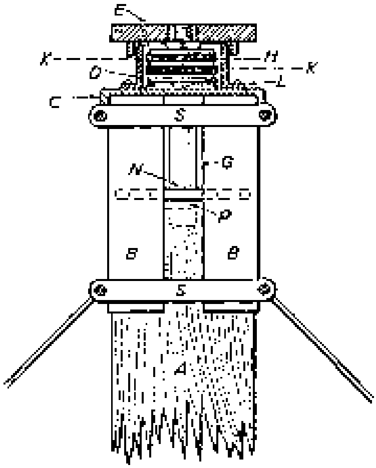


FIG. 12. *Details of the rotatable head.*

separate circuit C through the fields only, a small current being "shunted" from the main terminals for the sole purpose of exciting the field magnet coils.

Metal Rectifiers. This type of rectifier has developed to such an extent that it competes favourably with the valve rectifier.

In brief, the principle upon which the metal rectifier operates is that copper in contact with a certain oxide permits of the flow of current in one direction only.

In the metal rectifier which is used in wireless, discs of copper, oxidised copper, and lead are mounted on a non-conducting tube, with a large cooling fin interspersed at frequent points to dissipate the heat and thus prevent damage.

Various methods of connection are possible, according to the use to which the rectifier is to be put. The metal rectifier is very robust in construction and has a higher efficiency than most other types of rectifier.

Fig. 15 shows two theoretical circuits for the metal rectifier, arranged in what is known as the Bridge Circuit.

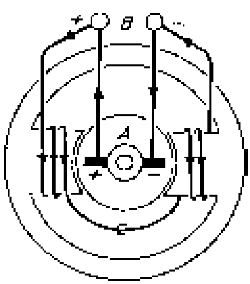
A smaller type of rectifier has also been developed for use in the high-frequency circuits, and this is commonly referred to as a "cold valve" (*which see*).

Transforming Alternating Current. Unlike direct current, alternating-current voltage can be transformed to higher or lower potentials without the use of rotary converters. This means that a simple piece of apparatus can be used in place of the resistance, the advantage being that the excess voltage need not be dissipated and, therefore, wasted.

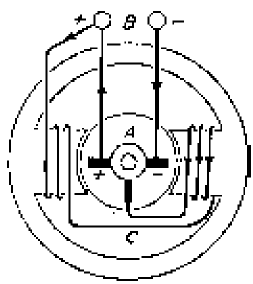
Cleanliness is another very important factor in accumulator management. Dirt and dampness on an accumulator permit the current to leak away, in addition to attracting and holding small quantities of acid. This is liable to cause corrosion and rotting of wooden crates, etc.

Neutralising Spilled Electrolyte. If electrolyte is spilled, it should be immediately treated with a neutralising solution, such as sodium carbonate (soda) and water, or ammonia and water. Either of these liquids is excellent for checking the effects of acid on clothing. Benches, trays, and other fittings which have become acid-sodden should be treated with a solution of 1 lb. of soda to 1 gallon of water, and then dried before coating with acid-proof paint.

Finding Polarity of Mains: First Method. With D.C. mains, connect the + pole of



FIGS. 13 AND 14. (*Left*) *A shunt-wound 2-pole dynamo.* (*Right*) *A constant voltage dynamo.*



a D.C. voltmeter to the (supposed) positive main, and allow a wire from the — terminal of the meter momentarily to touch the (supposed) negative main. If correctly connected, the hand of the meter will swing in the proper direction. If reversed, the hand will tend to swing backwards. Make sure that the connection is broken immediately, for a reversed connection might bend the hand of the meter. The meter must have a resistance of at least 200 ohms per volt.

Second Method. Dip the ends of the two wires into a glass containing a weak solution of salt and water. Bubbles of colourless gas will be formed on the negative wire. It is necessary to connect a lamp of "mains" voltage in series with one of the wires to avoid the danger of short circuits (see Fig. 16).

ACCUMULATOR CHARGING FROM DIRECT CURRENT. Unlike alternating current, which, as has been explained earlier, needs to be rectified or made unidirectional before it can be used for accumulator charging, direct current does not need any special apparatus other than that necessary to restrict the flow of current to the correct charging rate—a comparatively simple matter. Should any doubt exist regarding the nature of the supply, this may be easily ascertained on application being made to the offices of the supply company.

Mains Voltage for Accumulator Charging. The voltage of the current for accumulator

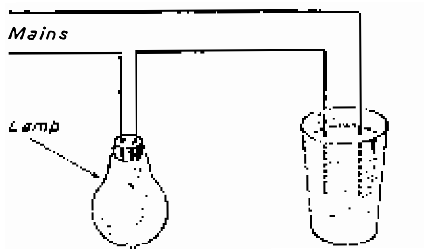


FIG. 16. *Dissolve a teaspoonful of salt in a glass of water and dip the ends of the charging wires in the solution. Bubbles of gas will form on the negative wire.* (*See also* FIGS. 25 *and* 26.)

charging is immaterial, providing that it is in excess of the total voltage of the cells to be charged and (this is most important) that the current that is allowed to flow is restricted to a suitable amount by means of a resistance. Voltage or potential, as it is sometimes termed, is not capable of producing a heating or chemical effect, but it has the power of forcing current through a conductor, and as it is the actual current flowing that counts, it is the volume of

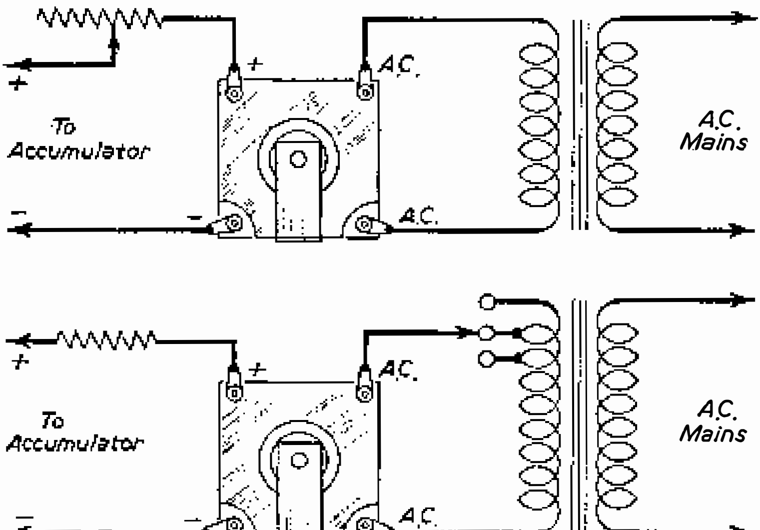


FIG. 15. *Two standard methods of employing a metal rectifier for charging accumulators.*

this that must be restricted to a suitable amount.

The Safe Charging Rate. The maximum safe charging rate of an accumulator is approximately one-tenth of its actual capacity. For instance, the charging rate of a 60-ampere-hour cell would be 6 amps. Any excess would cause heating and disintegration of the plates.

Determining the Resistances to be Used. It will be apparent that the resistances to be used will differ with different voltages of charging supply and also with cells of different capacity. The ideal voltage for charging a 6-volt battery would be approximately 8, as in this case there would be no necessity to interpose a resistance,

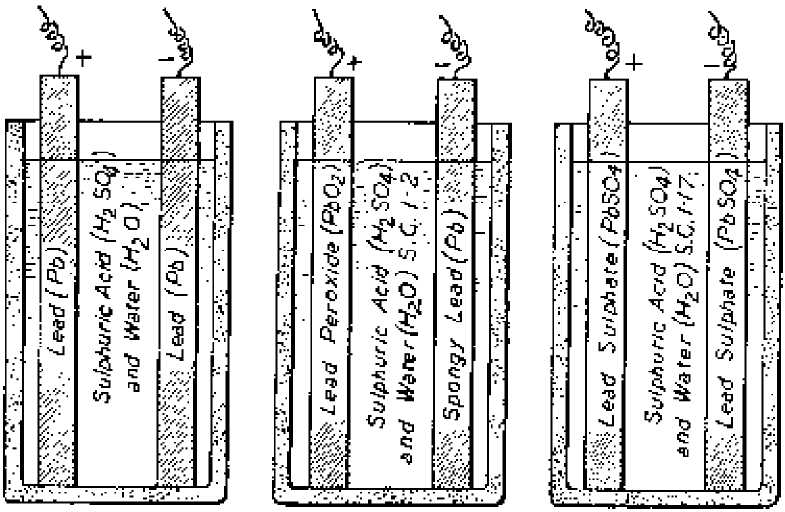


FIG. 17. *(Left) Simple cell ready for charging. (Centre) State of cell when charged. (Right) State of cell when discharged. Note the acid becomes weaker, having been used up in forming lead sulphate.*

the difference of the voltage of supply and that of the battery being charged not being sufficient to cause an excess amount of current to flow. With increase of the voltage of supply, however, such as by the use of lighting mains, suitable resistances are necessary, and the higher the voltage the greater must be the resistance. Incidentally, high voltages are wasteful, inasmuch as no use is made of the excess, though it figures in the total cost of the units used. Carbon filament lamps are used for charging purposes chiefly because they take almost four times as much current per candle-power as do metal-filament lamps (see table following and on page 12).

CURRENT PASSED BY CARBON FILAMENT LAMPS

Current in amperes per Lamp	*Voltage of Supply*				
	25	50	100–200	200–250	
$\frac{1}{4}$	—	—	8 c.p.	16 c.p.	At 4 watts per c.p.
$\frac{1}{2}$	—	8 c.p.	16 c.p.	32 c.p.	
1	6 c.p.	16 c.p.	32 c.p.	60 c.p.	
2	12 c.p.	32 c.p.	60 c.p.	100 c.p.	

Example 1. Suppose the battery has to be charged at 10 amps. and the voltage of supply = 250.

Total watts required = $250 \times 10 = 2{,}500$. Divide this value by the wattage of the lamps available to get the number required. Thus the number of 60-watt lamps required = $\frac{2500}{60} = 42$ approx.; 100-watt lamps = 25, etc.

Example 2. To find the current which a certain number and value of lamps will allow to flow.

Four lamps of 60 watts each are available and the town supply is 250 volts.

Current flowing

$$= \frac{\text{Number of lamps} \times \text{wattage of each}}{\text{Voltage of supply}}$$

$$= \frac{4 \times 60}{250} = \frac{240}{250} = \cdot 96 \text{ amp.}$$

A Typical Charging Arrangement. In practice the first essential is to find out what the charging rate of the accumulator is, a fact which, as a rule, is stated on the label, though, as mentioned earlier, it is approximately one-tenth of the capacity. The next matter is to provide a suitable arrangement for holding the lamps. A simple way of doing this is to mount a number of batten-type lamp holders on a board, as shown in Fig. 18. The method of connecting the lamps and the accumulator is clearly shown, and from a study of this it will be apparent that the current can be regulated to a particular amount by the removal or insertion of lamps. Any number of lamps up to the maximum can be used, but it must be understood that the fewer that are used the longer will the charging time be, owing to the reduced amount of current passing. A table giving the amount of current that different lamps will pass on different voltages is given on the next page, and the worked examples which follow it should make the calculation clear.

Whilst the accumulators are being charged, the light from the lamps, which is only slightly less brilliant than usual, is being wasted, and this suggests a method of charging whilst the lamps are in use. One method of doing this is clearly shown by Fig. 19.

In this case one lead to a single pendant lamp is cut and a wire joined on to each

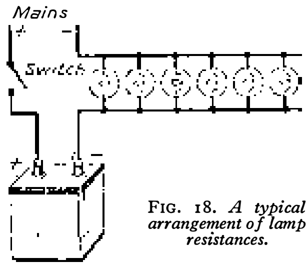


FIG. 18. *A typical arrangement of lamp resistances.*

end. These wires are then simply connected to the accumulator, observing, of course, the correct polarity as detailed before. Another method, which is applicable to either a single or three-light fitting is to remove the screw-on cover of a switch and connect a wire to each of the contacts. The two wires, after their polarity has been determined, are then connected to the accumulator in the usual manner (see Fig. 21).

EUREKA RESISTANCE WIRE

S.W.G.	*Diameter in inches*	*Turns per in. D.S.C.*	*Length per ohm in inches*	*Ohms per yard*	*Wt. per 1,000 yards in lb.*
16	·064	14·7	173·8	0·21	37·20
18	·048	19·6	96·8	0·37	20·93
20	·036	25·6	54·4	0·66	11·77
22	·028	32·2	32·9	1·10	7·120
24	·022	40·0	20·3	1·77	4·392
26	·018	48·8	13·7	2·64	2·942
28	·014	57·8	9·2	3·91	1·989
30	·012	67·1	6·5	5·57	1·399
32	·010	75·2	4·9	7·35	1·059
34	·009	85·5	3·6	10·12	0·7688
36	·007	90·1	2·4	14·84	0·5249
38	·006	118·0	1·5	23·80	0·3272

COMPARATIVE RESISTANCES

Material	*Relative Resistances*
Copper	1·0
German Silver	11·7 to 18·5
Eureka	29·3
Nichrome	55·0
Silver	0·94
Gold	1·5
Aluminium	1·6
Bronze (about)	1·5
Zinc	3·6
Tungsten	3·9
Nickel	4·3
Phosphor Bronze (about)	4·7
Platinum	5·3
Iron	6·1
Tin	8·1
Lead	12·1
Mercury	57·8
Carbon (about)	2,500 to 6,000

CURRENT-CARRYING CAPACITY OF WIRES

S.W.G	*Current Capacity (Amps.)*	*S.W.G.*	*Current Capacity (Amps.)*	*S.W.G.*	*Current Capacity (Amps.)*	*S.W.G.*	*Current Capacity (Amps.)*
10	19·305	19	1·8855	28	·258	37	·0545
11	15·855	20	1·527	29	·218	38	·0425
12	12·7425	21	1·206	30	·1812	39	·0318
13	9·872	22	0·9237	31	·1586	40	·0272
14	7·5405	23	0·6786	32	·1374	41	·0228
15	6·108	24	0·5702	33	·1178	42	·0189
16	4·8255	25	0·4703	34	·0998	43	·0153
17	3·6945	26	0·3818	35	·0831	44	·012
18	2·715	27	0·3168	36	·0681	45	·0093

When it is desired to adopt this latter method as a permanent fitting, it is essential that the two wires from the switch should be attached to some form of in-

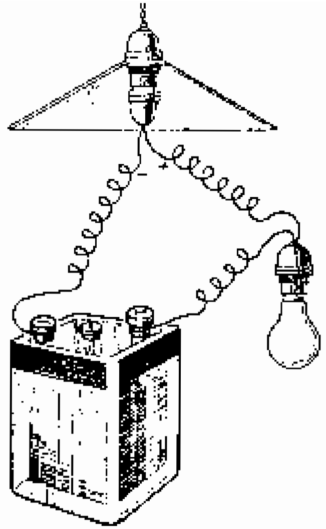


FIG. 19. *Simple charging arrangement from D.C. mains.*

sulated board, and the terminals, or other attachments for the accumulator, should be protected so that they will not be short circuited or touched when no accumulator is connected to them.

Determining Resistance Values. Ordinary metal filament lamps are one of the most popular and convenient forms of resistance obtainable. The actual value of charging resistance required will vary, as already explained, according to the voltage of the charging supply, the voltage of the accumulator to be charged, and the charging rate required.

To determine this, connect a bank of lamps and an ammeter in series with the battery, as suggested earlier, and increase or decrease the number of lamps until the correct rate of charge (as indicated by the ammeter) is obtained. Fig. 20 shows the complete charging circuit.

Charging from a Dynamo. Those who are not so fortunate as to have electricity in their homes may be interested in another method of accumulator charging. This consists of a small dynamo driven by a small petrol engine. The dynamo should have an output of 100 volts at 35 milliamps., and 4 volts at 2 amps.

Charging Hints. If it is intended to charge accumulators on a large scale, have the charging-room well ventilated in order to dispose of the gases generated in the accumulator. Never bring a flame or spark near to an accumulator during or shortly after charge, as the hydrogen given off is highly inflammable.

Avoid high temperatures. The temperature of any accumulator on charge should be kept below 110° F. If this is exceeded, the charge should be suspended for a time, otherwise the life of the accumulator may be shortened.

Never charge at rates greater than those specified by the makers of the accumulator. Continue the charge until all the cells are gassing freely and at an even rate, and the specified gravity of the electrolyte will not rise any higher. For testing the gravity of the electrolyte, use a hydrometer with a graduated float, showing the actual strengths of the acid (Fig. 22).

CURRENT-CARRYING CAPACITY OF LAMPS

Carbon-filament Lamps

Candle-power	*Voltage*	*Current passed*
8	110	·254
16	110	·509
32	110	1·018
8	220	·127
16	220	·209
32	220	·509

Metal-filament Lamps

Candle-power	*Voltage*	*Current passed*
8	110	·09
16	110	·18
32	110	·36
8	220	·049
16	220	·09
32	220	·18

Corrosion. To prevent corrosion, wipe with a rag soaked with ammonia, and then coat with pure vaseline. Once corrosion has started, it must be removed from all metal surfaces by scraping, filing, or with a wire brush. Ammonia and vaseline should then be applied as before. Pay particular attention to keeping the top of the affected accumulator clean and dry. Vaseline is specified as a preventive of corrosion, because ordinary grease contains animal or vegetable fats which increase rather than prevent the evil (see Fig. 24).

Use Distilled Water only. Under normal conditions, nothing but pure distilled water should *ever* be added to an accumulator. Water evaporates, sulphuric acid does *not*. It is therefore very necessary to make up the water lost by evaporation, but quite unnecessary to add acid. Fresh acid should only be added when some of the

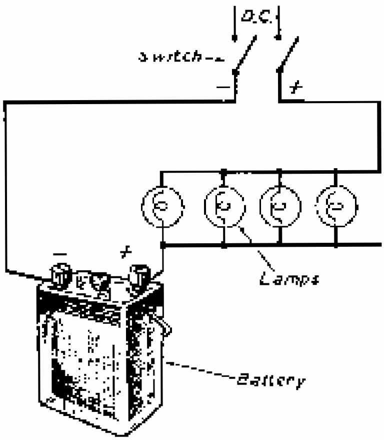


FIG. 20. *The complete charging circuit.*

original electroyte has been lost through spillage, and it should then be carefully adjusted to the correct strength before adding.

Never allow the level of the electroyte to fall below the tops of the plates. The best time to add distilled water is just before charging, as the gassing of the accumulator ensures the liquid being well mixed.

Never carry or store water in any metallic vessels other than lead. Glass, earthenware, or lead-lined vessels are the most satisfactory, and they should be kept clean and well covered to keep out impurities.

Precautions. When handling and mixing acid, the precautions already given and here tabulated should be observed :

(1) Use glass, china, earthenware, or lead-lined vessels.

(2) Pour the acid carefully into the water —not the water into the acid, as this may cause spluttering and possible personal injury.

(3) Stir very thoroughly and use a wooden spoon or paddle.

(4) Allow the liquid to cool before taking hydrometer readings.

Chemical Action Explained. Before proceeding further, it would, perhaps, be as well to explain the chemical action which takes place in a cell during charge and discharge. In a fully charged cell (Fig. 17) the negative plate is spongy lead (Pb) and the positive plate lead peroxide (PbO_2), while the electrolyte is a mixture of sulphuric acid and water (H_2SO_4 and H_2O). This electrolyte is now at its maximum strength.

When the cell is placed on discharge, the acid splits up into H_2 and SO_4. The H_2 combines with some of the oxygen in the lead peroxide and forms H_2O, while the SO_4 combines with the liberated Pb to form lead sulphate ($PbSO_4$). As the discharge continues the gravity of the electrolyte falls, both plates become entirely sulphated, and the current finally ceases to flow. The strength of the acid is now at its minimum (Fig. 17).

Direct current must now be passed through the cell in order to recharge it. When this is done, a reverse action to the above will take place. The lead sulphate on the plates is converted into lead peroxide and spongy lead, while the acid which has combined with the active material in the plates is driven back into the electrolyte.

It will now be apparent why specific gravity readings are the most reliable means of ascertaining the state of charge in an accumulator.

Causes of false hydrometer readings are :

(1) An inaccurate or cracked hydrometer float.

(2) Taking readings when freshly added water has not had time to mix with the acid.

(3) Wide variations in electrolyte temperatures.

Hydrometer readings may always be supplemented by means of voltage tests. Use

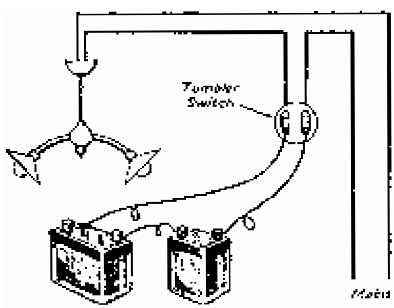


FIG. 21. *Charging from house-lighting switch.*

an accurate moving-coil voltmeter, reading 3-0-3 volts, and take all readings while the cells are on discharge. Voltmeter readings taken on open circuit are liable to be misleading. Low voltages registered on open circuit indicate that the cells are exhausted or unhealthy, but high readings do not always mean that the cells are in good condition.

Overcharging. A furred or blistered appearance of the negative plate is often an indication of over-discharging. If hydrometer readings suggest the presence of strong acid, charge fully, and then make the necessary adjustments or change the electrolyte entirely. Over-discharging cannot be remedied, but it should be checked at once, and the accumulator given a long, slow charge at a reduced rate. If the defect has gone unchecked for a considerable period, the accumulator may require new plates.

Excessive frothing on charge and discoloration of celluloid boxes is another indication of too strong acid. Frothing is sometimes caused by the presence of an impurity in the electrolyte, and in this case the accumulator should be treated as for strong acid. Wash thoroughly with distilled water before adding the fresh electrolyte.

Swollen or broken positive plates are often a sign of over-charging at too high a rate. Ill-treatment of this nature causes high temperatures and subsequent "growing" of the positive plates. It is impossible to cure, and a seriously affected accumulator generally requires new plates.

A small deposit of sediment in the bottom of a cell is no cause for alarm, as there is a slight deposit in even a brand-new cell. Excessive deposit, however, indicates that the active material is being forced out of the plates—probably through overcharging.

White deposits of lead sulphate or hydrate are caused by leaving the accumulator standing in a discharged condition or allowing the level of the electrolyte to fall below the tops of the plates. Small deposits may often be removed by means of a long, slow charge at, say, half the normal rate, but a seriously sulphated cell will often require new plates and separators.

Reversed Charge. It sometimes happens that an accumulator is "reversed"—*i.e.* connected to the charging board so that the current flows through in the wrong direction. In this case an attempt should be made to recondition the accumulator by means of a prolonged, slow charge in the right direction. This treatment is generally successful unless the reversal has been going on for a considerable period.

Choosing a Wireless Accumulator. The battery wireless set of today requires an accumulator capable of giving a small supply of current over an extended period. These cells have exceptionally thick and robust plates, specially designed to give a small flow of current for a considerable period. Moreover, they are not so liable to deteriorate if left standing in a discharged or semi-discharged condition for any reasonable length of time (see Fig. 28). It is possible to purchase quite reasonably a 2-volt accumulator which will work the average three-valve set for about 150 hours. Using the set 5 hours per day, this gives a period of one month between recharges, and is about the cheapest and most satisfactory form of low-tension supply for wireless receivers obtainable.

Thin-plate cells are constructed to stand a far higher rate of discharge than the massive-plate type, but they are, as a rule, more expensive to operate, as they require more frequent charging. The purchaser of one of these cells must remember that, to keep the accumulator in first-class condition, it is essential to recharge at least once a month—whether it has been in use or not.

The moment a dry battery is put into use the voltage begins to fall slightly—and this gradual fall continues until the battery is useless. Now the voltage drop in a wet accumulator is not gradual—it is rapid, but it does not take place until the end of the charge is reached. This ensures a steady flow of current during discharge and improved reception.

The Size of an Accumulator. Many wireless amateurs purchase accumulators far too small for the sets they use. It is necessary, when purchasing an accumulator, to estimate how much current in ampere-hours is to be taken from it. Most accumulator manufacturers clearly state on the label affixed to the accumulator its discharge rate, which should not be exceeded. For example, suppose it is required to operate a three-valve set using three ·25-amp. valves, the total current consumption per hour will be ·75 amp., and it is wasteful and expensive to buy an accumulator which will not stand this rate of discharge. Another factor is that the accumulator is needed to work the set for at least a fortnight on one charge. In selecting an accumulator, proceed on the following lines: total up the current consumption of the valves used in the set; assume this to be ·75 amp., and that the set is to be used for 3 hours every evening. It will be consuming ·75 amp. for 21 hours a week, equal to approximately 16 ampere-hours. In a month this would total 84 ampere-hours, and to allow a slight margin to meet the case an 80 ampere-hour accumulator should be purchased.

ACCUMULATOR PASTES. The following ingredients are required : 4 parts by weight redlead (Pb_2O_4), 1 part by weight litharge (PbO), 1 part by weight sulphuric acid (1·12 specific gravity). Add the acid gradually to the mixture of redlead and litharge, stirring well until a fairly stiff paste has been formed. Thorough mixing is essential, and care must be taken not to make the paste too thin.

How to Apply. Place the grid on a flat board and use a scoop to place the paste in the grid. A wooden spreader should then be used to force the paste into the pockets of the grid. A piece of newspaper is then placed on top of the plate, and another flat board on top of that. This enables the plate to be turned over so that it can be pasted on the opposite side.

Drying. Stack the plates carefully in a warm room to dry. After three or four days dip the plates in sulphuric acid (1·25 specific gravity) and re-dry.

Paste for Negative Plates. Use the following ingredients : 5 parts by weight litharge, 1 part by weight of 1·10 specific gravity sulphuric acid. Mix, apply, and dry as for positive plates.

For a high-rate discharge cell, the paste for the negative plates can be varied as below :

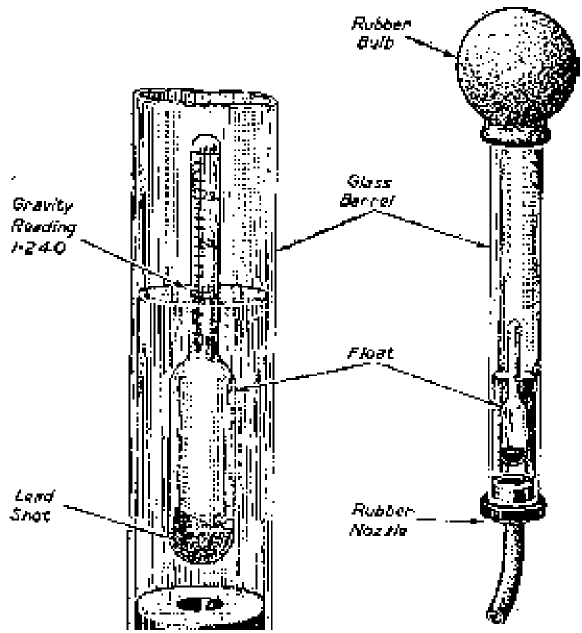


FIG. 22. *The hydrometer.*

Litharge, 99·96 per cent.; lamp-black, ·03 per cent.; wood flour, ·01 per cent. One-sixth of the total weight of the above of 1·10 specific gravity sulphuric acid.

Use acid of 1·12 specific gravity, charge at the rate of about ·02 amp. per square inch of the plate area, counting both sides of the plate.

ACCUMULATOR REPAIR. Accumulator failures and troubles are usually due to one of the following causes : sulphated plates, short circuits inside the battery, low level of acid, wrong specific gravity of acid, buckled plates, shedded plates (that is, plates from which some of the paste has fallen out), loose connectors between the cells, faulty terminal connections. The usual voltage and specific gravity tests of individual cells will indicate the faulty cells and the probable cause of the trouble, but it is possible for a battery to have a comparatively low output or capacity whilst the voltage and specific gravity readings are apparently correct.

Examination of the Battery. Open the case and scrape away as much dust and dirt as possible by means of a brush; then clean

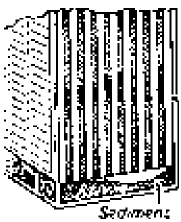


FIG. 23. *Sediment should be removed periodically, to prevent short-circuiting of plates.*

off all grease and acid with a cloth moistened in a solution of washing soda or a brush dipped in petrol. Do not allow the soda to mix with the electrolyte. Examine the terminal connections. If they are loose, tighten them; if they are badly corroded, scrape them clean. Examine the connections to the battery and make sure that they are not frayed. Look for cracks in the sealing compound, test the level of the electrolyte, and if the level is low fill up with pure distilled water so that the level is about $\frac{1}{2}$ in. above the top of the plates. After the battery is fully charged test the specific gravity of each cell after it has gassed freely for some time. If the battery is in good condition, the reading should be 1·250 to 1·300.

Dismantling and Repair. Accumulators of the bitumen type are usually made up of single containers in a wooden case with both lower and top covers burnt on to the connecting straps and terminals. Before any repair can be undertaken the accumulator should be drained and thoroughly washed out.

Removing Connecting Bars. Use a drill of the same size as the post, and drill a hole partly through strap and terminal. Place a piece of bar iron on the edge of the case, and with a screwdriver prise off the connecting bars, removing the cover and compound. The compound softens at about 200° F. It should be heated up with a blowlamp, after the vent plugs have been removed and all gas blown from the inside of the cell by means of a pair of bellows. It has been known for explosions to occur through failure to observe this precaution. Keep the flame on the move, and then with a large screwdriver, which has been heated, clean out the compound along the edges of the case and work it about until the cover is free. It will then be found possible to remove the plates by means of two pairs of pliers gripping the terminal posts. In cases where a blowlamp cannot be used, immerse the battery in boiling water.

Examining the Plates. Gently prise the plates open and make a preliminary examination. If the condition is fairly good remove any visible short circuit and insert a small piece of ebonite to prevent the trouble recurring. Now place the group of cells back in the container, fill up to the correct level with acid, replace the connecting straps, and charge at about one-third of the normal rate until the colour of the plates is good, and see that they are gassing freely. No attempt should be made to straighten the plates or replace the separators until this charge has been given, as this charge anneals them and renders them soft and workable. After charging, drain and remove for further examination. Open out the plates, remove a few separators, and joggle the plates free of each other and the separators. It will be found that positive plates suffer more than negative. A slight rub with the finger on the negative plates should produce a shiny lead appearance. If they are hard, bulged, and have a rough granulated appearance, and if the positives are cracked, soft, or brittle or thin, due to shedding, the plates are useless, and new ones should be obtained. If the positives and negatives are hard, white with sulphate, and dry, do not waste further time upon them. If the plates are usable wash them under the tap, and interleave wooden boards of the correct thickness, finally pressing them between wooden cramps in the jaws of a vice. Charged negatives should not be kept out of acid or water for more than a few minutes at a time.

The Positive Plates. Now attend to the positive plates. These are rather more delicate; if they are buckled they may be straightened in the vice in the same manner as the negatives, or the edges may be gently gone over with a pair of parallel jaw pliers.

Lead Burning. This requires considerable experience and apparatus. Plates of different ages or types should not be used for the repair of any particular group, but a positive group need not necessarily be of the same age as the negative group used with it. If all the plates are bad it is cheaper to buy a new set, but if only one or two require replacing this may be attempted.

If the plates to be replaced are on the outside, saw them off just below the connecting strap. If one or two inner plates are to be replaced, break them off at the lug close to the junction with the connecting strap by bending backwards and forwards with a pair of pliers.

Saw slots in the strap to receive the lugs of the new plates with a good fit.

A burning rack is now required to hold the plates firmly in position. An oxy-coal, gas, or acetylene flame is required for burning. The parts to be joined should be thoroughly cleaned by scraping, and heat being applied carefully by a small pointed jet, lug and connecting strap are melted together, lead being added as required.

Renewing the Separators. Always renew the separators after the plates are removed, when they are made of wood. Hard rubber and ebonite separators can usually be used again. After replacing the assembled plates and separators in the cell, immediately fill with electrolyte of specific gravity 1·300 to ½ in. above the tops of the plates. Scrape the inside clear of compound ready to receive the covers. Clean these with boiling water. The covers can be fitted over the plate posts before or after fitting in the boxes. When the cover has been fitted, pour sufficient compound around the edges to effectively seal the top, and level off by application of the gas flame or a piece of hot iron. If the cover is a loose fit, a piece of asbestos string can be inserted to stop the compound from running through. The compound is heated in a plumber's ladle on an ordinary gas-ring. Next charge the battery at about one-third of its normal rate, and if at any time during this period the temperature exceeds 100° F. reduce the charging current. Continue the charge until no further rise in voltage or specific gravity takes place for a space of 4 hours, after which the charge may be considered complete.

Adjusting the Electrolyte. Various changes will have taken place in the newly added electrolyte, due to the action of sulphate soaking into separators and plates, and the effect of charging. At the end of charge, if the specific gravity of any cell is above 1·300 draw off some of the electrolyte and replace to correct level with distilled water. Use good-quality acid when necessary to replace it.

If the specific gravity is below 1·300 draw off some of the electrolyte and make up with acid of 1·400 or 1·350 specific gravity. Charge the battery again to mix the electrolyte thoroughly, and test again. Continue the adjustment, until with the electrolyte at the correct level the specific

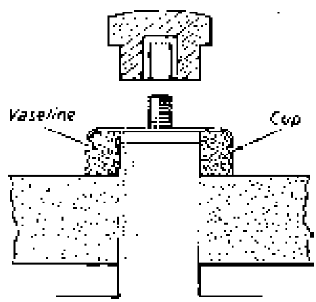


FIG. 24. *Method of preventing corrosion of terminals by means of a vaseline gland.*

gravity is 1·300. Never add any but distilled water. Tap water should never be used. Refer to the tables on page 2.

Correction for Temperature. The values given on page 2 are correct for a temperature of 70° F. A correction must be made if the temperature differs from this. To obtain the actual specific gravity at 70° F. add one point to the reading obtained for every 3° the temperature is above 70°, subtracting one point for every 3° below this temperature. Some makers prefer a lower specific gravity, and in such a case the table given here should be used.

Condition of Cells	*Actual Hydrometer Readings at Temperatures shown below to give 1·280 at 60° F.*						
	40°F.	50°F.	60°F.	70°F.	80°F.	90°F.	100° F.
Fully charged	1·288	1·284	1·280	1·276	1·272	1·268	1·264
Half discharged	1·207	1·204	1·200	1·196	1·193	1·189	1·186
Fully discharged	1·115	1·113	1·110	1·107	1·104	1·101	[illegible]

To ensure satisfactory working the battery should now be charged at its normal rate until fully charged, when it should be discharged through a coil or water rheostat at its normal discharge rate until the voltage equals an average of 1·8 per cell. This discharge current should be kept at a constant value by varying the rheostat, and the number of hours for which the battery will give out this current should be noted. The product of hours and amperes gives the capacity in ampere-hours.

Effects of Overcharging a Battery. Except in the case of a sulphated cell, when gassing takes place at the plates at all times, gassing on a large scale only occurs when the chemical changes at the plate are nearing completion. Consequently, continued gassing after such completion of charge has taken place is simply wasting energy. In any case, the charge should be reduced so that gassing is not excessive. If continued in excess the gas which is being produced in the pores of the plate causes disruption of the paste, loss of capacity due to shedding, and perhaps short circuiting. A battery is kept in better condition if at some periodical time, say once per week or fortnight, it is given a prolonged gassing charge, as this ensures all the active material being in a healthy condition. This will give an efficient battery, but overcharging generally is of no value, and may be detrimental both to the life and capacity of the cells. It is indicated by high specific gravity at all times.

Effects of Under-charging. Habitually under-charging, on the other hand, is bad policy. It is not good practice to get as much out of a battery as possible nor to use it without intelligence. Nothing undermines the efficiency of a battery so much or reduces its useful life to such a degree as persistent under-charging. If the voltage per cell is allowed to fall below 1·8 repeatedly, and discharge is continually drawn from it at this or lower values, sulphation invariably occurs. The sulphate so formed is the same as that produced when a battery is left for long periods in a discharged state, and is of the hard, greyish crystalline kind, which is an insulator, and is difficult to get rid of. Under-charging is indicated by low specific gravity.

The Cadmium Test for Faulty Plates. An instrument known as a cadmium tester is really a voltmeter with a central zero reading in its scale, an arrangement which permits of polarity tests. Two flexible leads are attached to it. The positive lead is of the ordinary type, but the negative lead has a piece of cadmium about 4 in. long by ⅜ in. diameter soldered to it. This cadmium extremity has a perforated rubber covering or ebonite tube covering, so that when used the metal cannot make direct contact with the plates. This negative lead is placed through one of the vent holes into the liquid between the two plates, and preferably in the centre of the section. It will readily be perceived that the cadmium is really another electrode which forms two other cells with the positive and negative plates and the acid.

To make a cadmium test, place the cadmium between the plates and the centre sections as described, and make contact with the other voltmeter terminals on + and − lead terminals of the cell alternately. The reading with the contact on the + terminal should be to the right of zero and about 2·4 to 2·5 volts. The reading with the contact on the − terminal should be to the left of zero and about −0·15 to −0·2 volt. This is obviously equal to a voltage of 2·4 + 0·15 = 2·55 volts between battery terminals. If the positive reading is appreciably less than 2·4 volts, or the negative near zero or even on the + side of zero the positive or negative plates respectively are defective. Towards the end of charge the cell voltage is obviously the sum of the two readings obtained (see Fig. 27).

Celluloid Accumulators. Celluloid cases are either moulded or built up. Plastic celluloid is made from a mixture of nitrate cellulose and gum camphor in amylacetate, pressed in a mould or rolled into sheets. The sheets, cut to size, have their edges stuck together with a paste made of celluloid and amylacetate.

The only advantage of the celluloid jar is its transparency. Its great disadvantage is its inflammability.

Examination of plates can be made without opening out. To open out, when necessary, insert the blade of a knife in the join between cover and side of jar and prise open.

To repair a case after overhaul of plates, scrape the edges of case and cover with a knife. Dissolve some scrapings of celluloid in amylacetate to form a thick solution and apply this to the edges to be joined. Clamp in position by clips until set. Keep all terminals and connectors coated with vaseline to prevent corrosion.

Capacity of a Cell. Capacity depends on the amount of active material in the cell, the charge put into the cell, the rate of discharge, the temperature and the state of the cell as regards sulphation, and short circuit. The *condition* of the plates has a great deal to do with the capacity of a cell and its ability to hold a charge.

The amount of active material available depends on the quantity upon the plates and the acid which has access to it. At slow rates of discharge, the acid can circulate into the pores of the plates, and thus the greater portion of the paste will be chemically active. At high rates of discharge only the surface of the plates is acted upon, and acid diffusion being limited, the capacity suffers temporarily. A sufficiency of charge must, of course, have been given to the plates to convert the paste to chemically active material in the first case. If a lead-acid cell be discharged below 1·8 volts per cell, trouble may ensue. The conducting sulphate of the discharged negative plate is converted to hard non-conducting sulphate, which is so difficult to reconvert to useful spongy lead, and covers up areas of useful paste from the action of the acid. The capacity

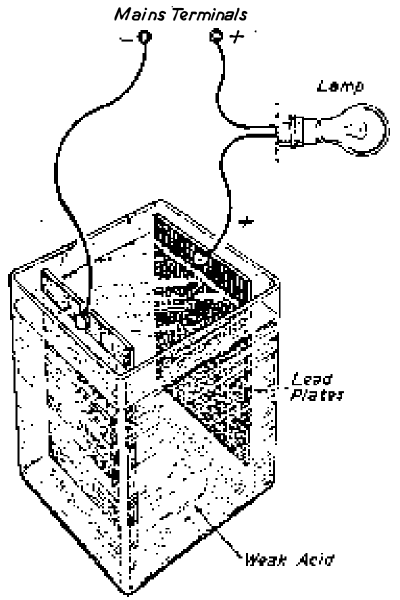


FIG. 26. *Method of testing mains for polarity.* (*See also* FIG. 16.)

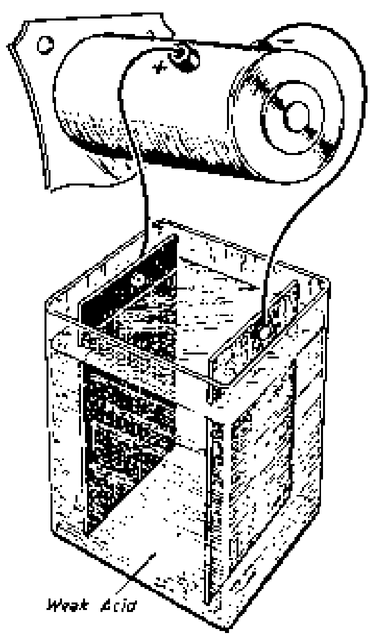


FIG. 25. *Method of testing a dynamo for polarity.* (*See also* FIG. 16.)

therefore decreases when such sulphate is produced, and in the endeavour to get rid of it, shedding of paste, with consequent loss of capacity or internal short circuiting of plates, results with decreased capacity, and still more sulphating. Temporary loss in capacity therefore always results from too-rapid discharge, whilst prolonged discharges below 1·8 volts, or leaving the cells in a discharged state results in sulphation and permanent injury, which it is almost impossible to rectify.

Removing Sediment and Sludge. If only one cell of a battery is deficient, and it is required to empty the box of acid and sludge after the plates are taken out, this should be done by a syphon or sludge pump. The case should not be tipped, or the deposit in the good cells gets mixed with plates and separators to their detriment, considerably shortening their life.

A syphon can be made from a piece of lead tubing to which is attached a longer length of flexible rubber tubing. The syphon, filled with water and with both ends closed, should be placed with its lead end below the liquid level in the box, and the other hanging to a lower level outside, and then the ends opened. Acid will then be drawn over, and the sludge, stirred about by the piece of lead tubing, will come over with it. Meanwhile, water is run into the box for so long as is necessary to rid it of all traces of sediment (see Fig. 23).

Portable Accumulators. Many portable sets are fitted with special unspillable cells of

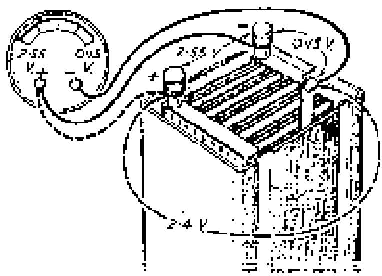


FIG. 27. *Testing a fully charged accumulator with a Cadmium Tester.*

either the "free acid" or "jelly acid" type. Unspillable cells of the "free acid" type may be tested in the usual way by taking hydrometer readings of the specific gravity of the electrolyte. It is, however, impossible to test the gravity of a "jelly acid" cell, and the only way to ascertain the state of charge is by taking voltage readings.

Maintain the acid level by adding distilled water only, but be careful not to fill above the "danger line." Even an unspillable cell may leak if the correct volume of electrolyte is exceeded.

Keep all terminals and connections clean and well coated with vaseline, and make sure that the filling plug is screwed up *tight.*

Nickel-Iron-Alkaline Accumulators. The nickel-iron-alkaline battery as used for lighting and starting purposes on commercial vehicles is capable of withstanding a considerable amount of neglect and rough usage. The state of charge when the cells are stored is not of very great importance, but the best conditions are maintained if the cells are fully charged and then half discharged before storing. The electrolyte consists of a solution of potassium hydrate in distilled water, and is supplied at the correct density by the battery manufacturer. The specific gravity does not alter with the state of charge, and gassing is not an indication of full charge.

The temperature of the solution is an important factor, and should be kept within similar limits to that of the lead-acid type. Acid must not be allowed on or in an alkaline cell, and considerable damage will result if this is permitted. Hydrometer tests are useful in determining whether a change of electrolyte is desirable. These tests should not be taken during a charge, nor after adding distilled water for topping up until a further charge. The temperature of the solution should be noted, and corrections made to obtain the density readings at 60° F. The correction constant is ·00025 for each 10° F. variation, and this amount should be added to the density readings for temperatures above 60° F., and subtracted for temperatures below that value. The normal specific gravity of the solution used in Ni-Fe cells is 1·190. This density will gradually decrease during the charge and discharge operations over a period of about twelve months, until a specific gravity of 1·170 is reached. At this point the battery will have lost its efficiency, and the electrolyte should be emptied out and renewed.

The normal density of the solution as used in Edison storage cells is 1·200, and when this decreases to 1·160 it should be renewed. Alkaline cells must not be allowed to stand empty. Glass or enamel ware should be used for filling purposes, and

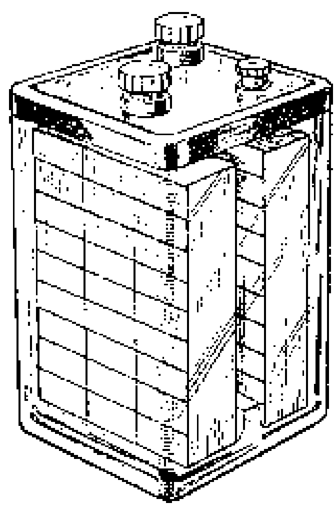


FIG. 28. *A 2-volt cell for radio purposes. The moulded glass container obviates the use of separators.*

vessels previously used for acids must not be allowed to come in contact with the solution.

Choked vent plugs may cause excessive swelling of the steel cell cases, and the plugs should be tested periodically to ensure that efficient ventilation is maintained.

The charging voltage of alkaline cells commences at 1·4 volts and rises to 1·8 volts per cell, so that it is necessary for the charging voltage of the D.C. supply to be not less than 1·85 times the number of cells charged in series. The first charge must be at the normal current for double the normal period. On discharge, the voltage of this type of cell should not be allowed to drop below 1·0 volt per cell. When the cells are charged the cases are electrified, and short circuits will occur if contact is made between them by metal spanners used for tightening terminals or for other purposes, and extensive damage may result. The same types of charging equipment described for acid cells can be suitably applied for charging alkaline cells.

ACETONE. A colourless and inflammable liquid $(CH_3)_2CO$ related to acetic acid, but containing less oxygen, pyro-acetic spirit, sometimes used in wireless for jointing and repairing celluloid. Used as a solvent for fats, camphor, and resins, for making chloroform. Also known as dimethyl-ketone and methylacetyl. (See *Amyl Acetate.*)

ACIDIMETER. Obsolete name for the apparatus used for measuring the strength of acids. A hydrometer (*which see*).

ACLINIC LINES. Any line on a diagram or map which represents the magnetic equator.

ACORN VALVE. A type of miniature valve similar in size and shape to an acorn and having a ring seal about half way along its length.

ACOUSTIC. The sense of hearing. The science of sound is known as acoustics.

ACOUSTIC FEED-BACK. The effect produced when the sound from a loudspeaker feeds back to the input (microphone, etc.).

ACOUSTIC WATT. The unit of sound energy, based on a reference level of 10^{-16} watt, or 10^{-9} ergs per sq. centimetre per sec. (See *Bel, Decibel, Neper* and *Phon.*)

ACOUSTIC WAVES. Sound waves.

ACTINOMETER. Apparatus which measures the actinic value of light.

ACTIVATION (Quartz Crystal). Cleaning and edge-grinding processes to increase the *activity* of quartz crystals.

ACTIVITY (Quartz Crystal). The ability of quartz crystals to oscillate.

ADAPTOR, SHORT-WAVE. A device which, coupled to a receiver designed for reception on medium and long wavebands, adapts it for the reception of programmes radiated on short waves.

ADMIRALTY UNIT. The unit of capacity known as the Jar (*which see*).

ADMITTANCE. The property of an electric circuit, by means of which a current flows under the action of a potential difference. May be calculated by dividing 1 by the impedance. The unit is the Mho (ohm reversed).

AEO LIGHT. A lamp used in the production of sound or "talkie" films, and yielding a glow which has greater actinic value than a neon lamp. A microphone is employed to convert the speech and music into electrical vibrations, which are changed into light variations (through the medium of the Aeo Light), and are thus recorded on the film.

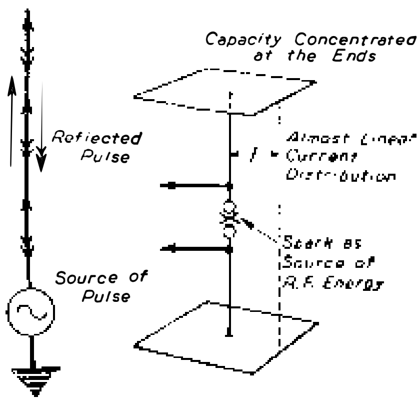
AERIAL. A wire or rod elevated above ground level and used to radiate a signal or to pick up a radiated signal. It can take many forms, and for standard broadcast reception usually consists of a horizontal wire running from the house to a suitable pole or tree in the garden. For ultra-short-wave working it may consist of a short rod only about 2 ft. in length. Whilst an aerial is mainly capacitive, it also possesses inductance. Capacity must exist whenever a difference of potential is possible, i.e. every substance possesses capacity—except the mythical perfect conductor; also, whenever magnetic lines-of-force cut a material, the property known as inductance exists. It is obvious that if an aerial possesses inductance and capacity distributed throughout its substance, then it can behave as a tuned circuit, giving maximum results when its resonant frequency is equal to the frequency of the transmitter or receiver to which it is attached. As in the case of a tuned circuit, the aerial's resonant frequency can be adjusted by variation of its capacity or inductance.

The Hertzian Doublet. Heinrich Hertz, in 1885, investigated electro-magnetic radiation and developed the Hertzian Doublet as an efficient radiator. He discovered that the more capacitive the radiator (aerial) the more efficient it became, also maximum radiation was obtained when the resonant frequency of the aerial was the same as the frequency of the energy supplied. The capacity of the Hertzian

Doublet is mainly concentrated at the ends, thus giving an almost linear current distribution, and facilitating calculation (Fig. 30).

Standing Waves. The following are the properties governing the manner in which an aerial radiates.

In Fig. 29 is a length of wire supplied with radio frequency energy. Consider a voltage pulse leaving the source of radio frequencies: it passes along the wire at a speed almost that of light, reaches the end of the wire, is reflected and journeys back again; thus, an alternating voltage from



FIGS. 29 AND 30. *(Left) Reflection of voltage pulse. (Right) The Hertzian Doublet.*

the source would pass its effects up and—by virtue of reflection—down the wire. As shown in Fig. 31 (A) and (B), the two travelling waves would give rise to stationary or standing waves provided that the length of wire was a multiple or sub-multiple of the wavelength of the energy provided. Current waves will rise, the current being maximum when the voltage is minimum. Fig. 31 (C) shows the voltage and current distribution along a wire one wavelength long.

It can be seen that the position of the standing waves upon an aerial is governed by the length of wire in terms of the wavelength supplied, also that the position of the standing waves will influence the directional properties of the aerial.

The dipole aerial is an unearthed symmetrical aerial not having linear current distribution (see Figs. 35, 36 and 37).

Practical Considerations of Aerial Length and Wavelength. It has been stated that the more capacitive the aerial the more efficient it becomes, thus, whenever possible, it is advisable to tune the aerial by the use of a correct length rather than the insertion of an inductance. Obviously on short waves it is practicable to have the length of the wire $\lambda/4$, $\lambda/2$, etc., but on long waves such an aerial would have to be a mile or more in length and is out of the question. In such cases we have to resort to "loading" coils effectively to lengthen the aerial for maximum results with the wavelength concerned. Loading coils, however, are not to be desired, because of the reduction of the aerial's overall efficiency.

Marconi Aerials. Marconi discovered that if the dipole type of aerial was earthed at one end, it was possible to double the wavelength transmitted, because the length of wire required was reduced to half that of the dipole. Fig. 33 shows a $\lambda/4$ Marconi aerial. Notice the aerial's "image," giving an effect the same as a $\lambda/2$ dipole—if the earth is a perfect conductor. Owing to the fact that the earth is not a perfect conductor, losses occur; these losses can be minimised by the use of a good earth conductor or a counterpoise system.

Inverted-L and T-type Aerials. It is sometimes advantageous to obtain added length of aerial for the longer wavelengths by bending the top of the aerial over, forming an inverted-L or a T-shaped system (Fig. 32 (A) and (B)). Also, because of the effect of the horizontal or "roof" portion of the aerial in concentrating capacity at the end of the vertical or "feeder" portion, the current distribution becomes almost linear and a larger current flows in the "feeder." Examination of Fig. 34 shows that it is not advantageous to have the aerial length equal to one wavelength or multiples of a wavelength unless special precautions are observed. Radiation from adjacent $\lambda/2$ sections would oppose and cancellation result. In practice a little radiation occurs horizontally and a "funnel" exists at about 35° from the earth around the aerial.

For the smaller wavelengths (higher frequencies) the aerial length required does not prohibit the use of a vertical aerial. Fig. 36 (A) shows a Marconi $\lambda/2$ aerial with its voltage and current distribution. Fig. 36 (B) shows how the $\lambda/3$ aerial can be effectively lengthened by the use of a loading coil for longer wavelengths, whilst

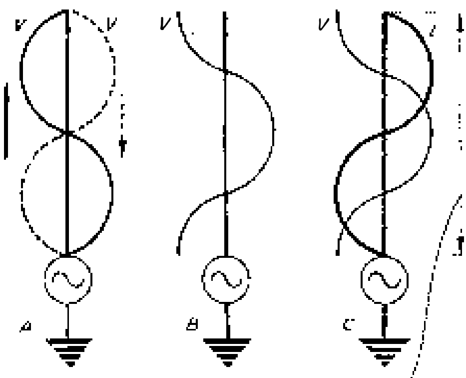


FIG. 31. *A, Travelling waves; B, Standing waves; C, Current and voltage distribution.*

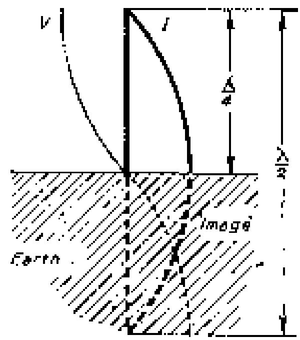
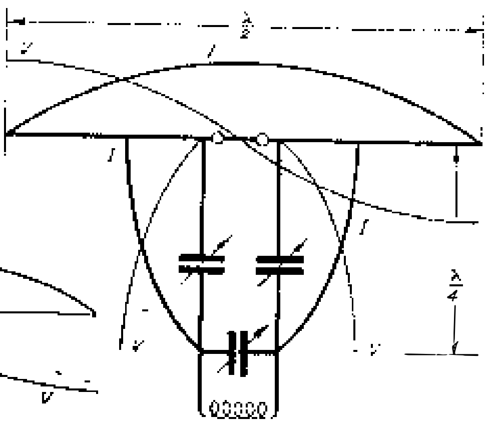


FIG. 33. λ/4 *Marconi (earthed) aerial*

FIG. 34 (*Right*) *The use of a* λ/4 *resonant feeder for centre-feeding a* λ/2 *dipole.*



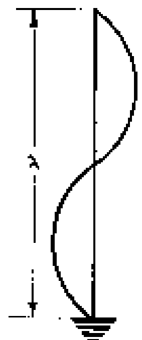


FIG. 35. *Cancellation of radiation when aerial length is a multiple of* λ.

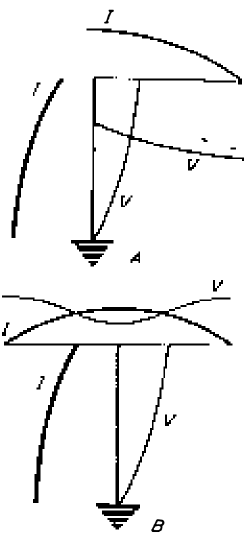


FIG. 32. *A, "Inverted L" aerial; B, "T" type aerial.*

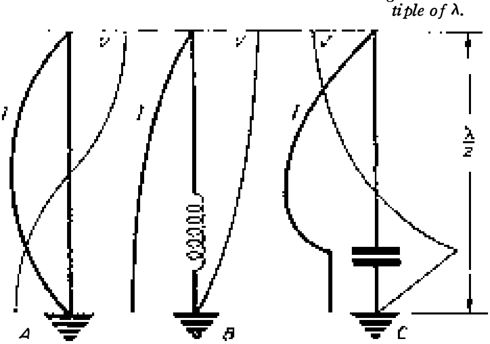


FIG. 36. *The Marconi* λ/2 *aerial. A, Voltage and current distribution; B, Effect of loading coil; C, Effect of loading condenser.*

Fig. 36 (C) shows the effect of placing a condenser in series with the aerial.

Dipole Aerials. Unlike the Hertzian Doublet the dipole aerial has its capacity distributed, causing the current to be maximum in the centre (Fig. 38). In order to supply energy to the λ/2 aerial it is obvious that maximum current may be supplied at its centre or voltage at one of its ends. An acceptor circuit (series resonant circuit) supplies large currents at resonance, whilst a rejector circuit (parallel tuned circuit) gives large voltages; thus an acceptor feeding into the centre or a rejector feeding into one end would be satisfactory. In order to bridge the distance between the aerial and the transmitter the use of feeders becomes necessary.

Resonant Line Feeders. In Fig. 35 a practical method of coupling the aerial and transmitter is shown. Remember that the length of the feeders is important. Examining the voltage and current distribution along a feeder we see that for centre feeding the λ/2 dipole we would require an acceptor circuit at the transmitter end, whereas in the case of the λ/4 feeder to the λ/2 dipole a rejector circuit becomes necessary.

It is obvious that if an efficient feeder system is desired the wires must not radiate. Each wire has opposite voltage and current distribution, so that radiation from them is effectively cancelled—providing that the lines are equal in all respects. In order that the lines can be balanced, suitable condensers are inserted in each and adjusted until the currents are equal.

This method of feeding, the resonant line method, is satisfactory for comparatively short feeders, but becomes undesirable for long feeders because of the difficulty in preventing radiation and other losses in the lines.

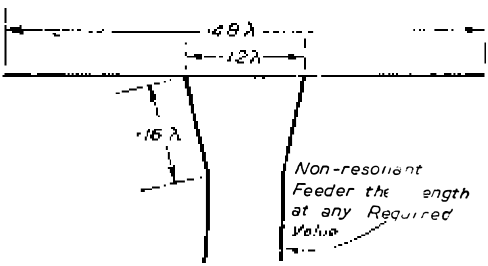


FIG. 37. *The use of a non-resonant feeder with a λ/2 (approx.) dipole.*

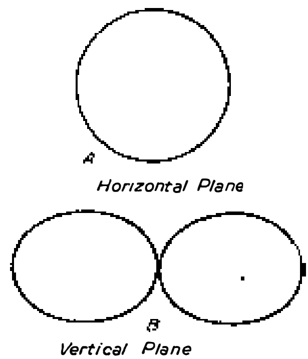


FIG. 39. (*Above*) *Polar diagrams of λ/2 dipole in free space.*

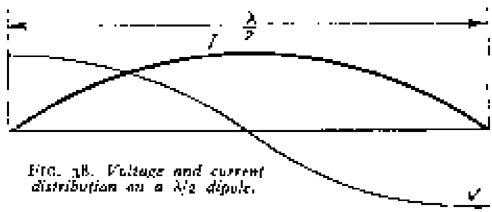


FIG. 38. *Voltage and current distribution on a λ/2 dipole.*

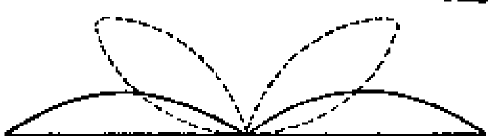


FIG. 40. (*Left*) *The effect of earth conductivity upon a λ/2 aerial.*

Non-resonant Feeders. Radiation from aerials is due to the presence of standing waves, which, in turn, are caused by reflection of travelling waves from the ends of the aerial, thus if reflection was prevented then radiation would cease. Similarly, the prevention of the formation of standing waves upon feeder lines will make them non-resonant.

It has been proved that if the impedance

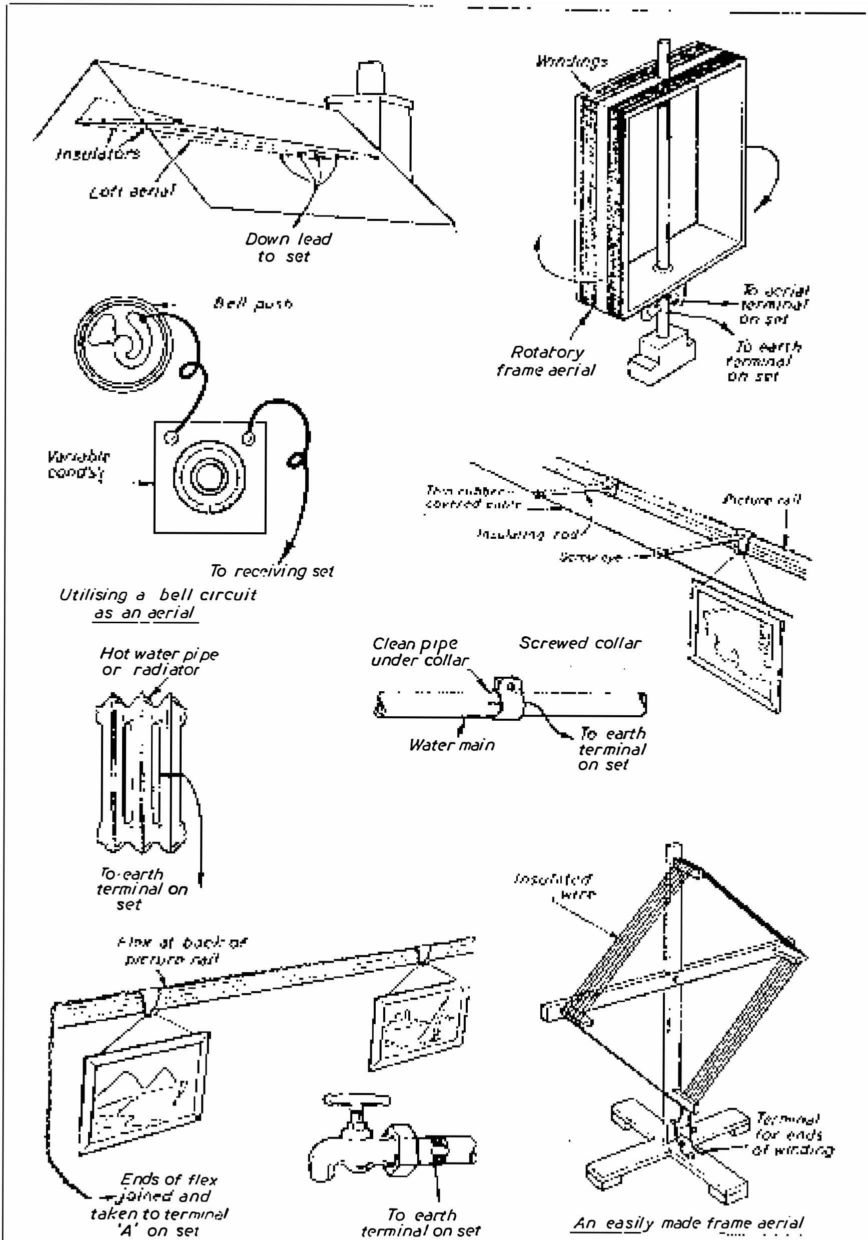


FIG. 41. *Indoor aerials and earths.*

(z) of the feeder has the same value as the impedance of the aerial then no reflection occurs. This is because energy is absorbed by the aerial at the same rate that it arrives from the feeders. There are several methods of obtaining this condition, one of which is shown in Fig. 37. The spacing of the wires, junctions, feeder lengths, etc., must be carefully adjusted to obtain a non-resonant condition in the feeder.

Directional Properties of Aerials. It has been mentioned that the manner in which standing-waves form upon the aerial governs its directional properties—with other factors. The formation of standing-waves depends upon the length of the aerial in terms of the wavelength to be employed.

The general structure of the aerial system; vicinity of houses, rivers, railways, etc., frequency, conductivity of the earth, height of the aerial above the ground, etc., all affect the directional properties of aerial systems.

Polar Diagrams. The directional properties of aerials are usually shown by the aid of polar diagrams.

A polar diagram indicates the field strength of the radiation (as a distance from the centre of the diagram) with relation to the direction of the radiation with respect to the aerial. As radiation occurs in both horizontal and vertical planes, two polar diagrams are necessary to show the full directional properties of the aerial concerned.

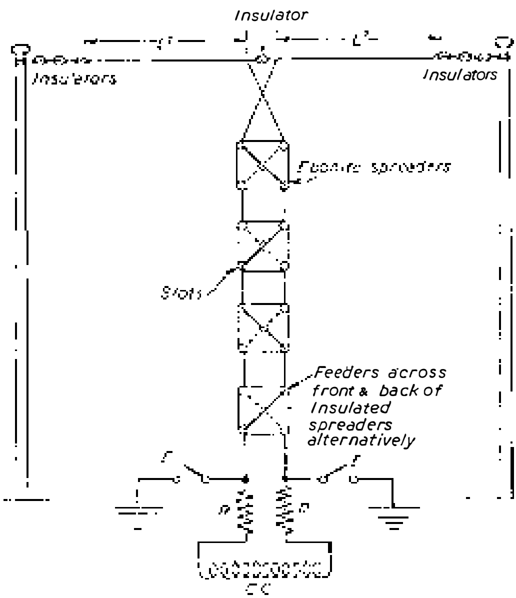


FIG. 42. *Transposed or horizontal doublet aerial. E, earthing switches; CC, coupling coil; RR,* 600-*ohm resistance; L^1 and L^2,* 40 *ft. aerials.*

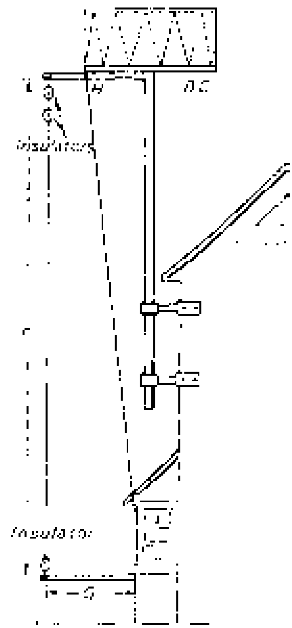


FIG. 43. *A "cage" aerial. F,* 30 *ft.; G and H,* 2 *ft. minimum; BC, broadcast aerial.*

Consider a $\lambda/2$ dipole situated in free space, i.e. away from all influencing factors. Fig. 39 (A) and (B) shows its directional properties in a plane horizontal to the dipole and a plane vertical to the dipole, respectively.

If the aerials are of the earthed type (Marconi) then the directional properties are modified by the presence of the earth. Fig. 40 gives the vertical polar diagram of a $\lambda/2$ aerial, assuming that the earth is a perfect conductor, if, however, as is the case, poor earth conductivity is met with, the polar diagrams are modified as shown by the dotted lines.

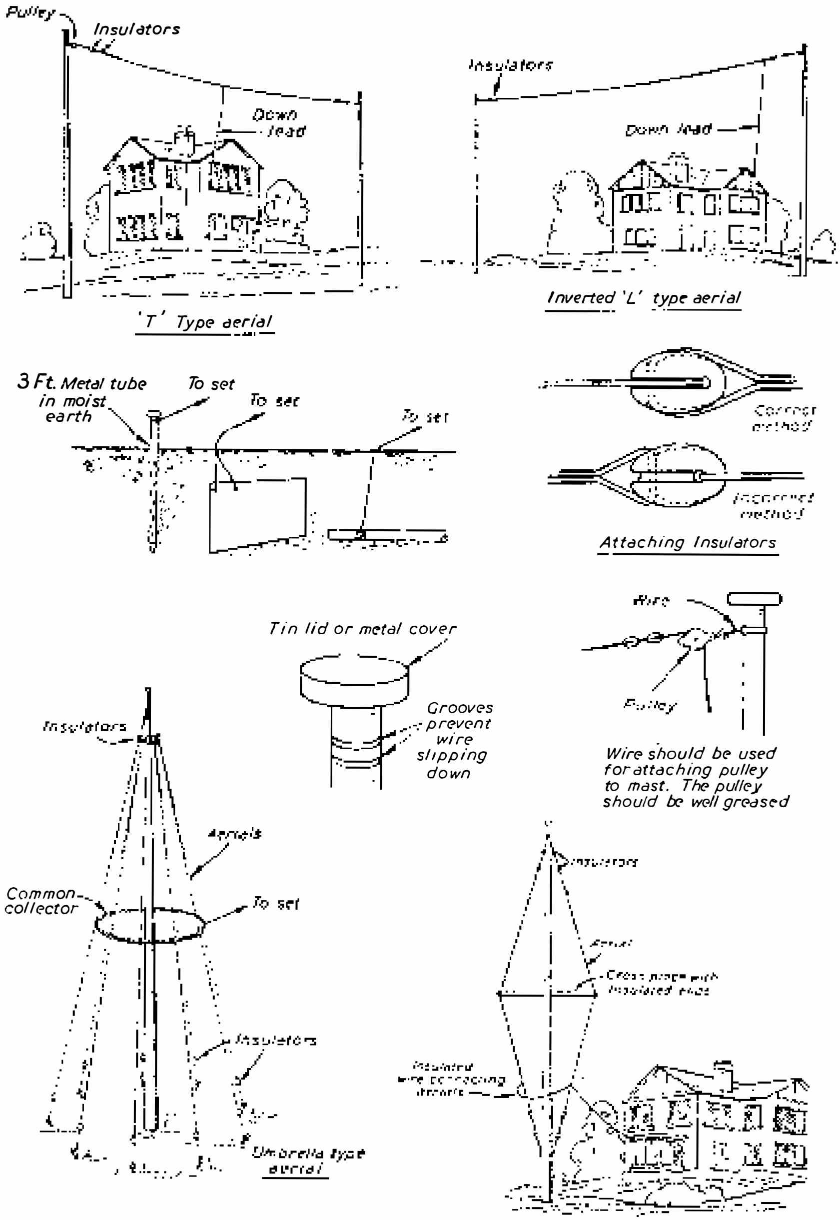


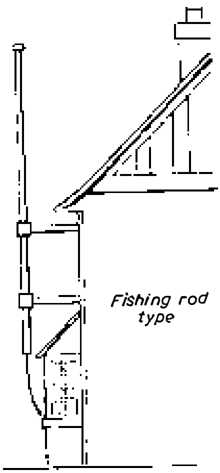
FIG. 44. *Outdoor aerials and earths.*

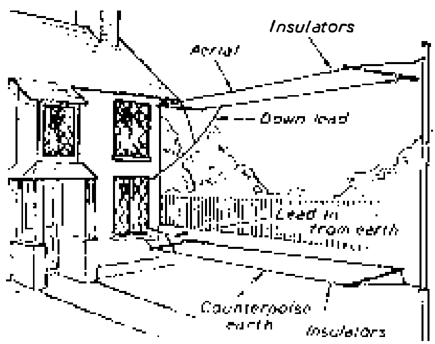
If a dipole is suspended close to the earth, radiation reflected from the earth will influence the directional properties. Obviously, the reflected and reflecting waves will add or cancel in a manner governed by the relative positions or phase, thus, the height of the dipole above the earth is an important factor. (See *Frame Aerial.*)

A RIALS AND EARTHS. A satisfactory mast consists of sections of steel tubing screwed together, with the bottom section about 2 in. in diameter, and top about 1 in. Lengths of the timber known as 2-in. quartering may also be bolted together to form quite a good strong mast. A pulley should be fixed at the top to enable the aerial to be lowered periodically in order that the insulators may be cleaned. The mast should be supported by guys at either side and at the back. These may be of either rope or galvanised wire, and should each be broken in two places and insulators inserted.

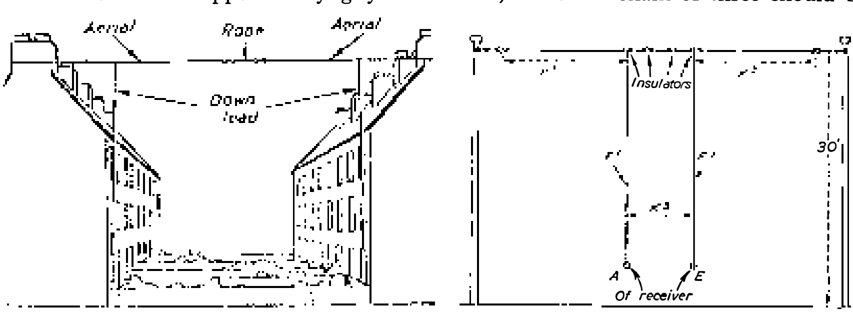
Where a total length of 60 ft. can be obtained, use a single-wire aerial, but if the amount of space available will only allow a run of about 30 ft. or less, then use a double-wire aerial with the two wires spaced by means of a bamboo stick, with a separation of 3 ft. Do not have the wires closer than this.

Egg and Reel Insulators. Insulators of either the egg or reel variety are both cheap and efficient, and in the case of a single-wire aerial, six should be the minimum to use, three at either end. They should be joined together to form a chain and at the lower (or garden) end one end of the chain should be attached to a length of good quality rope threaded through the pulley. One end of the aerial should be securely fixed to the other end of this chain. At the house end, the other chain of three should be





FIGS. 45 AND 46. (*Left*) *A "fishing-rod" type of vertical aerial.* (*Right*) *An "L" type aerial with a counterpoise earth.*



FIGS. 47. (*Left*) *Two aerials erected as shown obviate the use of a mast.* (*Right*) *A divided aerial: K1 and K2 are equal in length to half the wavelength. K3 equals 4½ in.*

fixed to a pole, or a length of galvanised wire attached to a staple in the wall or chimney stack.

The Aerial and Lightning Switch. The best material for an aerial is the stranded copper wire, known as 7/22. This consists of seven separate strands of No. 22 gauge copper wire, twisted together like a rope, and is quite cheap. At the house end, the aerial wire should be passed through the hole in the end insulator to form a double bight. In this way the aerial and lead-in are all in one, with no connection to become corroded.

If, however, owing to insufficient wire or any other reason, a joint has to be made, it should be thoroughly soldered, and then bound with insulation tape of the rubber variety, or painted, to avoid corrosion.

Outside the window a lightning switch should be fitted, and this should be of the type known as "double-pole-double-throw".

The Earth Connection. There is no doubt that the ideal earth connection is a buried plate of metal. This should be as large as convenient (a 7-lb. biscuit tin is quite good), and the earth wire should be securely soldered into it. Dig a hole about 3 ft. deep, place at the bottom a layer of coke or some similar rubble, put the earth plate on this, and cover with another layer of coke. Fill in the hole and saturate with water. Remember that the earth connection should be kept as damp as possible to keep the resistance low. Of course, if a buried earth is inconvenient, a connection to the water pipe may be made, but this should be a main pipe, if possible, and connection made by means of a proper earth clip. Whatever type of earth is employed, keep the lead to it as short as possible.

Television Aerials. A uniform scheme of catalogue suffix numbers for television aerials to indicate clearly the channel for which an aerial is suitable has been agreed upon by the manufacturers.

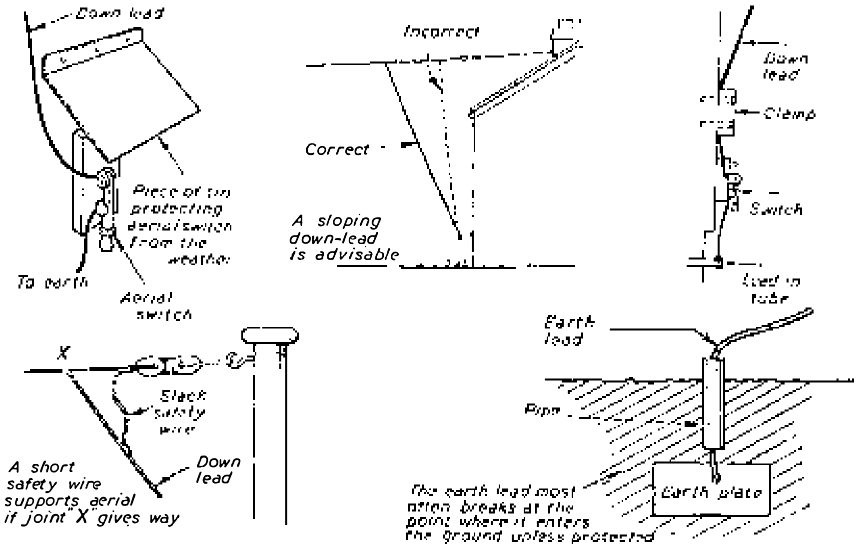


FIG. 48. *Practical hints regarding aerials.*

The channel number is marked clearly on aerial packages.

Some manufacturers use a colour code, as shown below :

N	*Channel Location*	*Frequencies Mc/s Vision*	*Sound*	*Catalogue suffix*	*Optional colour code*
1	London	45·00	41·50	/1	Yellow
2	North England	51·75	48·25	/2	Light blue
3		56·75	53·25	/3	Red
4	Midlands	61·75	58·25	/4	Green
5		66·75	63·25	/5	Dark blue

The scheme was initiated by the Aerials Panel of the Radio and Electronic Component Manufacturers' Federation to simplify storekeeping and records, not only for manufacturers but for wholesalers and retailers.

Basically, any television aerial consists of a rod cut to one-half the wavelength of the television transmitter, with a connection taken from the centre. As, however, the sound and vision are transmitted on different wavelengths, or frequencies, the aerial is cut to a point mid-way between the two in most cases, although some aerial manufacturers cut for vision, as this is the most critical part of the received signal. If you make your own aerial, you can experiment and find which is the most satisfactory length for your own particular local conditions. For the London transmission the length of the aerial should be about 11 ft. and for the Sutton Coldfield transmission it should be about 7 ft. 9 in. A few inches either way on these measurements may make quite a difference in some places.

The type of television aerials now commercially available are shown in Figs. 49 to 54 and can be classified as follows :

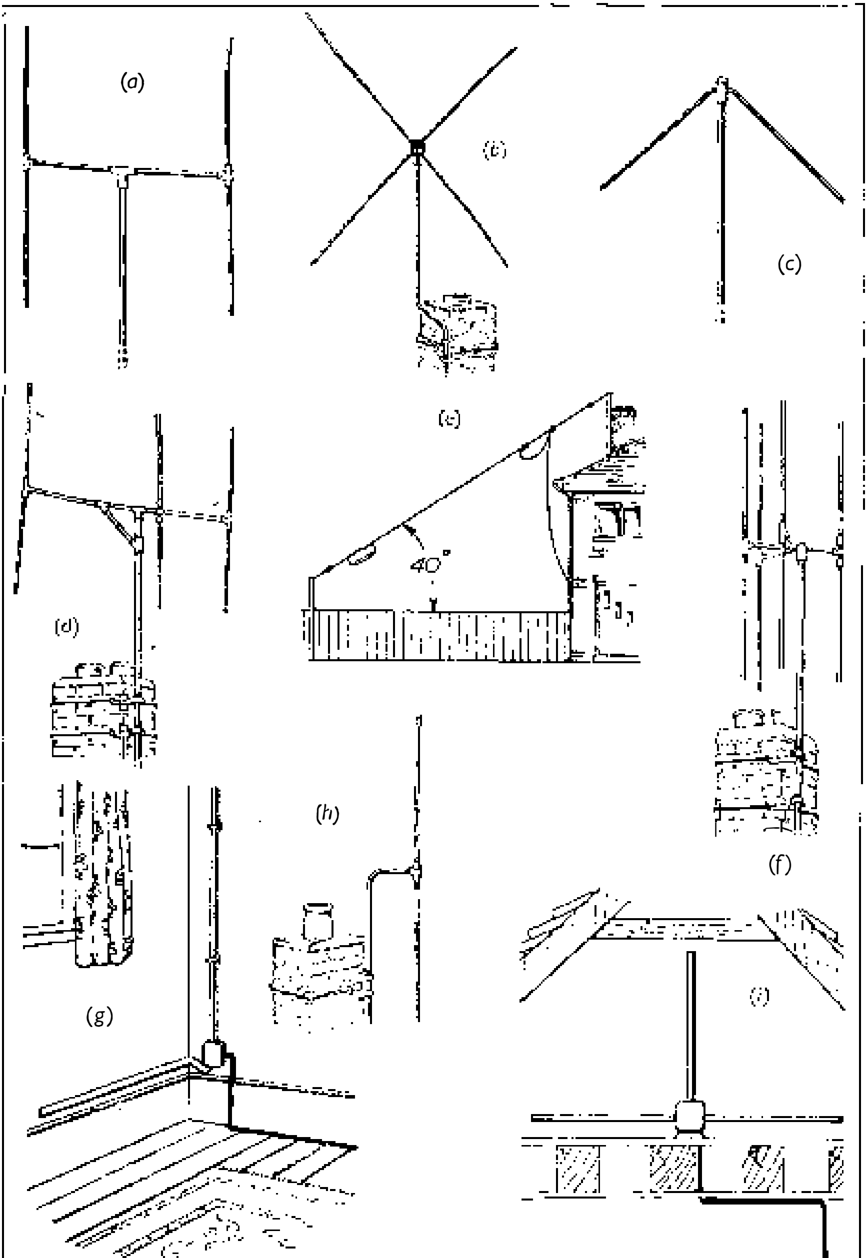
Types of Aerial	*Properties and General Remarks*
(*a*) (*b*)—" H " or " X " Aerial.	This type is directional and must be oriented according to the site. Reception will depend largely upon the height at which it is mounted.
(*c*)—Inverted " V " Aerial.	Possesses certain directional properties which can be used to reduce interference.
(*d*) (*f*)—Multi-element Aerial.	Highly directional for weak areas, must be mounted as high as possible.
(*e*)—Tilted wire Aerial.	A long wire aerial of highly directional properties which requires space for erection.
(*g*)—Indoor Aerial (fitted in same room as, or integral with, the receiver).	Reception may vary from room to room and house to house. The picture may be affected by persons moving in the room or by the presence of other indoor aerials fitted in the same building. Generally unsuitable for steel-framed buildings.
(*h*)—Single Dipole Aerial (mounted outdoors).	Reception will depend largely upon the position and height of mounting. The optimum position may vary even with similar buildings situated near to one another.
(*i*)—Indoor Aerial (fitted in loft).	Some types of loft aerial have directional properties which assist in reducing interference.

Wide experience has shown that reception conditions for which these types are generally suitable are as follows :

Reception Conditions		
Signal Strength	*Interference*	*Type(s) of Aeria*
Very strong	Slight	(*g*) (*h*) (*i*)
Very strong or Strong	Moderate or Slight	(*c*) (*h*) (*i*)
Moderate	Moderate	(*a*) (*b*) (*c*) (*e*)
Very strong Strong Moderate or Weak	Severe or Moderate	(*a*) (*b*) (*e*)
Very weak	Slight	(*d*) (*f*)

All-wave Anti-interference Aerial Systems. The aerial system (which includes the aerial, lead-in wire, earth wire, and the coil connected between aerial and earth terminals) will resonate at a particular frequency dependent upon its inductance and capacity. When the grid circuit to which this is coupled is tuned, the aerial is also tuned, due to the coupling between the aerial and grid coils, but the resonance is most pronounced at the natural frequency of the aerial system. At harmonics of that frequency it will also provide strong resonance and therefore it should be possible to find a length which will give maximum response at two or three different frequencies or wavelengths. In practice this is not easy to attain, and it is preferable to use separate aerials, each chosen to resonate at a frequency roughly in the centre of the waveband covered by the tuning coil being used. Thus for a three-band receiver three separate aerials are desirable, a short wire, say 10 ft. or so in length, being included in addition to the normal aerials. These may be arranged in many ways, and one of the most convenient is depicted in Fig. 57. Here the two broadcast aerials are joined end to end (insulated at the junction), and the short-wave aerial is suspended from the point at which they are joined.

In some cases it may be necessary to use even more than these three aerials, including other lengths to resonate at some other part of the wavebands covered. Such an aerial is known as the spider-web aerial, a diagram of it being given at Fig. 55. It will be seen here, however, that the aerials each consist of a dipole, or half-wave aerial, each built up from two quarter-



FIGS. 49 TO 54. *Types of indoor and outdoor television aerials. For properties and general remarks see page* 30.

wave aerials, and this necessitates twin feeder wires from the centre point. The advantage of an aerial of this type is that the feeder wire (or lead-in) will not pick up any energy, as it is either screened or transposed throughout its length. This is the arrangement which has to be adopted if local interference is experienced, as the aerial array may be placed well away from the building (out of the area of interference) and the lead-in will play no active part in picking up the signals. If a very long feeder is needed it will be necessary to include two transformers in the aerial system, one at each end of the lead-in, to balance out losses. This is carried out by using a step-down transformer at the aerial end and a step-up transformer at the receiver. The two sections of the transformers which are connected together which has been found to offer good results from an all-round point of view is to wind the aerial transformer (that is the one joined direct to the multi-aerial system) with a primary of 100 turns of 28 D.C.C. wire on a 1-in. diameter former, and to split this into two equal sections, separated by $\frac{1}{2}$ in. Over the centre space three or four layers of thick brown paper are wound, and in the centre of this fifteen turns of a similar gauge of wire are wound for the secondary. The ends of this winding should be anchored with sealing wax or Chatterton's compound, and taken straight across the primary at right angles before being led through anchoring holes in the ends of the former for connecting purposes.

This coil should be mounted inside a small aluminium screen can, and the

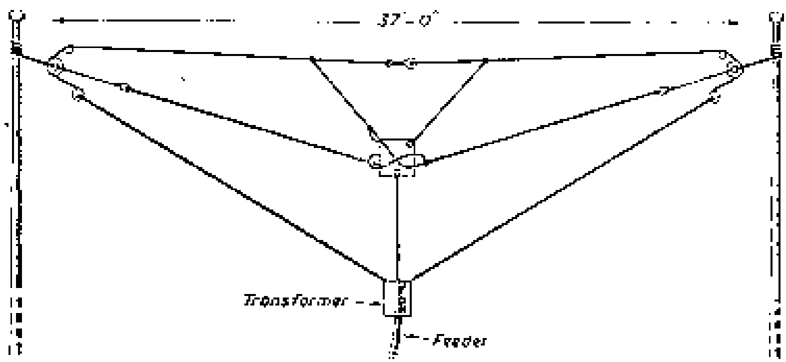


FIG. 55. *The spider-web anti-interference aerial.*

form a low-impedance circuit, and consequently the capacity between the feeders will not have such a marked effect upon the signals, which would otherwise be seriously interfered with. The usual way of arranging such a feeder is to use parallel-laid insulated wires in a heavy rubber cable. An alternative scheme is to use a single wire laid inside an insulated cable with a braided metal screen surrounding it, and this screen may form one of the feeder wires by being connected to one side of both transformers. The separate schemes are shown in Fig. 56. The majority of modern impedance-matching transformers employ iron-cored coils providing a high inductance-capacity ratio, and are accordingly beyond the scope of the average amateur to build. A design bottom of this should be sealed with a disc of waxed wood or ebonite. Chatterton's compound or some similar wax will make it waterproof, and the holes through which the ends of the aerial and lead-in are passed should also be sealed. The receiver transformer will be wound in exactly the same manner, but the larger winding (which is in this case the secondary) must be tapped to provide the necessary wave-change selection points. The ideal system is to use a two-point switch so that equal tappings are selected from each end of the secondary, although in many cases it is quite sufficient simply to transfer one connection by stages down the secondary, leaving the earthed end permanently connected.

The receiver transformer should be

mounted as close as possible to the aerial and earth terminals of the receiver, and the leads to these terminals should also be screened.

High-frequency currents travel on the surface of the wires; therefore, the more wires included in the aerial, within reason, the greater will be the surface on which these

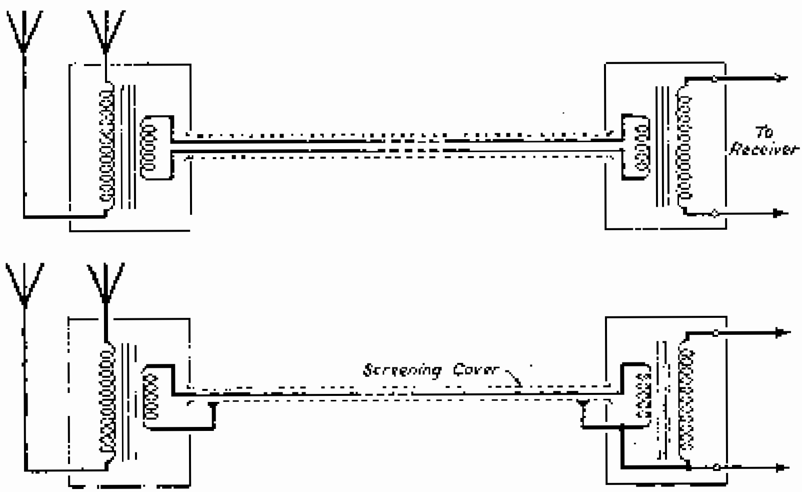


FIG. 56. *Connections for two types of impedance-matching transformer for anti-interference aerials.*

It must be emphasised that these details will not apply to every set, and therefore the constructor must be prepared to carry out some experiments as previously mentioned.

currents can travel and the lower will be the resistance to their passage. The earth should be for preference as short as possible and, as stated earlier, be of at least the same gauge as the aerial.

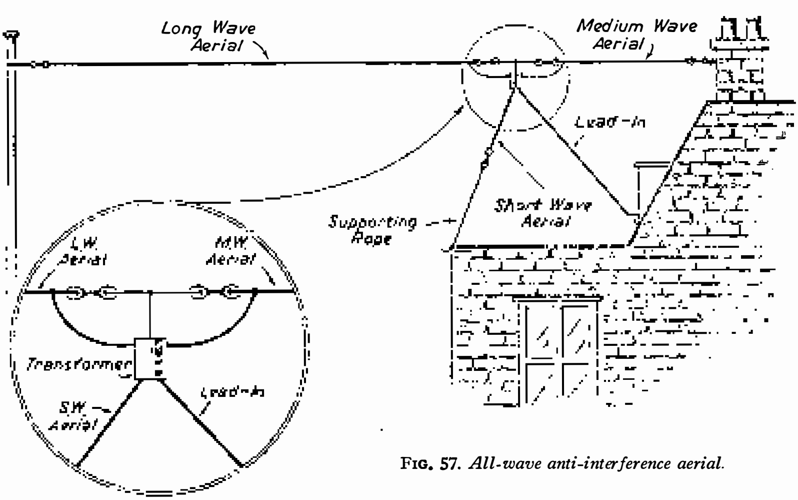


FIG. 57. *All-wave anti-interference aerial.*

The earth should have as low resistance as possible, and to ensure this a soldered connection should preferably be employed. The lead-in should be kept as far as possible from any earthed objects. The aerial itself should be situated at right angles to any adjacent telephone wires or overhead tramway cables. If the aerial is fixed parallel to them it will be screened and the reception will be difficult, and the set suffer from considerable interference. Indoor aerials, which may be fixed to the picture rail, are satisfactory for the modern receiver. It is not necessary today to use multiple wire aerials. It is important to note that local authorities object to the erection of an aerial passing over a street or other highway. The electric bell system may be used as an aerial if a variable or fixed condenser of suitable capacity is connected between it and the set.
(See also *Television*, for details of television aerials. See also *Frame Aerials.*)

AERIAL ARRAY. (See *Beam Aerial.*)

AERIAL-ISOLATING STAGE. A device which allows a common *aerial system* to be used by two receivers simultaneously.

AERIAL, NATURAL WAVELENGTH OF. The natural wavelength of an aerial is approximately four and a half times its electrical length (length between insulators plus length of lead-in). An aerial of 100 ft. has a natural wavelength of about 120 m. If connected direct to the grid of the detector valve, it would receive transmission on this wavelength. (See also *Wavelength.*)

AERIAL, P.M.G. The maximum length of aerial, inclusive of lead-in, permitted by the Postmaster-General, is 150 ft.

AERIAL, REFLECTOR. An arrangement generally employing a dipole (*which see*) aerial, for preventing a signal from being radiated in all directions, or for ensuring maximum reception in a given direction. It consists of a vertical or horizontal aerial behind which is erected a similar aerial (unconnected), the spacing between these being adjusted according to the frequency of the signals. A multi-reflector system will generally have the reflectors arranged in the form of a parabola with the aerial at the focal point.

AERIAL SYSTEM. The assembly of aerial and the electrical and mechanical devices for supporting, insulating and/or rotating it.

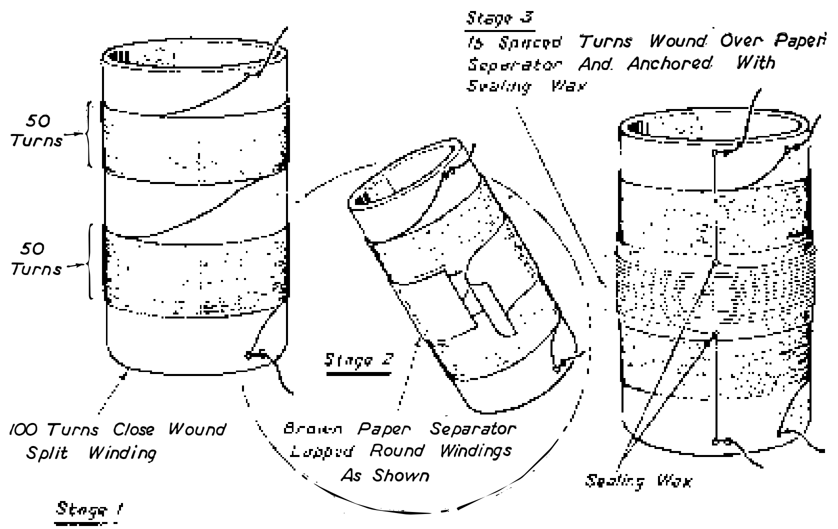


FIG. 58. *Constructional details of the transformers for anti-interference aerials.*

AERIAL TUNING CONDENSER. The variable condenser by means of which the aerial tuning inductance (the aerial coil)

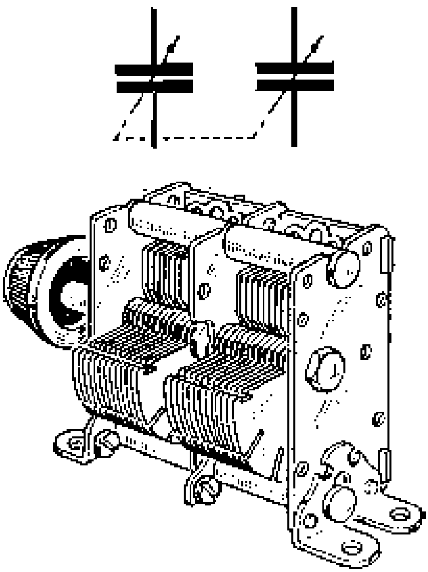


FIG. 59. *Twin-gang variable condenser with air dielectric; above, the theoretical symbol.*

is tuned to a required wavelength. Usual capacity for medium and long wavebands is ·0005 μF. For short-wave receivers, the value is ·0001 μF. or less. (See also *Condensers* and *Variable Condensers.*)

ÆTHER. (See *Ether.*)

A.F. Audio Frequencies (*which see*).

A.F.C. (See *Automatic Frequency Control.*)

AFTERGLOW. The phosphorescence of a cathode ray screen after it has ceased to be excited by the electron *beam.*

A.G.C., also A.V.C., meaning automatic volume control or automatic gain control. (See also *A.V.C.*)

AGEING. The formation of crystallites and deposits of foreign matter on the major faces of quartz crystal plates, resulting in loss of *activity.*

AIR CHOKE. A coil of wire of such a size that it has a large impedance and therefore offers a high resistance to high-frequency oscillating current, preventing the passage of such current. (See also *Chokes.*)

AIR CONDENSER. A condenser with air space as dielectric, e.g. a variable condenser which is not of the solid di-electric type. (See also *Condenser* and *Variable Condenser.*)

ALL-WAVE AERIAL. (See *Aerial,* p. 21.)

ALPHABET, WIRELESS PHONETIC. The phonetic alphabet generally used for wireless telephone call signs is as follows: A, Ack; B, Beer; C, Charlie; D, Don; E, Edward; F, Freddie; G, George; H, Harry; I, Ink; J. Johnnie; K, King; L, London; M, Monkey; N, Nuts; O, Orange; P, Pip; Q, Queenie; R, Robert; S, Sugar, T, Toc; U, Uncle; V, Vic; W, William; X, X-ray; Y, York or Yorker; Z, Zebra.

ALTERNATING CURRENT. A current whose direction of flow surges first in one direction and then in another, and at a regular period (see Fig. 5). The trace of A.C. produces a sine curve.

ALTERNATION. A complete element of an alternating-current cycle from zero point of one wave to zero point of the next.

ALTERNATOR. A type of dynamo in which alternating current is delivered through slip rings, as against the usual method of using a commutator.

AMBROIN. Insulating material consisting of a mixture of fossil copal and silicates.

AMMETER. An instrument for measuring the current (in amperes) flowing in a circuit. It must be connected *in series* with

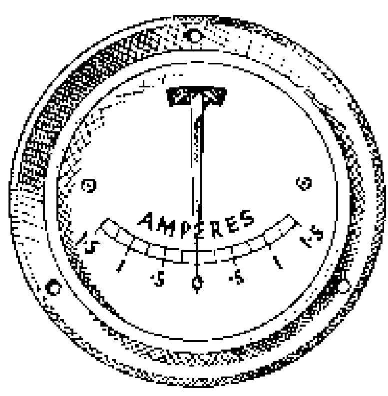


FIG. 60. *Ammeter.*

the circuit. Usual and cheapest type is the moving iron. Other types: the *hot wire* and the *moving coil, which see*). (See also *Meter.*)

AMP.—Abbreviation for ampere.

AMPERE. The unit of measurement of current. The current which will flow through a resistance of 1 ohm under a pressure of 1 volt. With small currents, such as that taken from a H.T. battery in wireless circuits, the milliampere is the unit used. This is equal to one-thousandth of an ampere. Even smaller currents are measured in microamperes.

1 ampere = 3×10^9 statamperes = 0·1 abampere; 1 statampere = $3{\cdot}33 \times 10^{11}$ abamperes; 1 abampere = 3×10^{10} statamperes (see *Abampere*). 1 ampere turn/weber = $1{\cdot}257 \times 10^{-8}$ gilbert/maxwell.

AMPERE-HOUR. This unit is equal to 1 coulomb per second for 3,600 seconds, or 3,600 coulombs.

AMPERE TURNS. The number of turns in the coils of an electromagnet, multiplied by the current flowing through them.

1 ampere turn = 1·257 gilberts or 12·57 pragilberts.

1 ampere turn = 1·257 gilberts; 1 ampere turn/inch = 0·495 oersted = 495 praoersteds; 1 ampere turn/metre = 0·01257 oersted = 12·57 praoersteds.

AMPERE'S RULE. Refers to the deflection direction of a magnetic pointer that is influenced by a current; an analogy being that if a person is assumed to be swimming with the current and facing the indicator, the north-seeking pole is deflected towards the left hand, the south pole being deflected in an opposite direction.

AMPERE'S THEOREM. The magnetic field from current flowing in a circuit is equivalent to that due to a simple magnetic shell, the outer edge coinciding with the electrical conductor with such strength that it equals that current strength.

AMPLIFICATION. In an amplifying valve the overall amplification is measured by comparing the signal voltage applied to the grid of the valve with the voltage developed across some piece of apparatus, termed the "load," included in the anode circuit of the valve. For a given value of anode current, the voltage drop across the load will be proportional to the impedance of the load.

The formula for the total stage gain in a resistance-capacity coupled stage :

$$\text{Gain} = \frac{\text{Resistance of load} \times \text{amplification factor of valve}}{\text{Anode resistance of valve} + \text{resistance of load}}$$

(See also *Stage Gain*, *Push-pull*, *Quiescent Push-pull*, *Class A*, *Class B*, and *Class AB*.)

AMPLIFICATION FACTOR (Mu or μ). The ratio between change in plate potential or voltage and change in grid potential.

$$\mu = \frac{V_{a2} - V_{a1}}{E_g}, \text{ when E}$$

equals the grid voltage applied to restore the anode current reading produced by V_{a2}, to that flowing when the anode voltage was V_{a1}. V_{a1} and V_{a2} represent the anode voltages. The Mu can be expressed, therefore, as the ratio of change of anode volts to change of grid volts to produce a constant anode current.

$$\text{Or } \mu = \frac{\text{Mutual Conductance} \times \text{Impedance}}{1{,}000}$$

when Mutal Conductance is expressed in mA./volt.

AMPLIFIER. A valve used in the amplifying stages of a receiver. A complete unit coupled to an existing receiver for increasing its output. (See also *Inverted Amplifier*, and *Circuit*.)

AMPLITUDE MODULATION. The term applied to the modulation system of a transmitter when the "carrier" wave has its amplitude varied or modulated by another wave-form corresponding to the sound affecting a microphone, or variations in light intensity in the case of television picture transmission. The frequency of the "carrier" wave is not affected.

AMPLITUDE SEPARATION. The process of separating parts of a waveform differing considerably in amplitude.

ANELECTRIC. Any body unaffected (i.e. does not become electrified) by friction. The reverse of *dielectric*.

ANGLE OF INCIDENCE. The angle from the perpendicular at which the sound waves impinge upon a surface.

ÅNGSTRÖM UNIT. A standard of measurement of the wavelength of light. One Ångström unit equals one ten-millionth of a millimetre, or one ten-thousandth of a micron (*which see*). (See *Lux*, *Lumen*, *Footcandle*.)

ANION. Obsolete term for negative ion. The electro-negative constituent of an electrically decomposed compound, appearing at the anode of a voltaic battery. (Opposed to *Cation*, *which see*.)

ANNEAL. To soften (a metal) by heating and quenching or heating and gradual cooling. Brass may be annealed by the former method; steel is *hardened* by it.

ANODE. The positive voltaic pole. The point where, or the path by which, a voltaic current enters an electrolyte.

The plate of the valve. The opposite of *Cathode*.

ANODE BEND RECTIFICATION. A process of rectification which depends upon the bend in the lower part of the grid-volts anode-current curve. If such a curve

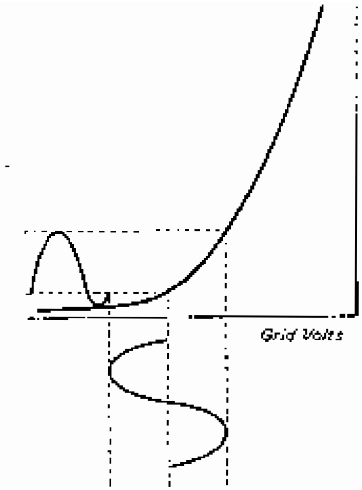


FIG. 61. *Grid volts/anode current curve for anode bend rectification.*

is examined it will be seen that at the bottom of the curve it tends to become horizontal. The result of applying a large negative grid bias to the valve is to bring the working point to this bend. When oscillations are received by the grid of the valve the anode circuit can only increase at positive half-cycles, no change being recorded (theoretically) at negative half-cycles. The result of this is to rectify the incoming oscillations. A certain amount of amplification also takes place (see Fig. 61).

ANODE DISSIPATION. (Class A)

$$\text{Watts} = \frac{V_a \times I_a}{1{,}000}$$

When V_a = anode volts, and I_a = anode current in mA_s.

ANODE EFFECT. That very quick current drop that is caused by film formations of gas on an anode or plate situate in electrolysis.

ANODE OF ACCUMULATOR. The positive pole or plate.

ANODE OF VALVE. Terminal to which high-tension current is applied. The plate of the valve.

ANTENNA. American term for aerial (*which see*).

ANTI-BREAK-THROUGH CHOKE. Coil of wire connected in the aerial lead to prevent the passage of medium-wave signals when receiving long-wave signals. (See also *Chokes*, *High-frequency Chokes*, and *Break Through*.)

ANTI-CLUTTER GAIN CONTROL. A device which automatically and smoothly increases the gain of a radar receiver from a low level to the maximum, within a specified period after each *transmitter pulse*, so that short-range *clutter*-producing *echoes* are amplified less than long-range echoes.

ANTI-INTERFERENCE AERIALS. (See *Aerial*.)

ANTI-JAMMING. Reducing the effects of enemy jamming.

ANTI-JITTER CIRCUIT. A valve stage which is operated by unwanted voltage fluctuations of a D.C. supply to produce a stabilised voltage output for the reduction of *jitter* in the *display*.

ANTINODES. In a series of oscillations, the points of greatest amplitude. Known also as loops.

APERIODIC. A term applied to a circuit which is untuned—or possesses high resistance, thus precluding oscillation.

APERTURE. The open end of a *flare*, *reflector*, etc. The significant linear dimension of this.

APERTURE ILLUMINATION. The distribution of the field intensity over the area of an illuminated *aperture*.

APPLETON LAYER. An electrically conducting layer, existing 140 miles above the earth, but at times extending up to 300 miles. Known as the F layer. Caused by the ionising action of the sun on the gases comprising the earth's outer atmosphere. (See *Heaviside Layer* and *Ionosphere*.)

ARC. When a current "jumps" an air gap it is said to "arc."

ARCHIMEDES' PRINCIPLES. (1) A body in liquid loses part of its weight, the loss to equal the weight of the liquid displaced. (2) The gas pressure on bodies immersed in gases is equally transmitted in every direction.

AREOMETER. Another term for hydrometer, used to determine the specific gravity of a liquid. Some hydrometers of the "floating-ball" types are practically useless to the accumulator user, as they give no indication when the acid is too strong or too weak.

Hydrometer readings can sometimes give a false indication. If, for instance, acid had been added to an accumulator instead of water, a hydrometer reading might incorrectly indicate it to be fully charged. Additional causes of false hydrometer readings are : An inaccurate or cracked hydrometer float; taking readings when freshly added water has not had time to mix with the acid.

Hydrometer readings may always be supplemented by means of voltage tests. Use an accurate moving-coil voltmeter, reading 3-0-3 volts, and take all readings while the cells are on discharge. Voltmeter readings taken on open circuit are liable to be misleading. (See also *Hydrometer*.)

ARMATURE. (See *Loudspeaker*.)

ARMSTRONG. The circuit employing the super-regenerative principle. The value of

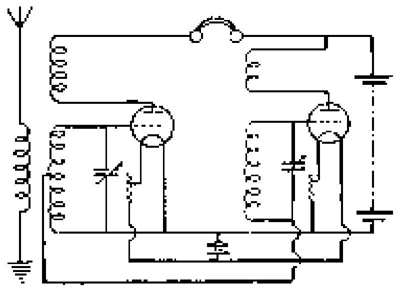


FIG. 62. *The Armstrong circuit.*

the circuit elements are critical, and the arrangement is now chiefly used in ultra-short-wave reception (see Fig. 62).

ARTIFICIAL AERIAL. A non-radiating transmitting aerial. A "dumb" aerial.

ASPECT RATIO. The proportions of the raster in the television receiver. In the present British system this is 4 : 3.

ASTATIC. State of neutral equilibrium. An astatic coil is one wound in two sections, half the winding being on one coil and half on the other, but wound in the opposite direction. The "field" of each coil is therefore neutralised.

ASTATIC GALVANOMETER. A galvanometer (*which see*) having an astatic pair of index fingers or needles.

ASYMMETRICAL EFFECT. An inaccuracy of reading in radio direction finding that is due to unequal current distribution in the two halves of the loop. This is said to be the result of either inductive or geometric asymmetry.

ASYNCHRONOUS. (See *Non-synchronous*.)

A.T.C. Aerial Tuning Condenser.

A.T.I. The Aerial Tuning Inductance. The aerial tuning coil.

ATMITE. (See *Metrosil*.)

ATMOSPHERICS. Crackling noises in the receiver. These do not occur in this country except during periods of thundery weather. Not to be confused with crackles caused by a worn-out H.T. battery or faulty or dirty connection in the set. In this case disconnect the aerial temporarily. If the crackles cease, they are due to atmospherics. (See also *Interference* and *Noises*.)

ATOM. All matter is composed of minute particles or *atoms*; elements consist of atoms of one kind—carbon, copper, gold, etc. Compounds consist of groups of atoms. Thus water consists of two atoms of hydrogen and one atom of oxygen, forming a molecule of water.

ATOMIC WEIGHT. The weight of one atom of any element, as compared with an atom of hydrogen. Atomic weight of hydrogen is unity.

ATTENUATION. A lengthening out, or a thinning. The term is applied in wireless to a weakening of the frequency response at the ends of the scales. For instance, if the constants of a circuit are designed in such a manner that the high notes are cut off, it is said that the high notes are attenuated.

ATTENUATION FACTOR. A ratio of initial and received amplitude, it being determinable from e^{ax}, where x = distance and a = the circuit attenuation constant. (See *Absorption Factor*.)

ATTENUATOR. A circuit or a piece of apparatus for reducing or cutting off the output from a transmitter, receiver, or amplifier.

AUDIBLE SPECTRUM. This extends above and below the visible spectrum (*which see*). Below infra-red we find radio frequencies, and below these alternating and audio frequencies. Above the visible band we find X-rays, gamma-rays, and others not yet named, although the cosmic rays are found in these extreme upper ranges.

AUDIO FREQUENCIES. Frequencies of less than 10,000 cycles per second are assumed to be audible, and so are described as of audible frequency. (See *Radio Frequencies*.)

AUDION. The de Forest and Fleming types of valve. The main feature is the second plate, which makes it a rectifier and amplifier.

AUTODYNE. Where the inductances of

the grid and plate are part of a common coil in a circuit, that circuit is of the autodyne type (see Fig. 63).

The tight coupling provided by the common coil ensures constant operation, provided that the condenser used is of a suitable value. Probably the most popular

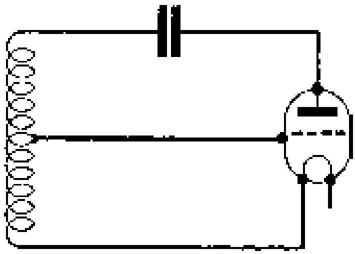


FIG. 63. *Autodyne circuit.*

form taken by this type of circuit is the Hartley although the arrangement used in the well-known Reinartz circuit also utilises the autodyne principle.

AUTOMATIC AIMING. A system in which a mechanism actuated by the echo signal automatically keeps a radar *beam* pointing at a moving object.

AUTOMATIC CALL DEVICE. An arrangement used chiefly on ships for giving an audible signal when distress calls are made. It usually consists of a selector so designed that a series of 4-second dashes broken by spaces of 1 second cause bells to sound the alarm.

AUTOMATIC FOLLOWING. As *Automatic Aiming*, but with the addition of *Automatic Range Measurement*. The use of the term Automatic Following to mean Automatic Aiming is deprecated.

AUTOMATIC FREQUENCY CONTROL. An arrangement whereby the frequency of an oscillator is automatically maintained in the neighbourhood of a desired value.

The term applied to an arrangement which causes a circuit automatically to be tuned after the main control has been tuned to approximately the correct wavelength setting. In its simplest form it consists of a double-diode valve, each diode of which is coupled to the oscillator circuit in a superhet. The out-of-balance effect of the signals on the two diodes, after rectification, is fed back to the oscillator circuit and causes a readjustment of this to bring the set into tune and thus an equal voltage across the two diodes.

AUTOMATIC GAIN CONTROL (A.G.C.). A device, actuated by the received signal, which varies the overall amplification of the receiver so as to maintain the output level for a given modulation depth substantially constant.

AUTOMATIC GAIN STABILISATION. Making the gain of a receiver independent of unwanted variations in circuit conditions.

AUTOMATIC GRID BIAS.—The object of biasing a valve is to render the potential of the grid less than that of the cathode, that is the filament in battery-fed valves. With ordinary battery bias, the cathode is at a potential equal to the potential at the negative end of the high-tension supply, and by connecting the positive pole of the grid-bias battery to the same spot, the grid potential is equal to the voltage of as much of the grid battery as is included in the grid circuit. In order to bias the valve, it does not matter whether the cathode is at zero voltage and the grid at some negative potential, or whether the grid is at a zero potential and the cathode at some positive potential. This latter condition is that which usually obtains when automatic bias is used. In most of these arrangements, the grid is maintained at the same potential as the negative terminal of the high-tension supply, while the cathode is raised to a higher potential by the inclusion of a resistance in the lead connecting the cathode to the high-tension negative terminal.

Voltage Drop. This will be made clear by

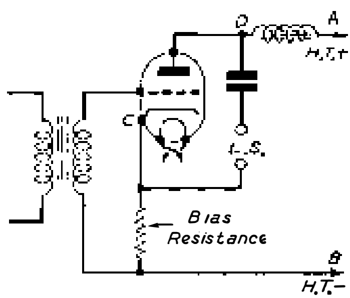


FIG. 64. *A resistance inserted in the cathode lead of an indirectly-heated valve.*

a reference to Fig. 64, which shows the essential connections for automatic bias to an indirectly heated low-frequency output valve. In this diagram, certain refinements, such as the decoupling arrangements, are omitted for the sake of simplicity. It will be seen that the full-high-tension voltage exists between the points A and B, the point B being at zero potential. It is obvious, therefore, that there will be a drop of voltage, equal in all to the total high-tension voltage, along the complete valve circuit.

Advantages of Automatic Bias. The advantages of automatic or self-biasing are many. In the first place, if the value of the biasing resistance is correctly calculated, there is no possibility of under biasing or over biasing the valve. Also the biasing resistance automatically controls the value of the anode current, for should the anode current rise, due, perhaps, to an increase in anode voltage, the drop through the biasing resistance will rise in

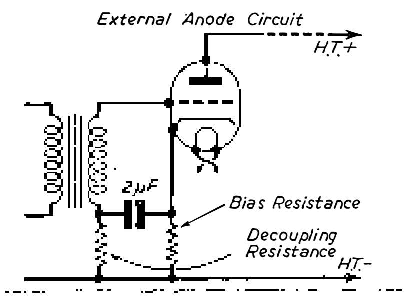


FIG. 65. *The arrangement of* FIG. 64 *with a decoupling resistance added.*

proportion, the negative bias will be increased, and the anode current again reduced to its normal value. Further, the biasing resistance does not deteriorate as does a grid-bias battery, does not vary in value, and needs no replacement. If desired, the biasing resistance can be made variable, or semi-variable.

There is one disadvantage. Any biasing voltage thus applied is subtracted from the total H.T. voltage. This makes no practical difference to the efficiency of the average mains set where 200 or 250 volts H.T. is available from a mains unit, and the maximum bias voltage required does not exceed 20 or 30 volts. In the case of some of the bigger output valves, however, which are designed to operate at about 400 volts on the anode, as each valve requires over 100 volts grid bias, the loss, if this amount of bias were subtracted from the available 400 volts H.T., would be serious.

Biasing Resistance. Biasing resistances generally should be of the stable type, and must be capable of carrying the full anode current of the valve continuously without overheating. In the case of early stage low-frequency amplifiers and screened-grid valves, ordinary fixed resistances are quite suitable, but for output valves, where a certain amount of preliminary adjustment of grid bias is usually necessary, it is advisable to use a variable resistor, or, preferably, a fixed resistor and a variable resistor in series. This allows of adjustment, but at the same time prevents the valve from being run entirely without bias if, by mistake, the variable portion is reduced to zero. For variable-mu valves, where continuously adjustable bias is required, the resistance must naturally be of the variable type. The calculation of the correct value of biasing resistance is a simple matter, and is merely the applications of Ohm's law. The formula is:

$$\text{Value of biasing resistance in ohms} = \frac{\text{Desired bias in volts}}{\text{Anode current in amps.}}$$

As the anode current is usually expressed in milliamps., the value of the biasing resistance is found by multiplying the desired bias voltage by 1,000 and dividing by the anode current in milliamps.

As a typical example, take an output valve requiring a grid bias of 32 volts at full anode voltage, the anode current being 30 milliamps. The correct resistance for self bias would be 32 multiplied by 1,000 and divided by 30, or 1,006·6 ohms. Actually, a total resistance of 1,250 ohms would be used, consisting of a 750-ohm fixed resistor in series with a variable resistor of 500 ohms maximum.

Decoupling Resistance. In addition to the biasing resistance itself, certain additional apparatus is usually required, by way of decoupling. If the anode supply is not efficiently smoothed, and a bad mains ripple is present, there is a risk that this may be transferred to the grid by the bias arrangement, when the anode current will be correspondingly modulated, and serious mains hum result. Moreover, there is always a chance that the biasing circuit may pick up mains hum from some other part of the apparatus, while any other low-frequency component in the anode curren will have a similar effect. To reduce this risk, a grid decoupling or smoothing circuit may be employed. This consists of a high resistance, usually of about 50,000 ohms, included in the grid return, and by-passed to the cathode through a condenser which, in the case of most low-frequency valves, should be of 2 μF. capacity.

Such decoupling is not essential, but should be added without hesitation if serious hum is noticed. The condenser value of 2 μF. is ample, and in many cases, especially in early low-frequency stages, 1 μF. may be sufficient. On the other hand, where a very bad hum is present, especially if the output valve is a pentode, it may be necessary to use a 4-mfd. condenser for decoupling the bias to the last valve. Different designers prefer different arrangements of the auto-bias circuit, but the circuits given are tried arrangements, and quite suitable for the types of valves for which they are recommended. Fig. 65 is the complete arrangement for an early stage indirectly heated L.F. amplifier, such as the input valve of a gramophone amplifier. It may also be employed where the detector valve of a receiver is required to act also as first low-frequency amplifier with a pick-up.

Precisely the same arrangement may be used for a pentode output valve of the indirectly heated type, but for three-electrode output valves a slightly different system is preferable. For a triode, the value of the biasing resistance is usually of the same order as the resistance of the load, and the loss of power in the biasing resistance, if this resistance were included in the load circuit, would be serious. This is avoided in the circuit shown in Fig. 66, where the cathode is maintained at the common potential of the set, and a negative potential given to the grid by the biasing resistance connected between the common negative wire and the H.T. terminal.

Fig. 67 gives the variant of this circuit for use with a directly heated triode or pen-

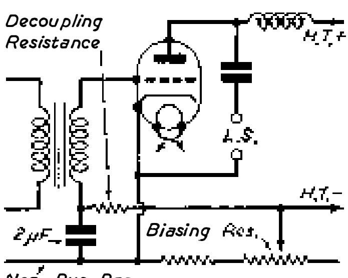


FIG. 66. *An alternative arrangement of* FIG. 65 *in which the cathode is maintained at the normal negative potential.*

tode output valve, a connection between the common negative wire and the centre-tap of the filament winding taking the place of the cathode lead in Fig. 66. For

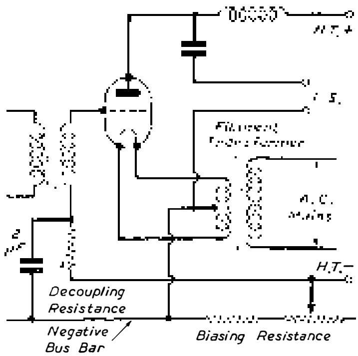


FIG. 67. *A directly-heated valve arranged in the same manner as* FIG. 66.

screened-grid high-frequency valves, the circuit is as shown in Fig. 68. This arrangement is similar to that in Fig. 64. It should not be forgotten that automatic bias can just as simply be applied to battery-operated receivers. The essential circuit is shown in F g. 69. Here is a wire-wound resistance a able of carrying the total H.T. current of the set is connected between H.T.— and L.T.—, and thus biases the output valve.

AUTOMATIC RANGE BEARING. A system in which range, bearing, or elevation is determined automatically by a mechanism actuated by the echo signal.

AUTOMATIC STROBE PULSE. A *strobe pulse* whose timing is automatically adjusted to coincide with that of a given *echo* even though the range of the corresponding object varies.

AUTOMATIC TONE COMPENSATION. The object of this is to compensate for the high-note cut-off introduced when reaction is advanced to its limit. An L.F. transformer of a type which emphasises the high-notes is used after the regenerative detector valve and the differential reaction condenser is so connected that when its capacity is reduced to a minimum it completes the circuit of a fixed condenser joined in parallel with the primary winding of the special L.F. transformer. The effect of the condenser is to reduce the high-note response.

AUTOMATIC TUNING. With rotary switch selection, an ordinary multi-contact rotary switch is used, a particular station being received at each switch position. Fig. 70 shows a suitable circuit where four stations are provided for, three on medium waves and one on long.

A 4-pole, 4-way switch is used. Two switch sections select pre-set condensers in pairs. The other two sections short the long-wave sections of the coils in three positions for medium-wave reception. The fourth position gives long-wave reception.

In use, the two pre-sets P1 should be adjusted to one of the desired stations. Pre-sets P2 and P3 are also adjusted for two other stations in the same way. The stations obtained with P1, P2 and P3 will be on the medium-wave band. The pre-sets P4 are then adjusted for the long-wave band. In each case the switch is turned to the appropriate position, and the stations will be automatically selected afterwards by rotating the switch.

Adding Manual Tuning. If it is felt manual tuning is also needed for the reception of foreign stations, etc., it may be connected as in Fig. 71. Here, one pair of pre-sets is abandoned, a 2-gang, ·0005 μF. condenser being brought into circuit at that position of the switch. The receiver can thus be tuned in the ordinary way, with the automatic selection of three stations when required.

In this circuit separate wave-change switching is shown, so that manual tuning is possible on both wavebands without much switching. A double-pole switch only is needed here. If a 4-pole, 5-throw

RESISTANCE VALUES FOR DECOUPLING AND VOLTAGE DROPPING

VOLTAGE DROPPED

Current mA.	8	9	10	20	30	40	50	60	
1	8,000	9,000	10,000	20,000	30,000	40,000	50,000	60,000	
2	4,000	4,500	5,000	10,000	15,000	20,000	25,000	30,000	
3	2,500	2,500	5,000	7,000	10,000	15,000	17,500	20,000	
4	2,000	2,500	2,500	5,000	9,000	10,000	12,000	15,000	
5	1,500	2,000	2,000	5,000	7,000	9,000	10,000	12,000	
10	1,000	1,000	1,000	2,000	2,500	5,000	5,000	7,000	1 *watt*
15	500	500	1,000	1,500	2,000	2,500	5,000	5,000	
20	500	500	500	1,000	1,500	2,000	2,500	2,500	2 *watt*
25	500	500	500	1,000	1,500	1,500	2,000	2,500	
30	300	300	500	1,000	1,000	1,500	2,000	2,000	
40	250	250	300	300	1,000	1,000	1,500	1,500	3 *watt*
50			250	500	500	1,000	1,000	1,000	
				1 *watt*		2 *watt*		3 *watt*	

Current mA.	70	80	90	100	125	150	175	200	
1	70,000	80,000	90,000	100,000	125,000	150,000	175,000	200,000	
2	35,000	40,000	45,000	50,000	62,500	75,000	87,500	100,000	
3	25,000	30,000	30,000	30,000	40,000	50,000	50,000	75,000	
4	17,500	20,000	25,000	25,000	30,000	40,000	40,000	50,000	1 *watt*
5	15,000	17,500	20,000	20,000	25,000	30,000	40,000	40,000	
10	7,000	9,000	9,000	10,000	12,000	15,000	17,500	20,000	2 *watt*
15	5,000	5,000	6,000	7,000	9,000	10,000	12,000	15,000	3 *watt*
20	5,000	5,000	5,000	5,000	7,000	8,000	9,000	10,000	4 *watt*
25	2,500	2,500	5,000	5,000	5,000	5,000	7,000	8,000	5 *watt*
30	2,500	2,500	2,500	3,000	5,000	5,000	7,000	7,000	6 *watt*
40	2,000	2,000	2,500	2,500	3,500	5,000	5,000	5,000	8 *watt*
50	1,500	1,500	2,000	2,000	2,500	2,500	2,500	5,000	10 *watt*
	4 *watt*		5 *watt*		7 *watt*	8 *watt*	9 *watt*	10 *watt*	

The values given above are correct to the nearest standard value.

switch were used, it could be connected as follows: position 1, manual tuning on L.W.; position 2, manual tuning on M.W.; positions 3, 4 and 5, automatic selection of long- or medium-wave stations. (Wave-change switching would be obtained as in Fig. 70.)

Reaction. Reaction is added to Fig. 71, and is controlled by a normal variable condenser. Reaction could be used in the circuit shown in Fig. 70 if additional sensitivity were required, but a panel control should be avoided if possible, a pre-set being used. If automatic selection of weak stations is intended and a panel

will switch on and operate on long waves. The ·0003 μF. condenser is then adjusted to the Light Programme.

Upon either of the central three buttons being depressed the top switch will spring out, changing to medium-wave reception. The pre-sets of these switches may be adjusted for medium-wave stations, for example, Third Programme, Midland and West Programmes.

When switching off depress the lower button. It will then remain in until any of the other buttons are depressed, according to the programme desired.

Some degree of reaction can be added by

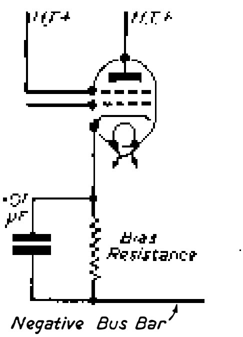


FIG. 68. *The biasing resistance arranged in the cathode lead of an H.F. valve.*

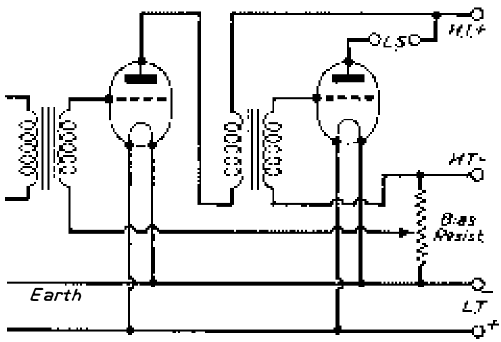


FIG. 69. *A common resistance connected up to provide bias for two battery-heated valves.*

reaction condenser not wanted, a switch with an additional section may be used and an individual pre-set reaction condenser provided for each position of the selection switch.

Push-button Switching. The majority of push-button switches have a single-pole, double-throw action with each button. To enable such a switch to be used, one tuned circuit only can be adopted. If constructed as in Fig. 72, with a loosely coupled aerial circuit, this will be sufficiently selective for receiving the major B.B.C. programmes. By careful arrangement it is also possible to avoid additional wave-change and on-off switching.

In Fig. 72, all the switches spring to the left, except that which is depressed. If the lower switch is depressed, the receiver is off. This switch will spring into the "on" position when any of the other buttons are depressed.

If the top button is pressed, the receiver

the ·0002 μF. pre-set connected to the reaction coil.

Pre-set Capacitances. These must be chosen with a maximum capacitance near that required. If too large condensers are used, it may be found that the minimum is too high for a station near the bottom of the band. (Plates may be removed to avoid this.) Normally ·0005 μF. pre-sets will be suitable for most stations, but with most coils one of these would have a minimum capacitance too high to receive, say, the West Programme on 216·8 metres. A ·0001 or ·0002 μF. maximum component may therefore be necessary here.

Amplifiers and Volume Control. A simple and efficient battery-operated amplifier is shown in Fig. 73. This is suitable for any of the circuits shown, giving reasonable volume and quality.

In all cases, a volume control is desirable. This could be ordinary V.M. bias in Figs. 70 and 71. For G_1 a low-frequency control could be added to the circuit. To do this the ·25 megohm leak in Fig. 73 is replaced by a potentiometer of similar value, the grid of the L.F. valve being taken to the slider of the component. If five stations were to be selected with a 5-way switch, then the volume control could have an internal on-off switch, the lower push-button being used to switch in an additional pre-set condenser.

Push-button Selection with R.F. Stage. This is best arranged by obtaining a switch in which double-pole double-throw switches are operated by each button. The simple switch may be wired as in Fig. 74, however, to give on-off, manual and two-station selection.

In Fig. 74 the on-off switching is obtained as in Fig. 72. The two pre-determined stations are obtained by the next two buttons, a double-pole, double-throw effect being obtained as one switch springs out when the other is depressed. These pre-sets are also obtained through the lower buttons being out.

When *both* the lower buttons are depressed, the pre-sets are disconnected and a 2-gang condenser brought into circuit for manual tuning. Both these buttons will stay in until the "off" button or either of the other buttons is operated.

As addition to Normal Receiver. Fig. 75 shows how push-button selection may be added to a receiver without interfering with the manual tuning of circuits (which may be of superhet or all-wave design).

The filament circuit of the R.F. and detector stages of the receiver (or F.C., I.F. and second detector stages in a superhet) should be broken. It is then connected so that depressing one button on the push-switch makes the circuit complete. A second button is also connected so that the aerial is connected to the receiver when the switch is depressed. Pressing these two buttons will then enable the receiver to be tuned and operated as before.

The other three push-buttons select stations as in the circuit in Fig. 72. Upon any of them being depressed, the first two switches spring open, connecting the aerial to the push-button detector and switching on the filament of the push-button detector. The anode of this new detector is connected to the L.F. coupling of the receiver, so that the signal is amplified by the receiver in the required way.

The necessary addition is shown to the left of the line AA in Fig. 75, the coil connection, etc., not being shown for clarity. These are as in Fig. 72.

Practical Layout. So that the method of connecting push-button switches is quite clear a wiring diagram is shown in Fig. 76. This unit forms an adaptor which may be added to any battery-operated receiver, as outlined in the circuit shown in Fig. 75.

A double-pole, double-throw switch is used for transferring aerial and filament

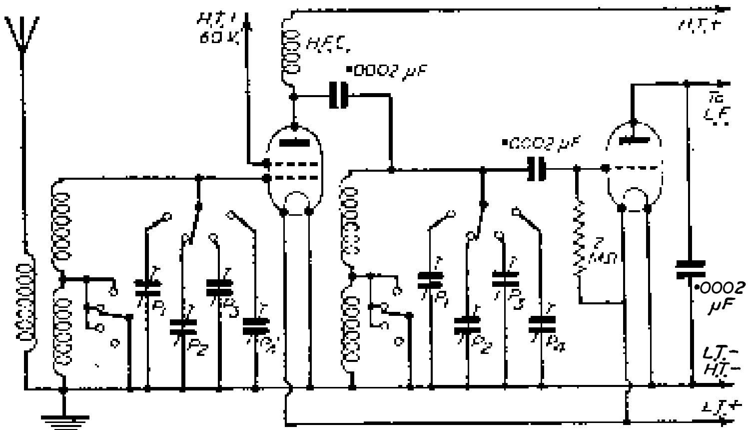


FIG. 70. *A simple two-valver with a rotary 4-position switch assembly to provide choice of four stations.*

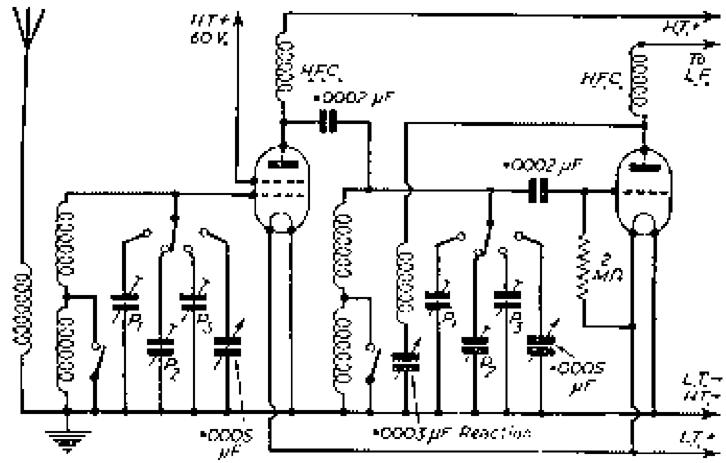


FIG. 71. *The same type of switch is used in this circuit, but manual tuning is provided and a reaction circuit is included.*

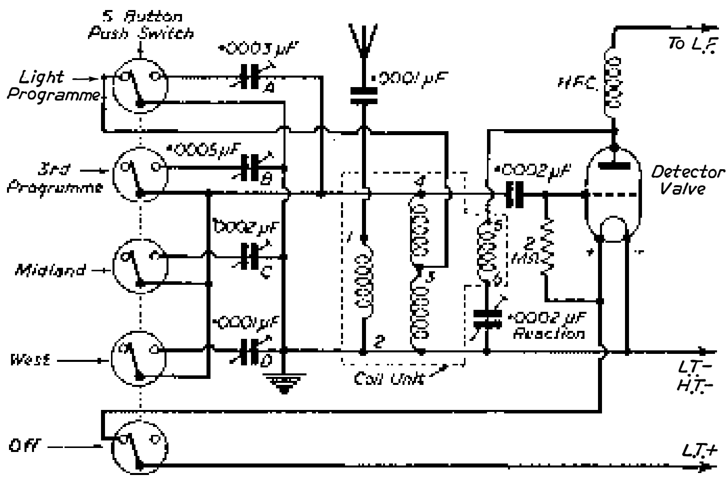


FIG. 72. *Push-button switching in its simplest form is indicated in this circuit diagram.*

connections. Lead X is taken to the aerial terminal of the receiver, and lead Y to the filaments of the R.F. and detector valves (see Fig. 75). The remainder of the circuit is as in Fig. 72, and the coil connections are numbered to agree with that circuit so that any coil may be used. A screened one is most suitable.

The diagram shows how switching is accomplished, one of the buttons always

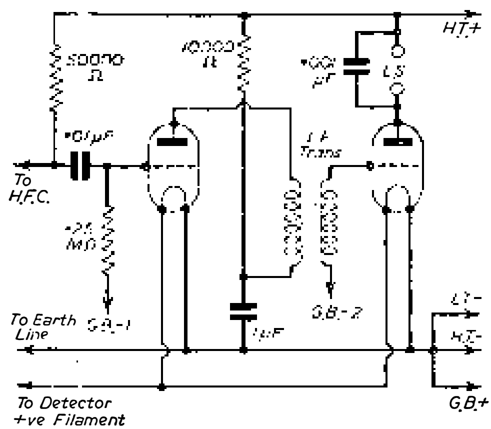


FIG. 73. *A simple L.F. amplifier in which the grid resistance of the first stage may be replaced by a variable component to provide volume control.*

being in the "in" position once the switch has been fitted to the panel. The double-pole switch should be marked "Normal Operation" in one position and "Push-button Operation" in the other. The latter position will then provide automatic selection of four transmissions by means of the buttons, one being on long waves.

For Light Programme, Third Programme, Midland and West Programmes pre-sets A, B, C and D should be set to approximately ·00025 μF. (or ·0003 μF. for the higher wavelength station). Pre-sets which have a capacity range accommodating these values should therefore be used. Other stations may, of course, be chosen. (See *Push-button Tuning* and also Figs. 74 to 76.)

AUTOMATIC VOLUME CONTROL, or A.V.C. A system by means of which the volume of sound delivered by the loudspeaker is of constant intensity regardless of the station being received. A.V.C. thus prevents overloading of the detector valve by a powerful local transmitter and also overcomes fading on distant stations. The principle of A.V.C. is that the signal voltage fed to the detector valve is employed to produce a negative bias voltage which is applied to preceding variable-mu amplifiers. The negative voltage produced is directly proportional to the detector signal voltage, and it produces a reduction in amplification of the H.F. valve or valves. As the reduction in amplification is proportional to the signal voltage it will be seen that the result mentioned above can be obtained. Most A.V.C. systems depend upon the use of a "Double-Diode" detector valve or else a "Cold Valve." (See also *Quiet Automatic Volume Control* and *Delayed Automatic Volume Control.*)

AUTOMOBILE RADIO. (See *Car Radio.*)

AUTO TRANSFORMER. A transformer having a single winding instead of the usual two windings. Part of it is tapped off to form the primary, the other part forming the secondary.

This type of component is often used in commercial broadcast receivers to economise in the cost of the usual mains transformer. The main objection to the use of this type of transformer is that the H.T. negative line in the broadcast receiver is usually connected to the metal chassis, and with the auto-transformer one side of the mains becomes "live" to the chassis. Thus the equipment is dangerous to handle unless the mains plug is first removed from the mains outlet socket.

An auto-transformer may be used as an L.F. coupling component, but this arrangement is not now generally employed.

AUXILIARY ANODE. The third electrode of a valve—the grid.

A.V.C.—Automatic Volume Control (*which see*).

AVOGADRO'S LAW. Defines that equal volumes of all gases at a similar pressure and temperature have the same number of molecules.

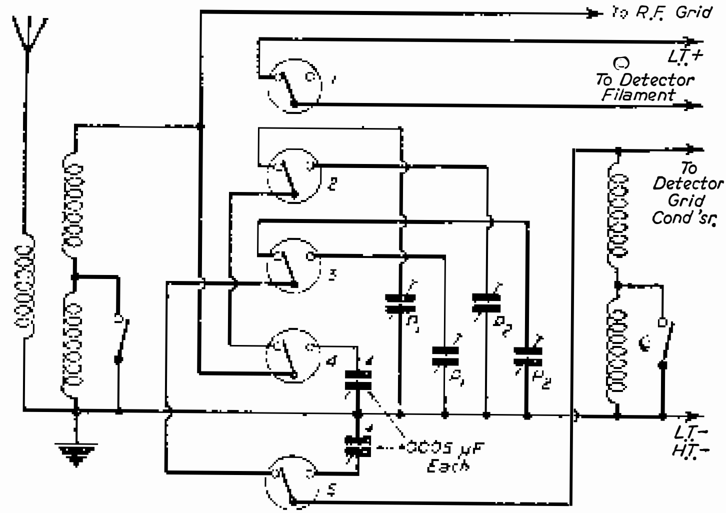


FIG. 74. *Utilising one of the push-buttons for on-off switching purposes.*

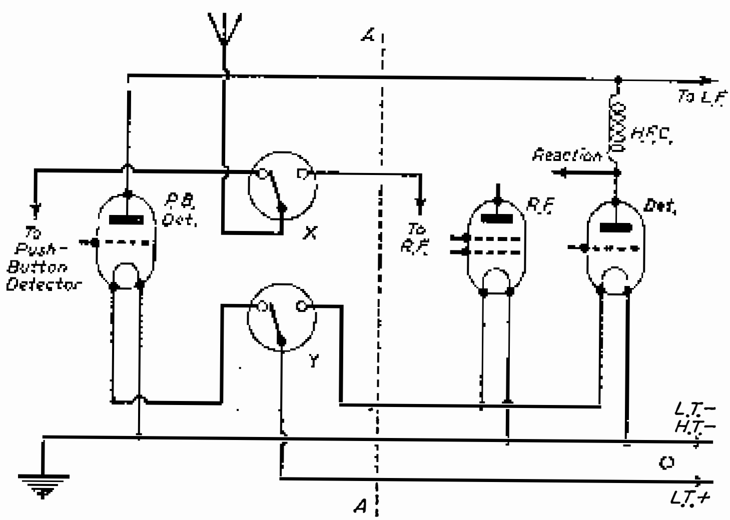


FIG. 75. *A simple method of adding push-button switching without interfering with normal circuit arrangements.*

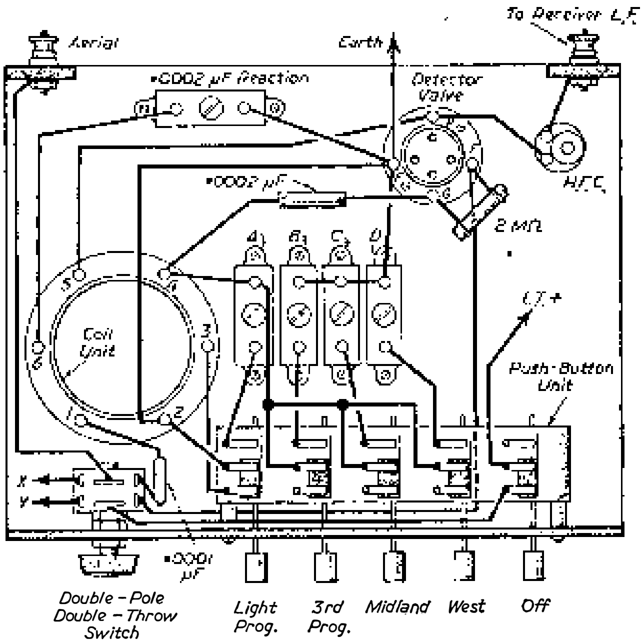


FIG. 76. *Practical layout for a push-button operated single valver.*

B

B.A. British Association, also the screw thread system used in the wireless and electrical industries. (See *British Association Screw Threads.*)

BACK BIAS. (a) A continuous negative voltage, derived from interfering signals, applied to the grids of one or more valves in a receiver to reduce overloading by the interfering signals. (b) The application of a continuous voltage to metal rectifiers to increase the impedance. (The opposite condition is forward bias.) (c) A voltage applied to the grid of a valve (or valves) to restore a condition which has been upset by some external cause.

BACK ECHO. An *echo* due to a back *lobe* of an *aerial.*

BACK E.M.F. Back or opposite electromotive force. Back E.M.F. in an accumulator or battery is due to polarisation. Produced in a circuit by self-induction due to varying input current.

BACK-TO-FRONT RATIO (in D.F.). The ratio of the signal voltage on the reciprocal bearing to that on the correct bearing.

BAFFLE BOARD. A board on which the loudspeaker is mounted. Its use is to ensure good bass reproduction.

BALANCE-TO-UNBALANCE TRANSFORMER. A device for matching a pair of lines balanced with respect to earth to a pair of lines not balanced with respect to earth.

BALANCING CAPACITY. Any artificial or capacity earth. Extra capacity inserted in the aerial circuit to replace the earth.

BALLISTIC GALVANOMETER. An instrument for measuring condenser discharges and similar currents of short duration.

BALUN. A *balance-to-unbalance transformer* for matching a balanced two-wire line or dipole to a coaxial line, consisting of a quarter wavelength coaxial shield around the outer conductor of the coaxial line and connected to it at the end remote from the junction of the lines.

BAND-PASS TUNING. A system of tuning which enables a very high degree of selectivity to be obtained.

There are three ways of arranging this circuit, the differences being in the manner of coupling the two tuned circuits. For the aerial circuit, a coil of the ordinary size is tuned by a condenser as is usual, and a similar arrangement is used in conjunction with this tuned circuit, but connected in the grid circuit of the valve. To connect these two tuned circuits together, in some cases a fixed ·01 μF. condenser is used (Fig. 77).

In some cases an inductance or resistance is used to couple the circuits (Fig. 78). A combination of these two devices, with the coupling inductance arranged in a negative manner, produces the best signal strength, combined with the best selectivity. (Refer to Fig. 79.) (See also *Tuning Coils.*)

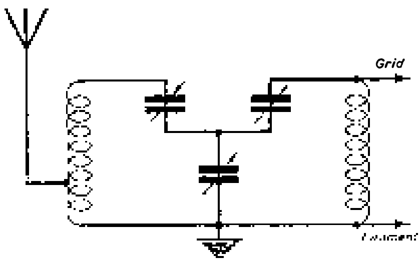


FIG. 77. *A capacity-coupled band-pass tuner.*

BAND-SETTER. The larger of the two condensers employed in band-spread tuning.

BAND-SPREAD TUNING. A method of ensuring good short-wave signals in which two condensers are employed in parallel across the tuning coil. One of these is a high capacity and the other a very small capacity, and this "spreads" out the tuning and thus gives a similar effect to a very accurate reduction drive tuning dial.

BANK. A bank of condensers. A number of condensers self-contained as one unit.

BARRETTER. An American term. In D.C. mains receivers, for instance, designed for a 100-volt supply and connected to a 200-volt supply, it will be necessary to include a lamp in series with the receiver to dispose of the excessive 100 volts. Such a lamp is called a Barretter or Ballast Lamp.

BARRIER OR PENETRATION FREQUENCY (Cut-off frequency). The frequency below which a radio wave fails to penetrate a layer, e.g. the E layer, at the angle required for reflection from a higher layer, e.g. the F layer, to ensure transmission over the given distance without excessive attenuation.

BASKET COILS. Flat coils of the basket-weave type. Now obsolete.

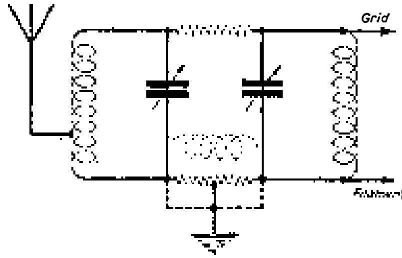


FIG. 78. *An inductance or resistance-coupled band-pass tuner. The dotted and broken lines show alternative methods of coupling a band-pass tuner.*

BATTERY ELIMINATOR. A device for connection to the mains for obtaining high-tension supplies without the use of dry batteries. For D.C. supplies, this simply consists of a smoothing circuit and appropriate voltage-dropping resistances. The smoothing circuit consists of an iron-core choke having a large inductance value, and a large-capacity condenser joined across the smoothed side of the mains leads. For A.C. supplies it is necessary to rectify the alternating current, and therefore some form of rectifying circuit is included before the smoothing circuit. For rectifying purposes it is possible to use metal rectifiers or valve rectifiers. The metal rectifier consists of a combination of metals which permits of a flow of current in one direction only, and the valve rectifier consists of a valve with two or three electrodes. The two-electrode valve gives "half-wave" rectification, and the three-electrode gives "full-wave" rectification. (See also *Eliminators.*)

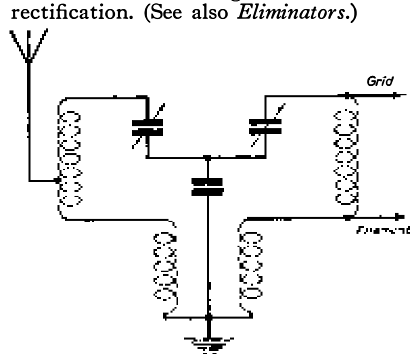


FIG. 79. *A combination of capacity-coupled and inductive-coupled band-pass tuner.*

BAUR'S CONSTANT. The voltage necessary to cause a discharge through a determined insulating material 1 mm. thick.

The law of dielectric strength is that breakdown voltage necessary to cause a discharge through a substance proportional to a 2/3 power of its thickness.

BEAM. A radiation of electro magnetic energy restricted mainly to a small solid angle.

BEAM AERIAL. An ordered assembly of elements spaced and fed in such a manner that the radiation is concentrated in one or more directions. Sometimes referred to as an *Aerial Array.* (See *Aerial.*)

BEAM POWER. Term applied in modern valves, where electron flow is directed in beam formation to overcome the loss resulting from secondary emission.

BEAM SWITCHING. (a) A method of obtaining more accurately the bearing and/or elevation of an object by comparing the signals received when the *beam* is in directions differing slightly in bearing and/or elevation. When these signals are equal, the object lies between the directions in a known angular relation to them. (b) A small periodic oscillation or conical motion of a *beam* by which improved accuracy of bearing and elevation is obtained by comparison of signal amplitudes at various points during the cycle. Of the two methods (a) is the discontinuous and (b) the continuous variety.

BEAM WIDTH. The angular width of a *beam*, at a sufficiently large distance from the *transmitter*, measured between the directions in which the power intensity is half the maximum.

BEAM WIRELESS. A process in which ultra-short wavelengths in conjunction with directional aerials are used. The result of this combination is to direct the wireless signals in a narrow channel instead of giving an equal radiation in all directions. Owing to this, only a very small power is necessary to cover large distances, as all the energy takes one line. (See also *Standard Beam Approach.*)

BEAT FREQUENCY. The number of beats per second which results from combining two frequencies. The effect produced when the frequencies are substantially equal and the beat frequency is zero is known as *Zero Beat.*

BEAT RECEPTION. One method of detecting signals by making them interact with artificially produced oscillations, local to the receiver, but of different and higher frequency. This gives rise to a "beat," the difference between the two frequencies.

BEAUFORT SCALE. A numerical scale of wind velocity ranging from 0 for a calm to 12 for a hurricane. If V = Velocity in m.p.h., and B = Beaufort number, then $V = 1{\cdot}87\sqrt{B^3}$.

BEAVERTAIL BEAM. A *fan beam* whose horizontal width is greater than its vertical width.

BECQUEREL EFFECT. A change in electrode potential observed by illuminating an electrode (surface) in an electrolyte.

BEL. The unit of sound intensity. The bel is too large for measuring the output of wireless apparatus, and therefore one-tenth of the bel, or a decibel (*which see*), is employed for this purpose. (Named after Alexander Graham Bell, inventor of the telephone (1847-1922). See also *Decibel, Neper, Phon,* and *Acoustic Watt.*)

BELLINI-TOSI AERIAL. A double-frame aerial, having the two sections arranged at right angles, used for direction finding.

BELOPOLSKY EFFECT. Those spectrum lines displaced by a small, measurable amount when a light beam is reflected from a system of moving mirrors, the light being analysed with a spectroscope.

B.E.M.F. Back Electromotive Force.

BEND. A continuous change in the direction of the longitudinal axis of a *waveguide.*

BERNE BUREAU. The broadcasting stations of Europe are subject to certain regulations laid down by a governing body having its headquarters in Berne. The most important duty of this body is that of settling the wavelength of each station, and this is done in such a way that no station may use a wavelength whose frequency is closer than 10 kc/s. to any other station.

BIAS. The voltage applied to a valve to ensure its correct working as an H.F. or L.F. amplifier. A valve operating as an anode-bend detector also requires an application of bias to bring the working point to the correct portion of the curve. (See *Grid Bias* and *Automatic Grid Bias.*)

BIAS RESISTORS. For automatic bias circuits, the value of the bias resistor can be determined by

$$R = \frac{E}{I} \times 1{,}000,$$

when R equals the value of the bias resistor in ohms; E the value of the grid-bias required and I the anode current in milliamps. of the valve, or the total H.T. current of the circuit. (See *Automatic Grid Bias.*)

BICHROMATE CELL. A cell containing two plates or rods of carbon which are immersed in a solution of sulphuric acid, bichromate of potash, and water, with a zinc plate between the two carbon plates. Such a cell yields 2 volts, and is of low resistance (Fig. 80.)

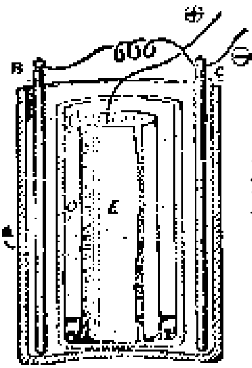


FIG. 80. *Section of a bichromate cell. A, glass jar; B and C, carbon rods; D, porous pot; E, zinc; M, mercury.*

BIFILAR WINDINGS. Windings which are non-inductive.

BIG BEN TIME SIGNAL. (See *Time Signal.*)

BI-GRID VALVE. A valve having two grids, an anode and a cathode. This valve differs from a screen-grid valve, which has also two grids, in that one of the grids of the latter valve is biased to negative the results of the space charge. In the bi-grid valve the two grids are used separately for such purposes as combined oscillator and frequency changer and for special purposes in superhets. (See *Valve.*)

BILLI. A synonymous term for millimicro (one billionth).

BILLI CONDENSER. A tubular condenser consisting of two telescopic tubes —one metal and the other of an insulating material with a metallic lining.

BIMORPH. Another term for the piezo-crystal used in some speakers, microphones, pick-ups, etc. (See *Piezo-Electricity.*)

BINDING POST. An American term for a terminal.

BINDING SCREW. The American term for a terminal.

BIPOLAR. Possessing two poles.

BLANKETING FREQUENCY. The lowest frequency at which an area of sporadic E ionization is partially penetrated, as indicated by the return of a wave from a higher layer. The term is usually applied to vertical-incidence transmission.

BLANKING. The reverse of *gating*, i.e. the rejection of part of the content of a signal either in frequency-range or time or in some other characteristic.

BLATTNERPHONE. The original system of recording sounds by means of the magnetic properties of steel. The apparatus consists, in essentials, of a powerful electro-magnet with the two poles arranged opposite each other and with only a small gap separating them. At each end of the machine are two spools, one of which contains a length of thin steel tape. This is taken across through the gap of the magnets and so to the other reel or spool. The tape then feeds from one spool to the other when the mechanism is set in motion, in the same manner as a typewriter ribbon. The sounds which are to be recorded are fed into the electro-magnet in the same manner as the wireless signals are applied to a loudspeaker. Now known as the Marconi-Stille Recorder.

BLEEDER. A resistor connected across a voltage supply in order to draw a steady current.

BLIP. A deflection or change of intensity, on a cathode-ray tube *display*, produced by the signal from a *responsor*.

BLOCK CONDENSER. A number of fixed condensers connected together. A bank of condensers.

BLOCKING CONDENSER. A term which was originally employed for a "by-pass condenser."

BLOCKING OSCILLATOR. A *self-quenching oscillator* which becomes cut off before half a cycle of oscillation is completed.

BLUE GLOW. A valve gives rise to blue glow when excessive current is flowing from filament to plate. Blue glow signifies that the valve is "soft"—not completely exhausted of air or containing residual gas.

BOARD OF TRADE UNIT. 1,000 watt-hours. 1 kilowatt hour, or 3,415 British Thermal units, or 3,600,000 joules, or 1 kelvin.

BOLOMETER. A particular type of Wheatstone Bridge possessing a quickly-heating resistance.

BOOSTER. Electrical apparatus for increasing voltage (see Fig. 81). A dynamo wired in series with it superimposes or adds its voltage to that of the mains. All methods of accumulator charging have certain drawbacks, which the booster eliminates. For example, in electrical equipment, in which the battery is simultaneously on charge and discharge, the accumulator is arranged to be supplied from a shunt-wound dynamo, a portion of the current from which will pass to the lamps. Assume that the generator in such an installation gives 50 amps., and that the accumulator

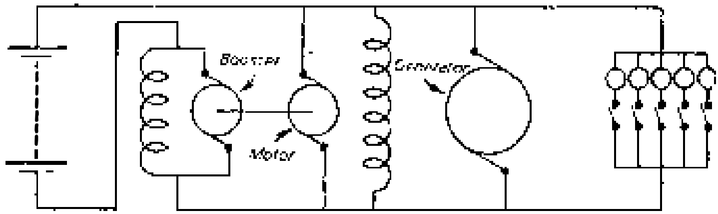


FIG. 81. *Circuit diagram showing how the booster is connected.*

is distributing 20 amps. to the circuit. It will readily be seen that the end cells will be charged at the normal rate, but the 20 amps. imparted to the circuit must be subtracted from the normal charging rate of the cell interposed between the negative end of the accumulator and the particular cell wired to the discharge switch. It follows that 80 per cent. of the cells will be charged at 20 per cent. lower rate than the remainder. For this reason the life of such cells is comparatively short. The booster entirely gets rid of this trouble.

A booster suitable for accumulator charging can conveniently consist of a shunt motor driving a shunt-wound dynamo. It may also consist of a small shunt-wound dynamo driven from an extension of the shunt motor shaft. It functions in the following way: the constant voltage generator will supply the amperage for the lighting circuit irrespective of whether the battery is on charge or not, for the booster will impose its voltage sufficiently to charge all of the cells of the accumulator simultaneously and at an equal rate. A great advantage is immediately obvious, for it will not be necessary to run the generating plant to charge the battery so that, say, it can be used at night.

Another type of booster is the automatically reversible, and it is chiefly used where an electrical load is imposed which is subject to considerable variations up or down. Such a case would be in starting an electric crane or a tramcar, and in such cases the plant must be capable of an output sufficient to deal with the heaviest

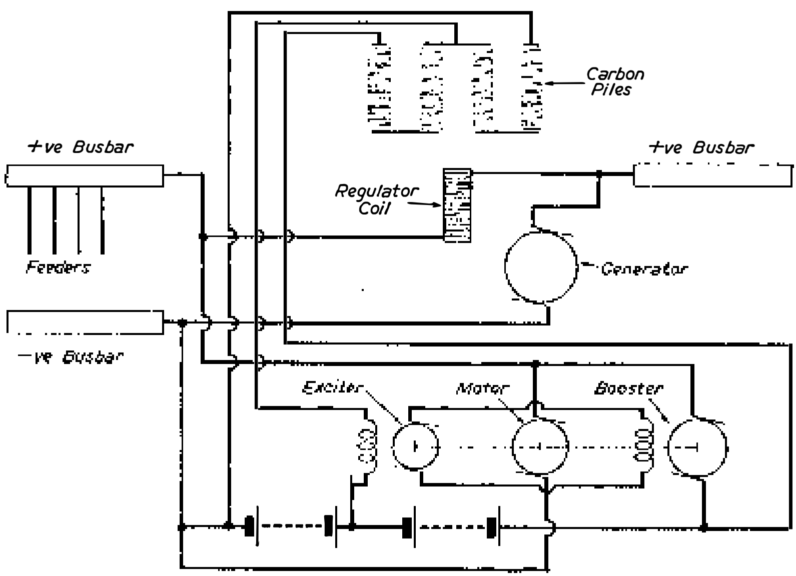


FIG. 82. *Arrangement of the Entz automatic reversible booster.*

current drain. The period between the load, therefore, necessitates running the plant very much below its maximum capacity. By connecting an accumulator in parallel with a shunt dynamo the latter would be aided by the discharge of the former when the voltage of the shunt dynamo dropped on account of electrical load. Pursuing this point further, it will be seen that once this load is imposed the voltage of the accumulator would also drop, thus rendering necessary some further aid. This assistance is forthcoming in the form of the reversible booster, which, wired in series with the accumulator, will increase the voltage to an amount equal to the voltage drop of the battery. This it does automatically and thus maintains at a constant voltage the booster and battery system.

Another type of reversible booster depends for its operation on variations in its output and not at all on variations in dynamo voltage. It is claimed that this type maintains a more even load than the former. Fig. 82 illustrates one of the most popular systems in use, known as the Entz. It consists of three chief parts—the booster, the exciter, and the motor itself. The complete plant as sold is fixed

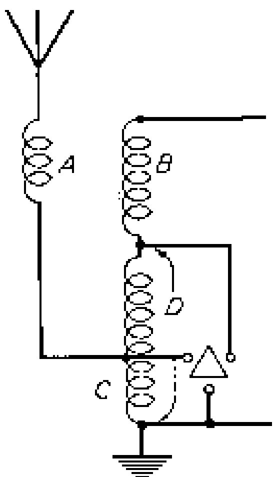


FIG. 83. *A typical dual-range circuit.*

to one bedplate casting. An examination of the diagram indicates a divided bus bar, and between this division is placed the coil which carries the generator current. In series with the main bus bars is connected the booster armatures, and the battery is connected to the chief bus bar. Only one

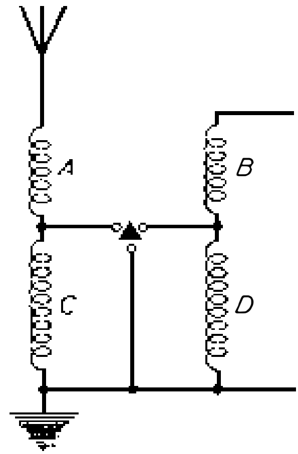


FIG. 84. *Circuit of a dual-range coil with which break through may occur.*

field coil is fitted to the armature of the booster.

The Entz booster is instantly reversible, and the chief features of it are the carbon piles which act as regulators. A lever is situated between these two sets of piles, and a soft iron core is attached to one end of the lever. A solenoid surrounds the iron core. A spring is secured to the opposite end of the lever, the tension of which is adjusted to counteract the pull of the solenoid. Any required load on the generator can thus be adjusted to a nicety. Any variations cause a change in the carbon piles which, varying the resistance, thus controls the degree of feed excitation in the booster. For example, if the electrical pull of the solenoid on the lever causes a deflection or extension of the spring, a compression and release of the carbon piles will take place, and if the spring conquers the thrust of the solenoid there will be a reversal of direction of excitation.

BORNITE. An ore of copper. One of the elements of the Bornite-Zincite crystal detector.

B.O.T. Board of Trade. (See *Board of Trade Unit and Abbreviations*, page vii.).

BOYLE'S LAW. Defines that if the pressure is not high the volume of a specified quantity of gas varies inversely as the pressure in a constant temperature.

BRAUN TUBE. The original name given to the Cathode-ray Oscilloscope, a device for producing visible indications of oscillating currents. (See also *Cathode-ray Tube.*)

BREAK. An alternative term for echo, limited to a lateral discontinuity in a *range-amplitude display*.

BREAK THROUGH. A troublesome form of interference sometimes met with in dual-range coils. It is the breaking through of one or more powerful medium-wave local stations on to the long waves. In extreme cases the station or stations on the medium waves which are causing the trouble can be heard all over the dial when the set is switched on to the long waves. Usually, however, it is not quite so bad as this, the interference being most noticeable at the lower end of the tuning dial and very gradually decreasing towards the upper end.

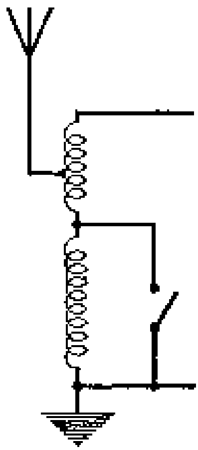


FIG. 85. *A very common circuit employed in commercial coils. Break through does not occur, but it is unselective on the long waves.*

Curiously enough, the cause of the trouble is usually due to an attempt on the part of the designer of the coil to obtain selectivity on the long-wave band. In order to do this it is usual to employ either a separate aerial coil of comparatively few turns coupled to the long-wave grid coil, or to tap the long-wave coil near the earthed end. This, of course, gives the desired selectivity as regards the long-wave stations themselves, but introduces break through with it from the medium waves.

Examine the diagram (Fig. 84), which shows a typical dual-range circuit. In this case when the switch is in the "in" position the medium-wave circuit consists of an aerial, or primary coil A, of from five to fifteen turns, and a grid, or secondary, coil B, coupled to it of about sixty turns. When the switch is "out" the windings C and D are included in series with A and B respectively so as to bring the total inductance up to that required for tuning in the long-wave stations. Now C may consist of twenty or thirty turns, and this, together with A, gives an aerial coil of about forty turns. This winding is not of itself very selective, and being of about the right wavelength, brings in the powerful medium-wave local sufficiently strong to impose the signal on to the grid coil BD. In other words, the medium-wave station "breaks through." In the case of the circuit shown in Fig. 83, which is another popular arrangement for a dual-range coil, the effect is similar. Here the long-wave primary circuit consists of windings A and C, but C this time is not a separate coil, but a tapped portion of D. The practical difference is that the circuit of Fig. 85 is more tightly coupled on the long waves than that of Fig. 83.

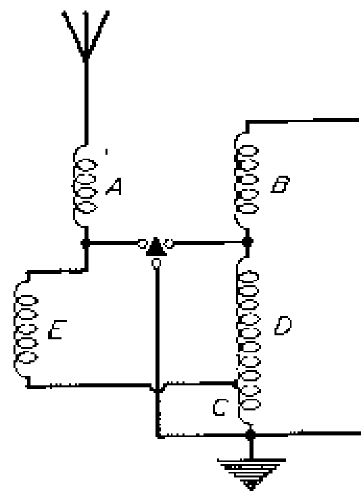


FIG. 86. *The insertion of a loading coil to cure break through.*

Any attempts at a cure must be in the direction of keeping the natural wavelength of the primary coil AC well away from the medium-wave band. Fig. 85 shows a very popular circuit much used in commercial coils where only the medium-wave winding is tapped, but here, of course, there is no attempt at selectivity on the long waves. With the circuits given in Figs. 84 and 85 there are two courses open. One is to raise the natural wavelength of the AC *above* the medium wave and the other is to take it well *below* it. The usual practice is to raise it. Fig. 86 shows one method. This consists of introducing a separate coil E in series with A and C. This raises the wavelength of the primary circuit sufficiently high to clear the medium band and at the same time does not decrease the selectivity. The coil E should consist of about fifty or sixty turns, and should be placed a little way from the tuning coil or with its axis at right angles to that of the tuning coil so as to prevent interaction. Screening is hardly necessary unless space is very limited. The design of the coil is not critical, and pile winding is quite suitable especially as this method tends to limit the external field. Fig. 87 shows a very simple and effective method which can be applied to the circuit of Fig. 84. A fixed condenser of ·0003 μF. or ·0005 μF. is placed across C. This again increases the wavelength of the aerial coil without increasing the coupling. In this way the selectivity on the long waves still remains good.

Taking the wavelength of the aerial winding *below* the medium band is not good practice, since it can only be done by making both A and C very small, and this naturally increases the selectivity on both the medium and the long waves to a degree which is not always desirable. However, it has been found that where great selectivity *is* necessary this method is admirable. The circuit is precisely the same as in Fig. 86, but A consists of about five turns tightly coupled to B, that is wound on top of B, and C is a tapping of about fifteen turns.

There is one advantage. There is no likelihood of trouble arising through the use of a condenser in series with the aerial as a selectivity control. It sometimes happens that when reducing the setting of such a condenser a point is reached where break through occurs. This is because the natural wavelength of the primary circuit is lowered. Obviously, this cannot occur with the second method, since the natural wavelength of the primary circuit is already below the medium-wave band, and the reducing of the condenser setting would only tend to lower it still further. Where, however, trouble of this sort does arise, the only cure is to increase the setting of the series aerial condenser and make up for the reduced selectivity by decreasing the coupling between the primary and secondary circuits. If the coil is a home-made one, this can easily be arranged, either by reducing the number of turns in the tapped portion C, in the case of Fig. 83, or by placing the windings C and D farther apart, in the case of Fig. 87. (See also *Anti-break-through Choke*, *Chokes*, and *High-frequency Chokes*.)

BRIDGE. A Wheatstone Bridge.

BRIDLE. The rope which is attached to each end of a spreader for suspending an aerial.

BRIGHTEN. To change the modulator potential of a cathode-ray tube so as to allow the *trace* to appear or to become more intense.

BRITISH ASSOCIATION SCREW THREADS

(See also *Screws* and *Wood Screws*)

No.	*Absolute Dimensions in Millimetres*		*Approximate Number of Threads per inch*	*Approximate Dimensions in Inches*	
	Full Dia.	*Pitch*		*Full Dia.*	*Pitch*
25	0·25	0·07	362·8	·010	·0028
24	0·29	0·08	317·5	·011	·0031
23	0·33	0·09	282·2	·013	·0035
22	0·37	0·10	254·0	·015	·0039
21	0·42	0·11	230·9	·017	·0043
20	0·48	0·12	211·6	·019	·0047
19	0·54	0·14	181·4	·021	·0055
18	0·62	0·15	169·3	·024	·0059
17	0·70	0·17	149·4	·028	·0067
16	0·79	0·19	133·7	·031	·0075
15	0·90	0·21	121·0	·035	·0083
14	1·0	0·23	110·4	·039	·0091
13	1·2	0·25	101·6	·047	·0098
12	1·3	0·28	90·7	·051	·0110
11	1·5	0·31	81·9	·059	·0122
10	1·7	0·35	72·6	·067	·0138
9	1·9	0·39	65·1	·075	·0154
8	2·2	0·43	59·1	·087	·0169
7	2·5	0·48	52·9	·098	·0189
6	2·8	0·53	47·9	·110	·0209
5	3·2	0·59	43·0	·126	·0232
4	3·6	0·66	38·5	·142	·0260
3	4·1	0·73	34·8	·161	·0287
2	4·7	0·81	31·4	·185	·0319
1	5·3	0·90	28·2	·209	·0354
0	6·0	1·00	25·4	·236	·0394

BRITISH SYSTEM OF UNITS. The foot-pound-second system (F.P.S.). The poundal is the Unit, consisting of the energy of one pound moving 1 ft. in 1 second.

BRITISH THERMAL UNIT. 252·0

calories, or 1,005 joules, 778·1 ft.-lb., or 1·4147 horse-power-second. Abbreviation: *B.Th.U.*

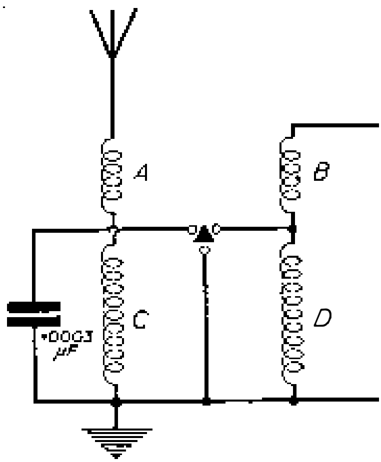


FIG. 87. *Another cure for break through on home-made coils.*

BUFFER CONDENSER. The condenser connected across the secondary winding of vibrator transformers to provide the correct time-constant.

BUFFER STAGE. A valve-coupled stage specially designed to prevent load fluctuations of subsequent stages from affecting the frequency or other characteristics of preceding stages (B.S.I.).

BUNCHER. The combination of electrodes which cause *velocity modulation* of electrons in a *velocity-modulation* valve.

BUNCHING. The formation of regions of maximum electron density moving forward with the stream. The electrons forming the bunches are not necessarily moving together, but their velocities are related to one another.

BUS BAR. A bar connecting several cells or pieces of apparatus. An omnibus bar.

BUTTERFLY CIRCUIT. A circuit designed for covering a wide range of frequencies; the moving tuning element varies the inductance and capacity simultaneously without the use of sliding contacts. The circuit is balanced and the angle of rotation of the condenser plates is 90°.

BUZZER. A smaller trembler coil of similar design to an electric bell. Chiefly used for testing circuits.

B.W.G. Birmingham Wire Gauge.

BY-PASS CONDENSER. A capacitor, used to provide a path of comparatively low impedance over a certain range of frequences

A condenser inserted in a circuit to provide an alternative and easy path for some frequency which it is desired should not proceed to other parts of the circuit. In a decoupling circuit, a resistance is inserted in the anode lead to prevent the passage of H.F. currents, and at the high potential end of the resistance a fixed condenser is joined to provide a bypass, or easy path, for these H.F. currents. This condenser is joined direct to the earth connection of the receiver.

C

CABLE. Any large diameter rope or wire of plural strands.

CAGE AERIAL. Any aerial consisting of several wires arranged on spreaders in the form of a cage.

CALIBRATING A RECEIVER. It is convenient to be able to make a note of the various stations heard, and at the same time to be able to know where to set the tuning dials to pick up any station. A chart will make this possible.

Marking out the Paper. A sheet of squared paper will be required. Rule along one of the lines near the bottom of the sheet, and mark along this the numbers corresponding to those on the tuning dial. This may be 0 to 100 or 0 to 180, it does not make any difference which it is. Now at the left-hand side of the sheet rule a vertical line running from the line marked with the 0. Along this line clearly indicate the metres (or frequencies in kilocycles, whichever is wanted) corresponding to the tuning range covered by the condenser. If the tuning condenser is of the type known as a "log" scale, then it is preferable to mark the tuning range in kilocycles. For the other types of condenser use the metre scale. The constructor may mark this in both the frequency and the wavelength. First of all tune in to the local station. If possible, avoid the use of reaction when carrying out this calibration. Having tuned in to the exact spot, make a careful note of the reading on the dial. Now find this spot on the bottom line of the chart, and run the pencil up the vertical line above this spot until it arrives at the place where the horizontal line corresponding to the wavelength of the station crosses it. Make a small dot at this spot. Now tune in another loud station, and carry out the same process. When one has, say, three or four dots on the chart, carefully join them up with a light pencil line. Now find the wavelength of a station which has not yet been marked, but which can be received, and run along this line until the pencil line is reached. Drop down the vertical line and see the dial reading this gives. If now the dial is set to this spot the station should be heard, but if any slight retuning is necessary, carry this out, and make the necessary alteration to the pencil line.

Identifying a Station. To use the chart in identifying a station which may be received, note the dial reading, and, as explained above, find its wavelength.

If the set consists of a detector valve followed by L.F. stages, one will have to use reaction during the compilation of the chart, and to avoid variations due to the varying amounts of applied reaction, use this at its maximum.

CALL SIGNS, INTERNATIONAL. (See *International Call Signs.*)

CALORIE. Same as *Calory* (preferred).

CALORY. The unit of heat. The degree of heat required to raise a gramme of water at 15° C. by 1° C. (C.G.S. system).

CANAL RAYS.—Diacathode Rays (*which see.*)

CAPACITANCE. The potential difference existing between a body and surrounding bodies when a quantity of electricity is imparted to it. Unit, the Farad. (See *Cold Impedance.*)

CAPACITOR. The modern term for a condenser (*which see*).

CAPACITY. The property of storing electricity under electrical pressure (see also *Condenser*). The property which some metallic bodies possess of storing electricity is known as the "self-capacity," and this must not be confused with the capacity between one metallic body and another. The term "self-capacity" is also often applied to the capacity existing between adjacent turns of an inductance. If two metal plates are joined to the terminals of a battery, and the plates are separated by air, a certain capacity will exist between those plates. If the distance between the plates is kept constant, but in place of the air a sheet of glass is placed between the plates, the capacity will alter. Similarly, the difference between different insulators, or dielectrics, will vary the capacity.

CAPACITY BRIDGE. A device for measuring the value of an unknown condenser. It consists in principle of a device similar to a Wheatstone bridge, and the unknown condenser is "balanced" against known values in the remaining arms of the bridge. (See also *Wheatstone Bridge*,)

CAPACITY EARTH. A counter-poise earth; or an earth consisting of some large body of metal. Sometimes referred to as a balancing capacity.

CAPACITY REACTANCE. The portion of the aggregate impedance due to capacity.

CAR RADIO. Before proceeding to the more practical aspects, it should be made perfectly clear that it is necessary to have a licence for a car radio receiver. The licence which is applicable to a "domestic" receiver does not cover the set fitted in a car. In taking out the licence at the post office it is desirable that the clerk should be asked to endorse the licence to show that it does apply to a receiver installed in a car. That would save a good deal of

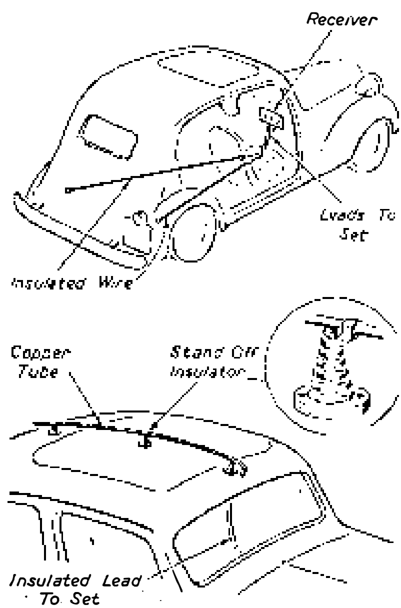


FIG. 88. *Showing one form of under-car aerial, and a popular single rod roof type.*

trouble in the event of being stopped by the police and asked to produce the licence; and, in some cases, particularly with Service personnel, a receiver may not be in use at the address stated on the licence.

Most British-built car-radio sets are made in two types, for 6- and 12-volt operation, but many of the American receivers are made in 6-volt models only. In the latter case it is necessary to fit a voltage-dropping resistor if the receiver is to be fitted in a car having a 12-volt supply. Do not attempt to connect the set between one side of the battery and a tapping; there are objections to this, and they will be referred to later.

The use of a voltage-dropping resistor is perfectly satisfactory, provided that the resistor is mounted in such a position—say under the bonnet—that there is a free circulation of cooling air around it. This method of feeding the receiver has one rather serious disadvantage, however, which is that the power consumption from the supply is double the power actually taken by the set. The average 6-volt car radio takes between 3·5 and 5 amps.; a 12-volt set usually takes between 2 and 3 amps. Consumption is dependent to a fair degree on the circuit arrangement in the receiver.

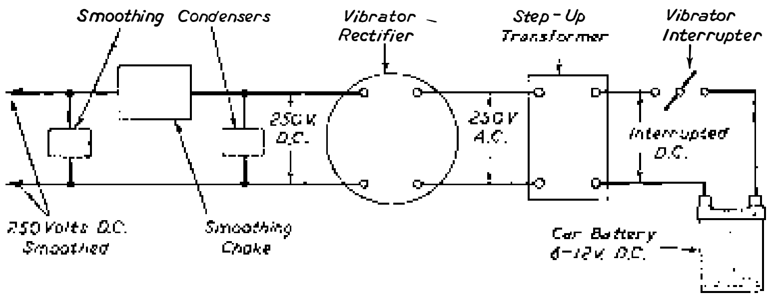


FIG. 89. *A schematic diagram of the fundamental arrangement for the power supply.*

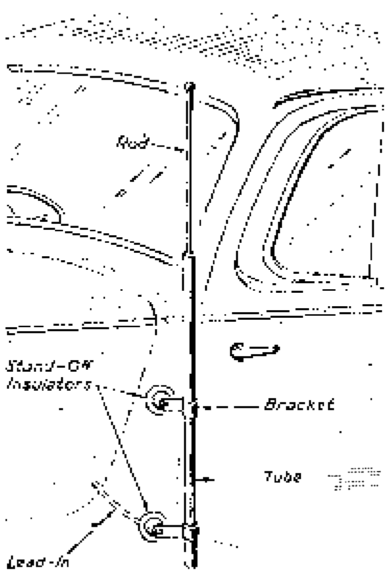


FIG. 90. *A popular form of car radio aerial. It is known as the "fishing rod" type.*

Circuit Details. Practically every car radio uses a superhet circuit, but whereas the simpler types of set have only four valves, others have six or seven. In general, the greater number of valves is to be preferred, because this means that there is a pre-frequency-changer H.F. stage. This gives increased amplification and also, in general, better A.V.C. In some cases the vibrator used for stepping up the voltage for H.T. is of the self-rectifying type, whilst in others the vibrator acts merely as an interruptor; in the latter case a valve is required for rectification.

Positive or Negative Earth. Apart from the voltage from which the set is designed to operate, there is a question of polarity to consider. As readers will be aware, the negative pole is earthed on some cars, whilst positive earthing is used on others. The metal case of a car radio is generally earthed, earth-bonding being obtained through the mounting bolt or bracket employed. It is generally possible to modify a "negative-earth" receiver to "positive-earth," and *vice versa*, but if possible it is far better to obtain a set with an earth system appropriate to the car into which it is fitted. Sometimes, the system of earthing can be reversed by withdrawing the vibrator unit and replacing after turning through about 90°; this is by no means standard, however, so if a change is to be made, each individual set should be considered on its merits if the makers' instructions are not available.

Aerial Types. Assuming that the above points have been satisfactorily cleared and a set is available for fitting, the question of the installation itself can be considered. It is well to start by deciding on the type and position of aerial to be employed. In the case of a car with a wooden-framed, fabric-covered roof, a roof aerial is most satisfactory, as shown in Figs. 88 and 92. The single- or "V"-rod type can usually be fitted by means of the rubber suction cups provided, after applying a suitable adhesive to the insides of the cups. The cups should simply be pressed firmly down on to the metal parts of the roof at the front and rear. Should the roof have a sliding portion the third or centre suction cup may present a difficulty, and it will probably be necessary to omit it, and trust that vibration will not loosen the other two. The alternative is to agree to have the sliding roof permanently closed or capable of being opened only a short way. The best solution is probably to use a "V"-type roof aerial, the suction cups of which can be fitted one at each side of the roof. In the case of a car with all-metal roof, a "fishing-rod" type of aerial is generally found most satisfactory (see Fig. 90). This can be mounted on the near side approximately in line with the dashboard. Suction-cup mounting can sometimes be adopted, but it might be necessary in other instances to drill the body side and to use pillar insulators fitted with studs.

Should it be preferred that the aerial be "invisible," one of the "running-board" type, which fits under the running board, can be fitted. Aerials of this pattern are often in pairs (one for each running board) and have a matching transformer to feed them into the set. A simpler under-car aerial consists of a length of wire in "V" shape between the base of the clutch housing and the two ends of the rear axle (see Fig. 91). The point of the "V" would be attached to the forward mounting, and the aerial lead-in would be taken from it. Since the distance between the mounting points will vary as the car traverses every small bump on the road, it is wise to use tension springs to join to the rear anchorages. Although it has not been mentioned, it will be understood that any type of aerial must be properly insulated.

Screened Aerial Lead. The lead from the aerial to the set, regardless of the type of aerial used, should be screened. If not, there will be a danger of ignition noises being picked up, even if suppressors (of which more later) are fitted. So-called coaxial cable is best for this purpose, since

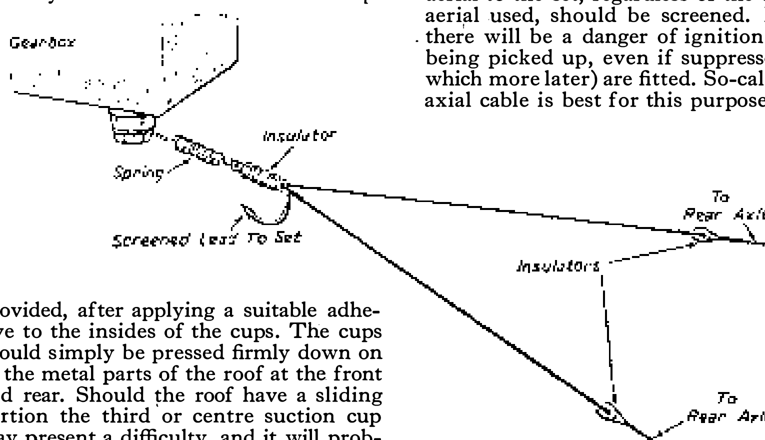


FIG. 91. *This diagram shows how an under-car aerial can often be arranged.*

it has a low capacity; ordinary screened wire has a comparatively high capacity and higher losses. The screening should be well earth-bonded at as many points as possible.

In most cars it will be found most convenient to mount the set beneath or inside the glove box on the near side. The method of mounting will vary according to the receiver used, but in every case care should be taken to ensure that the metal containing case is earthed; this may necessitate the use of a strip of copper or a length of heavy-gauge copper braid of the kind often used for earthing one car-battery terminal.

When a roof aerial is fitted it will be necessary to drill a hole through the front of the roof to allow the lead to be fed through. A rubber grummet should be used, which will be a tight fit in the hole and round the lead-in cable. The lead can then be led along the upper edge of the windscreen and down the near side. Provided that good co-axial cable is used the extra foot or so required to run the lead neatly will not matter. With a "fishing-rod" aerial will vary with different cars, but it is important that connection should *not* be made directly to the battery. This was once done on a car with a compensated-voltage-control charging system, with the result that the battery was run down in one day, despite the fact that the dynamo and voltage regulator were operating correctly. This also explains why a 6-volt

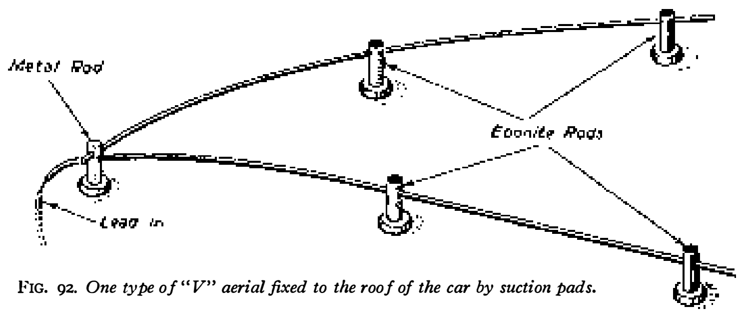


FIG. 92. *One type of "V" aerial fixed to the roof of the car by suction pads.*

the lead-in will probably be no more than 18 in. long if the set is mounted in the position previously mentioned. That being so, a length of ordinary screened wire may be used without introducing any appreciable loss. In the case of an under-car aerial, the lead-in can normally be brought through a hole near the forward edge of

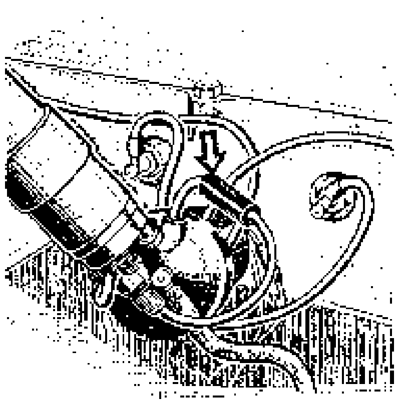


FIG. 93. *Interference suppressor fitted in the distributor lead.*

the footboards, and run up the inside of the bulkhead.

Supply Connections. The precise method of picking up the 6-volt or 12-volt supply

tapping should not be made to a 12-volt battery.

It is desirable that there should be a fuse in circuits and many car-radio receivers have one included in either the set itself or in a supply lead. If not, a fuse should be fitted. Connection can then be made between earth and the terminal marked "AUX" on the fuse-box. This terminal is in series with the "auxiliary equipment" fuse, and generally supplies the direction indicators, screen-wiper motor and electric horn. There may be a danger of this fuse being overloaded with the extra drain; in that case, connection should be made to terminal "A," which is connected to the ammeter (when provided) and to the other side of the auxiliary-accessories fuse.

Interference Suppression. In every case it will be necessary to suppress noise picked up from the car distributor and from the commutator of the battery-charging dynamo (see Fig. 93).

Distributor noise is usually reduced by including a specially-designed resistor in the H.T. lead between coil and distributor, as close to the latter as possible. Fig. 94 illustrates a typical suppressor of this kind. It is constructed to withstand vibration and engine heat. This resistor will often have a value of 20,000 ohms or more; but if its inclusion is found to make the engine difficult to start from cold, it may be necessary to replace it with one of lower value—say, 10,000 or 15,000 ohms. An inductance of about 10 millihenrys is sometimes used instead of a resistor in this position.

The dynamo suppressor may be a condenser having a capacitance of about ·5 μF. It must be designed to work at high temperatures. A correctly designed dynamo suppressor will have a metal case which is bolted to the metal housing of the dynamo. This provides one connection; the other is taken to the unearthed brush of the generator. This second connector (usually in the form of a "pigtail") must be kept as short as possible.

Some cars have a "two-wire" electrical system, instead of using the chassis as an earth return. In such a case, the dynamo suppressor condenser must have two leads, and must be connected between the positive and negative brushes.

Sparking-plug Suppressors. These are also resistors of special type, having a resistance of about 12,000 to 15,000 ohms. There are two popular kinds of sparking-plug suppressors — the "woodscrew-ended" type shown in Fig. 94, and those fitted with mounting lugs, as also shown in Fig. 94. The former are screwed into the exposed ends of the sparking-plug leads, which are cut to allow their inclusion, while the latter are fastened directly to the plug terminals, the leads being attached to the other ends of the suppressors.

Sparking-plug leads should be kept as short as possible, especially if it is not intended to fit plug suppressors.

Windscreen-wiper Suppressors. If noise is heard in the radio set when the windscreen wiper is switched on, the wiper motor casing should be inspected to ensure that it is electrically earthed to the chassis of the car. If this is found to be in order, a condenser of ·5 μF. capacitance may be connected across the terminals of the wiper. Complete suppression is ensured by using the choke condenser unit, shown in Fig. 95. Where a "two-wire" electrical system is in use, a ·5 μF. capacitor should be connected from each terminal to the chassis.

Electric Gauges. Most of the gauges on the dashboard of a modern car are electrical meters, and these may cause interference. The trouble does not originate in the meter itself, but in the unit supplying the current which the meter measures. In the case of a petrol gauge, as an example, one side of a metal-cased 1 μF. condenser should be connected to a screw securing the terminal escutcheon plate to the petrol tank, while the other side of the condenser is connected to the terminal which holds the lead from the petrol gauge meter.

The same principle may be applied in the case of other gauges, and a 1 μF. capacitor will, in most instances, remove the trouble.

Effects upon Engine Performance. Radio and motor-car manufacturers have conducted many tests to determine the effects of noise-suppressors upon engine performance, and their main conclusions are summarised below.

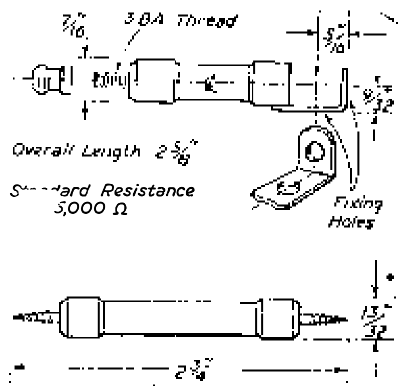


FIG. 94 (*above*). *Sparking plug suppressor with mounting lug.*

(*Below.*) *Distributor lead suppressor with screw ends for easy attachment of the cable.*

Tests made by ignition specialists have proved that there is no adverse effect on engine performance or petrol consumption.

The fitting of suppressors tends to retard the ignition timing of the car, but the effect is so slight that it can in most cases be ignored. Poor engine performance when suppressors are fitted usually indicates that ignition is in any case maladjusted, and calls for a general inspection of the system.

Some vehicles are fitted by the manufacturers with suppressors to prevent interference with external U.H.F. or television receivers. These will generally have resistors of comparatively low value —about 5,000 ohms—in the sparking-plug leads. These low-resistance suppressors will not necessarily prove effective in suppressing noise in a radio set installed in the vehicle concerned.

Intermittent Noise. Momentary clicks will be heard when electric traffic indicators are operated. Similar clicks may be heard from horns, starters, charger cut-outs, fuel-pumps, etc., and may be eliminated by fitting ·5 μF. capacitors, as explained for dynamos.
Ill-fitting lamp-bulbs may cause loud intermittent crackle.
When tracing the source of noises that occur only when the car is in motion, or is rocked from side to side, it is important to remember that any momentary change in the effective metallic mass of the car chassis may produce audible effects in the car radio set. For example, loose running boards, mudguards, radiator grille, or engine-bonnet may be potent causes of trouble. The bonnet is especially important; it serves as a screen for the engine

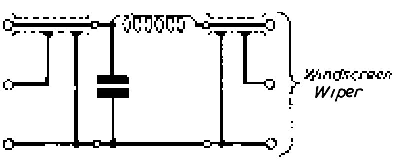


FIG. 95. *Windscreen wiper suppressor circuit.*

and the electrical devices housed close to the engine, and must therefore always be effectively earthed.
Loose chassis members may produce minute electrical static charges and subsequent discharges, and the cumulative effect of many such small noises may add appreciably to the general level of background "mush." Front and rear axles are particularly likely to cause noise of this kind, and it is desirable in bad cases to bond the axles to the main frame by flexible bonding strips.
The operation of control-wires and cables may be found to produce intermittent noise. The remedy is effective earthing at several different points on each wire.
The work must be tried out *on the road.*

CARBORUNDUM. A compound of carbon and silicon made by heating sand and coke in an electric furnace. Also a crystal rectifier used in conjunction with steel.

CARBOY. A large glass jar used to store acids.

CASCADE. In an amplifier, when the output of one valve is used to control the grid circuit of another valve, the valves are in cascade, or series.

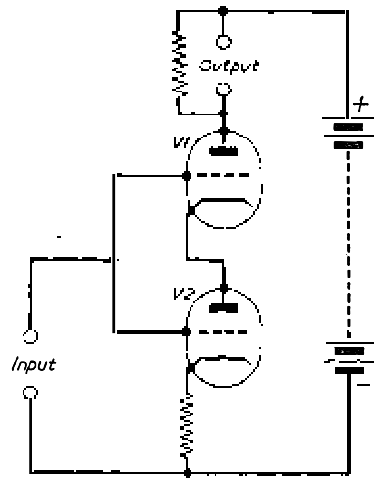


FIG. 96. *Valves in cascode.*

CASCODE AMPLIFIER. The cascode amplifier fundamentally consists of two triodes connected in series. An alternative arrangement is to provide a fixed positive voltage for the grid of V_1. A cascode amplifier acts as a single valve.

CATCHER. The combination of electrodes which extract energy from the electron stream in a *velocity-modulation valve.*

CATHODE. The negative pole or plate of a cell. The source of electrons in a thermionic valve.

CATHODE FOLLOWER. A circuit in which the output load is included in the cathode circuit of a valve, and the input to the valve is applied between the grid and the remote end of the cathode load.

CATHODE-INJECTION OSCILLATOR. An oscillator in which the feedback voltage is injected into the cathode circuit of the maintaining valve(s).

CATHODE RAY TUBE. An electrical device for giving a visual indication of the magnitude, shape, etc., of an oscillating current. It may also be employed to provide actual images of valve characteristics and other wireless data. It consists of a large glass tube which is conical in shape. The large end, or the base of the cone, is coated on the inside with some fluorescent material. At the point of the cone, or the narrow end of the tube, is sealed a cathode. A short distance from this cathode is fixed an anode. If a negative potential is applied to the cathode and a positive potential applied to the anode, a stream of electrons will be shot off from the cathode, and will be driven with great force on to the anode (see Figs. 97 and 98).

In the oscillograph a small pinhole is made in the anode, and the force of the electron bombardment drives some of the electrons through this pinhole. The tube is not

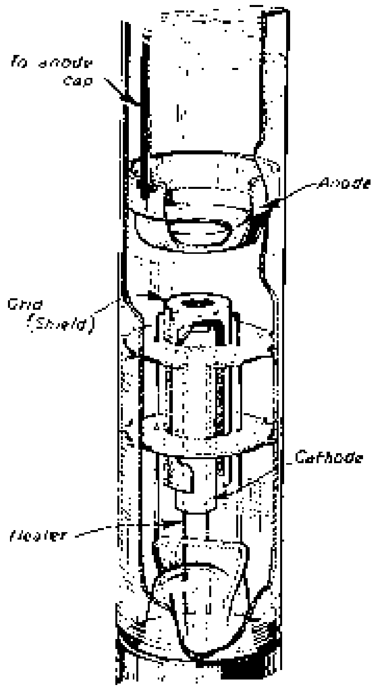


FIG. 97. *A typical electron gun assembly of a modern cathode ray (picture) tube.*

completely vacuated, but contains a residuum of gas, and the gas tends to conduct the electrons which pass through the hole, so that a stream of electrons passes from the anode down towards the fluorescent screen or plate. Immediately beyond the anode are two pairs of plates, one pair disposed horizontally and the other vertically. These are suitably connected to a circuit so as to form magnetic fields, or fields of stress between the plates, and these fields divert the stream of electrons. The fluorescent plate glows where the stream strikes it, and the size of the hole and all other internal details of the oscillograph have to be so designed that the spot of light on the plate is only a mere point. Various improvements on the above simple arrangement have been carried out. (See also *Braun Tube* and *Television.*)

CATION. Obsolete term for positive ion. An element which in electrolysis is evolved at the cathode. Sometimes spelt *Cathion.* Opposed to *Anion* (*which see*).

CAT'S WHISKER. A fine wire making contact at its tip with a rectifying crystal.

CAVITY MAGNETRON. A magnetron having one anode consisting of a block in which are formed a number of cavity *resonators* spaced around the cathode. (See *Magnetron.*)

CAVITY RESONATOR. A cavity, enclosed by metallic walls, in which standing electromagnetic waves can exist when properly excited. The resonant frequencies are determined by the physical dimensions of the cavity and by the dielectric and magnetic properties of the substance with which it is filled.

C.C. Cubic centimetres.

CELL CONSTANT. The ratio of the average distance between electrodes to the average cross section of a current path traversed.

CELLS IN PARALLEL. All positive poles joined together and all negative poles joined together. An arrangement for obtaining a greater current from a number of small cells. The voltage remains unchanged.

CELLS IN SERIES. Positive pole of one cell joined to negative of the next cell. An arrangement for obtaining a greater voltage from a number of small cells. In this arrangement the capacity will remain unchanged. A good example is a high-tension battery, where individual cells of 1·5 volts are joined together.

CENTI. One-hundredth.

CENTIGRADE. The system of measuring temperatures, in which boiling-point is 100° and freezing-point 0°.

CENTIMETRE WAVES. Waves from 1-10 cm. long.

CENTRE TAP. (See *Tapping.*)

C.G.S. The centimetre-gramme-second system of units. (See also *Absolute Units.*

CHARACTERISTIC CURVE. Data relative to a valve. A chart similar to that shown in Fig. 99. The right- or left-hand edge of the squared section bears a number of figures marked "Anode Current," and the thick lines running across the squares are labelled with figures termed "Anode Volts." Sometimes these three sets of figures are referred to by the standard references Vg for grid volts, Va for anode volts, and Ia for anode current. The grid volts line is usually divided into two parts, a zero line being placed near the right-hand edge, and the volts to the left of this being marked "negative," and those to the right "positive." Now, this set of curves will give us all the details which are known as the valve's characteristics, and they may be ascertained in the following manner.

Checking Valve Characteristics. Connect up a valve holder, grid-bias battery, H.T. battery, and L.T. battery, as shown in the diagram Fig. 101. A milliammeter should be inserted in the anode lead between plate and H.T. positive. Now prepare a piece of squared paper with a zero grid-potential line, as shown in Fig. 99, and mark the right-hand line with a series of numbers from 0 to 30, and insert a valve in the valve holder. With no grid bias and 60 volts H.T., note the current indicated by the milliammeter. On the squared paper on the zero line make a dot where the line corresponding to the anode current intersects. Now plug the grid-bias plug into the 1·5-volt socket, and note the anode current, making a dot on the chart about the 1·5 volt line at the point of intersection with the new anode current. Proceed in this way with various H.T. and G.B. values, joining up all the dots for each H.T. value. The result of this will be a set of curves exactly the same as those supplied by the valve makers, and the various figures, such as amplification ratio, slope, etc., may now be found.

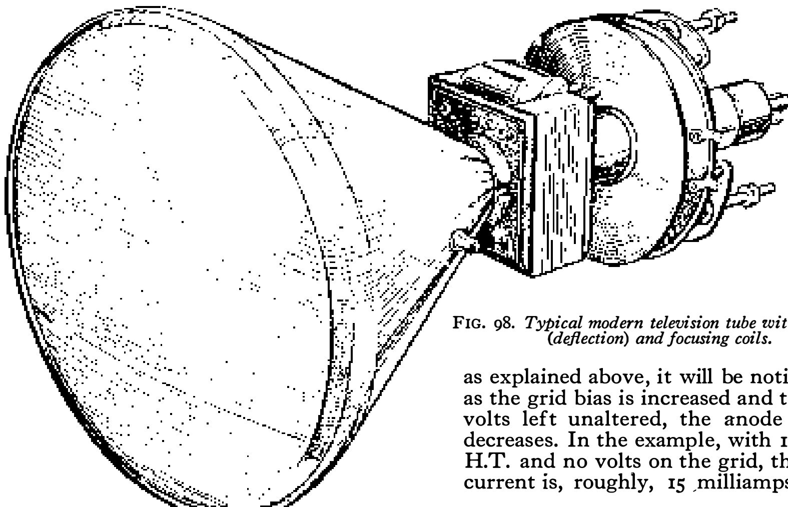


FIG. 98. *Typical modern television tube with scanning (deflection) and focusing coils.*

Amplification Ratio. This figure is the ratio of change in anode voltage to change in grid volts. (The sign μ is used for this characteristic.) When preparing the curves as explained above, it will be noticed that as the grid bias is increased and the H.T. volts left unaltered, the anode current decreases. In the example, with 100 volts H.T. and no volts on the grid, the anode current is, roughly, 15 milliamps. When

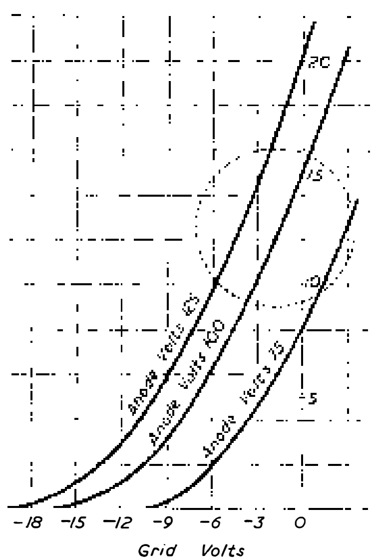


FIG. 99. *The ordinary grid-volts anode current curve*

the grid bias is increased by 3 volts the anode current will drop to just under 10 milliamps., a drop of approximately 6 milliamps. Therefore, to obtain the same anode current without altering the bias

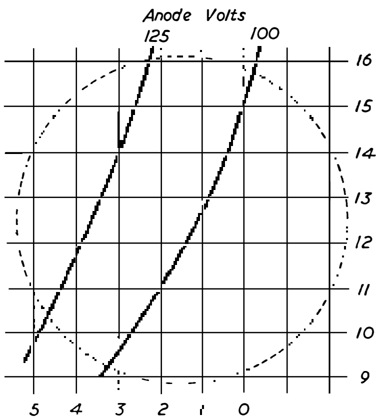


FIG. 100 *An enlarged view of the section shown in* FIG. 99.

it will be necessary to increase the H.T., and in the example about 24 volts are required to get the same anode current. Therefore it is necessary to add 24 volts H.T. for every 3 volts G.B. added, and this ratio, 24 over 3, is the amplification ratio, which in this case is 8 (see Fig. 99). A reference to the diagram will make this clear.

Slope. This term is the same as "Mutual Conductance." It is the change in anode current divided by change in grid volts, or, put in another way, the anode-current change per volt grid-potential change. For this factor, the anode potential, or H.T., must be left untouched, and the grid bias only altered. As the bias is increased, the anode current will decrease. Therefore a set of figures are obtained from which it can be seen that the anode current decreases 2 milliamps. for every volt that the grid bias is increased, and therefore the slope is 2 milliamps. per volt, or, as it is expressed on the valve chart, 2·0 mA/v.

Impedance. Upon this depends the value of resistance, etc., which is to be used in coupling the valve to a subsequent stage. No further calculation needs to be made to obtain this figure, as the two previous items, slope and amplification ratio, are used to ascertain the impedance. Simply

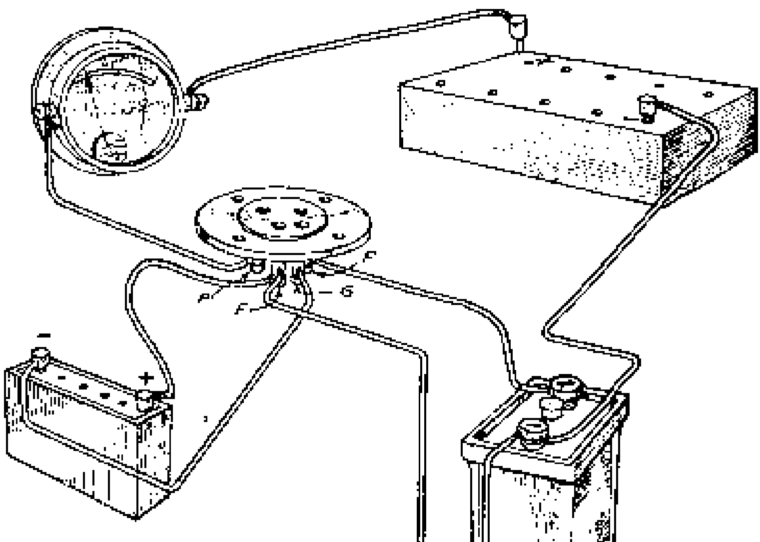


FIG. 101. *How to arrange the necessary parts in order to read a valve and prepare curves, or check valves.*

divide the amplification ratio by the slope, and multiply the answer by 1,000, which in the example will be 8 divided by 2 multiplied by 1,000, or 4,000, and this figure is quoted in ohms.

These are known as static characteristics, that is they are only applicable to a valve which receives constant voltages. When the valve is being used to receive signals

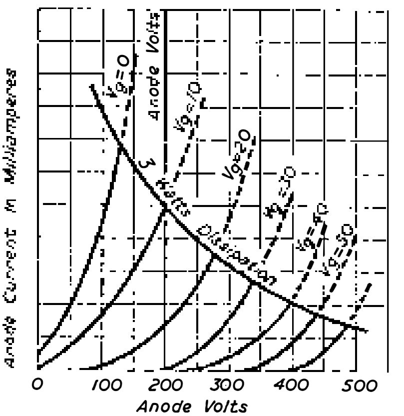


FIG. 102. *The dynamic valve curves—which are the most important curves to have.*

the grid and anode voltages are constantly changing. It is therefore impossible to ascertain from the curves such details as the "maximum undistorted output," correct "anode load," percentage of "second

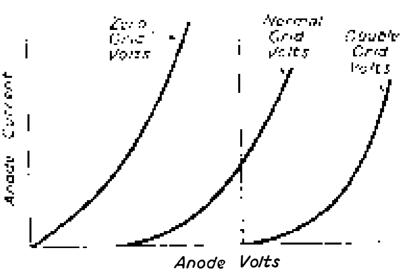


FIG. 103. *The dynamic curves simplified.*

harmonic distortion," etc., and it is necessary to prepare a set of curves known as "dynamic" curves. Fig. 102 shows the way these are drawn, and it will be observed that the values of both grid bias and H.T. are carried to a value higher than is normally used. In order to make use of these curves the current at the correct working point must be shown, that is correct anode volts and correct grid volts, and in addition at half and double these values. During the operation of the valve (dealing with the valve as an L.F. amplifier) the grid potential varies, when the valve is operating on the proper part of its characteristic, from half the applied bias to double that bias. If it does not do this, then distortion is taking place. The effect of the variation in bias is equivalent to a change in anode volts, and, therefore, the dynamic curves will show the anode current at various grid and anode volts.

Undistorted Output. The curves shown in Fig. 102 may be expressed in a much simpler way for the purpose of explaining

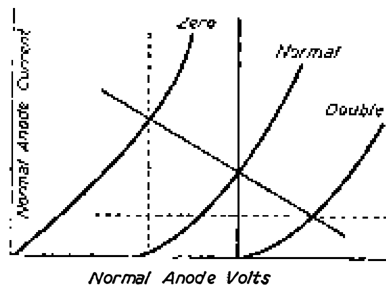


FIG. 104. *The "power triangle" marked out.*

the manner of ascertaining the undistorted output of the valve and the percentage of second harmonic distortion, etc. Draw Fig. 103, which is the anode-current curve at normal grid bias, double and half-grid bias, all the other lines in Fig. 102 being omitted. The diagonal line running across the curves is the "load line," and this gives the value of the resistance, which must be included in the anode lead to obtain the maximum output from the valve, or in other words, the correct matching resistance. The line is drawn by placing a ruler on the curves with its edge at the point where the normal grid-bias line, normal anode-current line, and normal anode-voltage line all intersect. The ruler is then swung about this point until an equal distance separates the zero grid-volts line and the line corresponding to double the normal grid bias. (The distances should not be equal, but one side should be slightly larger than the other, in order to obtain a 5 per cent. distortion scale.) Having drawn this line, drop a vertical line at the point of intersection of zero grid volts, and draw a horizontal line at the point of intersection of the load line and the line corresponding to double the grid bias. This gives a triangle as shown in Fig. 104. The formula for finding the undistorted output is :

$$\frac{(I\ max - I\ min) \times (E\ max - E\ min)}{8}$$

In other words, it is the anode *current* difference multiplied by the anode *voltage*

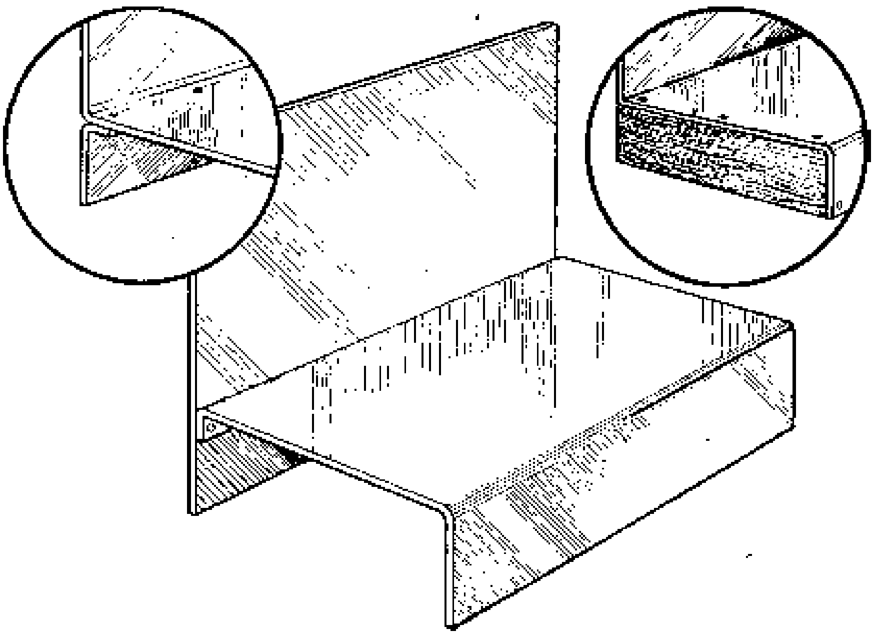


FIG .105. *The most common form of metal chassis, whilst inset are shown two alternative methods of making the chassis.*

difference, divided by 8. This figure is the most important in the list of valve details, as it gives a true indication of the power which the valve will deliver. For instance, if it is known that a P.5. valve will give an undistorted output of 500 milliwatts (or ·5 watts), and that a D.7 gives an undistorted output of 900 milliwatts, the latter valve is nearly twice as loud as the former.

CHARLES' LAW. All gases heated at constant pressure will expand by equal fractions of their volume at o.c. for temperatures of equal increment.

CHASSIS. The supporting base (usually of aluminium or foil-covered wood, but sometimes of wood or bakelite) on which are placed the components of a receiver or transmitter.

In its simplest form a chassis is that which is built of wood and covered with metal foil. An all-metal chassis is preferred.

An all-metal chassis can be built up in a variety of ways, and aluminium has the advantage of being easily workable. Fig. 106 shows one method of constructing a chassis. It will be noticed in this arrangement that no sheet-metal bending is required. The metal panel is attached to the platform with a convenient length of angle aluminium, and the same material is used for the returned portion or terminal panel. Thus the chassis comprises three flat pieces of sheet aluminium and a couple of lengths of angle. This material is obtainable in various gauges and with equal and unequal width of sides. For the present purpose ½ in. to ¾ in. width by 16 to 18 S.W.G. thickness is most suitable. The sheet aluminium and angles are joined together by drilling holes through both pieces and fixing with small brass screws and nuts. In another

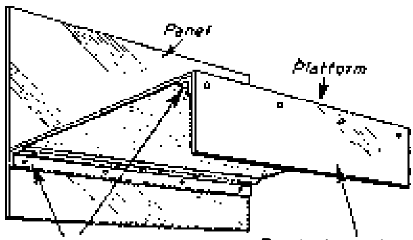


FIG. 106. *A metal chassis using angle-irons instead of bending the aluminium.*

adaptation of this arrangement an ebonite terminal strip may easily be incorporated. One further advantage to be obtained from the adoption of this or a similar form of construction is that, after marking out the positions of holes required to accommodate fixing bolts for the components or for the passage of wires, the chassis members may be taken apart, thus leaving the essential portions in the flat, thereby greatly facilitating drilling, and more especially will this convenience be appreciated where an irregular-shaped hole or two has to be pierced with a fret-saw.

The more usual form of chassis now employed is made by bending sheet metal into a fairly wide channel-section formation, the panel being either riveted or bolted on to one of the flanges or narrow edges. Fig. 105 shows such a chassis. Another form of bending is illustrated in Fig. 105. In this the panel platform and terminal panel are in one piece, and the remaining portion of the front panel below the platform is completed by the addition of an angle piece running the whole length. The fitting of side pieces in wood or metal as in Fig. 105 would make this unnecessary.

A simpler form of chassis is now available, consisting of a plywood base upon which is a coating of metal, sprayed on under pressure and giving the same effect as a sheet of metal. This is easy to work, and the surface may be scraped away with a pen-knife or similar implement when it is desired to mount a component, which must not be earthed. If this type of chassis is used for short-wave apparatus, the metal surface should not be employed for earth-return purposes, as it may become damaged due to handling and thus give rise to a high-resistance joint. It is also possible to make a similar type of chassis, having the working facilities of the wooden structure, with the advantages of the metal arrangement, by using ordinary plywood for the foundation and covering it with a layer of good copper or aluminium foil. For short-wave apparatus the copper is preferable, and all earth-return leads may be made through the foil, using holding-down bolts or screws as the anchoring points for the earth connections. It is also possible to solder the connections at these points, but if the latter is not adopted, the point at which the wire is attached should be very carefully cleaned if H.F. currents are to be

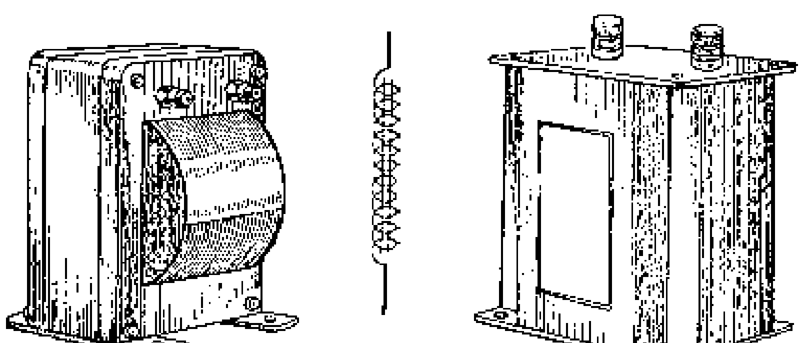


FIG. 107. *Conventional and actual diagrams of two forms of L.F. choke.*

fed through the coil. A word of warning should be added here not to use the various types of metallised paper which may be obtained from various sources, such as wallpaper and similar material, which consists of fine metallic powder held in position by some adhesive material which does not provide continuity in an electrical sense, and therefore the utmost care should be taken if such material is selected. For the same reason it is not worth while attempting to use small pieces of foil-covered paper, joining them together by overlapping and sticking them down, as this will also break the continuity.

CHATTERTON'S COMPOUND. A mixture of 1 part of Stockholm tar, 3 parts gutta-percha, and 1 part resin. This forms a black insulating substance of a plastic character.

CHEESE. A part of a cylindrical reflecting surface bounded by parallel plates perpendicular to the axis of the cylinder.

CHOKE. A coil possessing high self-induction, used to impede or check the amount of alternating current flowing in a circuit. It provides *impedance* (*which see*).

In wavelength technique, a surface discontinuity (which may take the form of a *ditch*, flange, *skirt* or stub), designed to prevent the transmission of R/F energy.

For a home-made H.F. choke a former and a quantity of wire are required. Two terminals may be used for connections, although these are not essential. Obtain a length of ebonite rod 1 in. in diameter, and turn out slots about $\frac{1}{4}$ in. deep by just over $\frac{1}{8}$ in. wide. Six such slots will be needed, and there is no need for great accuracy in the spacing. In order to make the choke easy to handle and mount, it is best to leave an inch or so at each end to carry the ends of the actual winding. In the absence of a lathe, obtain a piece of $\frac{1}{2}$-in. diameter ebonite rod and a similar length of ebonite tube having $\frac{1}{4}$-in. walls and an internal diameter of $\frac{1}{2}$ in. From this tube cut five rings $\frac{1}{8}$ in. wide and two rings $\frac{5}{16}$ in. wide. These should be slid over the rod and stuck in position with Chatterton's Compound. Fig. 108 shows the appearance of the former.

The most suitable gauge of wire is No. 36, and to enable the required number of turns to be accommodated in the slots it should be preferably of the enamelled variety. Anchor one end through two holes pierced in the end of the tube, and in the first slot wind 500 turns. At the five-hundredth turn allow the wire to run across the separating flange, and continue the windings in the second slot. Make sure that the wire continues in exactly the same direction. Wind another 500, and carry on in this way until you have 500 turns in each slot, that is, 3,000 turns in all (2 oz. of

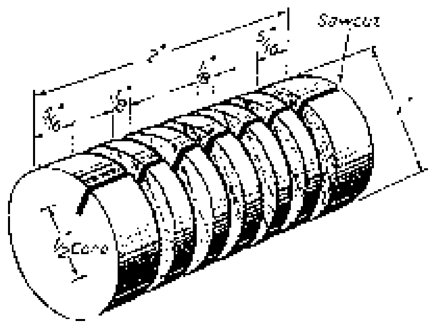


FIG. 108. *A home-made former.*

wire will be sufficient for this). Anchor the end of the wire, and the H.F. choke is complete. If desired, a piece of celluloid or cellophane may be wrapped round it to keep out moisture and to give it a finished appearance. (See also *High-frequency Chokes*, and *Anti-break-through Choke*.)

CHOKE-CAPACITY COUPLING. A form of low-frequency coupling, in which a low-frequency (iron-cored) choke is included in the anode circuit of a valve, and the grid of the following valve is

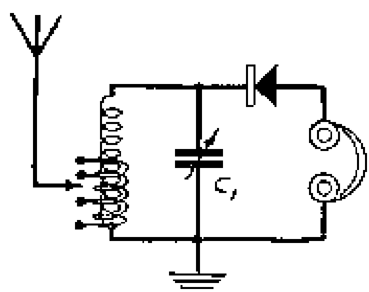


FIG. 109. *Crystal circuit using tapped coil.*

List of Components for FIG. 109*:*
·0005 μF. variable condenser (C1).
1 crystal detector.
Plug-in coil holder.
Plug-in coils.
Terminals, connecting wire, and screws.

coupled to the preceding anode by the customary condenser. A grid-leak resistance is joined to the grid, and the valve receives negative bias through this leak. It therefore only differs from resistance-capacity coupling by the use of a choke in place of a resistance in the anode circuit. (See also *Low-frequency Couplings.*)
In wavelength technique, a connection between two parts of a *waveguide* system requiring no mechanical contact, but in which leakage of R/F energy is prevented by suitable *chokes*.

CHOKED FLANGE. A flange in the surface of which is cut a *ditch*.

CHOPPING. Rapid on-off switching of a *transponder* for recognition purposes.

CIRCUIT. The path through which a current flows from negative to positive poles. (See also under *Hartley*, *Reinartz*, *Armstrong*, etc., *Gramophone Amplifier*, etc.)

RECEIVER CIRCUITS

Two simple crystal circuits are shown in Figs. 109 and 110.

ONE-VALVE. Using a 6J7 metal valve, which is a 6·3-volt type, it derives its power from a filament transformer and a 9-volt G.B. battery for H.T. A small filament transformer consumes very little power, and as the H.T. current is less than 1 mA, the running costs are almost negligible.

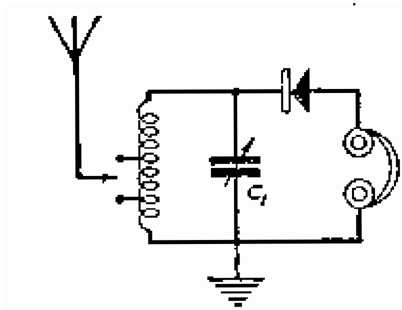


FIG. 110. *The very simplest crystal circuit.*

List of Components for FIG. 110*:*
·0005 μF. variable condenser (C1).
1 crystal detector.
Terminals, connecting wire, and screws.

Sensitivity is as good as that of most o-v-o receivers, and the controls are easy to handle. In most localities the receiver will give comfortable 'phone signals from Home and Light transmissions with a 20 ft. indoor aerial; but to do it justice it is better to use an outdoor aerial and earth, when the performance will greatly be improved. Plenty of continental stations will be audible after dark, as well as other B.B.C. transmissions.
The circuit is shown in Fig. 111. There are two aerial tappings, one at the 40th turn

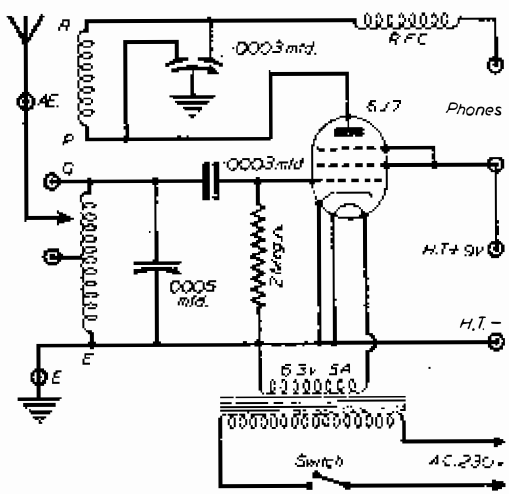


FIG. 111 *A one-valve circuit.*

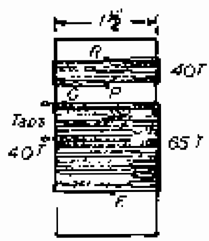


FIG. 112. *Details of the coil.*

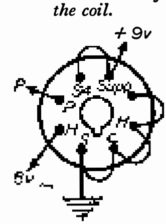


FIG. 113. *The valve connections.*

and the other at the top of the grid coil. A short flex, run from the aerial condenser, terminates in a crocodile clip which makes this connection direct to the coil. The tapping can therefore easily be adjusted when necessary. The tuning condenser is an ordinary ·0005 μF. type. Leaky-grid detection is used, with a condenser of ·0003 μF. and a leak of 2 megohms. The control grid (top cap) is used for detection; the screen and suppressor are connected together and to H.T. + 9v.

A ·0003 μF. differential condenser controls the reaction; this makes the adjustment rather smoother than with an ordinary variable condenser. Any *good* H.F. choke can be used.

The panel and chassis can be made of metal or thin plywood, whichever is available. A suitable size is 8 in. by $6\frac{1}{2}$ in. for the panel, and 8 in. by 5 in. for the chassis, the latter being supported on runners of $\frac{5}{8}$ in. wood, measuring 5 in. by $2\frac{1}{2}$ in. These sizes, however, can and should be increased or decreased to suit the particular components used (Fig. 114). A pointer knob and dial plate are the simplest form of tuning control; but a slow-motion dial can obviously be used if this is available.

The controls are: top, tuning; left-hand knob, reaction; centre, on-off switch; and, right-hand knob, aerial series condenser.

Connections to aerial, earth, 'phones and 9-volt battery are best made by mounting six sockets or terminals on a strip of paxolin or ebonite across the back of the runners. If the chassis is made of plywood, however, these can be mounted in a row along the rear edge.

There is not much drilling to be done; one large hole ($\frac{7}{8}$ in. or 1 in. diameter) for the valve, four holes, about $\frac{3}{8}$ in. diameter, on the panel, and a few $\frac{1}{8}$ in. mounting holes are all that are necessary. As actual dimensions and positions will vary with different components, no detailed particulars can be given.

The coil is quite simple to make (Fig. 112). The materials required are: 3 in. or 4 in. of $1\frac{1}{2}$ in. former, and about $\frac{1}{2}$ oz. each of 26 and 34 S.W.G. enamelled or silk-covered wire or approximate sizes. The grid coil has 65 turns of 26 S.W.G., tapped at 40 turns, where a small loop is made with the bared wire, on to which the aerial tap is clipped. A similar loop is made at the upper end of the winding. The reaction coil has 40 turns of 34 S.W.G., spaced $\frac{1}{4}$ in. away from the grid coil. All turns are close wound, and in the same direction.

The valve used is an American type 6J7, but 6J7G, 6J7GT or 6W7G can be used without making any change to the receiver. If it can be obtained, the 6W7G is a particularly suitable type, as the heater current is only ·15 amp. as against ·3 amp. for the 6J7. A 6L6 or 77 can be used, but the octal socket may have to be replaced by an American six-pin wafer valve holder. If a proper filament transformer is not available, a bell transformer

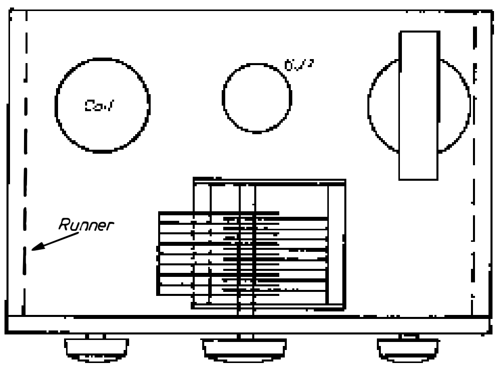


FIG. 114. *Chassis layout for the one-valver.*

with the secondary re-wound to give 6 volts can be used; but this voltage should be checked with an accurate A.C. voltmeter, since it must not exceed 6·5 volts, or the valve will be damaged.

Should a transformer of any kind be unobtainable, the heater can be supplied by a 6-volt accumulator, or even dry batteries. In this case, a flex, connected to the heater pins and brought out through the back of the chassis, will make suitable connections, the switch being inserted in series with one of these leads.

The aerial series condenser can either be ·0001 μF. or ·0003 μF., but the former value, which was used in the original, is recommended. The on-off switch must be a type rated for use in mains circuits, but otherwise the kind is immaterial.

When the construction and wiring are complete, connect up the H.T. battery (9 volts), aerial, earth and 'phones, and plug in the mains lead and switch on. Set the right-hand knob (aerial condenser) about half-way out; now turn the reaction knob clockwise. If all the connections have been made correctly, a slight "plop," and possibly a whistle, will be heard, showing that the valve is oscillating. If the reaction is found to increase anti-clockwise, the connections to the two sets of fixed plates must be reversed.

A little experiment with the aerial tappings and setting of the aerial condenser will enable the maximum results with any aerial to be obtained. The valve will take about 10 seconds to warm up.

1 Metal valve cap.
Wire, sundries, etc.

TWO-VALVE ALL-DRY PORTABLE. The circuit diagram is given in Fig. 115. It will be seen that the circuit is built around a couple of 1C5GT/G valves. The advantages of using such a valve are these:

1. The 1C5GT/G valve is only $2\frac{3}{4}$ in. in length. This helps to keep the set small.
2. Such a valve requires only some 15 volts H.T. and 1·5 volts L.T. in order to function well. The 15 volts H.T. is supplied by two G.B. batteries connected in series, and an arrangement like this will help more than anything else to keep the size of the finished set down to the very

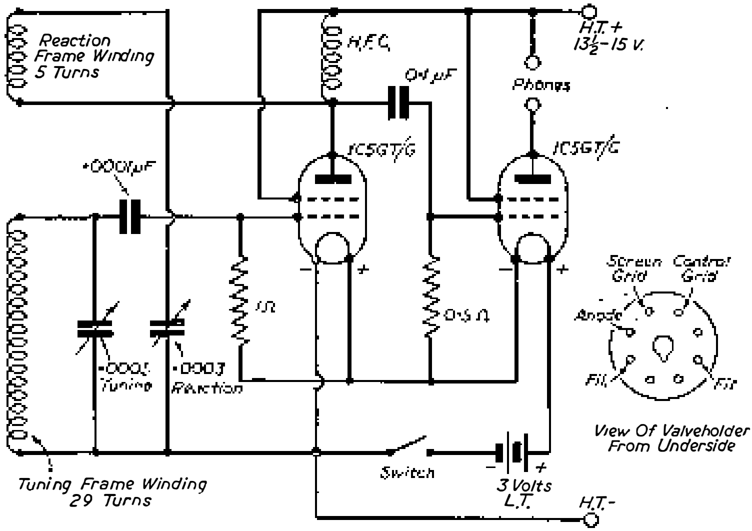


FIG. 115. *Circuit for a two-valve all-dry portable.*

List of Components

1 Tuning condenser, ·0005 μF.
1 Differential reaction condenser, ·0003 μF.
1 Midget variable condenser, ·0001 μF.
1 Mica fixed condenser, ·0003 μF.
1 Grid-leak, 2 megohms.
1 H.F. choke.
1 6·3v. ·5a. filament transformer.
1 on-off switch.
1 6J7 valve.
1 American Octal valve holder.
1 Chassis and panel.
6 Sockets or terminals.
2 Knobs.
1 Pointer knob and dial.
1 Crocodile clip.

minimum. Since two valves are employed, the circuit is so constructed that the L.T. needed is 3 volts, although each valve only needs 1·5 volts.

The number of parts used still remains small and the cost, even if all the components are bought new, still remains low. Finally, a most important point must be taken into account—namely, that of upkeep. An arrangement such as has been outlined allows one to maintain the set at an extraordinarily low cost.

The set is designed to be as light and compact as possible. The components are housed in a wooden cabinet which is made either from 3-ply wood or preferably 3-ply oak, which is somewhat thicker and helps to ensure a better job. The number of pieces of wood and the size of each piece is given in the following table (the figures given are for the 3-ply oak, which is slightly thicker than the ordinary 3-ply).

Top and bottom (5½ in. by 3¾ in.) : 2 pieces.

Front and back (5½ in. by 6½ in.) : 2 pieces.

Sides (6⅛ in. by 3¾ in.) : 2 pieces.

These pieces should then be drilled for holding the switch, condensers and 'phone sockets. The necessary data for this part of the construction is given below.

Fig. 116 (a) shows the left-hand side of the set as seen from the front. The holes for the plug sockets are both drilled ½ in. back from the front of the set and ¾ in. and 1⅜ in. down from the top of the set respectively.

The front of the set is shown in Fig. 116 (b). Two holes for the tuning and reaction condensers and one for the switch are drilled in this piece of wood. Those for the condensers are drilled 1½ in. down from the top of the set and 1⅜ in. in from the sides. The switch is fitted into a hole 3 in. down from the top of the set and 2¾ in. in from the sides.

It is quite a good idea to use panel pins for fitting up the case. At this stage only the sides, top and bottom should be joined together. When this is finished it is advisable to make quite sure that there is sufficient room for the G.B. batteries to lie in the set. Assuming that the fit is good a further piece of wood 3¾ in. by 5 in. is cut to fit above the G.B. batteries. This piece of wood is *not* yet fixed into position with panel pins, for at a later stage components have to be screwed into position on it. The front of the set is also left off for the time being so as to facilitate wiring up.

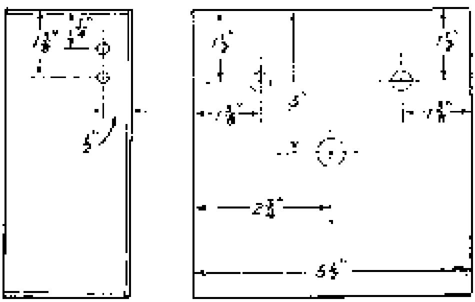
A strip of metal is now cut to fit behind the front of the set. It is then drilled in the appropriate places in order to allow the condenser spindles to pass through, when the variable condensers are fitted into position (i.e. through the holes which have already been drilled in the wood). In this way the metal strip which should measure 4¾ in. by 2 in. acts as a common earth to both variable condensers.

At this point some mention must be made about the valve holder strip (Fig. 120). This is constructed from aluminium or any other suitable material and should measure 4½ in. by 2 in. The strip is then bent along the dotted lines and cut so as to give the result seen in the illustration.

Finally, a holder for a No. 800 battery (L.T. battery), is also constructed from metal.

Once this has been done the valve holder strip and the L.T. holder may be mounted on the strip of wood which fits above the G.B. batteries. However, before finally screwing down the valve holder strip it is advisable to screw the two valve holders into position and then insert the valves in order to make quite sure that the valves do not project beyond the back of the set. The upper end of the strip may be secured to a suitable piece of wood which in turn is glued to the top of the set.

The frame aerial is now dealt with. This consists of 29 turns of wire which act as a grid winding, and five turns of wire



(a) (b)

FIG. 116. *Cabinet side and front, with drilling details.*

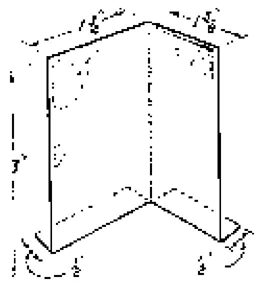


FIG. 117. *Details of the battery compartment.*

acting as a reaction winding. The turns are wound on the outside of the set as shown in Fig. 118. The wire is 24 gauge silk-covered. In winding the turns great care is taken to see that the wire is tightly wound on and that the various turns lie adjacent to one another. A gap of 1/20 in. is left between the grid and reaction windings. The ends of the frame aerial are soldered to the tags of a terminal strip which is fitted up inside the set. A suitable form of strip can be made by breaking off a small portion of a resistance board.

The components are now wired up. The wiring should be kept as short as possible for this helps to ensure greater all-round

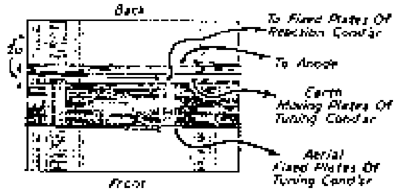


FIG. 118. *Coil details.*

FIG. 119. *Connections for the two grid-bias batteries.*

efficiency. In addition all joints are soldered and care is taken to make a firm joint. All earth connections may be taken to a single point on the metal plate which fits behind the front panel. The advantages derived by not fitting the front of the set into position until now will be appreciated. In the first place the wiring up of the set will be greatly eased, and in the second the length of wiring between the front panel and the rest of the set can be kept to a minimum.

As a final additional precaution it is advisable to check up all wiring from the circuit diagram and also the direction of the coil windings

Some mention must now be made concerning the method employed in wiring up the G.B. batteries. It has already been stated that the H.T. is supplied by two G.B. batteries joined in series.

The all-important point to be remembered is that the − 9 volts shown on the grid bias battery must be taken as true negative. From this it follows that the − 7 volts corresponds with 1½ volts positive, − 6 volts corresponds to 3 volts positive and so on.

If this point is kept in mind no undue difficulty should arise in the interpretation of the drawing shown (Fig. 119).

Between the H.T. + and the H.T. − there is a difference of potential of 15 volts, but the set will work quite well on a slightly lower voltage (13½ volts), and if distortion occurs it is advisable to step the voltage down a little.

The L.T. is supplied by a No. 800 battery, which delivers 3 volts. The battery

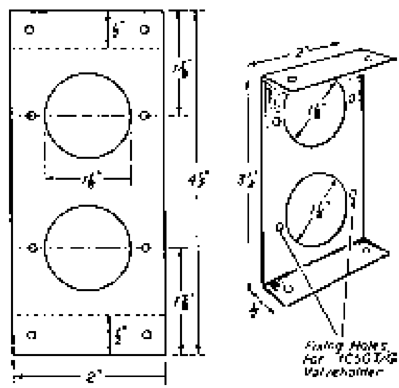


FIG. 120. *Valve mount details.*

fits into the holder already described, making contact with the negative strip at the side of the battery. The positive terminal at the top of the battery should be allowed to make contact with a strip of metal which then acts as the L.T. + terminal.

The tuning dial is first set approximately to the station it is desired to receive and the reaction control is then advanced until a soft hiss is heard in the 'phones. At this point the set is in its most sensitive condition. The tuning dial is next rotated until the carrier wave of the station is heard. Then the reaction condenser is eased back until the station is rendered intelligible.

Should oscillation be erratic—

(a) Check up on all battery connections. Make sure they are firm. Make sure that the L.T. battery is in good contact with the holder.

(b) See that the H.T. voltage is not too high.
(c) Look at the frame aerial. The gap between the grid and reaction coils should not be more than 1/20 in.
(d) Finally look at the wiring and make quite sure that all joints are good and firm.

List of Components

2 ·0003 μF. variable condensers.
1 ·0001 μF. fixed condenser.
1 ·01 μF. condenser.
1 1 megohm grid resistance.
1 half megohm grid resistance.
1 H.F. choke.
2 1C5GT/G valves.
2 valve holders for above valves.
1 Bulgin on-off switch.
1 pair 'phone plugs.

an exterior drive can be added to it. A pentode output stage is used, fed from the detector by means of a parafeed transformer to secure maximum gain with stability. A resistor is used instead of a reaction choke, and this will be found satisfactory over all the wavebands used. The coils have a separate coupling winding to reduce aerial damping, and details of the number of turns used will be found in the table.

The chassis is $5\frac{1}{2}$ in. by $7\frac{3}{4}$ in., and the runners are approximately 2 in. deep. The top is made from a piece of 3-ply, as also are the front and back runners. The two side runners are of thicker material (about $\frac{3}{8}$ in. being suitable) to permit of the top, front and back being screwed to them. Reference to Fig. 123

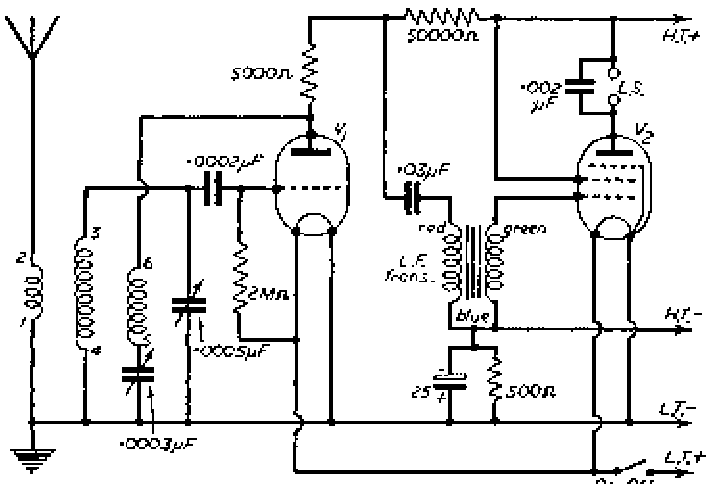


FIG. 121. *Circuit for an all-wave two-valve receiver.*

FIG. 122. *Winding details for the coils.*

ALL-WAVE TWO. This is a straightforward receiver which will provide speaker reception of the more powerful radiations on medium- and short-wave bands. 'Phones can be used for distant listening and practically any frequency can be tuned by inserting a suitable coil. A refinement is provided in the form of automatic bias, which simplifies battery connections considerably.

The circuit is shown in Fig. 121. With reception on the higher wavebands in mind a ·0005 μF. tuning condenser is used, and this should be of the type fitted with a good slow-motion drive, or

will show the arrangement of these pieces. Two holes are drilled in the front runner, each about $1\frac{1}{2}$ in. from the outside to accommodate the on/off switch and reaction condenser. Five holes are drilled in the back runner for speaker, aerial and earth terminals, and the battery leads. The speaker, and aerial terminals are insulated from the wood with suitable washers, but this is not required with the earth terminal. Three holes will also need to be drilled for the valve holders.

A component-mounting bracket is fixed centrally near the front for the tuning condenser. The switch and reaction condenser are mounted on the front runner and the L.F. transformer upon the side runner as shown. All other parts are suspended in the wiring.

Wiring should be carried out as in Fig. 123. Only two leads pass through the chassis, the moving plates of the tuning condenser going to the earth terminal and the fixed plates to the grid condenser. Insulated sleeving is used if there is any possibility of wires touching. The 25 μF. condenser is connected to one of the bolts holding the component-mounting bracket (which will be connected to earth *via* the tuning condenser) to hold it secure.

The leads from the transformer will be long enough to reach to the connecting points, and care must be taken not to pull them or they may come adrift from the bobbin of the component.

There are only four battery leads, and 3-ft. lengths of flex can be used, fitting the ends with spade terminals and plugs. All the leads pass through a hole in the rear runner.

The aerial terminal has no connection below the chassis, but a flexible wire goes from it to the top terminal of the coils (see Fig. 122). This terminal is used because the coils are made up on old valve-bases and otherwise the aerial coupling winding will have to be omitted, or the reaction coil connected to earth, which would give particular disadvantages, especially on short waves. The only alternative is to use valve-bases with more pins, if they are to hand, although the top terminal does not present much difficulty in actual use.

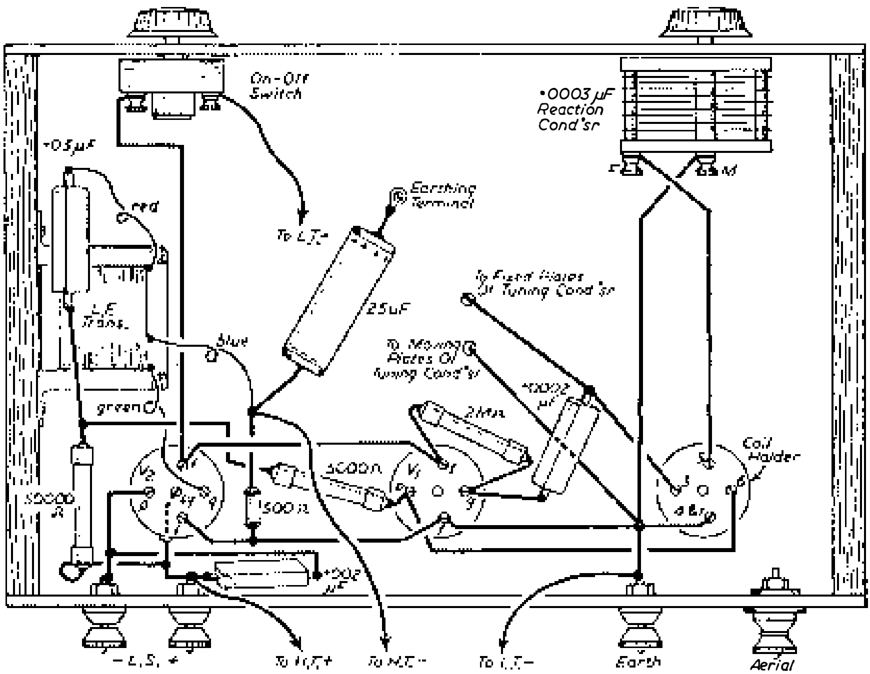


FIG. 123. *Wiring diagram of the all-wave two.*

Winding details for the coils will be seen in the table. All windings should be in the same direction, and the ends connected as shown in Fig. 122, where the ends are numbered to agree with the numbers shown in Fig. 123. The reaction and aerial coupling windings are approximately ¼ in. from the central grid winding, and all the ends of the windings are taken through small holes into the former. Point 2 is connected to the terminal, mounted upon a disc which is a push-fit in the top of the former, and the other points are taken down through the valve-pins and soldered in the usual manner. Winding details are for a former 1⅛ in. in diameter. The actual size may vary

1 ·0002 μF. paper tubular condenser } T.C.C.
1 25 μF. 12 v.w. electrolytic condenser } T.C.C.
1 5 kΩ resistor } Dubilier or Erie, ½ watt.
1 50 kΩ resistor
1 500 Ω resistor
1 2 MΩ resistor
3 5-pin valveholders.
1 on/off switch.

COIL DATA

	Grid Winding	*Reaction*	*Aerial Coupling*
Coil 1	5½ turns 18 S.W.G. wire spaced by diameter of wire	4½ turns 30 S.W.G. close wound.	2½ turns of 30 S.W.G. wire spaced slightly
Coil 2	12 turns 20 S.W.G. wire spaced by diameter of wire	9 turns 32 S.W.G. close wound	5 turns of 30 S.W.G. wire spaced slightly
Coil 3	20 turns 22 D.C.C. S.W.G. wire close wound	14 turns 32 S.W.G. close wound	7 turns of 32 S.W.G. close wound
Coil 4	96 turns 32 S.W.G. enam. close wound	50 turns 36 S.W.G. close wound	20 turns of 36 S.W.G. close wound

with the valve bases used, but is not very critical. If a larger size is used, and it is found that a coil will not tune to a sufficiently low wavelength, then a few turns can be removed from its windings. Ebonite or paxolin tube is suitable for the coils.

When completed the valves should be inserted—the HL2 type in the central holder and the 220HPT in the holder by the speaker terminals. A speaker is then connected. It must be of the high-impedance type, such as a moving-coil model with output transformer for pentode valve. The aerial used should not be too long; if it is, a pre-set condenser should be connected in series with it.

Stations will be found by tuning with the central control, the reaction control being turned to bring volume up to maximum if required. On the short-wave bands the reaction control will be rather critical, and it should be kept so that the receiver is almost upon the point of oscillation.

The grid bias will be automatically right for whatever H.T. voltage is used, but if more economical running is required, and a loss of volume can be tolerated, the bias resistor may be increased from 500 to 700 ohms.

List of Components

1 ·0005 tuning condenser and dial.
1 ·0003 reaction condenser.
1 ·0002 μF. mica condenser } T.C.C.
1 ·03 μF. paper tubular condenser } T.C.C.
4 terminals.
1 L.F. transformer, ratio 3 or 4 to 1.
Coil and chassis as described in text.

THREE-VALVE ALL-DRY PORTABLE. Fig. 124 shows the circuit. This consists of a simple leaky-grid detector, L.F. and a parallel-fed transformer-coupled pentode. Automatic bias is included. The value of ·0001 μF. was selected for the tuning condenser for ease in accurate tuning. Two-volt filament valves are specified, but 1·5 volt valves could be used with advantage, the filaments being series-parallel-fed, or the 2 ohm resistor replaced by another of greater resistance. Medium-wave tuning only is provided, and the band covered is from 200-450 metres approximately. A few turns could be added or removed from the frame aerial if the desired local was not included.

List of Components

2 ·0001 μF. variable condensers.
1 25 μF. fixed condenser (25 volt working).
1 ·5 μF. fixed condenser (250 volt working).
1 ·1 μF. fixed condenser (250 volt working).
2 ·05 μF. fixed condensers (250 volt working).
1 ·0002 μF. fixed condenser.
1 H.F.C.
1 2 megohm resistor, ½ watt.
1 3 megohm resistor, ½ watt.
1 2 ohm resistor, 2 watts.
1 50,000 ohm resistor, ⅛ watt.
2 20,000 ohm resistors, ½ watt.
1 250 ohm resistor.

3 Amphenol octal valve bases.
1 Premier parafeed transformer.
1 Premier tapped output transformer.
1 Rola $6\frac{1}{2}$ in. speaker.
26 s.w.g. enamel covered wire.
Paxolin, sleeving, wire, etc.

The chassis is made from tinned brass, but the usual alternatives will serve just as well. A piece 8 in. by $6\frac{3}{4}$ in. is required if the specified components are used. Slight alterations to the chassis dimensions may be necessary depending on the size of valves, interstage and output transformers.

The chassis may be drilled from the details in Fig. 126, assuming, of course, that international Octal valve bases are used. When the drilling is complete the chassis may be bent up along the marking lines, and the valve-holders and transformers fitted. The interstage transformer is mounted under the chassis alongside the L.F. and pentode valve bases.

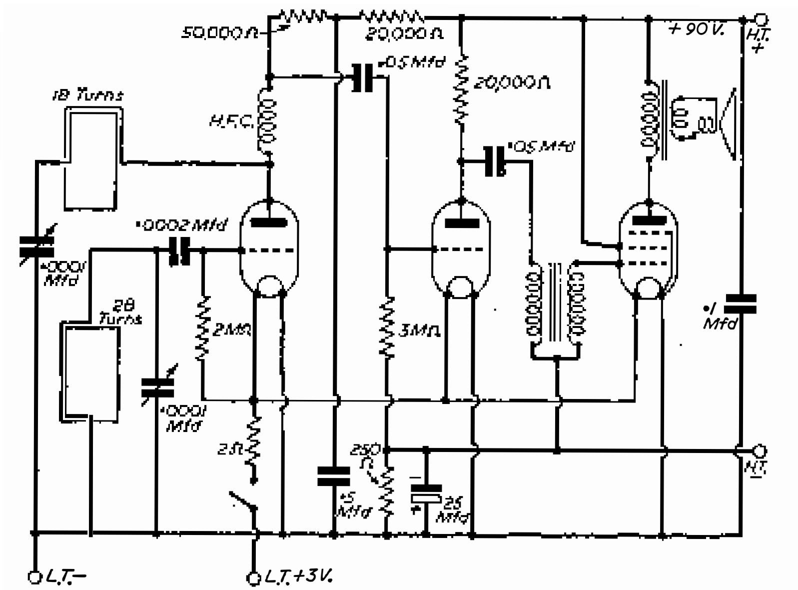


FIG. 124. *Circuit for a three-valve all-dry portable.*

The frame aerial is made up of four strips of paxolin, 6 in. by 2 in. and $\frac{1}{8}$ in. thick. The corners are fixed by small blocks and countersunk screws, but any suitable method may be used. A hole is drilled and countersunk on each side of the frame to take the bracket which fixes it to the chassis. Starting $\frac{3}{16}$ in. in on the top of the frame, wind on 18 turns of 26 s.w.g. enamel-covered wire to form the reaction winding. This should be finished at the bottom of the frame as near as possible to the anode pin of the detector in order to keep leads short. Now wind on the grid winding in the same direction, starting about $\frac{1}{8}$ in. from the completed reaction winding. Twenty-eight turns are required and these should

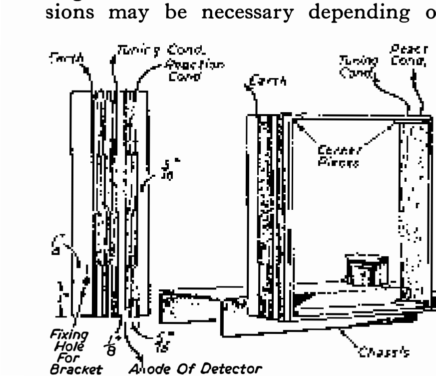


FIG. 125. *Construction of the frame aerial.*

be spaced the thickness of the wire from each other, 26 s.w.g. enamel-covered wire also being used for this winding. Fixing of ends and starts can be done by the three hole method.

Wiring may now be commenced, starting with the filament circuit, taking care to leave sufficient flex on the L.T. + lead to reach the on-off switch. All connections should be soldered for durability and efficiency. It is advisable to check the circuit and frame aerial carefully before bolting the frame to the chassis and completing the grid and reaction circuits. The set may now be connected to the battery and speaker and switched on. Rotate the reaction condenser clockwise until a slight plop is heard and search for the station desired by means of the tuning condenser. As soon as the carrier wave is picked up slack off the reaction condenser until oscillation ceases, holding the silent points of the carrier by slightly moving the tuning condenser. The set may now be rotated until maximum volume is obtained.

The size of cabinet will depend on the type of battery and the diameter of speaker used. In the original the cabinet measured 10 in. by 8 in. by 6½ in., the dry-battery standing on end at the right side of the cabinet and the speaker mounted in front of the frame aerial. The on-off switch may be mounted between the variable condensers.

ALL-WAVE THREE. As the circuit in Fig. 127 shows, this is a detector-L.F.-pentode arrangement with band-pass tuning on long and medium waves, but only a single tuned circuit on the short-wave ranges. As a result, the selectivity is as high on long and medium waves as with a H.F.-detector-pentode circuit, while on short waves there is considerably more volume than with the latter arrangement. In consequence the receiver performs very well on all wavelengths. So that the short-wave frequencies tunable are not limited, plug-in coils are used on this range, and the receiver will function well down to 10 metres.

In the L.F. part of the circuit a volume

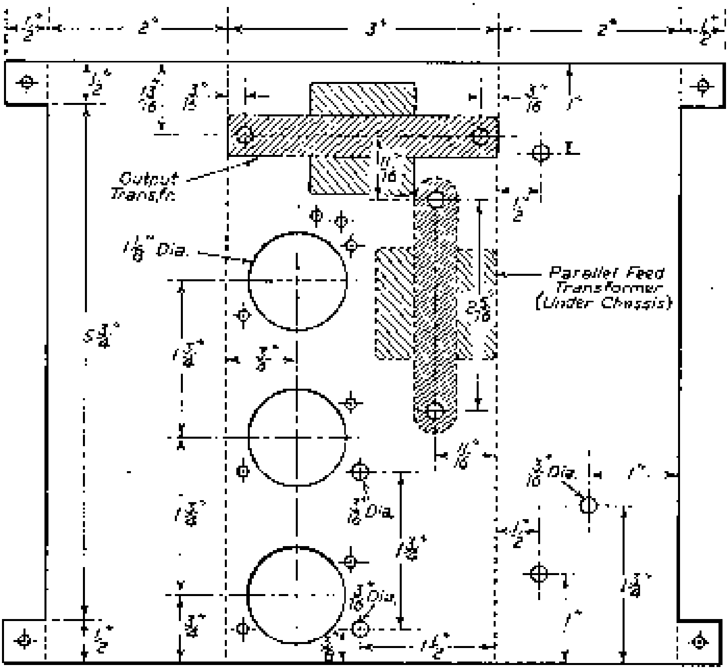


FIG. 126. *Details of the chassis.*

control and top-cut control are added, the latter being useful to remove or lessen high-pitched interference as well as for its usual purpose. A switch to change from speaker to 'phones is also used (this is not shown in the circuit, but in the wiring diagram) for listening to very weak stations.

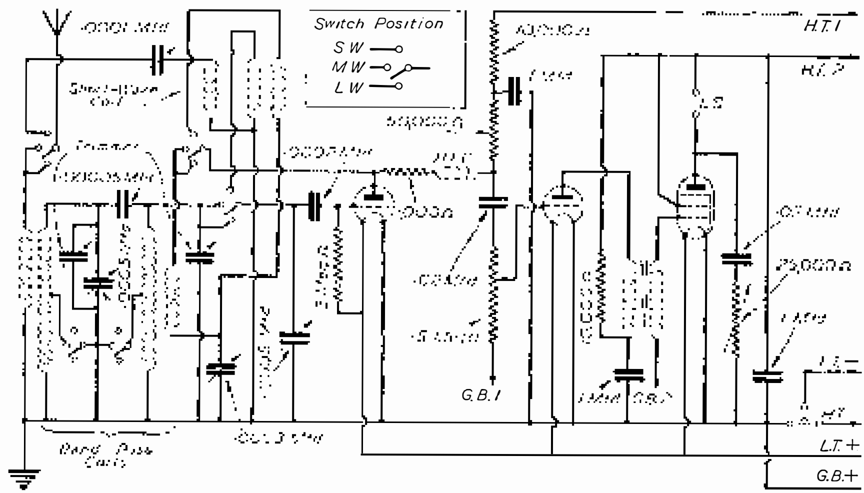


FIG. 127. *Theoretical circuit of the all-wave three-valve receiver.*

Ample decoupling assures stability. To avoid any trouble due to resonant peaks over the frequencies tuned a resistor is included in series with the high-frequency choke.

The panel layout will be seen in Fig. 131; 12 in. by 8 in. is a suitable size, although this may be adjusted to fit a cabinet available. The baseboard is of similar size; 5-ply is used for the latter and it is fixed 1½ in. above the lower edge of the panel to leave room for the switches and tone and volume controls. The rear of the panel should be covered with screening foil before any of the parts are secured to it; the foil is taken across the baseboard also, leaving the section of the panel below unscreened. This permits the 'phone-speaker switch, included in the H.T. circuit, volume control, etc., to be mounted upon the bare wood.

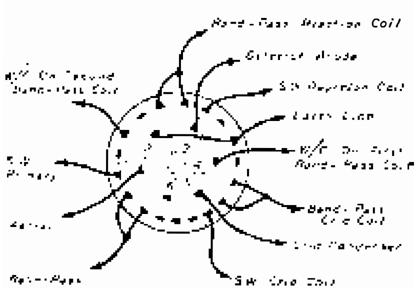


FIG. 128. *The switch wiring.*

The components shown in Fig. 129 are now screwed in position as depicted, paying particular attention to the short leads which will be necessary in the detector circuit for best results.

The gang condenser is mounted back from the panel to leave room for a good-quality reduction drive and dial. To shorten wiring the wave-change switch is similarly positioned, either by mounting on a plate bolted to the condenser or to a component bracket. A coupling and length of ¼ in. rod extends the spindle as necessary. To assist in tuning to high frequencies on the S.W. ranges the trimmer of the front section of the gang condenser is removed and subsequently connected across the long- and medium-wave detector coil.

The reaction condenser and controls below the baseboard are fixed directly to the panel in the position shown in Figs. 129 and 130.

The detector valve holder is raised about $2\frac{1}{2}$ in. so that its connecting tags come above the wave-change switch to shorten wiring. The rear octal holder is for coils and is raised 1 in. by means of bolts. When fixing, position the keyways as shown.

Baseboard holders are used in the L.F. section of the receiver, these being right to the edge of the base with the L.F. transformer between. Although a decoupling condenser with three 1 μF. sections is used, three separate components could be used instead.

Standard plug-in coils are used for short waves and if any other make is employed instead, connections must be changed accordingly. Whatever coils are used, the manufacturer's instructions should be followed so that no error arises. If care is taken with the wiring and a tuning condenser with low minimum capacitance used the smaller coil will enable the 10 metre band to be tuned, when many amateurs will be heard.

Any type of coil may be used for long and medium waves, those shown being Wearite. One coil is fixed to the panel. The particular connections for the coils used must be followed, any unnecessary primary or reaction windings being ignored. Unscreened coils are suitable although screened, iron cored coils naturally provide slightly better results. If the baseboard is not covered with foil the can of the rear coil must be earthed by a convenient lead.

Wiring of the switch should present no difficulty if Fig. 128 is examined. A small soldering iron will be necessary and the detector valve holder may be temporarily removed to facilitate connections. Commencing with section 1 on the switch, the first contact is taken to the S.W. primary and the second and third to the band-pass coil primary. Section 2 is wired so that when the switch is in the central position the long-wave winding of the band-pass coil is shortened for medium-wave reception. Section 3 connects the detector anode to the short-wave coil in its first position; in both second and third positions the anode is switched to the reaction winding on the

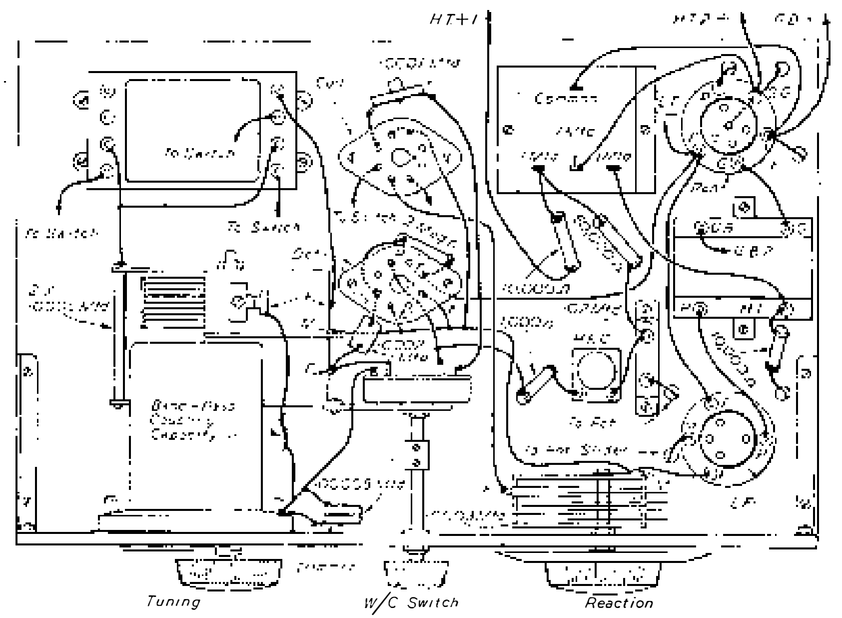


FIG. 129. *Chassis wiring of the all-wave three.*

second band-pass coil. Section 4 shorts the other band-pass coil in its central position for medium-wave reception. Section 5 connects the grid condenser to the short-wave coil in its first position; both second and third positions connect to the band-pass grid coil.

Section 6 is left blank because only a 5-pole 3-way switch is required. If the other sections are wired one at a time as in Fig. 128 no error should arise.

Fairly stout tinned-copper wire is used for all connections in the receiver, insulation being added where wires may touch each other or the foil. Leads in the tuned circuits should be short, and this is best attained by running the wires as shown in Fig. 129.

The ·0001 μF. pre-set connected to the short-wave coil is suspended in the wiring. The band-pass coupling capacity is obtained by twisting together two insulated wires for about 1 in. of their length.

Battery leads are made from flex and taken down through the baseboard. Other leads which pass through the baseboard are connected as in Fig. 130. Here, the left-hand switch is the on-off switch and the right-hand one 'phone-speaker switch, the headphones and speaker being connected to the four terminals on the strip to the left of the base. The right-hand variable resistor controls the tone and the potentiometer to the left the volume. Figs. 129 and 130 make these connections clear.

Above the baseboard the aerial connection is taken to a terminal fixed upon an insulated strip near the detector. If an earth is used it is taken to grid bias positive.

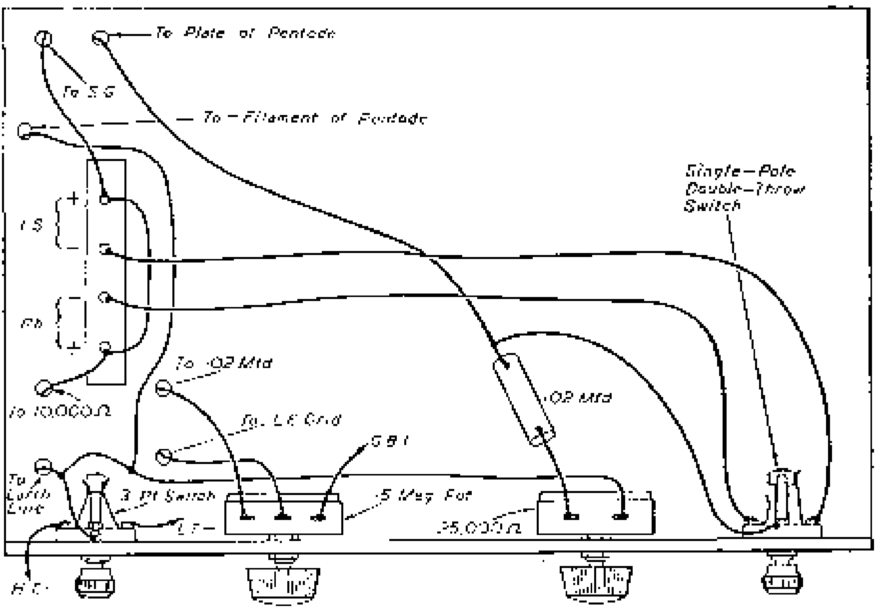


FIG. 130. *Under-chassis wiring of the receiver.*

Setting the switch to the medium-wave (central) position and switching on, stations should be received when the tuning and reaction controls are adjusted. The band-pass coils should then be trimmed in the usual way by having one trimmer fully opened and the other screwed down until further increase of capacity decreases volume. The band-pass coupling capacity may then be adjusted to reach the desired compromise between selectivity and volume on both medium and long waves. The circuits should be trimmed on a weak station with the reaction control near the oscillation point. On short waves there is no trimming, but the ·0001 μF. condenser should be adjusted to remove any dead-spots caused by a long aerial. For all-wave reception a high wire, clear of all walls, etc., about 30 ft. long is most suitable. Other short-wave coils may be inserted in the rear holder as desired.

List of Components

Fixed Condensers: three 1 μF., two ·02 μF., one ·0002 μF., one ·0005 μF. for band-pass coupling (see text).

Variable Condensers: Two-gang ·0005 μF., one ·0003 μF. Pre-sets: two ·00005 μF. trimmers, one ·0001 μF.

Resistors: one 3 megohm, one ·5 megohm potentiometer, one 50,000 ohm, one 25,000 ohm variable, two 10,000 ohm, one 1,000 ohm.

Premier short-wave coils and holder.

Band-pass or similar coils for long and medium waves, with reaction.

One 4-pin and one 5-pin low-loss octal baseboard holders.

High-frequency choke.

Low-frequency transformer for direct coupling.

On-off switch.

5-pole, 3-way switch.

Single-pole, double-throw switch.

High-grade reduction drive; knobs, etc.

Valves: Mazda HL23, Osram HL2, Cossor 220HPT (or similar types).

A Band-Pass All-Wave Four. As will be seen from the circuit in Fig. 132, this receiver is provided with band-pass tuning upon medium and long waves. On the short-wave band there are only two tuned circuits, but this is an advantage as slightly more gain will be obtained and there will not be the difficulty of ganging the three circuits. To obtain maximum gain tuned-anode coupling is used between the H.F. and detector stages, and so an adequate degree of both sensitivity and selectivity is obtained.

Two L.F. stages follow the detector, so that good speaker volume is provided on a considerable number of stations. Provision is also made for using 'phones from the L.F. stage if desired. The usual VM volume control is used, and the wave-ranges are selected by suitable switching, which is more convenient than the use of plug-in coils, although it naturally complicates the wiring.

A metal chassis is used, and no particular difficulty should arise, but it is recommended that care be taken, especially in wiring the coils. If this is done satisfactory results should be obtained.

The layout is shown in Fig. 133. A chassis 12 in. by 9 in. is needed, and the positions of the valve holders and other parts upon the top of the chassis are shown. Small bolts are used to secure all the components and tuning dial. A good-quality component is recommended for the latter, and it should have a large dial and be smooth in action or tuning will be made troublesome. Various reduction drives are available, and the kind used will depend in some degree upon the cabinet in which the set is to be placed.

A small insulated piece with two sockets is secured near the right edge of the

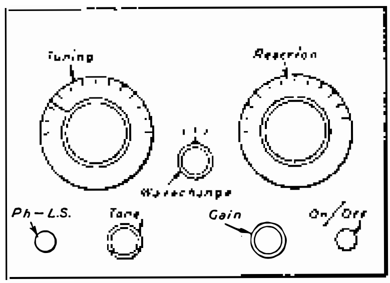


Fig. 131. *Layout of the panel controls.*

chassis for 'phone connections. Speaker connections are made with flex as shown, and the battery leads also energe from the top of the chassis near the L.F. valve. There are not many leads upon the top of the chassis, and only the anode connection to the H.F. valve is screened. As this is connected directly to the fixed plates of one section of the tuning condenser low-capacity screened wire is best used or otherwise ganging may be upset. Fig. 134 shows sub-chassis wiring. The L.F. and output stages are straightforward, and require little comment. An anchoring tag (insulated from chassis) is used for H.T. plus. The 'phone-speaker switch must have sections insulated from each other, as is seen in Fig. 132 will show. A double-pole double-throw switch can be used, wiring it so that when the 'phones are connected the filament of the output valve is disconnected. The positions of the decoupling condensers, etc., will be seen in Fig. 134.

In an all-wave circuit with switching and three tuned circuits the R.F. stages are naturally more complicated, and there are quite a number of connections. To avoid confusion the following method of wiring is recommended.

First of all, the wave-change switch should be fixed in position. A type with two sections is needed, and the rear section should have three poles, and the forward section two. The small screen shown in Fig. 134 should then be made from aluminium and bolted to the chassis. The spindle of the switch passes through a slot cut in this screen.

The tuning coils should now be fixed in position. Note that the short-wave coils are nearest the switch to shorten wiring, and that the cores of all the coils in each section are at a different angle. If the coils are arranged as shown the cores of the coils operating upon any band will also be at different angles, and the chance of interaction minimised.

The detector circuit may be wired first. A lead is taken from the anode to one section of the switch, and from the grid condenser to the second section (this connection is taken above the chassis as shown and connected also to section 1 of the gang condenser). The short-wave coils are now connected, all leads being shown in Fig. 134. Consulting the circuit in Fig. 132 should make this quite clear. When the circuits are wired for short-wave operation the switch should be turned to the next position. It is only necessary now to add the connections from the switch to the medium-wave coils, connecting these as for the short-wave coils. Note also that the additional coil in the aerial circuit has to be connected, this coil being tuned by section 3 of the condenser.

When the medium-wave coils are connected the switch should be turned to the last position and the long-wave coils connected in exactly the same manner. Note that in Fig. 134, the switched leads to the medium- and long-wave coils are not shown for clarity—they should be wired as for the short-wave coils, the leads for which are shown.

Coil connections are as follows: 1—grid; 2—earth (or H.T. plus in the tuned-anode coupling); 3—reaction condenser; 4—plate. Note that the earth ends of the tuning section of the band-pass coils are not connected to earth, but to the resistor R1 which provides the common-impedance coupling.

It will be seen that the anode leads of the detector are screened to prevent instability. Care should also be taken with the positions of all the wires in the R.F. stages, especially those to the switch and coils. They should be as short and direct as possible, and kept well clear of adjacent connections.

The reaction condenser has a small internal reduction drive and although this is not absolutely necessary it simplifies operation upon the short-wave range. The volume control potentiometer must be insulated from the chassis unless it had a "dead" fixing bush. A small stand-off insulator is used for the aerial. If an earth is used it can be taken to the chassis.

The voltages shown for battery connections are only approximate and may be modified with advantage with some valves, especially the grid bias and voltage of the H.F. screen.

Having found the receiver to function upon all wavebands, the circuit should be trimmed. The short-wave band can be taken first. To do this, unscrew the trimmers upon the gang condenser to minimum capacity and tune in a signal near the bottom end of the band. (The reason for choosing a station here is because an alteration in the trimmer capacity will have more apparent effect with the tuning condenser near minimum.) The trimmer on section 2 should now be screwed down. If this causes an increase in volume it should be screwed down until further movement causes a reduction in volume—e.g. "peaked" to the signal. If screwing down this trimmer causes a reduction in volume it should be returned to minimum and the trimmer on section 1 screwed down, and the tuning condenser readjusted to the station. The procedure should now be repeated, and if screwing down the trimmer on section 2 causes a reduction in volume the trimmer on section 1 will have to be screwed down even further.

When it is found that tuning or the adjusting of either trimmer brings no improvement in results the circuits are trimmed correctly.

The switch should now be turned to the medium-wave position and the trimmer on section 3 adjusted for maximum response. If screwing this down gives less volume it will be necessary to screw down both trimmers 1 and 2 and re-gang them until trimmer 3 can also be peaked to the signal.

Finally, as a band-pass characteristic is

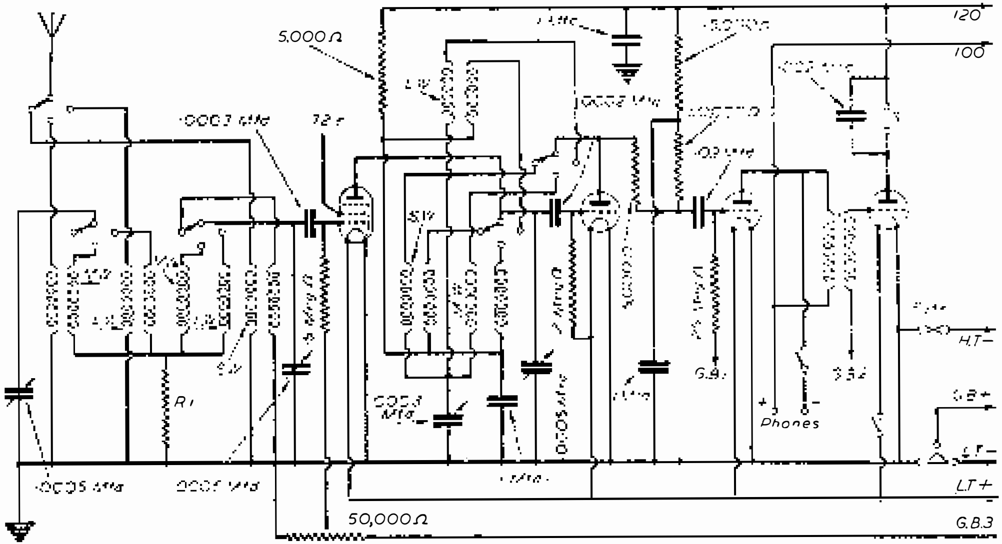


FIG. 132. *Circuit diagram for a band-pass all-wave four-valve receiver.*

List of Components

Resistors: 25,000, 15,000, 50,000, two 5,000 ohm; ·25, ·5 and 2 megohm. Coupling resistor R1.

Condensers: ·0002, ·0003, ·002, ·02 and three 1 μF. ·0003 reaction condenser.

3-gang ·0005 μF. tuning condenser.

5-pole 3-way rotary switch.

50,000 ohm potentiometer.

Double-pole switch.

Four 4-pin valve holders.

Midget "P" type coils: three each for medium and long waves; two for short waves.

L.F. transformer for direct feed (ratio 1 : 3).

Metal chassis.

Stand-off insulator, knobs, etc.

desired trimmer 3 is de-tuned, the amount depending upon the results desired. This will naturally reduce signal strength and if quality is considered satisfactory it may be left dead on tune. In any case the band-pass characteristic should not be obtained by de-tuning sections 1 or 2 or this will cause lack of volume on short waves.

In some cases it may be found that the circuits can be retrimmed upon a different setting of the tuning condenser with advantage. If so, the split end vanes of the condenser should be bent slightly in or out to give the additional capacity when required, opening the condenser each time and bending the section just coming into service opposite the fixed plates of the condenser.

When trimmed upon the short-wave range satisfactory results should be obtained upon the other two ranges. If not, the coils are not properly matched and this could be alleviated by adding a small trimmer to the coils in question.

No value has been specified for R1. Fifty-seven ohms were used in the original set, and the value has a great influence upon the selectivity on medium and long waves. A lower value will give sharper tuning. If less selectivity is required upon long waves a higher value shunted with a condenser should be used. The condenser will have less effect upon the lower frequencies and tighter coupling will result. The value used depends upon results required.

In any case a high value with no condenser must not be used or the first two tuned circuits will not gang with the third.

A Four-Valve Short-Wave Set. The circuit is shown in Fig. 136. There is an untuned H.F. stage with VM volume control, followed by a detector and two low-frequency stages. The H.F. stage is coupled by an H.F. transformer to the detector, this giving good gain with complete stability and reasonable selectivity. Plug-in coils are used so that any desired wave range can be tuned. The penultimate stage is resistance capacity coupled, and followed by a tetrode or pentode driven through a parafeed transformer, so that there is a very useful degree of L.F. gain. The set is amply decoupled, and will be found to be completely stable on all wavelengths with total absence of all undesirable threshold-howl, and similar effects.

The use of an untuned H.F. stage isolates the detector from the aerial with consequent advantages, such as the removal of hand-capacity due to the aerial-earth system, and the avoidance of fading caused by frequency-drift introduced by an aerial swaying in the wind.

A baseboard 12 in. by 9 in. is suitable for the set. A chassis could be used, but is hardly worth while as a very good layout in the detector and L.F. stages is obtained without it. Chassis type valve holders are used, long wood screws and spacing sleeves holding them about ¾ in. above the baseboard. The two variable condensers and potentiometer should first be mounted upon component mounting brackets. The other parts can then be arranged and finally screwed down.

A small stand-off insulator is used for the aerial connection, it being fixed by the H.F. valve and carrying the lead from one side of the pre-set condenser as shown. No speaker terminals are used, two lengths of flex being connected to the plate and screen-grid tags of the output valve.

Wiring should be carried out with a fairly stout gauge of tinned copper wire, and connections run approximately as shown. All the smaller components are suspended in the wiring, and their connections should be direct and short so that they do not tend to move about. It will be noted that the two sockets of the coil holder near the key-way are left blank.

The connections for the transformer will be found marked upon the component. The potentiometer is wired so that upon switching on volume is at a minimum, further rotation increasing volume. If the opposite effect is obtained with the particular component used the G.B. negative and earth connections to the element should be reversed.

Battery connections are made with suitable lengths of flex, and the lead from the transformer should be anchored to the baseboard or there is the danger of pulling the thin flexible wire out of the bobbin of that component.

It will probably be found that the addition of an earth does not make much difference to the results obtained. The aerial should for preference be fairly high and not too long. When suitable valves are inserted the pre-set aerial condenser can be adjusted for best results, and a position about threequarters shut will probably be suitable. The detector should slide smoothly into oscillation, and when

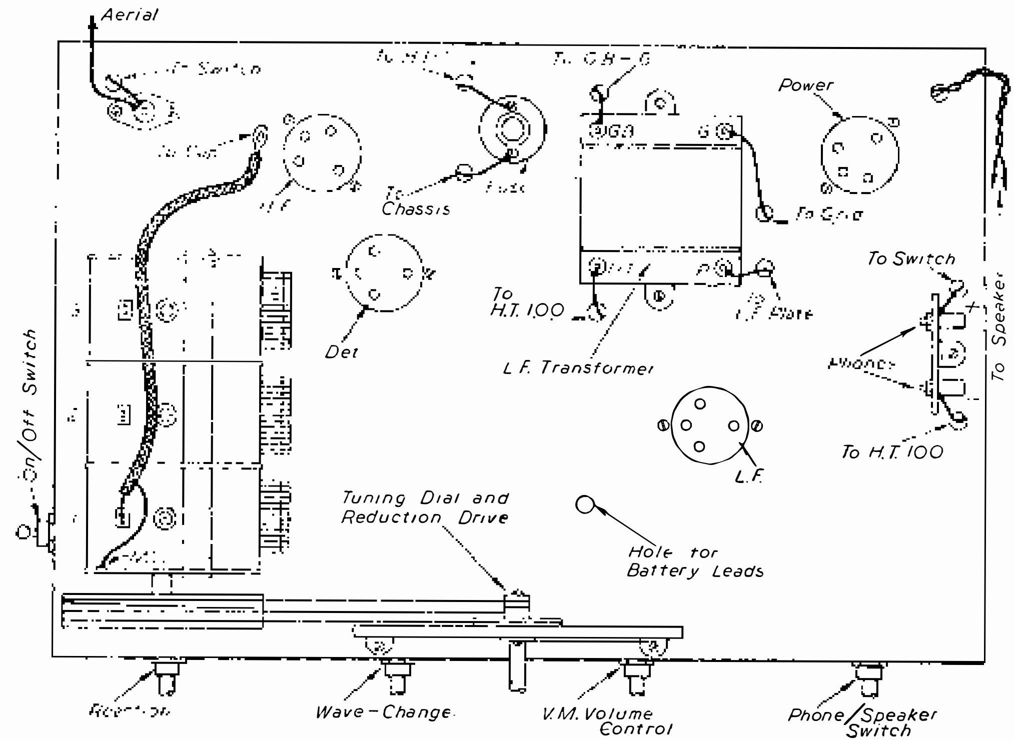
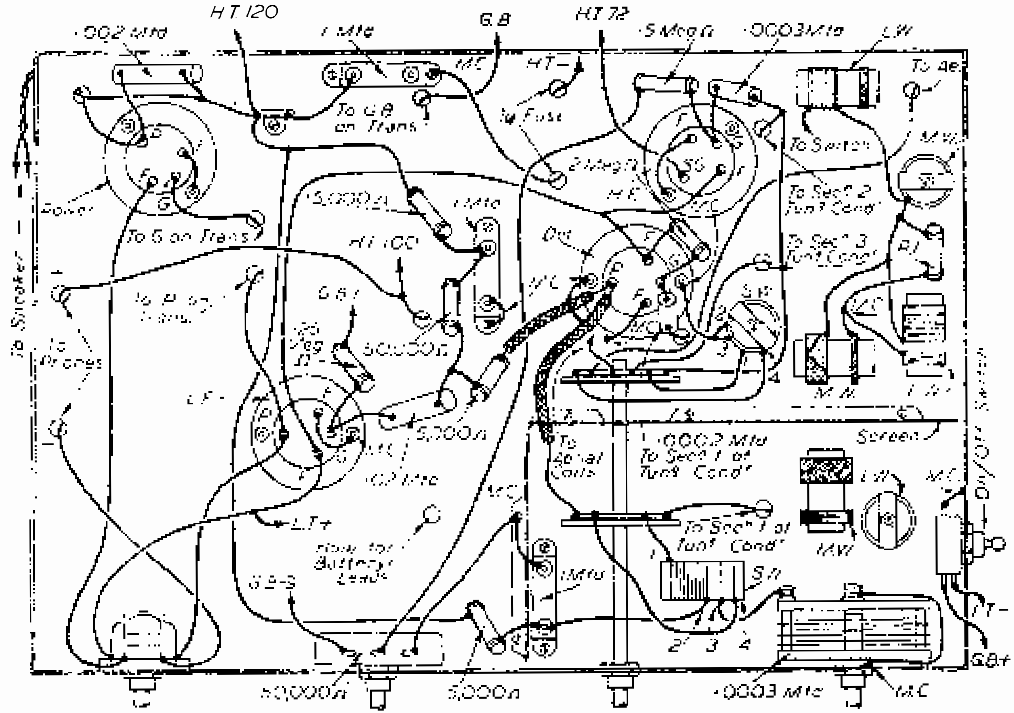


FIG. 133. *Chassis wiring diagram showing position of components.*



NOTE M.C. = Metal Chassis

FIG. 134. *Under-chassis wiring of the receiver.*

listening on congested bands it will be found best to reduce volume with the VM control, compensating for this with increased reaction. If this is done it will be found that the one tuned circuit will give ample selectivity for most conditions.

AMPLIFIER. The circuit of a 12-watt amplifier, shown in Fig. 135, is a comprehensive one capable of delivering sufficient volume for a small hall for dancing purposes, but may be coupled to radio unit for reproducing the wireless programmes. The output stage is of the push-pull type, and the input circuit is

10 fixed condensers: 4 μF. (C8), type 95; two 8 μF. (C4, C7), type 805; 4 μF. (C3), type 812; two 8 μF. (C9, C10), type FT150V; two 25 μF. (C1, C5), type FT25V; ·25 μF. (C6), type 250; ·02 μF. (C2), type 300.

2 L.F. chokes: 50H/25 mA.; 20H/150 mA.

1 mains transformer: 400-0-400V/120 mA.; 4V/2·5A; 4V/2A; 4V/2A; 4V/2A.

5 valve holders: two 5-pin; three 4-pin; with or without terminals.

6 insulated terminals.

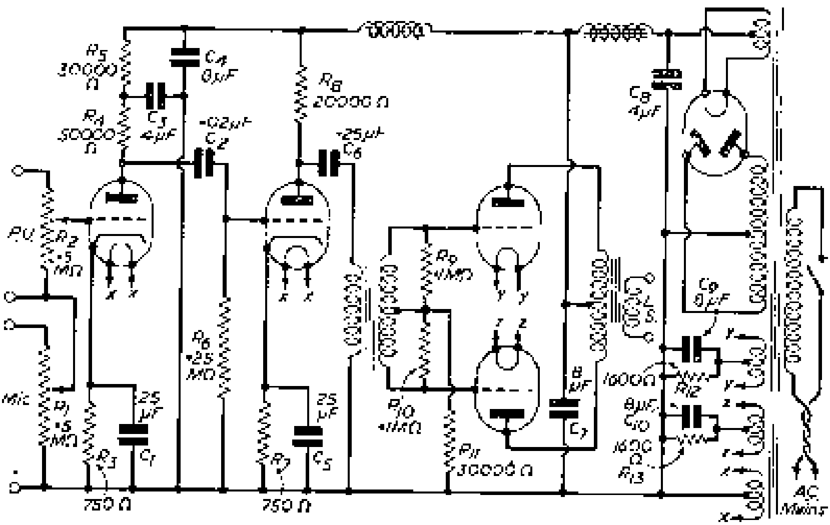


FIG. 135. *Circuit of a 12-watt amplifier.*

split so that the operator may use a microphone and pick-up and fade from one to the other for announcement purposes. The components should preferably be mounted on a rigid metal chassis and precautions should be taken to avoid shocks from the high voltages which are present.

List of Components

1 push-pull input transformer.

2 volume controls—500,000 ohms.

11 fixed resistances: two 100,000 ohms (R9, R10); 250,000 ohms (R6); ½ watt. two 750 ohms (R3, R7); two 30,000 ohms (R5, R11); 50,000 ohms (R4); 1 watt. 20,000 ohms (R8); 3 watts. two 1,600 ohms (R12, R13).

1 on-off switch.

1 fuse plug.

18 in. metal-screened lead.

Connecting wire and screws.

5 valves: MH4 (non-met.); ML4 (non-met.); 2 PX25A; MU14.

Metal chassis.

1 12-watt speaker with separate push-pull output transformer to match two PX25A.

A BATTERY UNIVERSAL AMPLIFIER. This amplifier is called "Universal," as it is so wired that it may be connected to any battery receiver, whether crystal or valve. A glance at the wiring diagram (Fig. 137) will show that no terminal has been provided for the H.T. negative

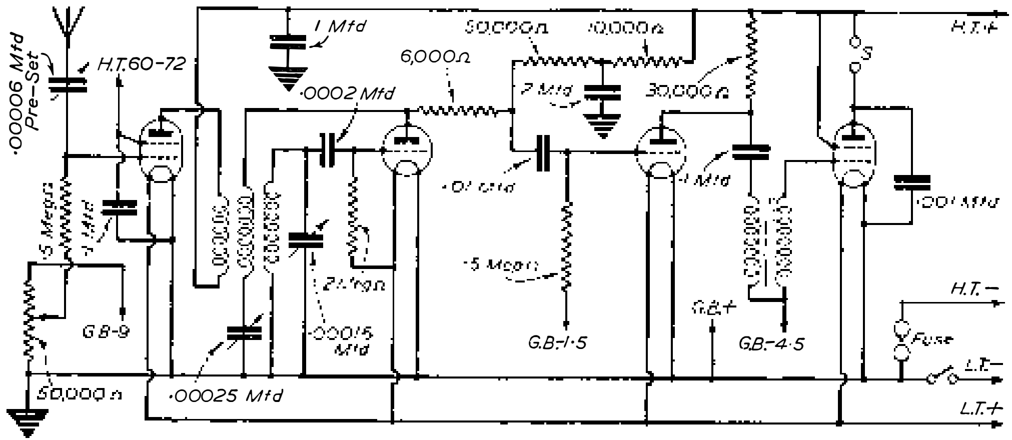


FIG. 136. *Circuit diagram of a four-valve short-wave set.*

List of Components

Three 4-pin and one 5-pin English-type valve holders.
Resistors: 6,000, 10,000, 30,000, 50,000 ohms; two ·5-megohm and one 2-megohm.
50,000 ohm pentiometer with switch.
Parafeed transformer.

Fixed condensers: ·0002, ·001, ·01, two ·1, 1 and 2 μF.
Variable condensers: ·00016 and ·00025 μF short wave; ·00006 μF. stamp-type pre-set.
Fuse and holder.
Three component-mounting brackets.

Premier 6-pin coils for wave ranges desired.
Holders for above.
Ceramic stand-off insulator.
Valves: Cossor 220VPT, 210HF, 210HF, 220HPT, or similar types.
Knobs and reduction drive, etc.

lead, and also that a grid-bias battery is supplied for the amplifier. These two facts are easily explained, however. In any valve receiver the H.T. — wire is connected to one or other of the L.T. terminals, and, therefore, when the two L.T. terminals on this amplifier are joined to the corresponding terminals on the receiver with which the amplifier is used, the H.T. — lead is automatically joined in circuit. The existing receiver may employ a grid battery, but in this case there is not the slightest objection to having a separate battery for the amplifier, especially as a valve will be needed in this case taking a higher value of bias, and then have a ratio of 7 : 1. If used after a single detector valve, the ratio may be 5 : 1; whilst if added to a receiver employing two or more valves, then the ratio should not be more than 3 : 1.

The panel of the amplifier may be constructed from 3-ply or any other wood, although if you wish to match your present set you may employ ebonite. This is an unnecessary expense, however. In the centre of the panel mount the on-and-off switch. The transformer and valve holder are screwed down to the baseboard as shown in the wiring diagram, leaving sufficient space at the right-hand side for two grid-bias batteries side by side. The

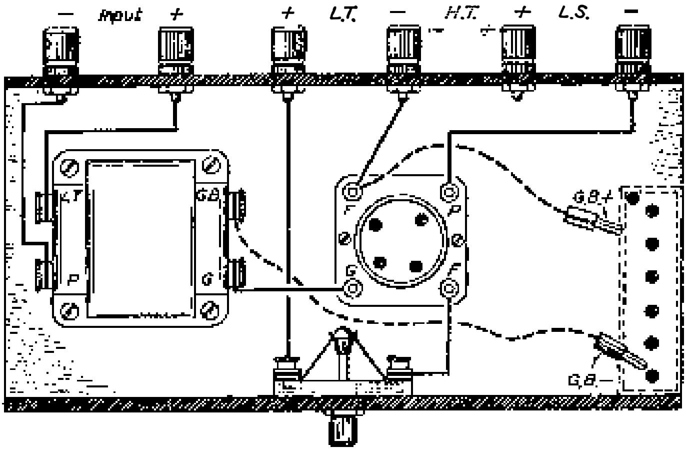


FIG. 137. *A one-valve amplifier.*

two of the 9-volt batteries may be joined in series, and the higher value of bias obtained in this way.

The above remarks apply, of course, only to the use of the amplifier with a valve set. In the case of a crystal receiver being used, the H.T. — lead is joined to the L.T. — terminal, and in addition a lead is taken from this terminal to earth.

So much for the design of the amplifier, and now to deal with its construction, which is of the very simplest, and should cause no trouble, even to the very youngest novice.

The only components are a transformer, valve holder, switch, terminal strip and terminals, wire for wiring-up, grid-bias leads, and wander plugs. The ratio of the transformer will depend on the use to which the amplifier is put. If added to a crystal set, the transformer should terminal strip with the six terminals fitted is then screwed to the rear of the baseboard. Use insulated wire for wiring-up, and take care that the two leads to the primary of the transformer (that is, those lettered P. and H.T.) are connected to the input terminals, so that when these latter are connected to the 'phone terminals of your present set, they will be in the correct direction. For this reason it is preferable to use the type of terminals which have engraved lettering so that no mistake can occur.

The input terminals are then joined to the phone or L.S. terminals of your present receiver, and if this is a valve set, two insulated leads should then be joined from the two L.T. terminals on the amplifier to the corresponding terminals on the set. A separate flexible lead is joined to the L.S. + terminal on the amplifier to an appropriate tapping on the H.T. battery. If added to a crystal set, a separate lead should also be joined to the L.T. — terminal, and this lead should be plugged into the H.T. — tapping. Adjust the grid-bias tapping according to the H.T. value and the valve makers' instructions.

List of Components

1 L.F. transformer; 1 valve holder; 1 on-and-off switch; 6 terminals; Ebonite strip.

CIRCUIT, REJECTOR. (See *Rejector Circuit.*)

CLAMP. To fix at a desired level a given part of each cycle of a periodic electrical variation (without affecting the alternating components).

CLAMPING SWITCH. A thermionic circuit device which while it is in operation imposes a predetermined potential on a point in the circuit.

CLASS A AMPLIFICATION. The method of L.F. amplification where the valves receive the normal values of grid bias. (See also *Amplification*, *Class A-B*, and *Class B*.)

CLASS A-B. The method of L.F. amplification where the voltage applied to the grid is half way between the normal bias and the double value used for Class B working.

CLASS AB1. Class AB operation in which the signal voltage is never great enough to drive the grid positive.

CLASS AB2. Class AB operation in which the signal voltage is great enough to drive the grid positive during some part of the cycle.

CLASS B. A form of push-pull amplification in which two similar valve assemblies are mounted in one glass envelope. The valves are of the type which require no grid bias, and the working point is so arranged that grid current flows. The transformer used to feed this dual valve is of the step-down variety (as compared with the step-up of ordinary L.F. amplification), and the secondary winding has to be of extremely low resistance to avoid distortion due to the grid current. The transformer is called a "driver" transformer, and the valve which feeds it is called the "driver" valve. The output is arranged as in push-pull. (See *Driver Transformer* and *Driver Valve*.)

CLIP. To remove the part of a waveform lying beyond a given limit.

CLOSE COUPLING. The arrangement of two inductances to obtain maximum induced currents.

CLUTTER. Interference on a radar *I.F.F. display* due to unwanted *echoes* or *responses*.

COAXIAL. Term applied to a special cable for television land-line transmission and H.F. work. One conductor is placed inside the other, the outer usually being a screening cover.

CODE. (See *Morse*, *O.S.T.*, *Colour Codes*, and Abbreviations on page ix.)

COERCIVE FORCE. The magnetomotive force required to annul the residual magnetism of a substance.

COHERENT-PULSE TECHNIQUE. The use of recurrent *R.F. pulses* whose R.F. oscillations bear a constant phase relationship to those of a continuous oscillator (real or imaginary), as though the R.F. pulses had been derived from the continuous oscillator by suppressing its output during the intervals between the R.F. pulses.

COHERER. A form of detector in which a non-conducting tube is filled with metallic filings loosely packed. The application of a current to the filings causes them to "pack" or "cohere" and so provide a conducting path.

COIL. An aerial tuning inductance, incorporated so that the circuit will respond or tune to various frequencies. (See also *Chokes*, *High-frequency Chokes Intermediate-frequency Transformers*, a companion volume, *"Coils, Chokes, and Transformers, and How to Make Them,"* and *Tuning Coils*. For Formulæ, see *Inductance*.)

Making a Dual Range Coil. Materials Required: One cardboard former, 4½ in. by 2½ in., 2 oz. No. 30 enamelled wire. Seven terminals (any type, bell or telephone). One small roll insulating tape. One piece of wood 3¼ in. by 3¼ in. by about ⅜ in. thick. Two strips of wood 2⅜ in. by 1 in. by about ¼ in. thick. Two strips of ebonite 3¼ in. by 1 in. up to ¼ in. thick. One doz. small brass wood screws (about ⅜ in. long). One ¼ in. wood screw (for screwing coil to base).

The coil shown in Fig. 138 has been specially designed for easy construction. It is a "General Purpose" one, and can be used in circuits ranging from a crystal set to screened grid.

The coil is "pile wound," which makes for easier winding, and saves the tedious method of layer winding.

In "pile winding" the wire is simply wound on anyhow (the turns on top of each other), in the slots or spaces on the coil, and the whole winding can be done in a quarter of an hour by this method.

The reaction winding has been placed between the short- and long-wave windings, and this gives far more even results in both wave bands. The reaction is also provided with a tapping (a most useful feature not found on manufactured coils), which is a proved success, and provides a simple method of adjustment.

To start the Former. This is wound with five windings of insulating or electricians' tape. These "windings" are $\frac{1}{4}$ in. apart; about four layers of tape to each "winding" will suffice to form the "slots" or spaces for the wire to be wound in.

The insulating tape should be doubled as it is wound on, as shown in Fig. 139. This operation, although sounding tedious, actually only takes a few minutes. The reel of wire is then taken and slipped over a long nail (Fig. 140), which is clamped in a vice or nailed on the table top, and the

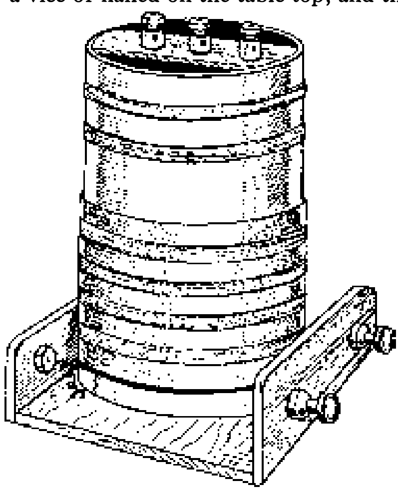


FIG. 138. *The completed coil.*

winding is commenced. Drill two small holes in the first slot (bottom slot), thread the wire through several times to secure it, and leave about 6 in. of wire inside of the former for connecting up. Wind fifty turns in the first slot, then cross over and continue winding in second slot, cross over again from second slot to the third slot, thus winding fifty turns in each slot, making a total of 150 turns on the *long-wave* winding (Fig. 144). Drill two more holes and secure coil end as before. The easiest way is to count ten turns and then jot it down with a pencil, then wind ten more, and so on. No mistake or miscount is then made, and one can complete the *whole* of the windings in a few minutes.

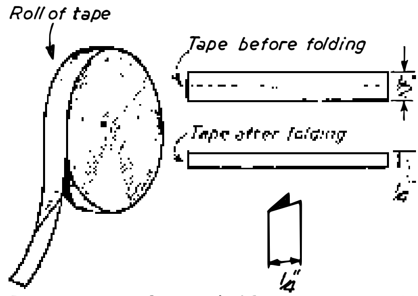


FIG. 139. *How the tape is folded over before being wound on the former.*

The short-wave windings are not wound in slots owing to the small amount of wire used, but be careful that these windings are wound on fairly tight to prevent them "springing" after completion.

Holes are drilled in the former for all the winding ends, and these are pushed *inside* the former.

The Wooden Strips. To connect up, these ends are brought down *inside* the former, to their respective terminals, taking care that the different ends do not touch.

The two wooden strips are next cut to size (Figs. 141 and 142), and holes are drilled in them ready for fixing to the coil ends. One strip is used for fixing the coil to the base (Fig. 143), and the others as the reaction terminal strip (Fig. 145). Before fixing this, connect up the reaction windings (Fig. 146) and terminals to the strip, for if the strip (top) is fixed *before* connecting up, difficulty will be expericed in reaching the windings from the inside of the coil. The base is now made, and the ebonite terminal strips (Fig. 147) are cut to size and fixed—this is really a simple job, and the sketches should make everything quite clear. The actual connections are shown in Fig. 148, and the theoretical circuit and practical wiring diagrams are given in Figs. 149 and 150, so that no further explanation is necessary.

Points to Watch. Do not forget to test the coil before fitting it to the set. This test is for continuity, and is quite simple, as a break which is not discovered until after the coil is installed in a set may lead to endless trouble in searching for a fault in the remainder of the circuit. Connect up as Fig. 150 first using the two *outer* terminals on the reaction coil. If reaction is too fierce reduce the high tension on your first valve (detector) to as low as 30 volts if necessary. If this fails, connect to the middle terminal on the reaction coil as shown in Fig. 149, but be careful to adjust with only *one* wire at a time, *preferably* the one leading to the plate and H.F. choke, leaving the wire on R.2 (which leads to reaction condenser) severely alone.

Making 465 *Kc/s I.F. Transformers.* A

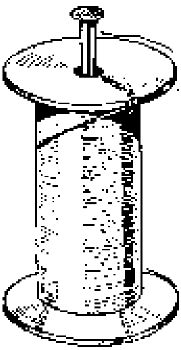


FIG. 140. *A nail driven in the bench to hold the reel while the wire is wound on the coil.*

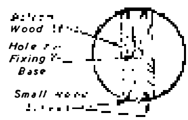


FIG. 141. *The bottom wooden strip.*

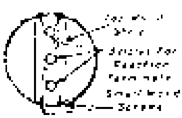


FIG. 142. *The top wooden strip.*

transformer to tune to 465 kc/s—which approximates to an equivalent wavelength of 650 metres—can be made by using 120 turns of 36-gauge d.c.c. or enamelled wire for primary and for secondary. This is the total number of turns on each former, although they are split up into sections to minimise self-capacity.

The transformer can be used as shown in the circuit in Fig. 151 by connecting a ·0003-μF. pre-set condenser across each winding for trimming purposes. It is better to employ one of the new types of trimmer on steatite or similar bases.

By following the form of construction

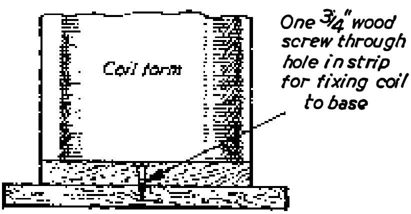


FIG. 143. *The coil fixed to the base.*

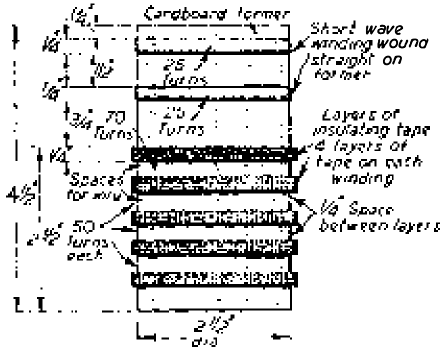


FIG. 144. *The main details of the coil.*

shown in Fig. 154 it is possible to alter the coupling between primary and secondary, and thus to vary the band-width covered; in other words, to obtain variable selectivity. The only objection is that the selectivity cannot be varied by means of an external control, and is therefore only pre-set, being adjustable only after removing the screening can and probing inside the set.

There are various methods of providing

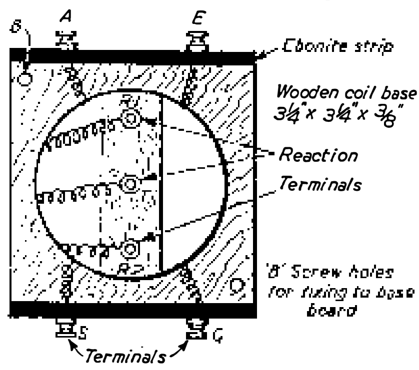


FIG. 145. *A top view of the coil.*

an external adjustment, one of the simplest being by using a ·0001-μF. variable condenser to provide "top-capacity" band-pass coupling. It is wired between the high-potential ends of the windings, as shown in Fig. 152 between the anode terminal of the primary and the grid terminal of the secondary. When using this system, the I.F. transformer should be mounted near to the panel control, so that the extremely short leads can be used between the condenser and the transformer.

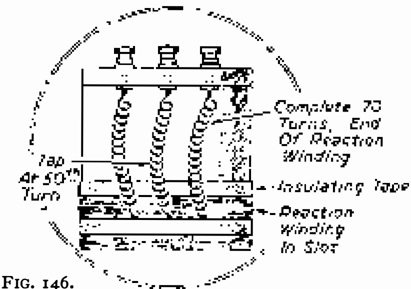


FIG. 146. *Details of the reaction.*

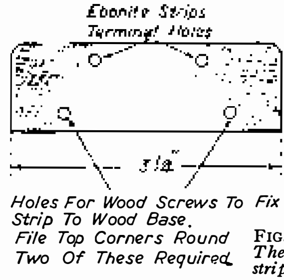


FIG. 147. *The ebonite strip.*

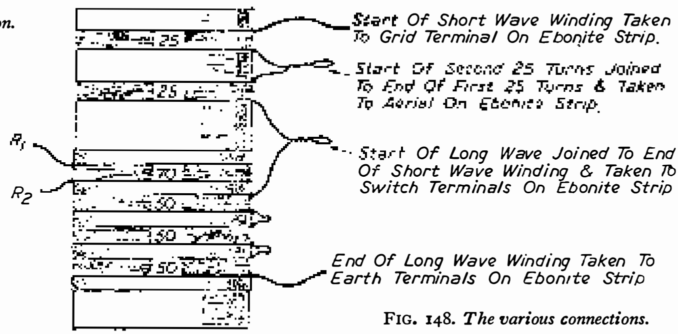


FIG. 148. *The various connections.*

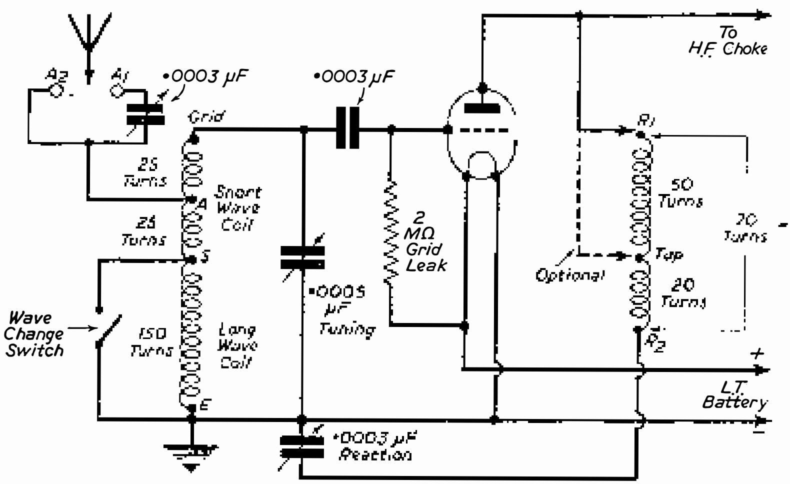


FIG. 149. *A circuit diagram showing the coil fitted in the set.*

COIL-WINDING

(LONG-WAVE COILS)

Diameter of Former	Inductance 1,600 Microhenrys			Inductance 2,100 Microhenrys			Inductance 3,000 Microhenrys		
	No. of Slots	Wire	Turns per Slot	No. of Slots	Wire	Turns per Slot	No. of Slots	Wire	Turns per Slot
1 in.	4	36 enam.	80	4	36 enam.	92	5	38 D.S.C.	95
	5	36 D.S.C.	69	5	36 enam.	80	6	36 enam.	85
1½ in.	3	36 D.S.C.	71	3	36 enam.	81	3	36 enam.	92
	4	36 D.S.C.	57	4	36 D.S.C.	65	4	36 enam.	78
	5	34 D.S.C.	53	5	34 enam.	60	5	36 D.S.C.	72
2 in.	3	34 enam. or 36 D.S.C.	56	3	36 D.S.C.	65	3	36 enam.	77
	4	34 D.S.C.	45	4	34 D.S.C.	51	4	36 D.S.C.	61
	5	34 D.S.C.	38	5	34 D.S.C.	44	5	34 enam. or 36 D.S.C.	53

(MEDIUM-WAVE COILS)

Diameter of Former	Inductance 175 Microhenrys			Inductance 200 Microhenrys			Inductance 230 Microhenrys		
	Wire	Turns	Length in inches	Wire	Turns	Length in inches	Wire	Turns	Length in inches
1¼ in	32 enam.	84	1·01	32 enam.	93	1·11	30 D.S.C.	115	1·71
	30 D.S.C.	93	1·38	30 D.S.C.	102	1·52	32 enam.	102	1·22
1½ in	30 D.S.C.	74	[illegible]	30 D.S.C.	82	1·22	30 D.S.C.	90	1·34
	28 D.C.C.	94	2·24						
1¾ in	30 D.S.C.	63	0·91	30 D.S.C.	68	1·01	30 D.S.C.	76	1·13
	28 D.S.C.	67	1·16	28 D.S.C.	73	1·26	28 D.S.C.	80	1·38
2 in.	30 D.S.C.	54	0·805	30 D.S.C.	59	0·88	30 D.S.C.	65	0·97
	28 D.S.C	58	1·01	28 D.S.C.	64	1·13	28 D.S.C.	70	1·24
2¼ in.	26 D.C.C.	70	1·66	26 D.C.C.	78	2·18	26 D.C.C.	86	2·40
	28 D.S.C.	52	0·925	28 D.S.C.	57	1·01	28 D.S.C.	62	1·10
	24 D.C.C.	65	2·08	24 D.C.C.	72	2·30	24 D.C.C.	80	2·56
2½ in.	28 D.S.C.	47	0·835	28 D.S.C.	51	0·91	28 D.S.C.	56	1·0
	24 D.C.C.	58	1·85	24 D.C.C.	64	2·04	24 D.C.C.	70	2·24
3 in.	26 D.S.C.	41	0·86	26 D.S.C.	45	0·95	26 D.S.C.	49	1·03
	22 D.C.C.	50	1·90	22 D.C.C.	55	2·09	22 D.C.C.	61	2·32

Still further to assist in eliminating unwanted "pick-up" and coupling, it is often an advantage to screen the leads. With the arrangement described, preliminary adjustment can be made by varying the distance between the two coils, the variable condenser being used only when the set is tuned to a signal. In general, it will be found that the coils must be well separated, for otherwise the coupling will be too great.

Another arrangement is to mount the two coils so that one of them can be rotated. The idea is shown in Fig. 153. Another system is to place a third coil (which is not connected to any part of the circuit) between the primary and secondary windings. The form of construction referred to is illustrated in Fig. 155. Each winding is divided into three sections ⅛ in. apart, and there is a space of 1 in. between primary and secondary. In this space are wound fifty turns of 36-gauge enamelled wire, the ends of the winding being connected to two terminals of a variable resistance, having a value of about 2,500 ohms—the exact resistance is not very critical.

When the resistance is set to its maximum value, the coil provides a fair degree of coupling between primary and secondary, but when it is moved to zero the coupling is appreciably reduced. Thus the degree of selectivity is increased, as is required when listening to distant stations or when interference is experienced. Experiment with different sizes of coupling winding.

It will be understood that with any of the forms of I.F. transformer described it is necessary to include the ·0003-μF. pre-set condensers in parallel with the two windings for trimming purposes.

Oscillator Coils. In making an oscillator coil for use in conjunction with these 465 kc/s I.F. coils, it will be necessary to understand the principal difference between an oscillator coil and one used for tuning to the signal frequency. An aerial coil has to cover the wavelength ranges (very approximately), 200 to 600 metres, and 900 to 2,000 metres. The corresponding frequency ranges are, roughly,

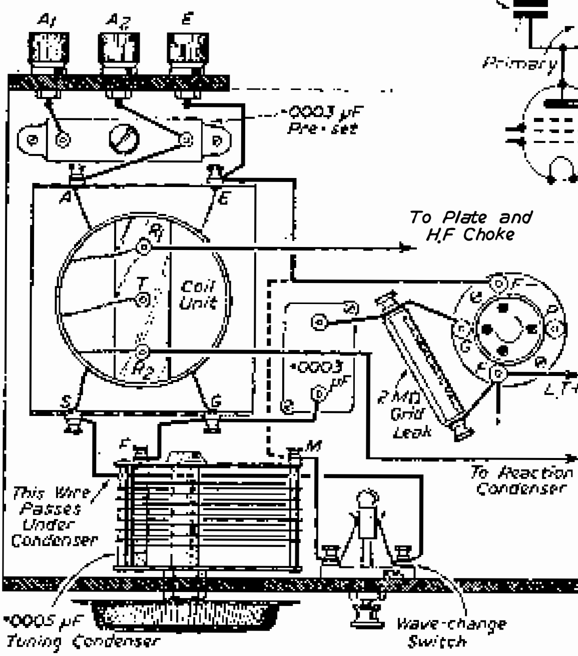


FIG. 150. *How the coil is fitted in the set.*

1,500 kc/s to 500 kc/s and 333 kc/s to 150 kc/s, and these are quite different from the tuning ranges which must be covered by the oscillator coil. The ranges of the latter, in kilocycles per second, are 1,965 to 965, and 798 to 615 (the original figures, plus 465). This is for a superhet using the now general intermediate frequency of 465 kc/s.

The ratios between maximum and minimum for the two ranges are also different. For example, whereas the ratio between maximum and minimum frequencies covered by the aerial circuit on short waves is 3 : 1, the corresponding ratio in the case of the oscillator circuit is only about 2 : 1. On long waves there is still greater divergence, for the aerial circuit frequency ratio is about 2⅛ : 1, and the oscillator ratio is about 1¼ : 1.

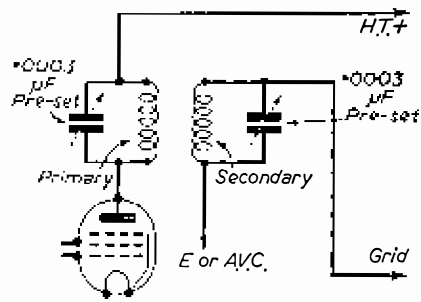


FIG. 151. *In this H.F. transformer coupling between the two windings is carried out inductively.*

Considered in another way, the wavelength ranges of the oscillator coil approximate to 150 metres to 310 metres, and 375 metres to 500 metres. This means that the oscillator coil requires to have fewer turns of wire than the signal-frequency coil. On medium waves the oscillator coil requires about three-quarters of the number of turns used for the standard coil, and on long waves less than half the number of turns is required. Thus, if the aerial coil is wound on a 1-in. diameter paxolin former, the numbers of turns for the two windings are about 100 and 300; the corresponding oscillator coil requires about 75 and 150 turns.

A typical frequency-changer circuit using a pentagrid valve is shown in Fig. 156. In the figures given above an approximate allowance has been made for the maximum frequency (minimum wavelength) difference, but we have still to compensate for the difference in ratio of the coverages.

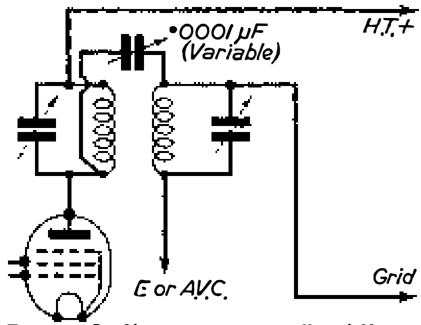


FIG. 152. *In this arrangement a small variable condenser provides the coupling and thus the selectivity may be varied.*

This is done in part by the specially shaped vanes of the oscillator section of the 465 kc/s superhet tuning condenser, but further compensation must be provided by use of a padding and tracking condenser (C.3 and C.4 in Fig. 158). These two condensers are of the pre-set type, and should have maximum capacities of ·00016 μF. and ·0003 μF.

Using the number of turns mentioned above, the reaction winding should have about 100 turns, these being arranged as shown in Fig. 157. The complete coil should be screened.

The position is less complicated when the oscillator coil is intended for use in a set with 110 kc/s intermediate frequency, for the frequency and frequency-ratio variations are then much less. Thus, if the aerial tuning circuit covers the range 1,500 kc/s to 500 kc/s and 333 kc/s to 150 kc/s, the corresponding oscillator frequencies are 1,610 kc/s to 610 kc/s and 443 kc/s to 260 kc/s; these ranges are equivalent to wavelength variations of approximately 160 metres to 500 metres, and 600 metres to 1,150 metres. Thus the approximate numbers of turns on a 1-in. diameter former would be 85 and 240; the reaction winding should have about 120 turns in all.

The circuit for a 110-kc/s frequency changer is given in Fig. 158, a pentagrid

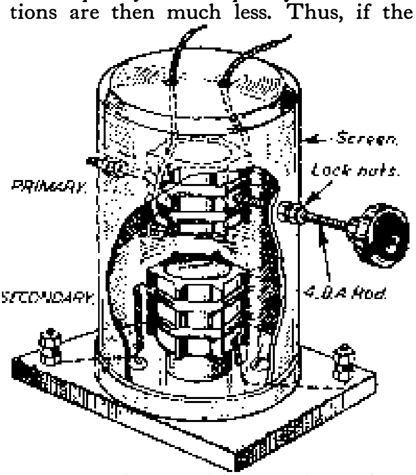


FIG 153. *Variable selectivity is carried out in this I.F. transformer by rotating one of the windings.*

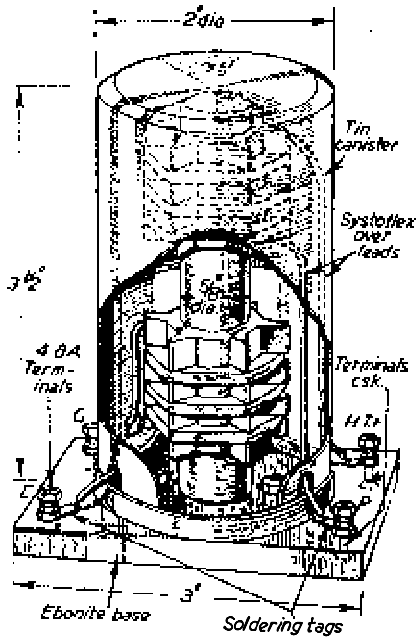


FIG. 154. *A simple form of I.F. transformer in which variable coupling can be introduced.*

again being used. The special superhet (110 kc/s type, of course) tuning condenser provides the correct tracking, but a long-wave pre-set padding condenser of ·002 μF. is required to compensate for the different frequency ratio. This is short-circuited by the wave-change switch on medium waves, but is actually in series with the oscillator section of the tuning condenser on long waves. Its effect is to reduce the maximum resonant wavelength when the tuning condenser approaches its maximum capacity, but it

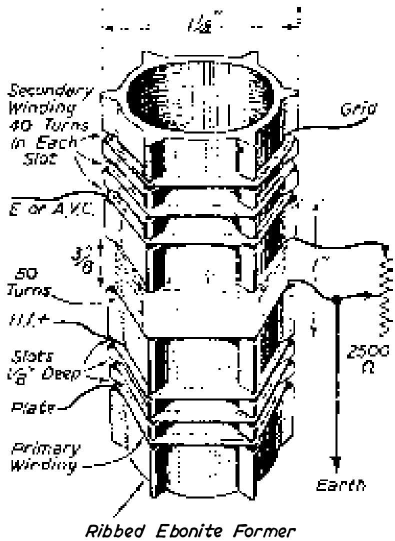


FIG. 155. *A third winding is used in this I.F. transformer to control the degree of selectivity.*

has a negligible effect on low settings; the ·0003-μF. padding condenser used in the 465 kc/s I.F. circuit has a similar function. It should be mentioned that although a single-circuit aerial tuner is shown in Fig. 158 for simplicity, a band-pass filter is a practical essential when using 110 kc/s I.F. If it were not used, there would probably be a good deal of second-channel interference. Even when using

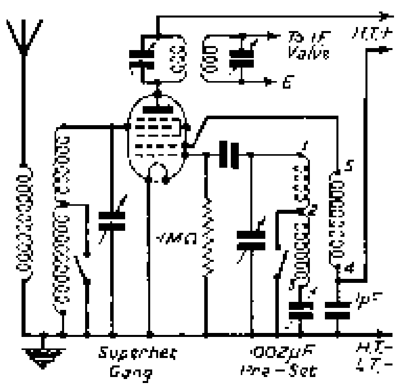


FIG. 156. *Theoretical circuit of the frequency-changing stage of a superhet receiver.*

465 kc/s, a band-pass circuit is desirable, but not quite as important, since second-channel troubles are less severe.

When experimenting with the home-made oscillator coils, it is essential to deal with each wavelength separately. First turn to medium waves and, with the condenser set to tune to a wavelength of the local station, try the effect of setting the trimmers. If it is found that what appears to be accurate tuning can be obtained when neither trimmer is at its maximum or minimum capacity, it can be assumed that the windings are reasonably correct. On the other hand, if one of the condensers can be turned to its full capacity, it will be an indication that the oscillator coil needs to be modified. Thus, if the trimmer of the oscillator section is "full

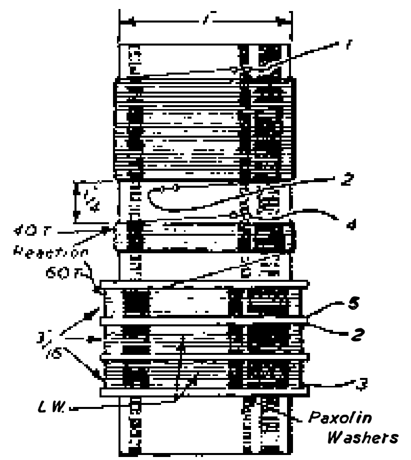


FIG. 157. *Constructional details of an efficient oscillator coil.*

in," additional turns must be used on the medium-wave section of the coil; if the trimmer of the aerial section is "full-in"—or if the oscillator one is "full-out"—a few turns must be removed. A rough guide to the extent of the discrepancy can be obtained by connecting a ·0001-μF. variable condenser in parallel with the condenser section, whose trimmer is screwed right down. Should this condenser require to be set to more than half its total capacity, a start can be made by removing about five turns.

The same general method of procedure can be adopted on long waves, after setting the padding and tracking condensers to various positions in order to note their effect. After obtaining a "balance" when the set is tuned to the powerful local station, it should be tuned to another and the tests repeated.

Coils for modern receivers are of very small dimensions and are often combined to provide a multi-range tuner, the necessary switch being included in the coil assembly. A set of coils may be made up for either the straight or the superhet type of circuit, and the following data gives instructions for coils to cover ranges

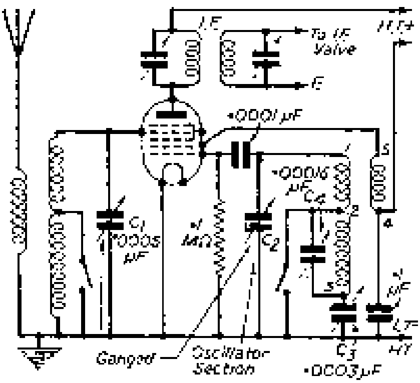


FIG. 158. *Similar arrangement to that shown in* FIG. 157, *but more efficient tracking is obtained due to the padding condenser across a section of the coil.*

from 12 to 2,000 metres: The coils should be wound on standard paxolin formers ½ in. in diameter and 2 in. long. Short lengths of tinned copper wire, about 21 S.W.G., should be twisted through holes at one end to act as anchoring points whilst a short length of ⅛ in. by $\frac{1}{16}$ in. brass strip should be inserted across the other end for fixing purposes. It should be drilled at the centre and taped 4 B.A.

Coils 1 and 2 should have the windings "pile wound," that is heaped up, to occupy approximately ½ in. space on the former. The other coils should have the turns spaced roughly one diameter of the thick wire, and the primary is interwound in betweeen the turns at the earth end of the coils.

Design Formulæ. Designers of coils have recourse to various formulæ from which to compute constants, though many are involved and are dependent on form factors from other formulæ. Nomographs, charts, tables, etc. are also used, the charts being devised with the assumption that if any two values of the required constants be known, the third aligns itself with it by aid of a ruler, on the requisite vertical scale (see page 103). Nevertheless, some knowledge of the relatively simple methods applied mathematically to coil design is necessary if one is to thoroughly understand the work, a very easy formula for this purpose being one where L (in microhenrys) $=(0{\cdot}2A^2N^2)/(3A + 9B)$, letting A = coil length in inches, from which, of course, the inductance value is got. Progressing: $L3A + 9BL = 0{\cdot}2A^2N^2$, so that N can equal

$$\sqrt{L\left(\frac{3A + 9B}{0{\cdot}2A^2}\right)}$$

B can equal $3AL + 9BL = 0{\cdot}2A^2N^2$, and $9BL = 0{\cdot}2A^2N^2 - 3AL$, or $B = (0{\cdot}2A^2N^2 - 3AL)/9L$, or

$$B = \frac{A\,(0{\cdot}2AN^2 - 3L)}{9L}.$$

The number of turns per inch to which suitable gauges of wire will wind on a coil former is also available from wire manufacturers' tables, turn numbers usually being halved if coils are to be space wound.

Physical Considerations. Coil self-capacity is reducible if the winding turns are spaced, though little benefit is derived by doing so if the spacing is in excess of the wire diameter used. Coils to operate on very high frequencies are, in general, wound with well-spaced turns, while

COIL-WINDING DATA

Diameter of Former	*Medium-wave Winding*		*Long-wave Winding Number of Turns 36's gauge Enamelled Wire*	*Reaction 36's gauge Enamelled Wire*
	Gauge of Enamelled Wire	*Number of Turns*		
3 in.	28	40	130	45
2½ in.	28	50	150	60
2 in.	[illegible]	58	174	75
1½ in.	34	80	220	84
1¼ in.	36	86	240	90

those for the usual broadcast bands are close-wound. Former sizes nowadays have become a standard 1- or 1·5-in. tubes of presspahn, $\frac{1}{16}$ in. thick. Ultra short-wave coils are usually wound from stout gauges of wire, bare to have them self-supporting—without former. Winding lengths and former diameters are, if possible, made equal.

Broadcast band coils may be met with, with cores of iron dust and an insulating compound mixed, the permeability help-

available for publication in reference to their physical make-up or electrical constants.

The checking of inductance against capacity must include provision for all strays. For example, with a tuning minimum of 18 $\mu\mu$F. and estimated strays of a similar value, the minimum design range should be 36 $\mu\mu$F. and this same figure allowed for in maximum coverage as well. Stray capacities have little effect on mid-frequency peaks of resonance—

H.F. TRANSFORMERS

	PRIMARY (*Aerial or Anode*)	*SECONDARY* (*Grid*)	*Space between windings*
COIL 1 650-2,000 metres	200 (34 S.W.G.)	450 (34 S.W.G.)	$\frac{1}{8}$ in.
COIL 2 200-600 metres	120 (34 S.W.G.)	250 (30 S.W.G.)	$\frac{1}{8}$ in.
COIL 3 30-100 metres	11 (34 S.W.G.)	30 (24 S.W.G.)	Interwound
COIL 4 15-45 metres	7 (34 S.W.G.)	14 (24 S.W.G.)	Interwound

OSCILLATOR COILS

COIL 1	80 (34 S.W.G.)	187 (32 S.W.G.)	$\frac{1}{8}$ in.
COIL 2	40 (34 S.W.G.)	87 (28 S.W.G.)	$\frac{1}{8}$ in.
COIL 3	13 (34 S.W.G.)	28 (24 S.W.G.)	Interwound
COIL 4	7 (34 S.W.G.)	13 (24 S.W.G.)	Interwound

ing to attain a satisfactory high Q factor. Such cores are not usually seen in short-wave coils, though experiments in this direction or respect have recently been undertaken and encouraging results obtained. At this time, however, little is

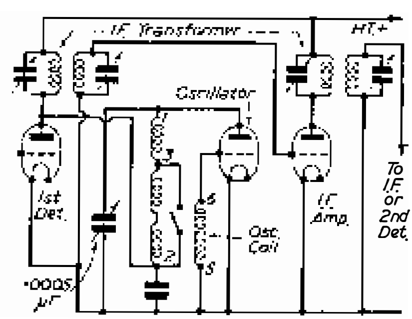


FIG. 159. *Connections for an oscillator coil in a standard circuit.*

broadcast operational bands, but must be well considered in the design of short-wave coils, 30 $\mu\mu$F. being an average allowance. With, say, acorn-types of valve, and ultra-short-wave design in hand, allowances for strays may be reduced to around $\mu\mu$F.

An Example of Design Calculation. Assume that a coil is wanted wound on a 1- and $\frac{1}{2}$-in. former, $\frac{1}{2}$ in. in length, to be used with a 35 $\mu\mu$F. variable condenser to tune to 4,500 kilocycles. The inductance can, if necessary, be got from a chart, and can be noted as 35 microhenrys. Checking by calculation: $f^2 = 1/(4\pi^2 f^2 C)$, letting $\pi = 3{\cdot}14$, C = capacity in farads, f = frequency in c.p.s.; L = inductance in henrys; π^2 can arbitrarily be taken to equal 10:

$$L = \frac{1}{40 \times (4{\cdot}5)^2 \times 10^{12} \times (35 \cdot 10^{-12})} \text{ or}$$

$$L = \frac{1}{40 \times (4{\cdot}5)^2 \times 35}$$

By recourse to logarithms, resolving can be shown as:

No.	log.	No.	log.
4·5	0·6532	1	0·0000
4·5	0·6532		
40·0	1·6021		
35·0	1·5441		
	$\bar{4}$·4526		

Therefore 0·0000

$\bar{4}$·4526

$\bar{5}$·5474 = 0·00003527
= 35·27 microhenrys

Next, from formulæ, L (in microhenrys)

$$= \frac{0{\cdot}2A^2N^2}{3A + 9B},$$

A = coil diameter in inches,
N = the number of turns wanted,
B = the length of the winding in inches.

So that $3AL + 9BL = 0{\cdot}2A^2N^2$, and $N^2 = (3AL + 9BL)/0{\cdot}2A^2$.

$$\text{Therefore } N = \sqrt{L\left(\frac{3A + 9B}{0{\cdot}2A^2}\right)}$$

Substituting figures:

$$N = \sqrt{35{\cdot}27\left(\frac{4{\cdot}5 + 4{\cdot}5}{0{\cdot}2(1{\cdot}5)^2}\right)} - \frac{9}{0{\cdot}450} = 20$$

or 900 ÷ 45

$$= 20 \times 35{\cdot}27 = \sqrt{705{\cdot}4}$$

By logs: No.	log.
705·4	2|2·8484
26·56	1·4242

Therefore N = 26·6, the number of turns required.

For a medium-wave coil designed to resonate between 200 and 600 metres shunted with a 500 $\mu\mu$F. condenser, the following constants are good approximations: Allowance for strays, 60 $\mu\mu$F. Minimum to maximum capacitance allowance being thus 60 to 560 $\mu\mu$F. Inductance value, 185 microhenrys. Former 1·5 in. diameter. Length of winding, 1·05 in. Turns 76 of No. 30 S.W.G. enamelled wire, close wound.

Shielding. Shielding with small diameter covers lowers the effective Q of encased coils, as also does shunting a high Q coil with a low-resistance diode detector valve, and while formulæ are available for the computation of designs to function beneath covers, in all reality, shield cans should be of such dimensions that coil Q is the same with the shield on or off. Such a condition is, of course, not always possible to secure, though it is decidedly one to be striven for. Finally, it is worthy of note to state that the most carefully computed and well-planned design may need practical "cut and try" adjustments before being finally passed on for multiple production.

COINCIDENCE VALVE. A valve which is operative only while two signal voltages, derived from two independent circuits, are applied simultaneously and separately to two separate electrodes.

COINCIDENT TRANSPONDER. A *transponder* which operates only if it is excited by simultaneous signals from an *interrogator* and another *transmitter* associated therewith.

COLD IMPEDANCE. The impedance (capacitance) between the electrodes of a valve when the cathode is not heated.

COLD VALVE. This name is a misnomer and is used in reference to a special type of high-frequency metal rectifier. It consists essentially of the same elements as the metal rectifier used for changing alternating electric current into D.C., but it is designed to have a particularly low self-capacity. This cold valve, or H.F. metal rectifier, can be used in place of the detector valve in superheterodyne receivers, and can also be employed in various ways to provide A.V.C. Another use is as an "economiser" of H.T. current in conjunction with large battery-operated power valves. (See also *Electron Multiplier.*)

COLOUR CODES, STANDARD. The colour codes for fixed condensers and fixed resistors are identical, the standard for resistors being ohms and for fixed condensers $\mu\mu$F. (Picafarads).

The details given below form the standard method of indicating resistance and tolerance values as published by the Radio Manufacturers' Association.

General. The nominal resistance values of fixed resistors and the tolerance on these values, expressed in ohms, may be indicated thereon either by numerical marking or by means of colours or by a combination of both methods.

Standard Colours. When colours are so used, they shall have the significance shown in the table, and shall as closely as possible conform to the shade therein specified by reference to British Standard Specification No. 381C—1931.

Methods of Marking.—Two alternative methods of marking shall be standard:

(i) The body, end and dot (or band) method.

(ii) The four band method.

Colour A. (Body colour or first band

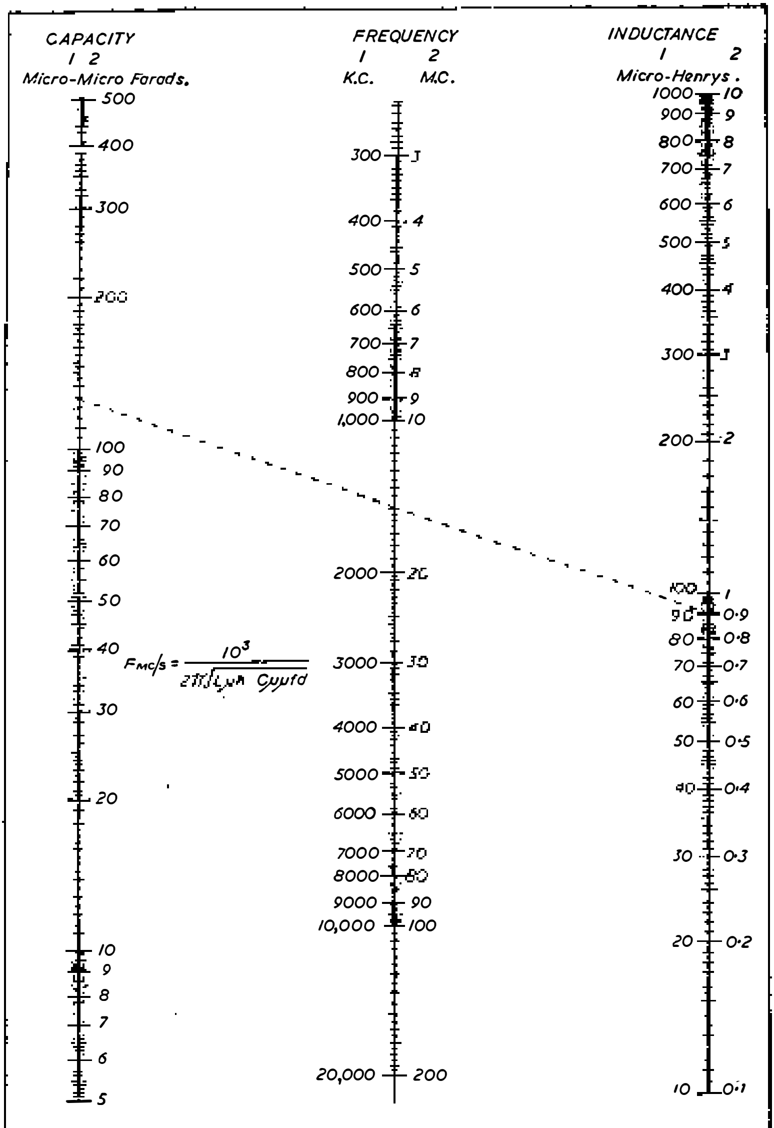


FIG. 160. *Nomogram showing the capacity and inductance needed to tune to a defined frequency or set of frequencies. A ruler lined across any two known shows the unknown on the remaining scale. The dotted line illustrates that a condenser of* 125 *μμF. will tune to* 15 *megacycles with an inductance of* 0·0904 *microhenry. See text, on 2nd column, page* 100.

colour) shall indicate the first significant figure of the resistance.

Colour B. (End colour or second band colour) shall indicate the second significant figure of the resistance.

Colour C. (Dot or band colour on body, or third band colour) shall indicate the decimal multiplier applicable to the two significant figures to give the resistance value.

Colour D. (Narrow end colour or fourth band colour) shall indicate the percentage tolerance.

Note. The four colour bands of method (ii) may touch each other or be slightly separated as desired.

Note. A band or dot of colour to designate the *tolerance* only of the resistance value may be applied if desired to a resistor that has the value of its resistance indicated by a numerical marking.

The order of reading these colours is:

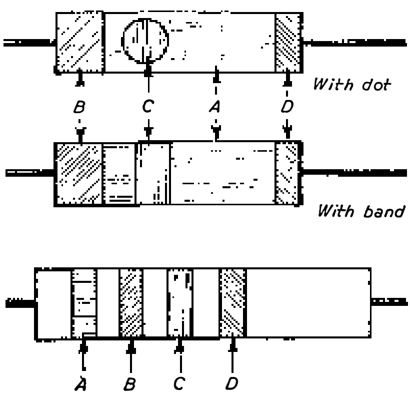


FIG. 161. *Colour code diagram.*

Body, Tip, Dot.

Example: Resistance with red body, black tip and orange spot will have value of 20,000 ohms. If there is no dot on the body it indicates that it is of the same colour as the body.

Multiple Condenser Blocks

The highest capacity positive voltage		Red
The second highest	do.	Yellow
The third highest	do.	Green
The fourth highest	do.	Blue
The fifth highest	do.	Violet
Principal negative connection		Black
Second	do.	Brown
Third	do.	Grey
Centre connection for voltage doubler condensers		White

Where only two leads are used, positive is red and negative black.

Fuses

60 mA.	Black	1 amp.	Dark Blue
100 mA.	Grey	$1\frac{1}{2}$ amp.	Light Blue
150 mA.	Red	2 amp.	Purple
250 mA.	Brown	3 amp.	White
500 mA.	Yellow	5 amp.	Black and White
750 mA	Green		

Mains Transformer Data

Primary zero	Black
Primary 10 volts	Black and Green
Primary 210 volts	Black and Yellow
Primary 230 volts	Black and Red
Primary 250 volts	Black and Brown
Secondary Rectifier Heater	Green
Secondary High Voltage	Red
Secondary Valve Heaters	Brown
Secondary Additional Valve Heaters	Blue

Centre-tap leads are marked with the same colour as the appropriate secondary winding, but with a yellow line interwoven.

Battery Leads

Highest voltage positive		Red
Second	do.	Yellow
Third	do.	Green
Fourth	do.	Blue
Low-tension positive		Pink
Common negative (L.T., H.T., G.B.)		Black
Max. G.B. negative		Brown
Second	do.	Grey
Third	do.	White

Colour	*Shade*	*Significant figures*	*Decimal multiplier*	*Tolerance*
Black	—	0	1	—
Brown	No. 13	1	10	—
Red	No. 38	2	100	
Orange	No. 57	3	1,000	—
Yellow	No. 55	4	10,000	—
Green	No. 26	5	100,000	—
Blue	No. 5	6	1,000,000	
Violet	*	7	10,000,000	
Grey	No. 31	8	100,000,000	—
White	—	9	1,000,000,000	—
Gold (metallic)			0·1	5%
Silver (metallic)		—	0·01	20%
No additional colour			—	10%

* No suitable shade is included in the B.S. Specification. The violet shall be a *dark* violet.

Any additional point, such as the fourth greatest G.B. negative, or fifth greatest H.T. positive, or positive bias, is violet, and any centre-tap is white.

COLOURS FOR COLOUR CODING

Colours given on B.S. Colour Card No. 381c.–1948, are as follows:

Brown, Dark	Shade No.	412
Red, P.O.	„ „	538
Orange, Light	„ „	557
Lemon	„ „	355
Blue, French	„ „	166
Violet, Dark	„ „	796
Grey, Dark Battleship	„ „	632
Pink, Salmon	„ „	443
Blue, Sky	„ „	101
Eau de Nil	„ „	216

For colour codes for television aerials see *Aerials.*

COMMON T-R WORKING. The use of a common *aerial* for transmitting and receiving radio signals.

COMMUNICATIONS RECEIVER. A special type of receiver primarily designed for the reception of amateur transmissions. It is a short-wave receiver incorporating every form of circuit control.

COMPENSATED DUAL LOUDSPEAKERS. (See *Loudspeaker*.)

COMPTON EFFECT. When short homogeneous X-rays are scattered by light elements their wavelength is slightly increased, the scattered radiation containing usually both the original and the modified wavelengths. For an angle of scattering of 90° the increase in wavelength is always 0·024 Ångstrom Units, irrespective of the nature of the scattering element. The use of electron discharge tubes, either alone or in conjunction with a photo-cell, enables circuits to be arranged either for controlling relatively heavy currents or for the delicate measurements of e.m.f.

CONDENSER. A piece of apparatus designed to store electricity under electrical pressure. It consists essentially of two or more metal plates separated by an insulator. For wireless purposes two types of condenser are in general use, fixed and variable condensers. The property of a condenser is known as the capacity, and this varies directly as the size of the conductors, and inversely as the distance separating them. The material used between the plates will also affect the capacity of the condenser. The material separating the plates of a condenser is known as the dielectric.

Making Fixed Condensers. Fig. 162 shows the construction.

To make up a selection of condensers, then, the requirements are: copper or tinfoil sheet between 0·001 and 0·002 in. thick, mica about 0·002 in. thick for the insulating material, scrap ebonite to make up the body of the component, and a few small brass nuts, bolts, washers, and terminals.

Two formulæ are given on the next page, one with centimetre units, the other inch units. However, should the measurements be in inches, and one desires to use the other formula, it is only necessary to

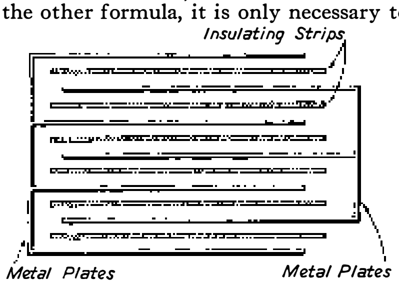


FIG. 162. *The plates in a condenser, shown on an enlarged scale.*

multiply inches by 2·54, and they are then reduced to centimetres.

The first formula is:

$$C = \frac{0{\cdot}0885 \times a \times K \times N}{1{,}000{,}000\ D}$$

where C = capacity in micro-farads.

D = thickness of the insulating material in centimetres.

a = area of one metal plate in square centimetres.

K = the dielectric constant. This is known as the specific inductive capacity (or S.I.C., as it is generally called) of the insulating material. This value is found from the tables contained in this book. For example, the table shows an average value of 6 for mica.

N = the number of insulating strips used. This is calculated simply by subtracting one from the total number of copper or tinfoil plates. In Fig. 162 there are 7 plates, hence the value of N = 7 − 1 = 6. Verify this by counting the number of insulating strips, when it is found there are 6, which is correct.

Taking a typical example, suppose we wish to find the capacity of a condenser using 11 copper foil plates, each 4 square centimetres in area, the plates being separated by mica insulating strips $\frac{1}{2}$ mm. thick. Substituting the values for the symbols:

$$C = \frac{0{\cdot}0885 \times a \times K \times N}{1{,}000{,}000\ D}$$

$$= \frac{0{\cdot}0885 \times 4 \times 6 \times (11 - 1)}{1{,}000{,}000 \times {\cdot}5}$$

$$= 0{\cdot}000424\ \mu F.$$

For practical purposes this can be called ·0004 μF.

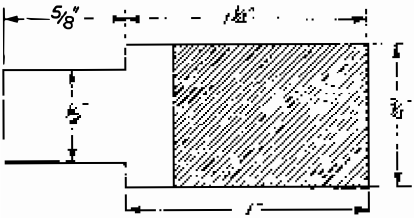


FIG. 163. *Size and shape of the copper foils. The additional area on the left enables the plates to be joined together.*

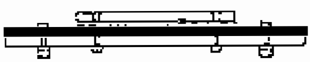


FIG. 164. *How the condenser is clamped together.*

The second formula, where the measurements are in inches, is:

$$C = \frac{0{\cdot}225 \times a \times K \times N}{1{,}000{,}000\ D}$$

Therefore, to find the capacity of a condenser consisting of, say, 6 copper foil plates each 1 in. by $\frac{1}{2}$ in., with mica insulators each 0·002 in. thick, proceed as before:

$$C = \frac{0{\cdot}225 \times 1 \times 0{\cdot}5 \times 6 \times 5}{1{,}000{,}000 \times 0{\cdot}002}$$

$$= \frac{3{\cdot}375}{2{\cdot}000}$$

$$= {\cdot}00168\ \mu F.$$

Having worked these simple examples,

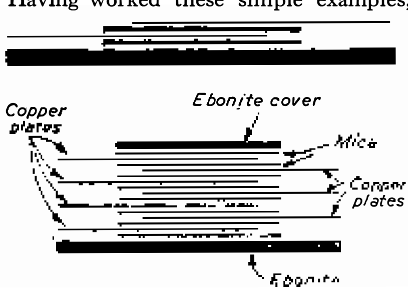


FIG. 165. *Diagram of the complete assembly.*

and determined the capacity of a condenser from given values, let it now be assumed that it is necessary to know the number of plates to be used in making a condenser of 0·001 μF. having plates $\frac{3}{4}$ in. by $\frac{1}{2}$ in. and mica insulators each 0·002 in. thick. Do the same as before and substitute the values known, except that the formula is now rearranged for the purpose:

$$N = \frac{C \times D \times 1{,}000{,}000}{0{\cdot}225 \times A \times K}$$

$$N = \frac{0{\cdot}001 \times 0{\cdot}002 \times 1{,}000{,}000}{0{\cdot}225 \times 0{\cdot}75 \times 0{\cdot}6 \times 6}$$

$$= \frac{2}{0{\cdot}506} = 4 \text{ approx.}$$

Now, the values of N in the previous examples were found by subtracting 1 from the total number of plates, hence 1

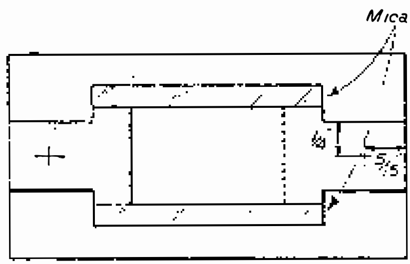


FIG. 166. *Plan view of the fixed condenser, showing how the alternate laminæ of mica and foil overlap.*

must be added to the value of N just determined, i.e. $4 + 1 = 5$. This is the number of plates required.

For the benefit of those readers who do not wish to spend time working out values from the above formulæ, a short list is appended, which will enable them to see at a glance the requisites for a condenser of a given value.

Copper Foil. Mica 0·002 in. thick

C in Micro-farad	*Dimension of Plate in In.*	*No. of Plates*
·001	$\frac{3}{4} \times \frac{1}{2}$	5
·002	$1 \times \frac{1}{2}$	7
·003	$1 \times \frac{3}{4}$	7
·00015	$\frac{1}{4} \times \frac{1}{2}$	3
·0005	$\frac{1}{2} \times \frac{1}{2}$	4
·0006	1×1	2
·0008	$\frac{1}{2} \times \frac{1}{2}$	6

To make a 0·003-μF. condenser, cut out seven pieces of copper foil to the shape and size shown in Fig. 163. The additional area on the left enables the plates to be joined together in the manner mentioned earlier. The shaded portion is actually the operative area. Next cut eight mica strips each $1\frac{1}{2}$ in. by 1 in. It will be noticed that the number of insulators is two in excess of those required to satisfy the value of N for this particular capacity. They are merely placed between the first and last metal plates and the ebonite base and cover respectively as additional insulation only. Notice also that these are of larger dimensions than those of the copper plates; this is necessary to prevent the metal plates from bending over and touching each other.

Cut a piece of ebonite $2\frac{3}{4}$ in. by $1\frac{1}{2}$ in. (see Fig. 167) to form the baseplate, and at the same time cut another piece $1\frac{1}{2}$ in. by $1\frac{1}{2}$ in. for the cover. Before commencing assembly place the smaller piece of ebonite on top of the larger, and drill four

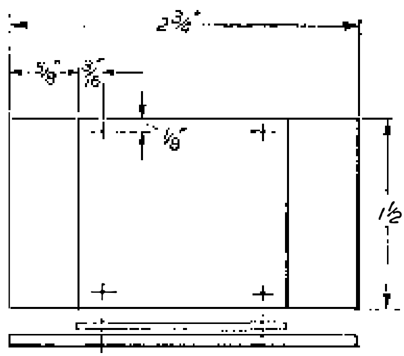


FIG. 167. *Dimensions of the ebonite plates for making fixed condensers.*

8 B.A. holes (number 42 drill) at the + positions indicated in Fig. 167, countersinking these if desired. With the ebonite base on a flat surface, place a strip of mica in a central position on the face, the longer side being parallel to the $2\frac{3}{4}$ in. side of the ebonite. Next, lay the first copper plate over the mica, the lug being flush with the $1\frac{1}{2}$ in. side, cover with another strip of insulation material, and place the second metal plate over this, so that the lug is on the opposite side to the first plate. A glance at Fig. 165 shows how this should be done. Continue the process, feeding on alternate strips of mica and copper, using the additional insulator to cover the last plate. The ebonite cover is then pressed over the whole, in the same position as when the drilling was done. Fig. 164 illustrates the assembly as it should now be.

Clamp the whole, and bolt together with four 8 B.A. brass bolts as tightly as is practicable. It is absolutely essential that no air space exists between the copper and mica strips, otherwise the capacity will be affected. It will be understood that this is so by referring to the formula, where it was seen that the insulating material possessed a certain definite value, denoted by K. If air, therefore, is present, the constant is altered to a value dependent upon the combination of mica and air.

The remaining operation is to fix the terminals. With a 6 B.A. drill (No. 24), drill two holes through the plates and base, using Fig. 167 as a guide to their position. Reverse the condenser, and from the base side insert two 6 B.A. terminals, firmly bolting together with washers and nuts.

The finished condenser should now resemble that shown in Fig. 165.

To construct a condenser of any other capacity adopt the same procedure as used in the given example, cutting the ebonite base and cover smaller or larger in proportion to the area of the copper plates employed. (See also *Variable Condenser.*)

CONDENSER VALUES. Series.

Aerial Condensers, ·0001-·0003 μF.

Aerial Tuning Condenser, M.W., L.W. ·0005 μF., S.W. ·0001 μF., U.S.W. ·00005 μF.

Anode Tuning Condenser M.W., L.W. ·0003 or ·0005 μF.

Anode Coupling Condenser, ·0001-·0003 μF.

Grid Condenser, ·0001-·0003 μF.

Detector Anode Bypass Condenser, ·0001-·0005 μF.

R.C.C. Condenser, ·01-1 μF.

Decoupling Condenser (H.F.), M.W., L.W. & S.W. ·1-1 μF., U.S.W. ·001 μF.-·1 μF.

Decoupling Condenser (L.F.), 2-8 μF.

Smoothing Condenser (Mains Unit), 2-32 μF.

CONDENSERS IN PARALLEL. Condensers connected in parallel increase the total capacity. The total capacity of the series is obtained by adding the capacities together.

Capacity of condensers in parallel:

$C = C_1 + C_2 \ldots$

CONDENSERS IN SERIES. Condensers connected in series reduce the total capacity. The capacity of a number of condensers so connected would be the reciprocal of

$$\frac{1}{C1} + \frac{1}{C2} + \frac{1}{C3} \cdots$$

CONDUCTANCE. The property a body possesses for conducting electricity. Reciprocal of resistance. The mho (ohm reversed) is the unit of conductance.

$$G = \frac{1}{R}$$

where G = conductance in mhos.
The conductivity of a material is the reciprocal of its specific resistance, and is denoted by the symbol γ (gamma).

CONDUCTIVELY COUPLED. Direct coupled (*which see*).

CONDUCTIVITY. Ability to conduct heat or electricity.

CONDUCTOR. Any material through which a current may be passed. All metals are conductors.

CONFUSION REGION. The region, surrounding an object, within which the radar echo from another object cannot be separately resolved.

CONICAL SCAN. A conical motion of the axis of a *beam* by which improved angular accuracy is obtained by comparison of the signal amplitudes at various points during the cycle.

CONNECTOR. In waveguide technique, the means for making a mechanical joint between parts of a *waveguide* system.

CONTACT PISTON. A *piston* in which there is metallic continuity with the walls of the guide.

CONTACT POTENTIAL (Diode). The potential between the anode and cathode of a diode working into an infinite load, due to difference of work function between anode and cathode surfaces.

CONTINUOUS CURRENT. Direct current.

CONTINUOUS WAVES. A train of waves whose amplitude is never varying. Produced usually by an arc discharge, by an oscillating valve, or frequency multiplying transformers.

CONTROL, REMOTE. (See *Remote Control.*)

CONVENTIONAL SIGNS. A wireless circuit diagram consists of some of the signs shown on page xi, linked together in a certain way. It will be seen from this that various wireless components have a standard form, and a wireless circuit is a combination of some of those signs. A circuit, it should be remembered, is a theoretical diagram; a wiring diagram shows the actual components with the wires attached (see pages xi and xii.)

CONVERTER. (See *Circuit* and *Short-wave Converter.*)

COPPER PYRITES. Copper ore crystal, containing also iron. Used as a rectifier. Correct name Chalcopyrites.

COPPER WIRE DATA. See table on page 109 and also "*Wire and Wire Gauges*" (vest-pocket book, obtainable from the publishers of this volume).

CORBINO EFFECT. If a uniform radial current flows through a circular metal disc in a magnetic field normal to the disc plane a circular current is in evidence, the density being inversely proportional to the radius.

CORKSCREW RULE. A current flowing in the twist direction of a corkscrew creates lines of force in the direction of thrust, letting the insertion direction be regarded as a south pole facing the holder of the corkscrew as the lines are entering the insertion.

CORNER (Elbow). A discontinuous change in the direction of the longitudinal axis of a *waveguide.*

CORNER REFLECTOR. A *reflector* consisting of two of three flat conducting surfaces intersecting mutually at right-angles so as to form one or more recesses which reflect incident waves parallel to their direction of incidence.

CORNER-REFLECTOR AERIAL. A directive *aerial system* comprising one or more *primary radiating elements*, with which *passive elements* may be associated, situated within the angle formed by two intersecting plane surfaces.

CORROSION. The eating away of metals or metallic bodies by acid or acid fumes. To prevent corrosion in a new accumulator, simply wipe all susceptible parts with a rag, wet with ammonia, and then coat with pure vaseline. Once corrosion has started, it must be removed from all metal surfaces by scraping, filing, or with a wire brush. Ammonia and vaseline should then be applied as before. Pay particular attention to keeping the top of the affected accumulator clean and dry. Vaseline is specified as a preventive of corrosion because ordinary grease contains animal or vegetable fats which increase rather than prevent the evil. (See also *Accumulator.*)

COSECANT-SQUARED BEAM. A *beam* whose power at any given angle of elevation, between certain specified limits, is

COPPER WIRE DATA

Standard Wire Gauge	Diameter in Inches	Resistance in Ohms per Yard	Resistance in Ohms per Lb.	Lb. per Ohm	Weight in Lb. per 1,000 Yards.	Yards per Lb.	Turns per Inch: Enamel Covered	Single Silk Covered	Double Silk Covered	Single Cotton Covered	Double Cotton Covered
10	·128	·001868	·0120	83·3	148·8	6·67		[illegible]	7·55	7·35	7·04
11	·116	·002275	·0200	50·0	122·2	8·16		8·41	8·30	8·06	7·69
12	·104	·002831	·0280	35·7	98·22	10·23		9·35	9·22	8·93	8·48
13	·092	·003617	·0550	18·1	76·86	13·00		10·5	10·4	10·0	9·43
14	·080	·004784	·0820	12·2	58·12	17·16		12·1	11·8	11·4	10·6
15	·072	·005904	·1400	7·14	47·08	21·23	↓	13·3	13·1	12·5	11·6
16	·064	·007478	·2021	4·95	37·20	26·86	15·0	14·9	14·6	14·1	13·2
17	·056	·009762	·3423	2·38	28·48	35·00	17·1	16·9	16·5	15·9	14·7
18	·048	·01328	·6351	1·56	20·92	47·66	19·8	20·0	19·4	18·5	17·2
19	·040	·01913	1·315	·757	14·53	68·66	23·7	23·8	23·0	21·7	20·0
20	·036	·02362	2·012	·497	11·77	85·00	26·1	26·3	25·3	23·8	21·7
21	·032	·02990	3·221	·309	9·299	107·6	29·4	29·4	28·2	26·3	23·8
22	·028	·03905	5·498	·181	7·120	140·6	33·3	33·3	31·8	29·4	26·3
23	·024	·05313	10·14	·098	5·231	191·6	38·8	38·5	36·4	33·3	29·4
24	·022	·06324	14·38	·069	4·395	228·3	42·1	42·1	40·0	35·7	31·3
25	·020	·07653	21·08	·0471	3·632	275·3	46·0	46·0	43·5	38·5	33·3
26	·018	·09448	32·21	·0309	2·942	340·0	50·6	50·6	47·6	41·7	35·7
27	·0164	·11138	46·55	·0215	2·442	410·0	55·9	55·1	51·6	44·6	37·9
28	·0148	·1398	70·12	·0141	1·989	503·0	61·4	60·4	56·2	48·1	40·2
29	·0136	·1655	98·65	·0101	1·680	596·6	66·2	65·2	60·2	51·0	42·4
30	·0124	·1991	142·75	·0069	1·396	716·6	73·3	72·0	67·1	54·4	44·7
31	·0116	·2275	185·80	·0054	1·222	820·0	77·8	76·3	70·9	56·8	46·3
32	·0108	·2625	248·20	·0040	1·059	943·3	83·0	81·3	75·2	63·3	50·5
33	·0100	·3061	337·50	·0029	·9081	1100	88·9	87·0	80·0	66·7	52·6
34	·0092	·3617	471·00	·0023	·7686	1300	98·0	93·4	85·5	70·4	54·9
35	·0084	·4338	676·50	·0014	·6408	1556	106	101	91·8	80·6	61·0
36	·0076	·5300	1009	·00098	·5254	1903	116	110	102	86·2	64·1
37	·0068	·6620	1574	·00064	·4199	2380	128	120	110	92·6	67·6
38	·0060	·8503	2598	·000385	·3269	3056	143	133	121	100	71·4
39	·0052	1·132	4645	·000217	·2456	4066	168	149	134	109	75·8
40	·0048	1·328	6360	·000156	·2092	4766	180	159	142	114	78·1
41	·0044	1·581	9020	·000112	·1758	5700	194	169	150	↑	↑
42	·0040	1·913	13150	·000076	·1453	6866	211	191	167		
43	·0036	2·362	20120	·000050	·1177	7500	230	206	179		
44	·0032	2·989	32210	·000030	·0929	10766	253	225	192		
45	·0028	3·904	54980	·000015	·0712	14066	282	247	208		

proportional to the square of the cosecant of the angle of elevation. This form of beam, used with a radar set, gives approximately uniform signal intensity for *echoes* received from near and distant objects in any one horizontal plane within the beam direction.

COULOMB. The electrical unit of quantity, named after Coulomb, the French physicist. It is the quantity which flows in 1 second through a conductor carrying 1 amp. One ampere-hour equals 3,600 coulombs. The coulomb is equal to one-tenth of an electro-magnetic unit. 1 coulomb $= 3 \times 10^9$ statcoulombs $= 0·1$ abcoulomb; 1 statcoulomb $= 3·33 \times 10^{-11}$ abcoulombs; 1 abcoulomb $= 3 \times 10^{10}$ statcoulombs.

COULOMB'S LAW. Implies that the mechanical force between two charged bodies is directly proportional to the charges and inversely so to the squares of the distance separating them.

COUNTER E.M.F. Back E.M.F.

COUNTERPOISE. An "earth" system consisting of a wire suspended above the ground and parallel to the aerial.

COUNTING DOWN. The production of recurrent *pulses* whose repetition rate is a sub-multiple of that of the initiating pulses.

COUPLING. L.F. coupling generally consists of a small fixed condenser (connected between anode and earth to bypass unwanted H.F. energy), a H.F. choke, and a transformer primary, anode resistance or L.F. choke. In R.C. coupling (Fig. 168) the higher the value of anode resistance the greater the amplification, but quality is impaired, as, although few people realise it, the valve is actually in parallel with its own anode resistance.

In general, the anode resistance should be three times the valve impedance, but when the most perfect quality is required at some expense of volume, this value may be lowered to twice the impedance or even less. The grid leak may have a value of four or five times that of the anode

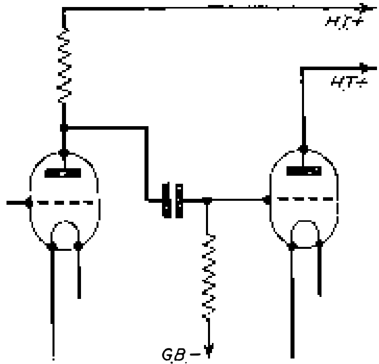


FIG. 168. *R.C. coupling.*

resistance; remember that 1 megohm is a million ohms, so that if the anode resistance happens to be 20,000 ohms, the grid leak might well be 100,000 ohms, or to quote it in megohms—·1. This rule holds good except in certain circumstances, unless a really big valve is following immediately after it, when the maximum value should be 50,000 ohms in the interests of safety.

The third component of the resistance capacity coupling unit is the condenser, which should always be a reliable type, as a serious leak would result in the high tension getting on to the grid of the following valve. As there is no simple way of working out the best value for this condenser, a table, No. 1, is given (see *Decoupling*) to indicate the best value of grid leak and condenser for various values of anode resistance.

At the present time transformers can be divided broadly into two classes: those

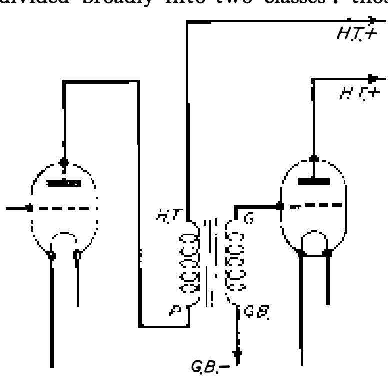


FIG. 169. *Transformer primary directly in anode circuit.*

containing generously proportioned iron cores and those containing comparatively small cores of a special mixture of nickel and iron. There are, in addition, certain badly designed, cheap transformers, containing very little ordinary iron, but these will not be considered. These two main clases of transformers call for entirely different treatment: the heavy ones, with the big cores, can be connected straight in the anode circuit as shown in Fig. 169, but the small nickel-iron transformers should be parallel fed as shown in Fig. 170. The reason for this is that the latter type have relatively poor efficiency when the high-tension current is passing through the primary winding, as the inductance of the latter gets smaller and smaller as

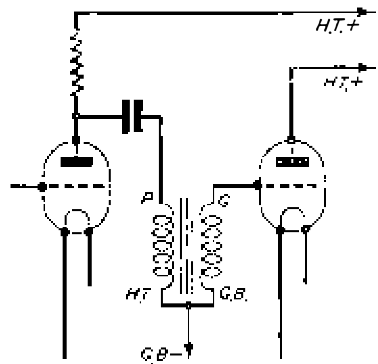


FIG. 170. *Parallel-fed transformer. With this arrangement direct current does not pass through the primary.*

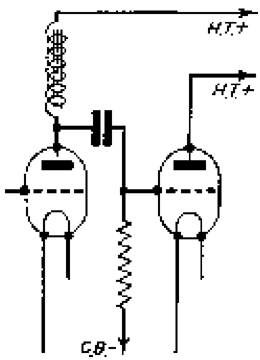
larger and larger currents are put through it, and a decrease of impedance means a decrease of bass.

Care must be taken when selecting resistance in the anode circuit, but three times the valve impedance is generally suitable, provided that there is a reasonable high-tension voltage, say 120 volts, available. Care should be taken, however, not to use the value of condensers shown in Table No. 1 (see *Decoupling*), as a very much larger value is desirable, depending upon the transformer used. However, 1 μF. is a good general value, but if with the transformer used this results in one or two of the bass notes being reproduced out of proportion, condensers having a value of ·5 or 2 μF. may be tried. An L.F. choke is sometimes used instead of a resistance.

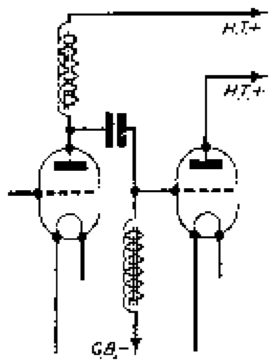
Figs. 171 and 172 indicate the method of using low-frequency choke coupling. Here, again, a certain amount of difficulty presents itself regarding the choice of grid leak and condenser, but as a rough guide the grid leak may be eight to ten times the value of the valve impedance, and the appropriate condenser selected from Table No. 2. (See *Decoupling*.)

There is the possibility of an additional low-frequency stage in addition to the output valve, but this is rapidly dying out with modern high-efficiency valves, although still retained when the detector is not preceded by a high-frequency valve. The great mistake when using two valves following the detector is to arrange for too much amplification, with the result that the output valve is overloaded.

Suppose, for example, that the detector



FIGS. 171 AND 172. *Two forms of choke coupling.*



valve gives a 2-volt swing in its anode, which is not unreasonable on a high-powered station, and that a $3\frac{1}{2} : 1$ transformer is used, almost 7 volts on the grid of the next valve. Assuming that this is an L.F. type, it might well have a working amplification factor of 12, which will give 84 volts in the anode. Assume a $3 : 1$ transformer: this would give almost 252 volts to the power valve, which, with an amplification factor of 7, would give 1,700 volts odd. This indicates what would happen *if* either the second or third valve overloaded.

In wav. guide technique that part of the joint between to lengths of *waveguide*, or a *waveguide* and a component essential to the transmission of R/F energy but not necessarily serving a mechanical function.

COUPLING COEFFICIENT. The ratio of the difference to the sum of the squares of the resonant frequencies of two oscillating networks, the coupling factor permitting the constants to determine the energy transfer rate. For inductive coupling it is that ratio of mutual inductance to the geometric average (mean) of respective self inductances.

COUPLING CONDENSER. A capacitor, connected between components or stages in a circuit, offering a small impedance to the signal which it is desired to pass but preventing the flow of D.C. (A *blocking condenser*.)

The value of the coupling condenser depends upon the stage of the receiver in which it is employed, and the correct value of the condenser is best found by experiment. In the case of a detector valve, the value depends to some extent upon the constants of the valve and upon operating conditions. In a power grid detector, for example, where the coupling condenser usually is smaller than the conventional ·0003 μF., say ·0001 μF., and the valve is operated at a high anode voltage and current, a much smaller grid leak, generally of the order of a quarter megohm, is necessary. A fairly wide range of choice is usually given for the value of the coupling condenser in low-frequency resistance capacity coupled amplifiers. A capacity value between ·005 μF. and ·05 μF. will be perfectly satisfactory, but the actual choice depends very much upon the band of frequencies it is desired to pass. If the set builder wishes for full round tone with plenty of bass, then the value of ·05 μF. or even greater should be chosen, while a lower value, by cutting off some of the bass response, will give a higher pitched and perhaps more brilliant tone.

COUPLING FACTOR. The factor by which the *impedance* in a secondary guide must be multiplied to obtain its effect in the main guide.

COUPLING LOOP. A form of *probe* in which the conductor is bent into the form of a loop terminating on the wall of the guide, or returning through the wall to an external circuit.

COVERAGE DIAGRAM. A diagram showing the areas (in the horizontal or vertical plane) within which a radio installation is effective to a given standard.

CRANK. A form of *spinner* in which the *flare* is offset from the axis of rotation.

CRITICAL DIMENSION. That dimension of the cross-section of a *waveguide* on which depends the *critical frequency* (or wavelength).

CRITICAL FREQUENCY. (a) The highest frequency which is reflected from a specified ionised layer in a vertical direction. (b) In *waveguides*, that frequency below which a *travelling wave* in a given mode cannot be maintained.

CRITICAL WAVELENGTH. The free-space wavelength corresponding to the *critical frequency* definition.

CROSS-BAND TRANSPONDER. A *transponder* whose response is not in the same frequency band as the interrogation.

CRYSTAL CHECK OSCILLATOR. A quartz crystal oscillator incorporated in an equipment to provide a range of calibration frequencies.

CRYSTAL-CONTROLLED OSCILLATOR. An oscillator, the frequency of which is determined by a quartz crystal.

CRYSTAL DETECTOR. A detector based upon the fact that some of the metallic crystals allow a current to flow in one direction only, or more readily in one direction only. It thus acts as a rectifier, converting oscillations as received by the aerial into intermittent D.C.

CRYSTAL TRIODE. A device with two catswhiskers spaced, literally, a hair-breadth apart on the surface of a germanium crystal. With suitable and independent voltages applied to the two catswhisker contacts the current traverses, more or less, a common path through the crystal. Thus any variation in one voltage is reflected in the other, in much the same way as the change in grid voltage affects that of the anode in a triode valve, which the crystal triode simulates as an amplifier and oscillator. It can be used in applications where cathode heating is either difficult or impracticable and not, generally, as a substitute for the valve. (See *Transistor*.)

CRYSTALS. Minerals and mineral ores used for the purpose of detecting, or rectifying, wireless signals. A small piece of the mineral is joined to one side of a tuned circuit, and the remaining side of the circuit is provided with a contact for the mineral. In some cases this contact consists of another piece of similar, or different, crystal and in other cases a metallic contact is used. A very common ore of lead goes by the name of galena, and this requires a contact of copper or brass, although sometimes silver gives better results.

The best form of crystal cup is that in which three screws are used. Wherever it is thought better to fix the crystal by means of solder, a particular grade known as Wood's metal (*which see*) should be used. In using crystals it is desirable that they be handled with a pair of tweezers, for the slightest trace of greasiness upsets their sensitivity.

For crystal contacts (the cat's whisker) it is desirable to use the correct wire according to the crystal in use. The crystal whisker to be used in connection with galena has already been described, but for molybdenite a flat silver strip is used, for silicon a gold or steel whisker, and for iron pyrites a gold point should be used. The carborundum-and-steel crystal detector is undoubtedly the best, but this necessitates the use of an applied potential in the form of a $4\frac{1}{2}$-volt dry cell connected across the crystal and contact. This, of course, must be used in conjunction with a potentiometer. With a crystal set, the best results are usually secured by wiring phones on the earth side : the crystal detector itself should be kept near the aerial terminal.

Table of Crystals :

Bornite	Haematite
Carborundum	Hertzite
Cassiterite (Tin-stone)	Iron Pyrites
Copper Pyrites	Malachite
Galena	Molybdenite
Ghane	Silicon
Graphite	Tellurium
Hessite	Zincite (See also *Quartz Crystal*)

CURIE CONSTANT. The coefficient of magnetism of a material multiplied by the *absolute* temperature. Ferro-magnetic materials possess a definite temperature of transition at which ferro-magnetic phenomena becomes para-magnetic, the property of ferro-magnetization disappearing; the temperature being usually lower than the *Curie Point*—the melting point of the material.

CURRENT. The flow of electricity in a circuit. Unit is the ampere (*which see*).

CURRENT DENSITY. The relationship or *ratio* between the cross-sectional area of the conductor and the current flowing through it.

CUT (Quartz Crystal). The angular relationship between the major faces of a crystal plate and the major axes of the mother crystal.

CUT-OFF ATTENUATOR. A fixed or variable length of *cut-off waveguide* introducing attentuation.

CUT-OFF FREQUENCY. (See *Barrier or Penetration Frequency.*)

CUT-OFF WAVEGUIDE. A *waveguide* used below its *critical frequency.*

CUT PARABOLOID. The part of a paraboloid which remains when the parts lying outside one or more pairs of parallel planes are missing, the planes of each pair being on opposite sides of the axis and equidistant from it.

CUTLER FEED. A *primary radiating element* in which a rectangular *waveguide* projects through the apex of a *mirror* towards the focus, at or near which it branches symmetrically into two guides of smaller *non-critical dimensions*, which then bend outwards and back towards the mirror and terminate in two radiating *apertures* on each side of the feed guide.

C.W. Continuous Waves.

CYCLE. Any sequence of events occurring in a regular *time* order. An A.C. cycle is the two alternations in opposite directions.

CYMOMETER. Obsolete name for the Fleming wavemeter, in which the capacity and inductance are varied by one control.

D

D REGION. The region of the ionosphere between about 50 km. and 100 km. above the earth's surface. In this region no "layer," as defined above, normally exists. It is the region of low ionisation density, which reflects without significant attenuation waves of frequencies below about 50 kc/s. It attenuates waves of frequencies above about 50 kc/s, whether they are deviated or not, to an extent which depends upon the frequency and depth of penetration. (See *Ionosphere.*)

DALTON'S LAW. In gas mixtures each exerts similar pressure as if acting singly. If several gases have similar temperatures in a mixture of them and occupy the same volume, the exerted mixture pressure must be equal to the sum of the pressures severally exerted by the gases.

DAMPING. The gradual reduction in amplitude of a train of waves or oscillations.

DANIELL CELL. A Daniell cell consists simply of an outer glass jar containing a porous pot. Surrounding the porous pot there is a cylinder of sheet copper in a solution of copper sulphate. The porous pot contains a diluted solution of sulphuric acid in which stands a rod of zinc. The details will be quite clear from the diagram (Fig. 173). The copper may be sheet stuff about $\frac{1}{64}$ in. thick, bent round into the form of a cylinder, with a lug soldered on for connection purposes. The outer vessel is charged with a saturated solution of copper sulphâte in water, and the porous pot with a solution of 15 parts of distilled water, or rain-water, and 1 part of sulphuric acid. In mixing the latter the acid should always

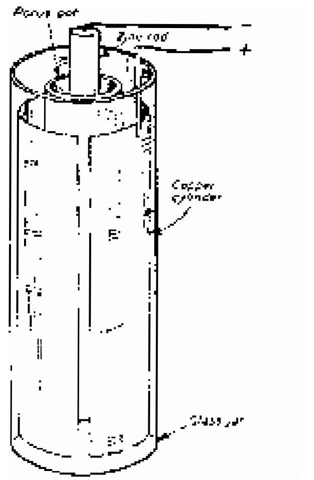


FIG. 173. *Constructional details of Daniell cell.*

be added to the water and not *vice versa*, otherwise violent action will take place, with risk of serious damage to the skin. The copper plate provides the positive terminal and the zinc rod the negative. Such a battery can be connected to an accumulator and allowed to remain charging continuously day and night, without attention beyond seeing that a surplus of the copper-sulphate crystal remains in the outer jar.

DARK-TRACE TUBE. A cathode-ray tube with a screen which changes colour but does not necessarily fluoresce under electron impact.

D.C. Direct Current (*which see*).

D.C. MAINS UNIT. A unit for supplying H.T. (and sometimes also L.T.) from the mains. (See also *Eliminators.*)

D.C. RESTORATION. Imposition, on a recurrent waveform, of a value of steady potential obtained by rectification from that waveform, such that the trough or crest of the waveform reaches a desired level.

DEAD BEAT. A term applied to meters where the pointer travels up to the reading and remains perfectly stationary. In cheap meters the needle usually passes beyond the maximum reading required and then oscillates backwards and forwards for some seconds before coming to rest. The dead-beat instrument avoids this.

DEAD IMPEDANCE. The impedance between electrodes in the absence of an electron stream, the cathode being heated.

DECAY, RATE OF. Time taken to absorb sound energy.

DECIBEL. The decibel is one tenth of a bel (*which see*). It is a measure of power ratio, based on logarithms to the base ten, and may be expressed as a gain or loss; it does not express absolute values, but by having a datum of reference one can express absolute values in decibels, up or down from this datum. The zero output level of 1 milliwatt in 600 ohms is frequently chosen in this country. American engineers frequently use 6 milliwatts in 600 or 500 ohms. The fact that the decibel is logarithmic means that they can be added, although the powers they represent are multiples.

If we have two powers W_1 and W_2 the gain of the second power W_2 on the first power W_1 expressed in decibels is

$$\text{Gain in decibels (db)} = 10 \log \frac{W_2}{W_1}$$

Decibel Table

Power Ratio		Decibels	
100,000 : 1		Gain	50
10,000 : 1		,,	40
1,000 : 1		,,	30
100 : 1		,,	20
10 : 1		,,	10
5 : 1		,,	7 (approx.)
1 : 1		,,	0
1 : 10		Loss	10
1 : 100		,,	20

Although the decibel is used as a relation of power, it can also express voltage or current ratios. If the input and output resistances are equal the power ratio will be proportional to the square of the voltage or current ratio as shown below:

Let $W_2 = I^2_2 R \qquad W_1 = I^2_1 R$

$\therefore$ the db gain of W_2 on W_1

$$= 10 \log \frac{W_2}{W_1} = 10 \log \frac{I^2_2 R}{I^2_1 R}$$

As the input and output resistances are equal.

$$\text{Gain in db} = 10 \log \frac{I^2_2}{I^2_1}$$

$$= 20 \log \frac{I_2}{I_1}$$

It can also be similarly shown that, as

$$W_2 = \frac{V^2_2}{R} \text{ and } W_1 = \frac{V^2_1}{R}$$

$$\text{Gain in decibels of } W_2 \text{ on } W_1 = 20 \log \frac{V_2}{V_1}$$

The above only holds good in the case of equal input and output resistances. If the input and output resistances are equal the following is obtained:

Expressed as Current Ratios with Unequal Resistance

Let $W_2 = I^2_2 R_2$ and $W_1 = I^2_1 R_1$

Gain in db of W_2 on W_1

$$= 10 \log \frac{I^2_2 R_2}{I^2_1 R_1}$$

$$= 10 \log \left(\frac{I_2}{I_1}\right) 2 + 10 \log \frac{R_2}{R_1}$$

$$20 \log \frac{I_2}{I_1} \qquad + 10 \log \frac{R_2}{R_1}$$

Expressed as Voltage Ratios with Unequal Resistances

$$W_2 = \frac{V^2_2}{R_2} \qquad W_1 = \frac{V^2_1}{R_1}$$

Gain in db of W_2 on W_1

$$10 \log \frac{V^2_2/R_2}{V^2_1/R_1} = 10 \log \frac{V^2_2 R_1}{V^2_1 R_2}$$

$$= 10 \log \left(\frac{V_2}{V_1}\right)^2 + 10 \log \frac{R_1}{R_2}$$

$$20 \log \frac{V_2}{V_1} \qquad + 10 \log \frac{R_1}{R_2}$$

as $\frac{R_1}{R_2} = \left(\frac{R_2}{R_1}\right)^{-1}$ the above can be written as:—

$$\text{db Gain} = 20 \log \frac{V_2}{V_1} - 10 \log \frac{R_2}{R_1}$$

Example:

Calculate the current in a 600 ohm resistance in which the power dissipated is 6 db above 1 mW.

$$\text{Gain 6 db} = 10 \log \frac{W_2}{W_1}$$

$$\cdot 6 = \log \frac{W_2}{W_1}$$

$$\text{or } 10^{\cdot 6} = \frac{W_2}{W_1} = \frac{W_2}{1}$$

Therefore $W_2 = 10^{\cdot 6}$ mW = 3·981 mW. The current flowing in the 600 ohm resistance—

$$W_2 = \frac{3\cdot 981}{1{,}000} = I^2 R$$

$$\therefore I = \sqrt{\frac{3\cdot 981}{6 \times 10}} — \cdot 002575 \text{ amps.}$$

= 2·575 mA.

To convert decibels to Nepers multiply by 0·1151.

(See also *Bel*, *Acoustic Watt*, *Phon* and *Neper*.)

RELATIONSHIP BETWEEN DECIBELS AND POWER RATIO

Decibels	*Power Ratio*	*Decibels*	*Power Ratio*
1	1·25	— 1	$\frac{1}{1\cdot 25}$ = ·8
2	1·6	— 2	$\frac{1}{1\cdot 6}$ = ·625
3	2·0	— 3	$\frac{1}{2}$ = ·5
4	2·5	— 4	$\frac{1}{2\cdot 5}$ = ·4
5	3·2	— 5	$\frac{1}{3\cdot 2}$ = ·3125
6	4·0	— 6	$\frac{1}{4}$ = ·25
7	5·0	— 7	$\frac{1}{5}$ = ·2
8	6·0	— 8	$\frac{1}{6}$ = ·166
9	8·0	— 9	$\frac{1}{8}$ = ·125
10	10·0	— 10	$\frac{1}{10}$ = ·1
20	100·0	— 20	$\frac{1}{100}$ = ·01
30	1000·0	— 30	$\frac{1}{1{,}000}$ ·001

DECIMETRE WAVES. Waves from 1-10 dm. long (10-100 cm.).

DE-COHERER. A device for breaking down the circuit formed by the contents of the coherer. It is usually mechanical in action and consists of a small hammer arrangement which taps the tube (or coherer) and causes the contents of the coherer to fall apart when current has ceased.

DECIMAL EQUIVALENTS. The following table gives the decimal equivalents of all fractions of an inch, progressing in sixty-fourths of an inch.

TABLE OF DECIMAL EQUIVALENTS

$\frac{1}{64}$	·015625	$\frac{33}{64}$	·515625
$\frac{1}{32}$	·03125	$\frac{17}{32}$	·53125
$\frac{3}{64}$	·046875	$\frac{35}{64}$	·546875
$\frac{1}{16}$	·0625	$\frac{9}{16}$	·5625
$\frac{5}{64}$	·078125	$\frac{37}{64}$	·578125
$\frac{3}{32}$	·09375	$\frac{19}{32}$	·59375
$\frac{7}{64}$	·109375	$\frac{39}{64}$	·609375
$\frac{1}{8}$	·1250	$\frac{5}{8}$	·6250
$\frac{9}{64}$	·140625	$\frac{41}{64}$	·640625
$\frac{5}{32}$	·15625	$\frac{21}{32}$	·65625
$\frac{11}{64}$	·171875	$\frac{43}{64}$	·671875
$\frac{3}{16}$	·1875	$\frac{11}{16}$	·6875
$\frac{13}{64}$	·203125	$\frac{45}{64}$	·703125
$\frac{7}{32}$	·21875	$\frac{23}{32}$	·71875
$\frac{15}{64}$	·234375	$\frac{47}{64}$	·734375
$\frac{1}{4}$	·2500	$\frac{3}{4}$	·7500
$\frac{17}{64}$	·265625	$\frac{49}{64}$	·765625
$\frac{9}{32}$	·28125	$\frac{25}{32}$	·78125
$\frac{19}{64}$	·296875	$\frac{51}{64}$	·796875
$\frac{5}{16}$	·3125	$\frac{13}{16}$	·8125
$\frac{21}{64}$	·328125	$\frac{53}{64}$	·828125
$\frac{11}{32}$	·34375	$\frac{27}{32}$	·84375
$\frac{23}{64}$	·359375	$\frac{55}{64}$	·859375
$\frac{3}{8}$	·375	$\frac{7}{8}$	·8750
$\frac{25}{64}$	·390625	$\frac{57}{64}$	·890625
$\frac{13}{32}$	·40625	$\frac{29}{32}$	·90625
$\frac{27}{64}$	·421875	$\frac{59}{64}$	·921875
$\frac{7}{16}$	·4375	$\frac{15}{16}$	·9375
$\frac{29}{64}$	·453125	$\frac{61}{64}$	·953125
$\frac{15}{32}$	·46875	$\frac{31}{32}$	·96875
$\frac{31}{64}$	·484375	$\frac{63}{64}$	·984375
$\frac{1}{2}$	·5000	1	1·0000

DECOUPLING. In the straight three-valve set, the H.T. sides of each of the components in the anode circuit are joined together either directly or through the few intervening cells of the H.T. battery, with the result that the major portion of the battery is between the anode leads and earth. This portion of the high-tension battery may have a considerable high-frequency resistance which, being common to all three valves, redistributes such stray currents as are flowing in each anode circuit to the other anode circuit, thus causing instability, motor-boating, or violent oscillation. This effect is considerably more marked if an eliminator is used.

In order to stop this trouble, it is necessary to give other than battery current a direct path to H.T. —, and to

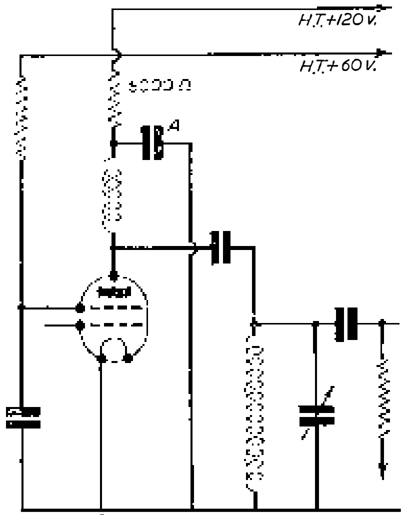


FIG. 174. *S. G. stage decoupled.*

separate the anodes from each other by a resistance, or choke, and a condenser. In general practice the choke is very seldom used, as it only becomes useful when a very heavy high-tension current is passing. It is, however, generally used in the output stage to choke-feed the loudspeaker and direct the speech current through the loudspeaker winding to earth. Fig. 174 shows the anode and screen circuits of a screen-grid valve with decoupling added. The screen resistance may be 600 to 1,000 ohms, while a reasonable value for the anode circuit is 5,000 ohms. As the screen is provided with a condenser in any case, an additional one is not necessary, but in the anode circuit the condenser marked A has to be inserted. This might be a 1-μF., non-inductive type. When using a mains screen-grid valve the screen is usually fed by a fixed or variable potentiometer as shown in Fig. 175. The top part of this, marked B, acts automatically as a decoupling resistance, so no further precautions are necessary.

The decoupling of the detector is probably the most important. Here it is necessary to make certain that the values are adequate. Unfortunately, however, if too high a resistance is used, the H.T. value will be lowered, which is undesirable below a certain point. In order to ensure that decoupling is efficient, the resistance in ohms when multiplied by the capacity of the condenser in microfarads should not be less than 40,000. It would appear that the simpler way would be to use 40,000 ohms with 1 μF., but such a value of resistance may reduce the high-tension voltage. The amount of voltage lost over the resistance is simple to calculate, it merely being necessary to multiply the resistance by the number of milliamps. passing and take off three noughts. For example, if the anode resistance were only 30,000 ohms, and the current 3 milliamps., multiply these two together and the result is 90,000; take off three noughts and it will be seen that the loss of voltage would be 90. Decide first of all what voltage it is desired to apply to the detector stage and subtract this from the H.T.-bat-

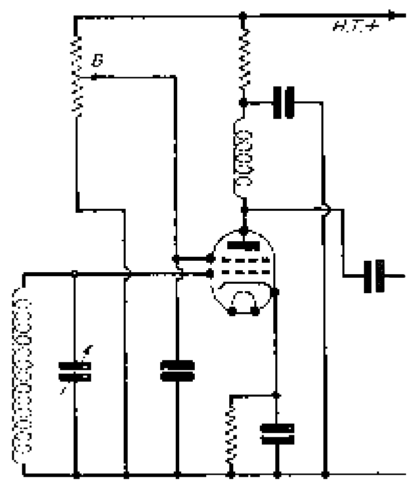


FIG. 175. *With the usual arrangement of a mains set the potentiometer acts as a decoupler.*

tery voltage, which will leave the amount that may be sacrificed in the interests of decoupling. If 80 volts is required on the detector, and the battery voltage is 120, then 40 volts can be spared. Now, reference to the valve curve or the use of a milliammeter will show what current the valve is taking. Suppose it is taking 3 milliamps.; it is now desired to find what resistance will drop 40 volts when 3 milliamps. is flowing. This is arrived at by dividing the milliamps. into the voltage, when the answer will be the number of thousands of ohms required. Divide the 3 milliamps. into the 40 volts; this goes approximately 13 times, and as the answer is in thousands of ohms, the resistance will be 13,000 ohms. The nearest value obtainable will be 15,000 ohms, which will have to be associated with a 4μF. condenser in order to reach the 40,000 indicated.

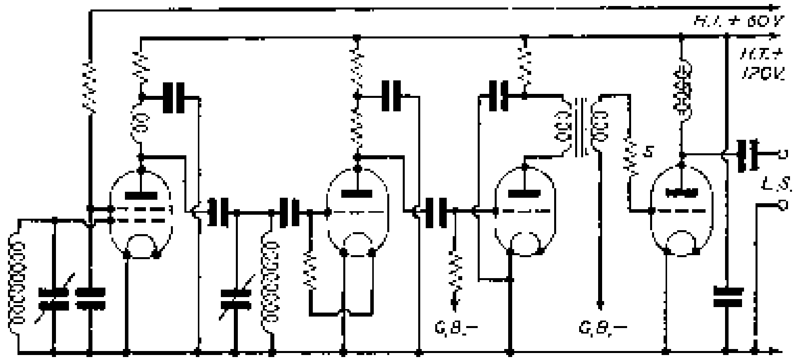


FIG. 176. *A typical four-valve circuit showing the position of the decoupling resistances.*

TABLE No. 1

Anode Resistance	*Grid Leak*	*Condenser*
Ohms	*Meg.*	μF.
250,000	1	·006
200,000	1	·006
100,000	·5	·01
75,000	·5	·01
50,000	·25	·02
30,000	·2	·03
25,000	·1	·05
20,000	·1	·05
15,000	·05	·1
10,000	·05	·1

Table No. 2 gives values from which to arrive at any intermediate figure.

In a first L.F. stage the result can usually be lowered to 30,000. (See *Automatic Grid Bias* for table of decoupling and voltage-dropping resistances.)

DELAY NETWORK. A network or transmission line designed to delay a signal for a certain time.

DELAYED A.V.C. A system of automatic volume control in which the A.V.C. bias is not applied to the variable-mu stages until the signal currents applied to the detector valve reach some minimum intensity. With this form of A.V.C. the effect does not manifest itself except on fairly powerful signals, and thus the signal strength of comparatively weak transmissions is not reduced in the slightest degree. Because of this, delayed

TABLE No. 2

Anode Current m/A	*Volts Drop* 20		40		60		100		200	
	Res.	*Cond.*	*Res.*	*Cond.*	*Res.*	*Cond.*	*Res.*	*Cond.*	*Res.*	*Cond.*
1	20,000	2	40,000	1	60,000	1	100,000	1	200,000	1
2	10,000	4	20,000	2	30,000	2	50,000	1	100,000	1
3			15,000	3	20,000	2	30,000	2	70,000	1
4			10,000	4	15,000	3	25,000	2	50,000	1
5					12,000	3	20,000	2	40,000	1
6					10,000	4	15,000	3	35,000	1
8							12,000	3	25,000	2
10							10,000	4	20,000	2

Correct to nearest values obtainable. The resistance used must be capable of carrying the current flowing. Condenser must be capable of carrying the voltage.

A.V.C. is particularly suitable for use in small receivers. (See also *Quiet Automatic Volume Control* and *Automatic Volume Control.*)

DEMOCRITUS' PRINCIPLES. (1) From nothing comes nothing. Nothing that exists can be destroyed. All changes are due to the combination and separation of molecules. (2) The only existing things are the atoms and empty space; all else is mere opinion. (3) The atoms are infinite in number and infinitely various in form; they strike together and the lateral motions and whirlings which thus arise are the beginnings of worlds. (4) The varieties of all things depend upon the varieties of their atoms, in number, size, and aggregation.

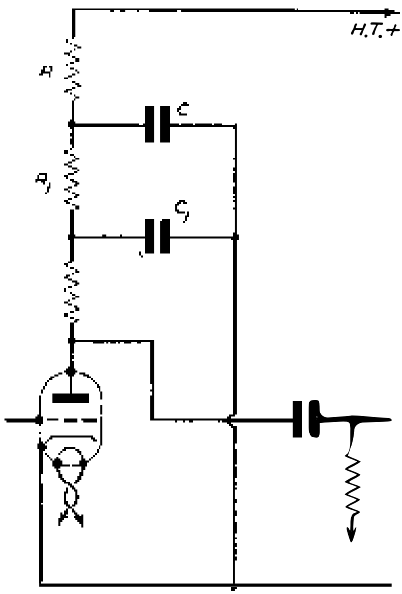


FIG. 177. *R.C.C. stage with double decoupling by resistance R and R1, C and C1.*

DEPOLARISER. The substance used to prevent local action (polarising) in a primary cell.

DETECTOR. (See *Valve.*)

D.F. The abbreviation for Direction Finding or Direction Finder.

DIAKATHODE RAYS. Ions, positively charged, which travel at a reduced velocity as compared with cathode (kathode) rays. Sometimes referred to as Canal Rays or, more generally, Positive Rays.

DIAMAGNETIC. Having the property of taking up, when freely suspended and acted on by magnetism, a position transverse to that of the magnetic axis. Opposed to *Paramagnetic* (*which see*).

DIAPHRAGM. A thin plate or plates placed transversely across the *waveguide,* not completely closing it, and introducing usually a *reactive impedance.*

DIAPHRAGM RING FILTER. A *filter* in the form of an annular slot in a *diaphragm.*

DIELECTRIC. The insulating material in a condenser. A condenser consists of two or more plates separated by some insulating material. The nature of this insulator will vary the capacity, although the distance separating the plates of the condenser be kept constant. All insulators have a value given to them according to their efficiency, compared with air as a dielectric, and this is known as the dielectric constant (another term for this is specific inductive capacity). Air is rated as 1, and therefore the dielectric constant is rated as a comparative figure to the air dielectric. For instance, the dielectric constant (or S.I.C.) of ebonite is $2\frac{3}{4}$, which means that for a given size of plate, and a given separation between them, a condenser with ebonite as a dielectric would have a capacity $2\frac{3}{4}$ times as great as one with air as the dielectric. (See also *Dielectric Constants.*)

DIELECTRIC CAPACITY. The inductive capacity.

DIELECTRIC COEFFICIENT. Dielectric constant.

DIELECTRIC CONSTANTS. The following table gives the specific inductive capacities of various materials. These figures represent the dielectric constants.

Material	*S.I.C.*
Air	1
Paper	1·5
Paraffin Wax	2·5
Ebonite	2·75
Shellac	3
Presspahn	3
Flint Glass	4 to 6
Plate Glass	4·5
Mica	5 to 8

DIELECTRIC HYSTERESIS. The dielectric of a condenser does not rid itself from "strain" after first discharge. A second and smaller discharge may be obtained after a short lapse of time. Residual charge. Electric absorption.

DIELECTRIC MATCHING PLATE. A dielectric plate used as an *impedance* transformer for matching purposes.

DIELECTRIC STRENGTH. The degree of strain, without breaking down, of a dielectric. Refer to the following table :

Material	*Dielectric Strength per Mm.*
Glass	8,000
Shellac	10,000
Presspahn	6,000 to 15,000
Porcelain	16,300
Rubber	18,000
Mica	17,000 to 28,000
Ebonite	30,000
Micanite	40,000

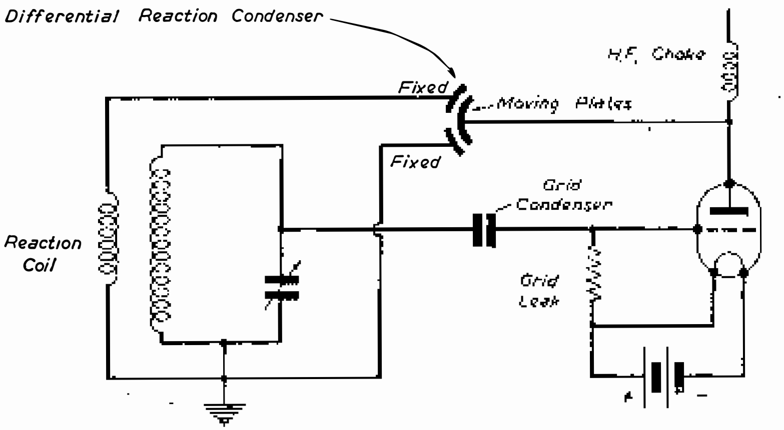


FIG. 178. *The method of connecting a differential condenser when the reaction coil is joined to the earth line. The connections to the reaction coil govern the differential condenser connections.*

DIFFERENTIAL CONDENSER. A condenser having one rotor but two stators. In the most common form the stators are disposed at opposite sides of a plate, and the rotor arranged so that as the plates are rotated they mesh with one stator as they unmesh with the other stator. The result of this arrangement is that the total capacity always remains the same, no matter what position the rotor is in, but the capacity is distributed between the two stators. The principal use for this component is in reaction circuits. The actual connections will depend upon the coil used; in some cases it may be desirable to earth the moving vanes and *vice versa.* Therefore the capacity from anode to earth remains constant, providing greater stability and smoother reaction control. The condenser may also be used as an aerial volume control by joining the rotor to the aerial, and the stators to each end of the aerial coil.

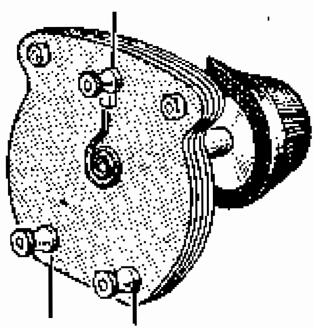


FIG. 179. *A differential condenser of the solid dielectric type.*

DIFFERENTIATING CIRCUIT. A circuit whose output voltage is approximately proportional to the rate of change of the input voltage.

DIODE. The two-electrode valve.

DIODE SWITCH. A diode which is made to act as a switch by the successive application of positive and negative biasing voltages to the anode (relative to the cathode), thereby allowing or preventing, respectively, the passage of other applied "waveforms" within certain voltage limits.

DIPLEX. Duplex.

DIPLEXER. A device which allows a common *aerial system* to be used by two *transmitters* simultaneously.

DIPOLE AERIAL. A form of aerial used for ultra-short wave work and particularly for television reception. It consists of two short lengths of metal rod, vertically disposed on the same axis, with a space separating them. The transmitter or receiver is joined to the centre. A similar arrangement may be used for reception. The overall length of the aerial must be equivalent to one-half of the wavelength of the transmission. Also known as half-wave aerial.

DIRECT CURRENT. Continuous current flowing in one direction.

DIRECTION FINDER. A special type of frame aerial arranged so that it is possible to ascertain exactly in what direction a transmitting station is situated. It consists of two frame aerials arranged one inside the other at right angles. The signals in one aerial cancel out those in the other when in a certain position relative to the transmitting station, and it is therefore possible to ascertain correctly the direction. (See also *Bellini Tosi*.)

DIRECTION OF POLARISATION. (a) The direction of the electric lines of force, or (b) for a *mode* possessing at any cross-section two and only two axes of symmetry or anti-symmetry at right angles, the direction of polarisation is the direction of the electric field at, or limitingly near to the intersection of the axes.

DIRECTIONAL COUPLER. A coupling between a *waveguide* and another *waveguide* or external circuit such that the direction of energy flow in the latter is related to the direction of energy flow in the former.

DIRECTIONAL RECEPTION. Assume that a station is broadcasting a speech,

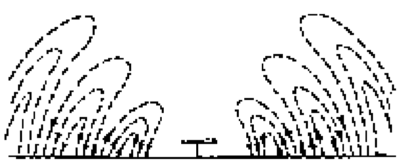


FIG. 180. *How the lines of stress radiate.*

its transmitting aerial being charged alternately positive and negative, emitting a high-frequency-carrier wave, modulated at audible frequency. To simplify what takes place, imagine, by way of example, the first complete cycle of electro-motive-force (E.M.F.) which charges the aerial. When the latter has reached its maximum voltage, and the current is at zero value, we can imagine lines of electric strain existing between aerial and earth. Directly the voltage falls and current flows down the aerial, this electric field, with its imparted energy, separates itself from the aerial charge and radiates outwards in the form of annular loops. The current then flowing in the reverse direction produces a reverse effect. The illustration (Fig. 180) will serve to make more clear how these lines of electric stress combine to travel outwards with extending height, but of constant width, at the tremendous velocity of 186,000 miles per second. This alternating moving system of electric force, varying in intensity, has associated with it a magnetic property, which always attends electrons in motion, and is at right angles to these lines of electric strain in the form of horizontal bands as in Fig. 181.

The strength of the magnetic flux density will, of course, vary as the strength of the electric field after the first quarter cycle has passed, when they come into step and rise and fall in phase, gradually dissipating energy as various conductors are encountered.

By studying the accompanying sketch (Fig. 182) it will be seen that the frame aerial is inductively coupled to the high frequency or detecting stage of the receiver by the mutual coupling coil, while Fig. 183 is a plan form of the aerial, with rings indicating the approaching wave from broadcasting stations at different points. First consider the electric component of waves F and J as either pass the aerial, which is at right angles to the direction of the waves as shown in Fig. 183. This force has induced simultaneously an electro-motive force (potential difference, or difference in electrical pressure as it may be called) in the order of milli- or microvolts in our vertical conductors—so that A is at a higher voltage with respect to B—as is also C to D—but the induced E.M.F.s, which are exactly the same in value, are acting in opposition to each other, and as the resultant current round the aerial circuit depends upon the difference between these two opposing forces (which in this case is zero) by neutralising each other, no current results, consequently the coupling coil is not influenced. Reasoning in the same way, the waves from L or H do not strike both sides of the aerial simultaneously as before—one conductor being reached in advance of the other—so that the total effective E.M.F. driving the current round the circuit will be the difference between the induced E.M.F. in both conductors.

A similar state of affairs takes place by magnetic induction. According to Lenz' Law (*which see*), an alternating magnetic field will induce an E.M.F. in any vertical conductor when it is cut *across* by the flux. Referring to the oncoming waves in the same sequence as before, a potential difference is set up in both sides of the frame aerial, the magnitude of which will depend upon the linkage of the magnetic lines of force with the aerial. From whichever part of the compass it is desired to receive signals, the set must be rotated, thereby placing either side of its aerial in the direction of the incoming wave in order to receive maximum current through the aerial circuit, assuming, of course, that this circuit is already in resonance with the desired wave frequency.

If two high-powered stations are situated in the same direction, it will not be possible to obtain any advantage from the aerial's directional property as a selectivity aid. In this case, all that can be done is to rotate the frame to a position slightly out of the correct line, and use the reaction control to make up for the loss of signal strength caused by this "off-setting." By a judicious use of the reaction and this method of using the frame, it is possible to eliminate an interfering station. In constructing a frame aerial to cover both short and long waves, it is preferable to arrange the two sections at right angles to one another. This avoids losses due to the unused section.

The presence of any metallic body will affect the directional property of the frame.

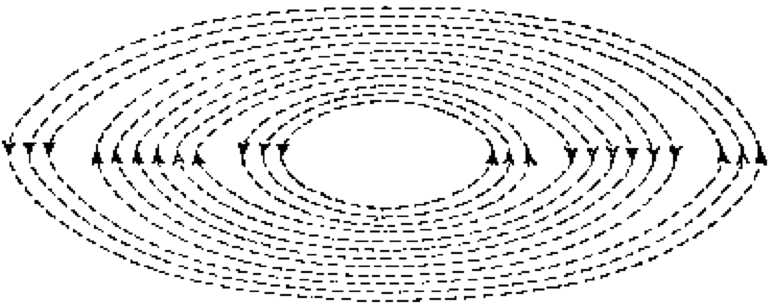


FIG. 181. *A diagram of the lines which accompany the radiation illustrated in* FIG. 180.

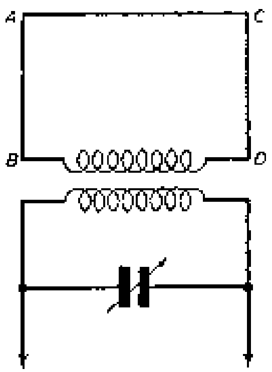


FIG. 182. *The frame aerial with its small coil coupled to the main tuning circuit.*

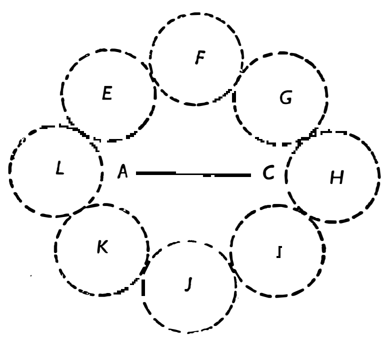


FIG. 183. *The wave-forms of different stations approaching the frame aerial A-C.*

DIRECTOR ELEMENT. A *passive element* so situated with respect to its associated primary element(s) that the direction of maximum radiation from the *primary radiating element* is that from the primary element(s) to the *passive element.*

DISCRIMINATOR. (See *Frequency Modulation.*)

DISH. A *reflector* whose surface is part of a surface of revolution, generally a paraboloid or sphere.

DISPLAY. Visual indication of received signals.

DISSOCIATION EFFECT. That theory which assumes that substances in solution are dissociated into positive and negative ions carrying respective charges in opposite directions.

DISSOLVER. (See *Fader.*)

DISTILLED WATER. (See *Accumulator.*)

DISTORTION. For perfect reproduction, the sound issuing from the loudspeaker should be an aural replica of what is

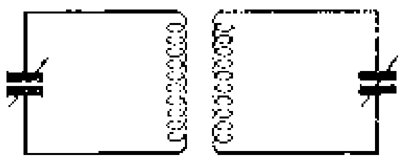


FIG. 184. *Inductively coupled coils.*

taking place at the broadcasting studio of the station tuned in. When this fails to happen, as judged by a critical ear or by the movements or tell-tale meter needles inserted at correct positions in the power feeds, distortion is said to be taking place. (Later sections deal with the use of meters.)

The high-frequency section of a wireless receiver is more often the cause of distortion than the low-frequency side. When a station is sending out speech or music it broadcasts, in addition to the carrier wave, other frequencies which are known as sidebands. These are spaced equally on either side of the carrier frequency, and may extend as far as 7,000 to 8,000 cycles either side.

A receiver of the ordinary type having sharp selectivity cuts off a large section of these sidebands, or at least reduces their amplification to such an extent that they compare very unfavourably with the amount of amplification accorded to the lower frequencies. The higher frequencies bring about the brilliance or timbre, and if they are not present then quality must to a certain extent be reduced.

In the band-pass arrangement there are three main types, and these are shown in Figs. 184 to 186. In every case it will be noticed that there are two tuned cir-

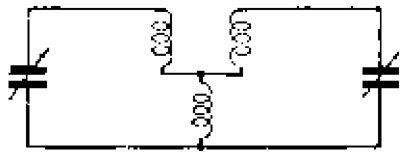


FIG. 185. *Coil common to both tuned circuits.*

cuits, and energy is transferred from one circuit to the other by a mutual magnetic interaction (Fig. 184), a coil common to both tuned circuits (Fig. 185), or a carefully controlled capacity-coupling (Fig. 186).

The frequency response of each circuit is thus combined, and it is possible to make the complete circuit accept frequencies over quite a wide range and almost wholly reject the others. In other words, brilliance and reproduction are maintained together with selectivity.

The items chiefly responsible for frequency distortion are the methods of coupling between the valves and the loudspeaker itself. Taking the first named, it must be remembered that if L.F. transformers are employed, the primary or input winding must have an adequate primary inductance. This does not necessarily mean that the transformer with the largest size is going to give the best results. Modern development has produced transformer cores which are quite small compared to the early types. It is also necessary to maintain the induc-

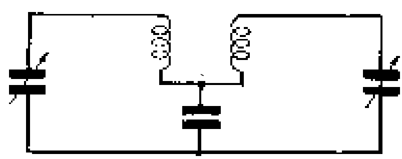


FIG. 186. *Capacity-coupled circuit.*

tance high even when quite large anode currents from the valve pass through the primary winding, so in this case it is necessary to learn whether a manufacturer guarantees the inductance value in henries.

With inadequate primary inductance in

transformers, there will be a loss of the bass frequencies, so that even with a perfect sound reproducer coupled to the set, if the bass frequencies are lost in the set, they will not be heard from the loudspeaker.

Next consider the resistance-capacity coupling method. Success here lies primarily in the selection of suitable valves and components. For most purposes the value of the anode resistance should not exceed about four to five times the valve impedance. The grid leak, on the other hand, may be about five times the value of the anode resistance, while the capacity value of the coupling condenser depends primarily on the value of the lowest frequency to be amplified, the ohmic value of the grid leak, and the fraction of maximum amplification desired at the lowest frequency. The greater this last-named fraction the greater will be the capacity of the condenser.

For example, if the grid leak is $\frac{1}{2}$ megohm, the lowest frequency 50, and the fraction just mentioned $\frac{9}{10}$, then the capacity is calculated to be about ·015 μF. Do not use a condenser of low value if it is desired to pass through the low frequencies.

Amplitude distortion produces a mutilation of the wave form of the original sound, and the incorrect use of valves is one of the principal causes.

Perhaps the valve is over biased or over loaded, or even under biased. To secure a faithful replica of the signals handed on to the grid of the valve, the incoming grid swing must take place over the straight portion of the valve characteristic. If by chance the valve is over biased, the incoming signals will operate over the lower curved part of the characteristic, and distortion will occur. If a valve is overloaded, that is to say, has a grid swing applied to it greater than it can handle on the linear portion of its characteristic, then distortion is most marked—one gets frequently what is known as blasting.

As the signal is amplified stage by stage, the grid swing increases in magnitude, and each valve following a particular stage must be capable of accepting what is passed on. A good indication of the strength of signal which a valve can handle without distortion is afforded by the value of grid bias recommended by the maker. For example, a valve of the H.L. class requiring a grid bias of about 3 volts might be used for the first stage, while a valve requiring 7 or 8 volts grid bias might follow it.

DITCH. A groove correctly proportioned to act as a *choke.*

DOORKNOB TRANSFORMER. A *mode changer* (coaxial to *waveguide*) in which the inner of the coaxial line is extended completely across the *waveguide* with progressive increase in diameter.

DOORKNOB VALVE. A type of very-high- and ultra-high-frequency valve similar in size and shape to a doorknob and having a ring seal rather greater in diameter than the axial length of the valve.

DOPPLER EFFECT. Is that apparent change in the wavelength of light which is produced by the motion in the line of sight of the light source or in the line of sight of an observer.

DOPPLER RADAR. Any form of radar which detects radial motion of a distant object relative to a radar set by means of the change in radio frequency of the echo signal due to the motion.

DOT-LOCK. A method in which a direction finder is operated by only the very first part, or other desired part, of the signal arriving at the receiving station at each morse dot or dash, components of signal due to all rays arriving later or earlier being eliminated.

DOUBLE ANODE VALVE. The valve employed for full-wave rectification in a mains battery eliminator. This type of valve has a filament and two anodes, and the two ends of the secondary winding of the mains transformer are joined to the two anodes. The two ends of a filament winding on the transformer are joined to the filament of the valve, and the result of this combination is to rectify the A.C. currents induced in the secondary windings. The centre taps of the two windings are used respectively for negative and positive high-tension supplies (D.C.). (See also *Eliminator*.)

DOUBLE-BEAM TUBE. A cathode-ray oscillograph or oscilloscope in one form of which the electron *beam* is split into two. Other forms exist with more complete separation of the beams. The two beams are controlled by separate Y plates enabling two different wave-forms to be examined simultaneously.

DOUBLE-COLOUR SCREEN. A triple layer screen consisting of a *double-layer screen* with the addition of a second long *persistence* coating having a different colour and different persistence from the first.

DOUBLE DIODE PENTODE. The combination of a double diode valve and the electrodes of a pentode valve (*which see*). The two diodes are generally employed for detection and automatic volume control, whilst the pentode acts by the variable-bias method as a controlled L.F. valve. (See *Valves.*)

DOUBLE DIODE TETRODE. The combination of a double diode valve and the electrodes of a tetrode. Its use is exactly the same as the double diode pentode, excepting the difference in amplification between the tetrode and the pentode section of the valve. (See *Valves.*)

DOUBLE DIODE TRIODE. A multi-electrode valve which really contains all the elements of two separate valves. There are the usual heater, a cathode, two "auxiliary" anodes, a grid, and a main anode. The first four electrodes operate together as a full-wave detector, whilst the first two and last two act as a normal triode L.F. amplifier. This valve is used principally for providing A.V.C. (See *Valves.*)

DOUBLE-LAYER SCREEN. A cathode-ray tube screen having two luminescent coatings: under electron impact the first emits light with a very short *persistence* (fluorescence) and the second absorbs this light and converts it into light of another colour with a long *persistence* (phosphorescence).

DOUBLE-PULSE-POSITION MODULATION. A form of *pulse modulation* in which the *pulses* occur in pairs, and intelligence is conveyed by varying the spacing between the pulses of each pair. The first of each pair recur regularly at equal intervals.

DOUBLE RING STRAPPING. The use of two *ring straps*, one being connected to alternate segments and the other to the remaining set of alternate segments.

DOUBLET. Another name for a dipole, divided, or half-wave aerial. (See *Dipole.*)

DOWN-LEAD. The wire leading from an aerial down to the receiver. Also termed the lead-in.

D.P. Double Pole. Difference of Potential.

DRIFT SPACE. The space between *buncher* and *catcher*.

DRILLS. For general purposes the twist drill is the best, as it permits being reground until worn out, has a constant cutting rake during its life, maintains its size, and is self-clearing. Straight flute drills are handy for brass and aluminium. Standard twist drills are commercially obtainable in fractional sizes ranging from $\frac{1}{64}$-in. diameter to 1 in. diameter by increments of $\frac{1}{64}$ in. In wire sizes from No. 80 (·0135 in. diameter) to No. 1 (·2280 in. diameter)—80 different sizes in all, and in letter sizes from Letter A (·2340 in. diameter) to Letter Z (·4130 in. diameter).
For wireless work, however, most requirements are covered in the tables given on page 127.
These drills, and a $\frac{7}{16}$-in. and $\frac{1}{2}$-in. diameter and possibly a few extra fractional sizes below $\frac{1}{2}$ in., should complete the range required.
When resharpening becomes necessary this should be done by grinding. Drills that do not get a lot of use may be sharpened with an oilstone to restore a keen edge. When regrinding, follow the original ground faces as closely as possible, grinding from the back and finishing at the cutting edge of each face. After grinding examine the drill for the following points:
(1) That the point is central.
(2) That the angles are equal.
(3) That the backing off is equal.
Where any appreciable thickness of metal has to be drilled it is a good practice to thin the point of the drill, that is, where the same is unduly thick. This will make the drill cut faster, and also less pressure will be required on the drill.
It is very noticeable, when drilling brass, aluminium, or ebonite, how the drill is inclined to "bite" into the material. A remedy for this is to grind the face at the cutting edges slightly to reduce the cutting rake.
When using an ordinary twist drill for countersinking, to prevent chattering occurring during cutting, the cutting clearance on the drill lips should be reduced to a minimum, so that the drill is almost rubbing. This will produce a clean-cut countersink.
To produce flat-bottomed holes, such as are required to accommodate the heads of cheese-headed screws, the hole or holes are first drilled to take the shanks of the screws and opened out with another drill to take the head. This drill is then ground off flat and backed off, and the drilling continued with it to the correct depth.
When a drill is incorrectly ground it will cut a hole larger than the diameter intended. As soon as the point of the drill has entered the material and the lips have

TWIST DRILL GAUGE SIZES

No. Drill	*Decimal Sizes*	*No. Drill*	*Decimal Sizes*
1	·2280	31	·1200
2	·2210	32	·1160
3	·2130	33	·1130
4	·2090	34	·1110
5	·2055	35	·1100
6	·2040	36	·1065
7	·2010	37	·1040
8	·1990	38	·1015
9	·1960	39	·0995
10	·1935	40	·0980
11	·1910	41	·0960
12	·1890	42	·0935
13	·1850	43	·0890
14	·1820	44	·0860
15	·1800	45	·0820
16	·1770	46	·0810
17	·1730	47	·0785
18	·1695	48	·0760
19	·1660	49	·0730
20	·1610	50	·0700
21	·1590	51	·0670
22	·1570	52	·0635
23	·1540	53	·0595
24	·1520	54	·0550
25	·1495	55	·0520
26	·1470	56	·0465
27	·1440	57	·0430
28	·1405	58	·0420
29	·1360	59	·0410
30	·1285	60	·0400

LETTER SIZES OF DRILLS

A	·234	H	·266	O	·316	U	·368
B	·238	I	·272	P	·323	V	·377
C	·242	J	·277	Q	·332	W	·386
D	·246	K	·281	R	·339	X	·397
E	·250	L	·290	S	·348	Y	·404
F	·257	M	·295	T	·358	Z	·413
G	·261	N	·302				

started cutting, both lands (the narrow spiral portions against each flute) should be in contact with the edge of the hole.

Holes requiring to be drilled at an angle with a square face or through the edge of a piece of round material should be started by commencing to drill square with the work until a hole about $\frac{1}{16}$ in. deep (full diameter) has been drilled, and then gradually bring the drill over to the desired angle, keeping the drill cutting slightly whilst so doing. Holes that have started slightly out of position may be pulled over in this manner.

Rose cutters are used for countersinking; resharpening when necessary is done with a small oilstone.

Two types of counterbores for larger holes are shown in Fig. 187. These are used by first drilling a small hole for the pilot to work in, and afterwards using as an ordinary drill until the desired depth is obtained. Large holes may be drilled out in this manner, but when dealing with ebonite, to prevent any raggedness when breaking through, the material is best drilled from either side.

Large holes in sheet metal or circles from ebonite for formers can be cut out with the fly cutter shown in Fig. 187. A centre hole is also necessary in this case to accommodate the pilot, and the cutter is adjustable to suit different diameters.

To deal with a hole of a special size, when the right-sized drill is not available, a flat drill may be made to overcome the difficulty. A piece of silver steel smaller in diameter than the hole required (if the hole is $\frac{1}{4}$-in. diameter $\frac{3}{16}$-in. diameter

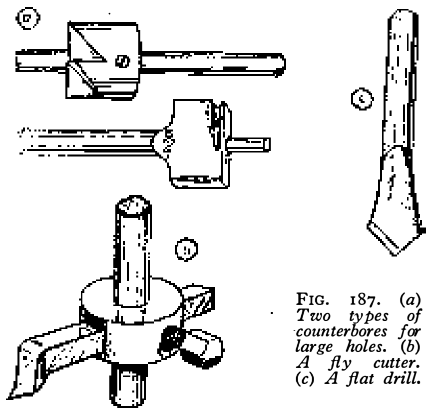


FIG. 187. (*a*) *Two types of counterbores for large holes.* (*b*) *A fly cutter.* (*c*) *A flat drill.*

silver steel will be about right) is heated at the end in the gas to a dull red and flattened out with a hammer. After allowing it to cool slowly the steel is carefully filed up to the shape shown in Fig. 187, the width of the point being made equal to the diameter of the required hole. The end of the drill is reheated to a dull red and cooled quickly in water. After polishing with emery cloth it is tempered in the gas until the polished portion assumes a yellowish brown tint; very little heating is required to accomplish this.

DRILLS, SHARPENING. It is essential that the angle of point shall be approximately 45° to the axis of the drill and *both sides exactly alike.* A simple guide, like that shown in Fig. 195, will ensure this. It consists of a piece of hardwood of L-shape bolted to the metal rests at 45° to the side of the wheel viewed in plan. A groove is filed in the top of the wood, this groove sloping down slightly (at about 10°), to form a facet on the cutting edge

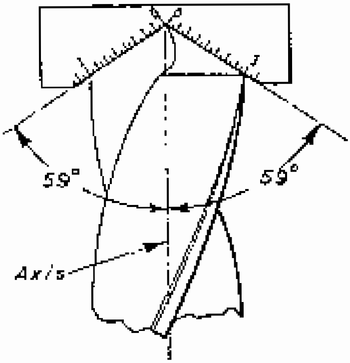


FIG. 188. *Correctly ground lips. The two lips of this drill are of the same length and make the same angle to the axis of the drill.*

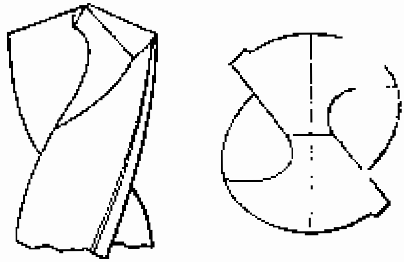


FIG. 190. *Showing what is known as notched-point thinning.*

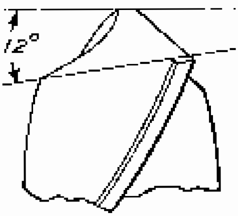


FIG. 189. *Showing the proper way to grind back the surface of the cutting lip. The angle indicated is the angle at the circumference of the drill.*

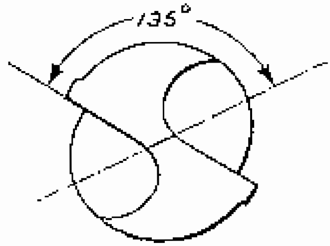


FIG. 191. *When the point is correctly ground the line across the centre of the web makes an angle of approximately* 135 *degrees with the cutting edges.*

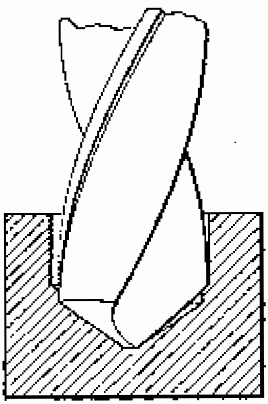


FIG. 192. *Incorrectly ground lips. The angles of the two lips are different. As a result the cutting edge on the left is doing most of the work while the one on the right is removing only a small portion of the metal. Note that the hole is larger than the drill.*

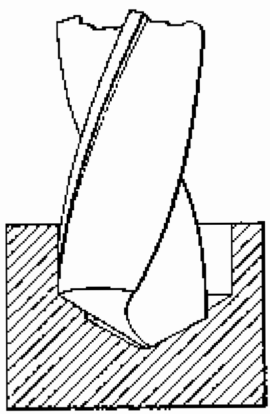


FIG. 193. *Incorrectly ground lips. The angles of the lips are equal, but their lengths are different.*

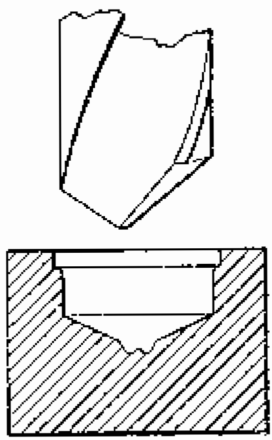


FIG. 194. *Incorrectly ground lips. The angles of the lips are unequal and the lips are of different lengths. Note the effect on the hole.*

WHITWORTH THREADS

Diameter	$\frac{1}{8}$ in.	$\frac{5}{32}$ in.	$\frac{3}{16}$ in.	$\frac{1}{4}$ in.	$\frac{5}{16}$ in.
Tapping size	$\frac{3}{32}$ in.	No. 31	$\frac{9}{64}$ in.	$\frac{3}{16}$ in.	Letter D
Clearing size	$\frac{9}{64}$ in.	$\frac{11}{64}$ in.	$\frac{13}{64}$ in.	$\frac{17}{64}$ in.	$\frac{21}{64}$ in.

B.S.F. THREADS

Diameter	$\frac{7}{32}$ in.	$\frac{9}{32}$ in.	$\frac{5}{16}$ in.	$\frac{3}{8}$ in.
Tapping size	No. 5	Letter D	Letter G	Letter O
Clearing size	$\frac{15}{64}$ in.	$\frac{19}{64}$ in.	$\frac{21}{64}$ in.	$\frac{25}{64}$ in.

B.A. THREADS

Diameter	0	1	2	3	4	5	6	7	8
Tapping size	No. 10	No. 17	No. 24	No. 29	No. 32	No. 37	No. 43	No. 46	No. 50
Clearing size	Letter B	No. 3	$\frac{7}{32}$ in.	No. 19	No. 27	No. 30	No. 33	No. 39	No. 43

WOOD SCREWS

Size No.	00	0	1	2	3	4	5	6	7	8
Clearing size	No. 52	No. 51	No. 50	No. 44	No. 40	$\frac{7}{64}$ in.	$\frac{1}{8}$ in.	$\frac{9}{64}$ in.	$\frac{5}{32}$ in.	$\frac{11}{64}$ in.

of drill equivalent to the back rake of the cutting tool.

The flat or "diamond-point" drill is the simplest form of drill, and until the advent of the twist drill was the only one used in all phases of engineering. It is made by hammering down the softened tool steel to a flat point to about one-fifth the thickness of the rod material employed. On it two facets are formed at the usual point angle (90° included angle approximately) as shown in the illustration (Fig. 187).

The twist drill has two merits as a cutting tool. In the first place, the groove clears the chips out of deep holes, and secondly, it forms an angle equal to the front rake desirable for a tool cutting iron or steel. This front rake is not really necessary for brass, and some mechanics, to prevent twist drills "grabbing" and "tearing" brass work, often grind off the points of their twist drills in the flute.

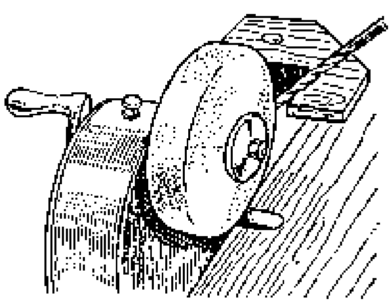


FIG. 195. *The correct angle at which to hold a drill, and details of a drill rest.*

DRIVER STAGE. An amplifying valve stage preceding a power amplifier stage.

DRIVER TRANSFORMER. The L.F. intervalve transformer used to supply signals to a Class B output stage. It differs from an ordinary L.F. transformer in that it is of step-down ratio and the secondary is wound to a low resistance of heavy gauge wire to avoid voltage drop due to the grid current flow.

DRIVER VALVE. The valve which feeds a Class B output stage. It is simply a small power valve, but gets its name from the fact that it supplies a fairly large power to a step-down transformer feeding a Class B dual valve.

DROPPING RESISTOR. A resistor inserted between a voltage supply and a valve electrode or other point, serving to reduce the potential of the latter.

DRY CELL. A primary cell of chemicals giving forth electrical energy. Active elements consist of a piece of carbon and a piece of zinc. They are known as the electrodes. Separating these is a chemical composition known as a depolariser, usually manganese dioxide. It is in this composition that the various types of dry cell differ. The voltage of a dry cell (one cell consists of one carbon electrode—the positive, and one zinc—the negative electrode with the appropriate depolariser) is 1·5 volts. The capacity, or the amount of current it will deliver, depends upon the size of the cell. These cells are used principally for H.T. batteries. (See Fig. 106, also *Leclanché Cell* and *Bichromate Cell.*)

D.S.C. Double Silk Covered (wire).

DUAL LOUDSPEAKER. (See *Loudspeaker.*)

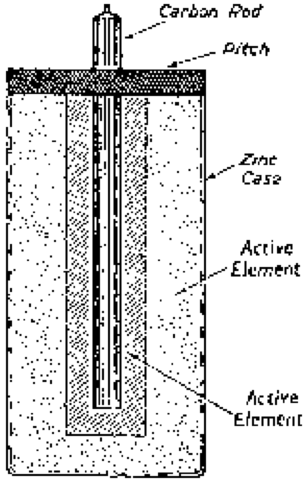


FIG. 196. *Section of a dry cell. The inner active element consists of a zinc chloride-sal-ammoniac paste, and the outer a mixture of sal-ammoniac, manganese dioxide and carbon.*

DUAL RANGE COIL. A tuning coil which covers the medium- and the long-wave bands. (See also *Coil.*)

DUCT WIDTH. The difference in height between the upper and lower bounding surfaces of a tropospheric radio duct. The upper bounding surface is determined by a local minimum value of the excess modified refractive index. The lower bounding surface is either the surface of the earth or a surface parallel to the local stratification of refractive properties at which the excess modified refractive index has the same value as that at the local minimum value of the excess modified refractive index.

DULL EMITTER. This is the name which some years ago was given to valves whose filaments could scarcely be seen to glow and which thus emitted electrons when heated to only a dull red. The term was used in opposition to "bright emitter," the name given to valves whose filaments were heated to incandescence.

DUMB AERIAL. An artificial aerial (*which see*).

DUMB-BELL SLOT. A dumb-bell-shaped hole acting as a *slot radiator* or as a *resonant diaphragm.*

DUMB-BELL WAVEGUIDE. A *wave-guide* whose section is shaped like a dumb-bell.

DUODECAL BASE. A television tube or valve having a twelve-pin base.

DUPLEX. Diplex. Two-way telegraphy and telephony.

DUPLEXER. (See *Common T.R. Working.*)

DUTY FACTOR. For a *pulse* transmission, the ratio (or its reciprocal) of the duration of the equivalent rectangular pulse to the pulse recurrence period.

D.X. An abbreviation for "distance."

DYNAMIC RESISTANCE. The resistance of a tuned circuit at resonance:

$$R = \frac{L}{C \times r}$$

r being the equivalent series resistance.

DYNATRON. A valve circuit which employs the negative resistance provided by secondary emission in a tetrode valve. A vacuum-tube device having two electrodes, a cathode, and an anode. The electrons from the cathode strike the anode with great force and set up a secondary emission, and the current received in the anode circuit is the difference between the re-emitted electrons and the original electron stream. (See *Magnetron.*)

DYNE. The C.G.S. unit of force. The force which gives a velocity of 1 cm. per second per second when acting on a mass of 1 gramme: 13,835 dynes = 1 poundal. 1 dyne = 10^{-5} newton; 1 newton = 10^5 dynes.

E

E BEND. A *waveguide* bent so that throughout the length of the bend a longitudinal axis of the guide lies in one plane which is parallel to the plane containing the *direction of polarisation.*

E LAYER. An ionised layer within the E region. It normally affects propagation in the day hemisphere. This layer reflects waves of frequencies from about 100 kc/s up to about 20 Mc/s under the most favourable conditions. (See also *Ionosphere.*)

E REGION. The region of the ionosphere between about 100 km. and 150 km. above the surface of the earth. (See also *Ionosphere*).

EARTH. The metal used for completing the earth connection. On aeroplanes a capacity earth (metal parts bonded together) is employed, and on board ship the metal hull of the ship. (See also *Aerials* and *Earths*).

EARTH RETURN. The single-wire system of wiring, the "earth" (metallic) being used as the common lead for the other (usually the negative).

EBONITE. An insulating material produced by vulcanising rubber with approximately 25 per cent. sulphur. Vulcanite.

ECHELON CIRCUIT. A circuit producing a progressive step wave from a set of n *pulses,* reverting to its initial state at the (n + 1)th pulse. (Used in counting circuits.)

ECHELON STRAPPING. Connecting the end of each segment by a single *strap* to the next segment but one. The straps are all alike and are arranged similarly to a set of blades in a radial-flow turbine.

ECHO. A deflection or change of intensity, on a cathode-ray tube *display,* produced by the radar echo from a target.

ECHO BOX. A *cavity resonator* with small damping, energised by *pulses* of energy radiated from a nearby radar aerial, or by a *probe* in a *waveguide.* The train of diminishing oscillations in the box, immediately following each pulse, is re-radiated to the radar receiver and is intended to provide an overall test of the radar set, excluding the *aerial.*

ECHO MATCHING. In *beam-switching,* turning the *aerial* or *array* until the two echoes corresponding with the two directions of the *beam* are equal.

EDDY CURRENTS. The small currents which are generated in a piece of metal or a coil of wire when placed in a magnetic field. The higher the frequency of the field the larger will be the eddy currents. If the eddy currents reach sufficient magnitude the metal will become hot. The energy dissipated in this manner is known as "Eddy Current Loss."

EDISON EFFECT. The effect of electronic flow from a heated filament in a vacuum to a metal place or anode which is connected to a positive source of high potential.

EFFECTIVE PARALLEL RESISTANCE. A measure of the *activity* of quartz crystals, taking into account all mechanical and electrical losses and the effective shunt capacitance of the maintaining system.

ELASTANCE. Unity divided by capacity. The reciprocal of capacity.

ELECTRICAL SCANNING. *Scanning* by variation of the electrical phases or amplitudes existing at the *primary radiating elements.*

ELECTRODE. Either of the two poles of a battery, dynamo, etc. An *anode* or *cathode.*

ELECTROLYSIS. (See *Accumulator.*)

ELECTROLYTE. (See *Accumulator.*)

ELECTROLYTIC CELL. A cell in which electrolysis takes place in its own electrolyte.

ELECTROLYTIC CONDENSER. A condenser consisting of two plates of different metals in a chemical liquid solution or paste. It is not a condenser until a potential is applied, whereupon a film forms over one of the plates, and this film is an insulator. The positive electrode takes this film, and the result of this insulation is to stop the flow of current, and so the two plates become the two electrodes of a condenser. These condensers are principally used in large capacities (up to 4,000 μF.) for mains smoothing purposes.

ELECTROLYTIC RECTIFIER. (See *Accumulator.*)

ELECTROMALUX. The electric eye, or photo-electric mosaic pick-up tube used in the television camera. The Iconoscope or the Emitron Camera (*which see*).

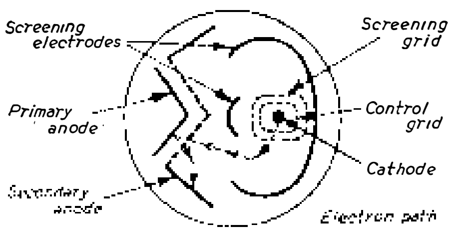
ELECTRON. An electrically charged particle of negative electricity. A negative ion is an atom plus an electron. A positive ion is an atom minus an electron. Mass when at rest$=9{\cdot}042\times 10^{-28}$ gramme.

ELECTRONIC MUSIC. The principle of electronic music is the same as that of an oscillating valve, which produces a "whistle" or high-pitched note. Music of this kind is produced by varying the capacity to earth of the grid circuit of an oscillating valve, and the "earth" consists of the hands of the performer since he moves them about a metallic rod connected to the grid of the valve. (See also *Theremin Principle.*)

ELECTRON MULTIPLIER. Seldom used for normal radio reception, the electron multiplier was developed primarily for television use. It is a form of valve the purpose of which is to obtain a much higher mutual conductance than can possibly be obtained by any normal type of valve. The principle of the device is that of directing the electron stream from the cathode on to an anode at comparatively low potential. When these primary electrons strike the anode at high velocity they cause a greater number of secondary electrons to be liberated; these are attracted to what might be termed a secondary anode, at higher potential than the first.

The form of construction for a tetrode type of electron multiplier is shown diagrammatically in Fig. 197, where it will be seen that in addition to the normal cathode, control grid and screening grid, there are two screening electrodes and two anodes. Actually, the primary anode is often described as a secondary cathode, since it is from this that secondary electrons are liberated.

The final or secondary anode is in three parts; the two "wings" are made from plain sheets of metal, while the V-shaped section joining them is in the form of a gauze mesh which will allow the passage through it of both primary and secondary electron streams. Electrons liberated by the normal cathode pass through the control and screening grids, and are deflected away from the large curved screening electrode. They strike this anode at high velocity, and so cause secondary electrons to be "knocked off." Due to the higher potential of the final anode, these secondary electrons are attracted to it. And, since the number of secondary electrons is greater than the number of primary electrons, the final anode current is greater than that of a normal anode surrounding the screening



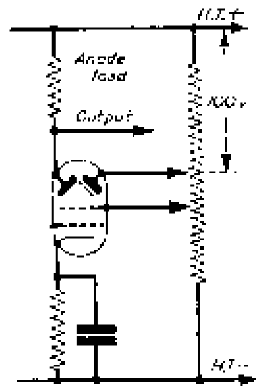


FIG. 197. *The diagram on the left shows the general form of construction for an electron multiplier. On the right are shown the connections to the valve electrodes.*

grid. More accurately, the variation in final anode current for any given variation in control grid voltage is greater—hence the increased mutual conductance.

It would appear that this electron-multiplication process could be carried on indefinitely by deflecting the electron stream from one anode to another, using any number of anodes. In practice, it can be carried to several stages, but every additional anode involves the use of a high H.T. voltage, since it is normally found that each successive anode must have a positive potential of about 100 volts in respect of that preceding it. For most purposes, therefore, only one primary and one secondary anode is used.

The principle of electron-multiplication has been applied to photo-electric cells, using a light-sensitive cathode and up to 12 anodes. The advantages of electron-multiplication for this purpose, where the primary cathode current is very limited, are obvious.

ELECTRONIC TUNING. (a) Adjusting the frequency of a circuit associated with a valve by altering the mean values of those electrical parameters (electric or magnetic fields) which influence the movement of electrons in the spaces in the valve. (b) Adjusting the frequency of a cavity by varying the magnitude of an electron beam passing through it.

ELECTROPHORUS. An instrument for producing very small charges of electricity. It consists usually of an ebonite sheet attached to a metal plate, together with a second metal sheet, provided with an insulated handle; a charge initially obtained by rubbing the ebonite can be multiplied many times.

ELECTROSCOPE. An arrangement of metal foils in a container for detecting charges of static electricity. It depends for its action on the electrostatic repulsion between charged bodies which indicates the presence of a charge or potential difference.

ELEVATION-POSITION INDICATOR (E.P.I.). A radar *display* which shows simultaneously angular elevation and slant range of objects detected in the vertical sight plane.

ELIMINATOR. An abbreviation of "Battery Eliminator" (*which see*).

A.C. MAINS UNIT. This A.C. mains unit is intended for receivers of not more than three valves (Fig. 198).

Mounting the Components. Mount the various components on the board in a position as near that shown in the wiring diagram as possible. In arranging these parts, take care to fix the fuse holder in such a position that it is easy to replace the fuse in the event of this blowing. A flexible resistance is the link between the terminal H.T.1 and one terminal on the choke but may be replaced by a normal 1-watt wire-end carbon resistor of standard type. Take care therefore to arrange the terminal strip and choke so that they are not too far apart for the resistance in use.

Carry out the wiring with thick-covered wire, of, say, 18 gauge. If condensers are obtained having only soldering tags, care must be taken in making the connections to them. The iron must be really hot, and must not be left too long in contact with the lug, or the condenser may be damaged or come adrift from the inside of the case. Note carefully that the correct connection is made to the transformer. The flex lead for connection to the mains socket must be of sufficient length to reach the socket you intend to use, and this may, of course, be a power or lighting one. Running off the lighting socket will in most cases be more expensive, but, even with lighting at 6*d.* per unit, the cost will not be nearly so high as the dry H.T. battery. When the correct length of flex has been obtained, tie a knot a few inches from the end which is to be connected to the transformer, and with a piece of wood or ebonite fix the flex to the baseboard. This will ensure that the ends are not inadvertently pulled off the transformer terminals with the possibility of blowing the mains fuse. One lead of this flex is connected to the lower terminal on the transformer, and the other lead is taken to the terminal marked with the voltage of the particular mains.

An Iron Case for Safety. For the sake of safety, and to satisfy the insurance company, it is preferable to enclose the complete unit in an iron case to which a terminal is fixed, without insulation. This terminal should be connected direct to earth. Of course, if a box is made to fit over the baseboard, make quite sure that no bare wires or terminals are likely to come into contact with the box.

Connect the unit to the receiver in exactly the same way as the H.T. battery, plug into the mains, and switch the set on. Probably signals will be much more powerful than when the battery was in use, as the unit delivers about 150 volts, and therefore the grid bias will need adjusting to avoid distortion. Examine the curves of your valves, and set the correct value of bias for the above amount of H.T. In the event of the unit being connected to a receiver having one H.T. positive terminal serving two or more valves, it is quite possible that trouble will be experienced from what is known as "motor boating" (*which see*).

A Simple Remedy. Each H.T. lead must be decoupled, as has previously been explained (see *Decoupling*). The detector valve should be connected to the H.T. + 1 on the unit, and the *last* valve of the set to the other H.T. + terminal. Any other valves in the receiver must then have their H.T. leads joined to this latter terminal via a resistance of 10,000 ohms, the end of the resistance farthest from the battery lead being connected to one terminal of a

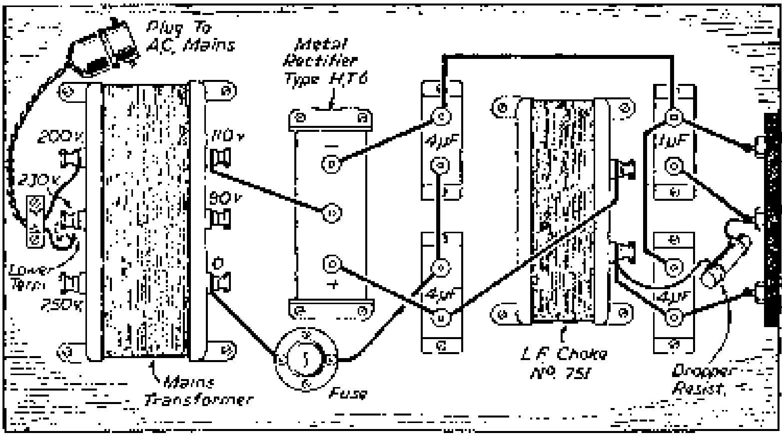


FIG. 198. *The wiring diagram of the A.C. mains unit.*

fixed condenser of at least 2 μF., the other terminal of which is connected to H.T. —.

Fig. 199 shows, by way of an example, the battery connections of a simple three-valver consisting of a detector and two transformer-coupled L.F. stages.

List of Components

1 mains transformer.
1 power choke.
1 Westinghouse metal rectifier.
3 4-μF fixed condensers (500-volt test type).
1 1-μF. fixed condenser.
1 fuse holder and fuse.

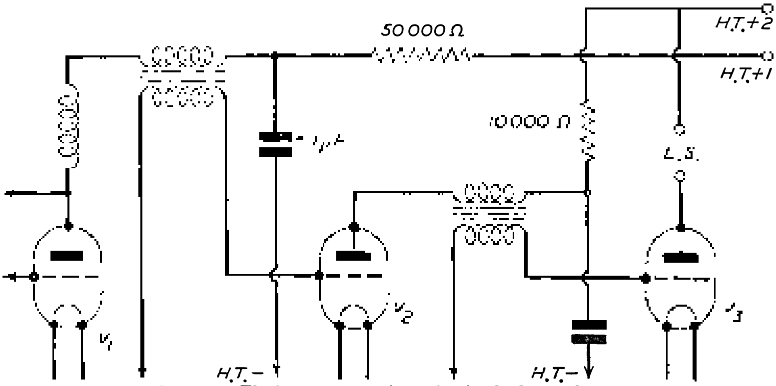


FIG. 199. *The battery connections of a simple three-valver.*

1 1-watt resistance, 50,000 ohms.
3 insulated terminals.
Small ebonite strip.
Wire, screws, mains plug, and flex.

A D.C. MAINS UNIT. Quite a number of houses are still connected to mains using direct current, and although this type of mains is gradually being superseded by the alternating-current mains, there is a demand for an eliminator to drive the wireless set from this type of mains. A D.C. unit suitable for the simpler types of broadcast receiver employing up to three valves, and not taking more current than about 20 to 30 milliamps, may be easily constructed.

The only components needed are shown in the list of parts, and here a word of warning is necessary. The condensers must be of the type tested at 250 volts or more. The remaining components may be of any desired make, and it is only necessary to ensure that the choke is rated at 30 milliamps. with an inductance of 20 henries, and that the mains voltage dropping resistance is robust enough to stand up to its job.

Marking Out the Baseboard. Having obtained the complete list of parts, commence by marking out the baseboard in accordance with the wiring plan (Fig. 200). This is quite simple, and no trouble should be experienced in getting the various parts screwed down without touching, so that wiring can be easily carried out. Drill the ebonite terminal strip and affix the terminals, which should be of the insulated variety, to avoid shocks and short-circuits. The flex for connection to the mains plug should be anchored to the baseboard with a small block of ebonite to avoid the risk of it being pulled away and shorting the mains. Do not use a brass clip to fix this flex down, as it may cut through the covering of the wire and so produce a short circuit. Wire up, using covered wire, and take care with the connections of the resistances as these are of different values and must be connected in the correct places.

Voltage Dropping Resistance. So far no value has been given for the voltage dropping resistance given in the list of components. First of all, ascertain the voltage of your mains supply. Next, find out from the makers' instructions what is the maximum voltage the last (or output) valve will take. Subtract this latter value from the former. For instance, suppose the mains are of 200 volts, and the last valve will take 150 volts. : 200 minus 150 will give 50 volts. This latter figure must then be multiplied by 1,000 and divided by the total current taken by the set. This, of course is simply the total of the current of each valve, to which must be added a further 5 milliamps, which is dropped through the smoothing and voltage dropping resistances R1 and R2. In the case of a simple three-valver using 2-volt valves, this figure should be in the neighbourhood of 20 milliamps. The answer gives the value of the resistance in ohms, and, if no resistance is made of the exact value, obtain the next nearest value.

Mounting the Unit. The completed unit should be mounted where it cannot be tampered with, or preferably enclosed in a metal box, and before it can be attached to the receiver the following points must be watched. First of all, disconnect the earth terminal on the wireless set.

Testing Out. Plug the mains plug into the nearest socket, and switch on. If no signals are heard, reverse the plug, and when the correct way round has been found, mark the plug to avoid it being plugged in the wrong way round.

Below is given an example of the working for the value of the resistance R3 in case the above particulars are not understood.

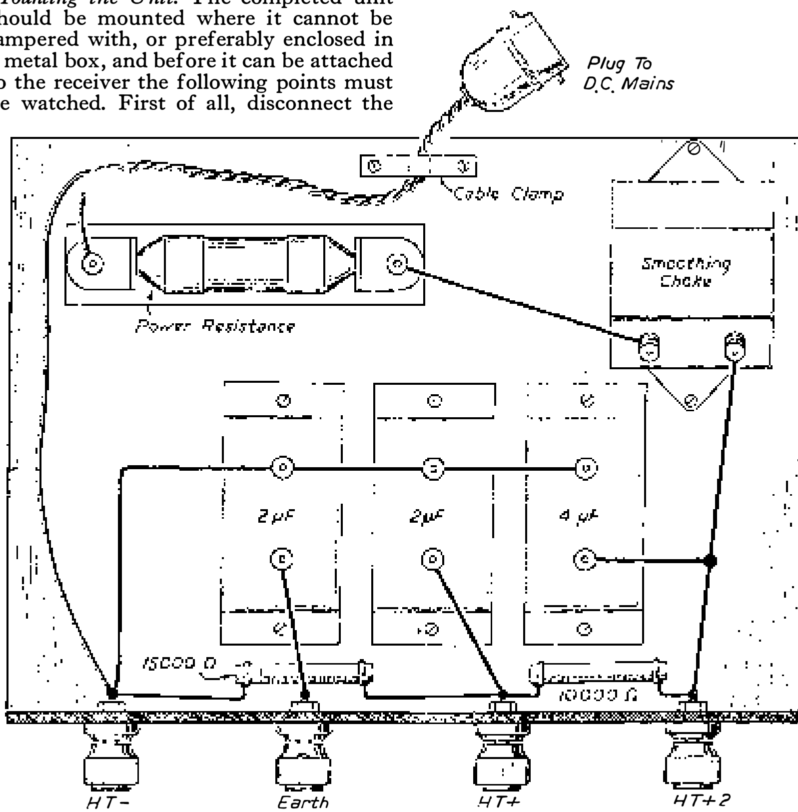


FIG. 200. *The wiring diagram of the D.C. mains unit.*

aerial and earth from the set. Next, mount a small fixed condenser (of ·01 μF or more) on the cabinet near the aerial terminal, and join one side of this condenser to the aerial terminal. The aerial lead-in is then taken to the free side of this fixed condenser instead of to the aerial terminal. The earth lead must be taken to the terminal on the D.C. unit marked "E," and *not* connected to the

Example

Mains voltage, 250 volts.

Last valve rated at 150 volts 8 milliamps.

Detector valve takes 2 milliamps.

First L.F. valve takes 6 milliamps.

Therefore, total current = 16 + 5 = 21 milliamps.

Volts to be dropped = 250 − 150 = 100 volts.

$\frac{100 \times 1,000}{21} = 4,762$ ohms.

The nearest value to this is 5,000 ohms.

List of Components

1 L.F. smoothing choke.
1 wire-end 10,000 ohms. (1 watt.).
1 wire-end 15,000 ohms (1 watt.).
1 power resistance (for values see notes).
1 4-μF fixed condenser.
2 2-μF fixed condensers.
4 insulated terminals.
Wire, mains plug, flex, baseboard, and screws.

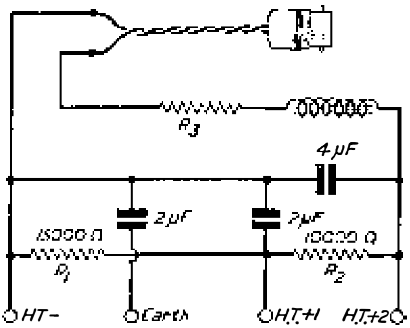


FIG. 201. *The circuit diagram.*

ELSTER AND GEITEL EFFECT. Defines that metal surfaces (polished) lose a negative charge if exposed to ultra-violet light, but retain a positive charge. Metals classified as *electro-positive* are most marked in this respect.

E.M.F. Electromotive Force (unit is the volt).

EMISSION. The flow of electrons from a heated filament in a valve. The emission consists of negative electrons, and is obtained by manufacturing the filament from a metal or combination of metals which have a good electronic emission.

EMITRON. Registered trade-name of the Marconi-E.M.I. television camera, incorporating the principle of Dr. Zworykin's Iconoscope. (See also *Orthicon* and *Photicon*.)

ENDODYNE. A method of reception differing from heterodyne reception, in that no particular valve is specially set aside for generating heterodyne frequency. (Same as autoheterodyne.)

ENERGISED SPEAKER. (See *Loudspeaker*.)

ENTHRAKOMETER. A resistive grid forming part of the wall of a *waveguide* and used for power measurement.

Note. Also used for a film similarly employed.

ENTZ BOOSTER. See *Booster*.

E OR T.M. (Transverse Magnetic) MODE. The type of *mode* in which the longitudinal component of the magnetic field is everywhere zero and the longitudinal component of the electric field is not.

EQUI-SIGNAL SURFACE. A surface around an *aerial* formed by all points at which, for transmission, the field-strength (usually measured in volts per metre) is constant.

EQUIVALENT NOISE TEMPERATURE. The absolute temperature at which a perfect resistor, of equal resistance to the component, would generate the same *noise* as does the component at room temperature.

ERG. The unit of work (C.G.S. system); is equal to the work done by 1 dyne moving, by 1 cm., its point of application. One foot-poundal = 421·390 ergs; 1 erg = 10^{-7} joules; 1 erg per second = 10^{-7} watts; 1 joule = 10^{7} ergs.

ETHER. The supposed medium pervading all space through which the vibrations of light, heat and electricity are propagated. Speed of ether waves is 186,282 miles per second, the same as the speed of light.

EVANESCENT MODE. A *mode* in which the phase is constant and the amplitude decreases rapidly with distance.

EXPAND (Radar Display). To spread out part or all of the *trace* of a *type A display*.

EXTENSION SPEAKERS. (See *Loudspeaker*.)

EXTRA HIGH TENSION (E.H.T.). An *H.T.* supply of considerably higher voltage than the normal H.T. supply.

F

F LAYER. An ionised layer within the F region. It normally affects propagation in the day and night hemispheres. Over the intensely illuminated portion of the day hemisphere, the single layer usually splits up into two layers. (See *F1 Layer* and *F2 Layer*.)

The single F layer reflects waves of frequencies up to about 35 Mc/s.

F1 LAYER. The lower and usually less densely ionised of the two layers which occur within the F region. It normally affects propagation in the day hemisphere. This layer reflects waves of frequencies from about 1·5 Mc/s to about 25 Mc/s under the most favourable conditions.

F2 LAYER. The higher and usually more densely ionised of the two layers which occur within the F region. It normally affects propagation in the day hemisphere. This layer reflects waves of frequencies from about 3 Mc/s to about 50 Mc/s under the most favourable conditions.

FADER. A device for switching out one radio reproduction and switching in another without a sudden break. It consists of a potentiometer with a fixed centre-tapping as well as a moving contact. The pick-up is joined across one half of the potentiometer and the remaining half is joined across an ordinary L.F. transformer. When the arm is at one end the radio reproduction is at a maximum and, as the arm moves across, the radio reproduction diminishes in volume until inaudible. (See also *Dissolver*.)

FADING. When wireless waves are sent out from a transmitter they divide into two portions. One part, called the "ground wave," follows the curvature of the earth and in time is all absorbed by metallic objects. The other part travels upwards at an angle to the ground until it encounters the Heaviside Layer. This layer, which is estimated to be about 40 miles above the earth, consists of ionised atmosphere and acts as a reflector to the waves. The upward waves are therefore reflected back again just as light waves are reflected by a mirror.

FAN BEAM. A *beam* whose angular width is much greater in one plane than in the perpendicular plane, the line of intersection of the two planes being the axis of the *beam*.

FARAD. The unit of capacity. A conductor is said to have a capacity of 1 farad when its potential difference is raised by 1 volt by a charge of 1 coulomb. Name is derived from Michael Faraday.

1 farad $= 1{,}000{,}000\ \mu$F.; 9×10^{11} statfarads $= 10^{-9}$ abfarads; 1 statfarad $= 1{\cdot}11 \times 10^{-21}$ abfarads $= 1{\cdot}11 \times 10^{12}$ F.; 1 abfarad $= 9 \times 10^{20}$ statfarads; 1 $\mu\mu$F. $= 0{\cdot}9$ statfarad; 1 microfarad $= {\cdot}000{,}001$ F.; 1 picafarad $= {\cdot}000{,}001\ \mu$F.

FARADAY'S LAWS. That of induction is that the e.m.f. induced in a circuit is proportional to the rate of change in the lines of force linking it. That of electrolysis is (1) That the quantity of a substance deposited in defined time is proportional to the current. (2) That different substances and quantities deposited by a single current in a similar time are proportional to the electro-chemical equivalents.

FASCICULATION. The term applied to the manner in which the electrons emitted from the cathode of the cathode-ray tube bunch together.

FAULTS. The more likely faults are (1) a complete cessation of signals, (2) a falling off in a signal strength, (3) intermittent reception, and (4) reception accompanied by crackling sounds.

For fuller information see *Practical Wireless Service Manual.*

When Reception Fails Entirely. First, suspect the aerial and earth. Test the down-lead for continuity with a flash-lamp battery and bulb (Fig. 202). Failure of the bulb to light, or an intermittent light, indicates a broken wire. Should the aerial and earth wires prove to be in order, test, in a similar manner, the loudspeaker and battery leads. Test the batteries. Connect the voltmeter or bulb across the accumulator terminals first; there should be a steady reading of 2 volts per cell or a constant light in the bulb. The most satisfactory way to test a high-tension battery is to measure the voltage between each tapping. If the voltmeter is a low-resistance one, do not keep it in contact for more than a second or so; the same thing applies when testing the cells with a 6-volt bulb. To make sure that high-tension current is passing through the output valve take out the H.T. wander plug and replace it; two distinct clicks should be heard in the speaker. To decide whether or not the valve is wrong connect a high-resistance voltmeter between the negative filament terminal and the anode terminal of the valve holder. If the voltage is normal the valve must be defective, or else it is not receiving the proper L.T. current.

If no reading, or even a low one, is obtained between the anode and H.T.½ the fault is more likely to be elsewhere. In sets employing a choke or transformer in the anode circuit one of these components is probably "burnt out." To test, connect a loudspeaker (or phones) and a battery across each winding in turn as shown in Fig. 203. When connection X is made and broken a distinct plop should be heard in the speaker. Do not mistake a feeble single "click" for the double "plop," because the former will probably be heard even if there *is* a break in the windings. Having made sure that the last valve is functioning correctly, pass on to the preceding one and apply similar tests. If decoupling resistances are connected in the anode circuit they will, of course, reduce the anode voltage, so a lower reading must be expected. Low-frequency transformers, chokes and resistances can be tested in exactly the same manner as the output transformer, but in the case of resistances the sound from the speaker will be less in proportion to the resistance value. Proceed with these tests until the detector valve is arrived at. The high-frequency amplifying valves can be tested in a similar manner, but it will be found quicker first of all to put them out of circuit by removing the aerial lead from its normal terminal and connecting it to the anode terminal of the valve immediately preceding the detector.

Where screened-grid valves are employed the lead normally going to the anode terminal on the glass bulb must be left in

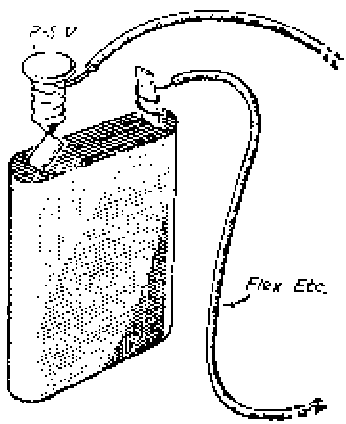


FIG. 202. *The simplest form of valve tester.*

place. The detector and L.F. stages should then work by themselves, giving good reception of the nearer stations. Once it is established that the fault is in the H.F. amplifying portion move the aerial lead to the anode terminal of the first valve (when two H.F. stages are included). This will show whether the first or second valve is not functioning, so after deciding this point the anode circuit tests can be carried out on the valve not working as explained for the L.F. valves. A further test is necessary in the case of H.F. valves; the voltage on the screening grid must be checked. This can only be measured with a *high-resistance* voltmeter. If there is no voltage reading disconnect the by-pass condenser wired between the screening grid and earth, and repeat the voltage test. If the voltage is normal in the latter case the condenser must be short-circuiting the H.T. supply. The correct way to test any condenser is as follows: connect a battery to its two terminals for a few seconds, disconnect battery, and allow the condenser to stand for some time. Then touch its terminals with a pair of loudspeaker leads; a distinct click should be heard in the speaker, showing that the condenser has held its charge. In carrying out such tests the condenser terminals must not be touched with the hands, or the charge will leak away. The battery voltage should vary from about 100 volts for capacities of ·0001 μF., to 4 volts for 4 μF.

Should it be found that the anode circuits are right, the tuning coils and condensers should receive attention. Coils can be tested in the same way as transformers, resistances, etc. (Fig. 203). The same apparatus is required for testing variable condensers, but in this case there should *not* be a click; rotate the vanes to make sure that they do not short-circuit at any point. Before leaving the tuning system see that the contacts of the wave-change switches are properly opening and closing. This is especially important when using ganged coils with self-contained switches, because it is often found that a switch blade in one of the coils has become jammed or strained, with a result that it does not move with the others. When testing any component it should be disconnected entirely from all others and preferably be removed from the set. All the above tests have referred only to battery receivers, but most of them apply equally well to mains sets. In testing the filament or heater supply in sets of the latter type a flash-lamp bulb is most convenient, but if a voltmeter is preferred it must be of a pattern suitable for alternating current.

Weak Reception. Generally speaking, the cause of weak reception can be traced in the manner just outlined, but there are a few additional tests which are sometimes necessary. The most important of these is to measure the anode current of each valve in turn. A milliammeter is required for this purpose, and one showing a full scale deflection on 10 milliamps. is most convenient. Measure the anode current to each valve by breaking the connection between H.T. + and the anode component (resistance, transformer primary choke, etc.), as shown in Fig. 203. The current passing can then be compared with that given on the maker's instruction sheet for the particular H.T. voltage in use. Remember that it is the voltage between the *anode of the valve* and H.T. — which counts and not the total battery voltage. Too low a current indicates (1) too much grid bias, (2) run-down accumulator, (3) defective valve. In the case of all-mains receivers it might also indicate that the recifier valve is losing its emission, but the H.T. voltage would then be low. An unduly high anode current indicates (1) insufficient grid bias (probably a burnt-out resistance, if an all-mains set), (2) a break in the grid circuit, (3) valve oscillating, or (4) if a S.G. or pentode, screen voltage too high. To check for (3) touch anode terminal with damp finger; the current will change if valve is oscillating. If the anode current fluctuates when signals are not being received there must be a bad contact in either anode or grid circuit. To check, first short-circuit the anode components in turn to find which, if any, is wrong. Then do the same with grid circuit components. When the anode current to every valve is normal and yet reception is impossible it is fairly safe to assume that a component in either the grid or anode circuit is short-circuited.

Intermittent Reception and Crackling. These two forms of trouble are often confused one with the other, so it might be well to explain the difference. Intermittent reception, that is when signals come and go without there being any noises, are generally caused by a fault in the aerial or tuning circuits, whilst crackling is more often due to a bad contact in an anode circuit. The method of testing anode circuit components has been dealt with previously and the tests described apply in this case. If the crackling can be provoked by lightly tapping the panel it is quite clear that a connection must be loose, but if it is unaffected by this treatment a transformer or similar component is probably defective. In the former case make sure that all the valves fit tightly in their holders and that the pins are clean. Also take the same precautions in respect of the high-tension wander plugs. Crackling noises are very frequently caused by a run-down high-tension battery or by a faulty cell. A new battery would, of course, put things right, but a temporary remedy might be effected by connecting a 2μF. or 4μF. condenser between H.T. negative and one of the positive tappings. Intermittent reception is often caused in a very sharply-tuned set by the aerial lead-in blowing to and fro and so changing its capacity to earth. The same effect would be noticed if some wires or components were free to move inside the set. Although this particular form of trouble is most common in short-wave receivers, it does sometimes occur in broadcast instruments.

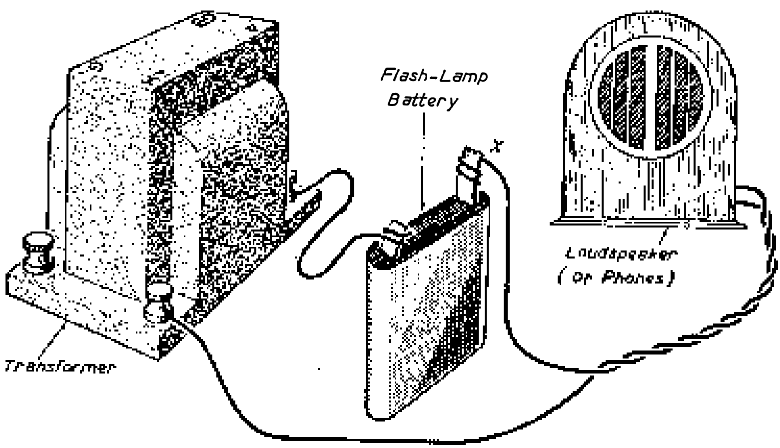


FIG. 203. *Method of testing a transformer winding.*

Other Common Faults. Another cause of much exasperation is low-frequency reaction. This sometimes manifests itself as a constant whistle which accompanies all reception, and sometimes as a peculiar spluttering noise commonly referred to as "motor-boating." It is more common in older sets, and becomes particularly troublesome when the high-tension battery begins to run down. The fault can often be cured by the well-known method of fitting a decoupling resistance in the detector anode lead and by-passing this with a 2-μF. condenser. Fig. 174 illustrates this point.

When two transformer-coupled L.F. valves are employed, the trouble can often be remedied by reversing the leads to the secondary terminals of the second transformer. Sometimes the howling is caused when the speaker is near to the set, by intercoupling between the loudspeaker leads and the first valve. In that case the remedy is to connect a ·002-μF. fixed condenser across the loudspeaker terminals or to employ metal-shielded wire for the speaker leads. In the latter case the the metal screening should be connected to earth or high-tension negative. Yet another way of preventing the howling is to connect the first L.F. transformer to the grid of the L.F. valve through a non-inductive resistance of any value about 100,000 ohms. A similar kind of trouble to that just dealt with is frequently caused by a "microphonic" detector valve. The detector valve is sensitive to vibration, and when it receives a slight jar, a "ring" or "hum" is heard in the speaker. If the speaker is near the valve the vibration set up by the diaphragm causes the valve to vibrate still more. This process goes on indefinitely, the sound increasing meanwhile. The cure in this case is to use an anti-microphonic valve holder and to wrap the valve in thick felt. Instead of felt, a good result is often obtained by sticking a lump of plasticine on top of the glass bulb.

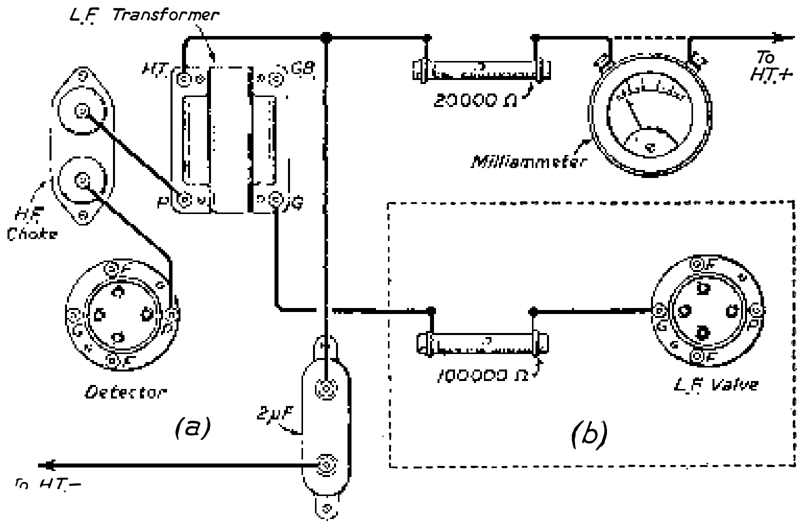


FIG. 204. *A decoupling resistance in the anode lead, and a resistance in the grid lead to cure instability.*

Mains Hum. Fig. 205 shows a method which is generally beneficial. Two ·01-

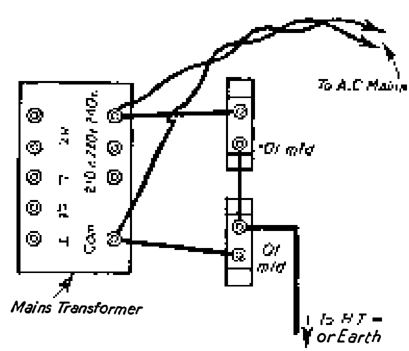


FIG. 205. *A method of curing "modulation" hum in mains-operated sets.*

μF. fixed condensers are put in series across the primary of the mains transformer and the junction is connected to H.T. — or earth. Hum caused by an electric gramophone motor housed in the same cabinet as the set can often be cured by a similar connection of condensers across its terminals. An inefficient earth lead can be the cause of the most troublesome mains hum. Instability of the kind dealt with as low-frequency reaction often appears as a troublesome hum in mains sets, and the tests are the same as those explained above. (See also *Noises*, *Testing*, and *Break Through*.)

FAURE PLATES. (See *Accumulator*.)

FIELD-STRENGTH DIAGRAM. A representation of the field strength at a constant distance from an *aerial*.

FILAMENT. The fine wire (of a valve) which, when heated (by the low-tension current), emits electrons.

FILAMENT RESISTANCE. A variable resistance used to control the flow of current to the filament.

FILTER (Waveguide). A combination of *waveguide* components designed to favour or oppose certain frequency bands or *modes* of propagation.

FILTER CIRCUIT. A circuit arranged to permit of the passage of low frequencies only. By "low" is meant all the audible frequencies, as distinct from high-frequency oscillations. The output filter circuit is perhaps the best-known form of filter. This consists of a large inductance iron-core choke arranged in the anode circuit of the output valve. Connected to the anode is a large-value fixed condenser.

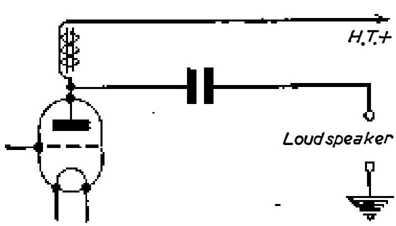


FIG. 206. *The filter circuit.*

The free side of this condenser is joined to one side of the loudspeaker, the other side of which is joined to earth. In this manner the speech frequencies pass through the easy path provided by the condenser and speaker, instead of going through the choke (see Fig. 206).

FILTER SLOT. A *choke* in the form of a slot designed to suppress unwanted *modes*.

FIRING CIRCUIT. The circuit which provides the impulse in *firing*.

FLANGE CONNECTOR. A mechanical joint in a *waveguide* run employing plane flanges bolted together.

FLANGE COUPLING. A connection between two parts of a *waveguide* run utilising flanges not in mechanical contact, which introduces no discontinuity in the flow of energy along the guide.

FLAP ATTENUATOR. A form of *lossy attenuator* in which a variable amount of loss is introduced by the insertion of a movable sheet of resistive material, usually through a non-radiating slot.

FLARE. A primary element consisting of a part of a metal *waveguide* in which one or both cross-sectional dimensions increase towards the open road.

FLEMING'S RULE. By placing the thumb and two fingers at right angles respectively, the forefinger can represent the direction of magnetic force lines, the second finger, current direction, the thumb, motion direction.

FLEWELLYN CIRCUIT. A circuit in which modifications are made to the filament circuit to produce large reaction

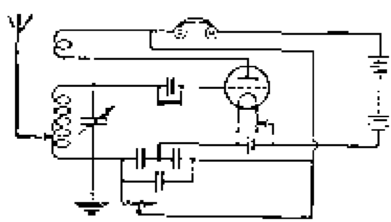


FIG. 207. *The Flewellyn circuit.*

effects. Like the Armstrong, and many similar unorthodox circuit arrangements, it is now chiefly used for short-wave work (see Fig. 207).

FLEXIBLE COUPLING. A mechanical connection between two lengths of *waveguide* normally lying in a straight line, designed to allow a limited angular movement between the axes.

FLIP-FLOP CIRCUIT. A *relaxation circuit* having one stable and one unstable condition. By applying a *triggering pulse* or signal it may be made to pass very rapidly into the unstable condition, whence, after a certain time interval, it automatically returns to the stable condition.

FLUORESCENCE. The property possessed by certain compounds of emitting light under electron bombardment.

FLUX. A substance employed in soldering to prevent oxidation of the metal being soldered.

Ammonium chloride is used for soldering copper and iron.

Ammonium phosphate is used for tin, zinc, copper and brass. It is non-corrosive and non-poisonous.

Hydrochloric acid for zinc and zinc-coated articles.

Lactic acid for copper and copper alloys. This acid tarnishes the metal round the soldered part.

Venice turpentine for pewter or Britannia metal.

Russian tallow for heavy lead work.

Palm oil for light lead work.

For wireless purposes the best flux is resin or one of the resin-cored solders. It is essential that non-acid fluxes are employed for this work. (See also *Soldering*.)

FLUX DENSITY. The strength of magnetic field around a magnet, permanent magnet or electro magnet. It depends upon the type of iron employed for the magnet, the number of ampere turns wound round the magnet, and the potential applied to the magnet.

F.M. RADAR. A system in which the radiated wave is frequency-modulated and the echo beats with the wave then being radiated, enabling the distance of an object to be measured.

FOLDED DIPOLE. A *primary radiating element* consisting of two parallel dipoles, separated by a small fraction of the wavelength, connected together at their outer ends, and fed at the centre of one dipole.

FOOT-CANDLE—UNIT OF LIGHT INTENSITY. Degree of light produced by a source of light equal to one candle-power on the surface of an object placed 1 ft. away, with its surface at right angles to the source of light. (See also *Lumen Ångström Unit*, *Lux*, and *Micron*.)

FORM FACTOR. Applying to alternating current, is that ratio of the effective root-mean-square values to the true mean values.

FOUR-ELECTRODE VALVE. A valve having two grids between plate and filament.

FOURNIER'S ANALYSIS. The scientist Fournier devoted a considerable amount of time to the investigation of wave-forms. He was able to show that waves of all shapes are always built up by combining two or more sine waves. Moreover, he proved that, however complicated the wave-form may be, it could be "broken down" into a number of sine waves.

One simple example which will easily be understood is the wave-form of a modulated oscillator. By combining two sine waves of constant amplitude—one an audio frequency, and the other a radio frequency—a resultant wave of constant frequency and varying amplitude is produced. By Fournier's method, it can be shown that a square wave consists of a greater number of sine waves than does a wave of any other form. Thus, when square waves, or others similar in form, are transmitted an unusually wide band width is required.

F.P.S. Foot-Pound-Second. The British system of units.

FRAME AERIAL. The principal feature of this type of aerial is its directional property. In use, the frame acts as two vertical aerials, the top and bottom being ignored for the sake of this non-technical explanation. If one visualises a signal from a station passing through the air, and the frame aerial being turned in the plane of oncoming waves, it is obvious

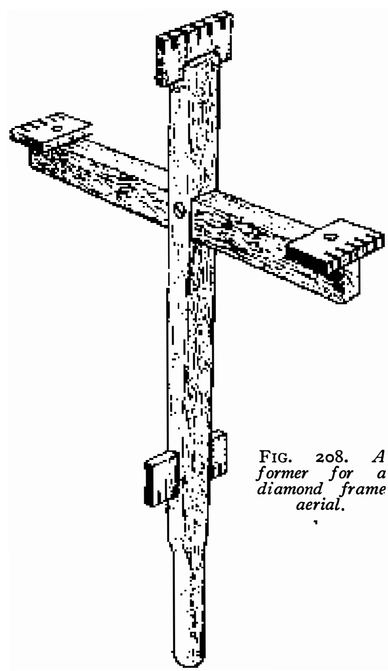


FIG. 208. *A former for a diamond frame aerial.*

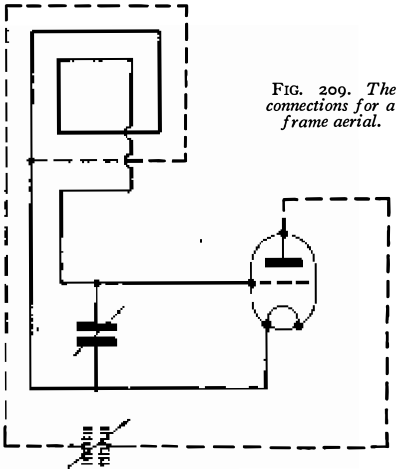


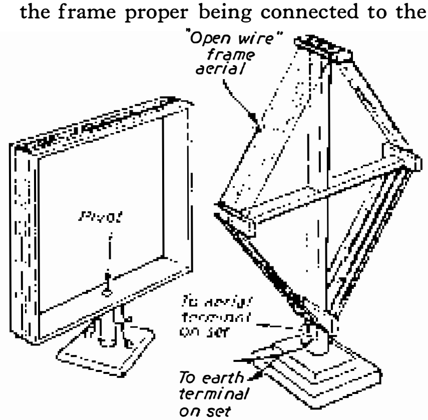
FIG. 209. *The connections for a frame aerial.*

that the waves will strike one side of the aerial before they arrive at the other side. Forces are therefore generated which are "out of phase," and a current flows. If, however, the waves hit the aerial broadside on, both vertical aerials receive the impulses at the same moment, and signal current will not flow. It therefore follows from this that maximum signals are heard when the frame is in the plane of the received signals, and the signal strength will diminish as the aerial is rotated until, when the frame is at right angles, no signals will be heard.

The Frame. In Fig. 210 will be seen the simplest of frames. Here, four pieces of ½-in. wood, 4 in. wide by 2 ft. long, are nailed or screwed together at the ends to form a square. At one side a fitting must be attached to enable the frame to be rotated to make use of the property mentioned above. This may be a section of round dowelling fitting into a socket mounted on a base of sufficient size and weight to prevent the frame from falling over. Holes bored near the pivot serve as anchorages for the ends of the wire.

In Fig. 208 a more ambitious arrangement is shown. Two lengths of quartering 1½ in. square are halved together, and at the ends strips of ebonite are fixed. Slots cut in the ebonite hold the wires securely, and the lower end is rounded off for a bearing.

The Wire for the Aerial. The wire for these aerials consists of thin flex, usually 14/36, that is, fourteen strands of No. 36-gauge wire. For the normal broadcast band 75 ft. should be sufficient, although the exact length will depend upon the shape of the aerial, the size of the condenser used for tuning, and the spacing between the turns. As a rule, the wire should be wound on with a space of about $\frac{1}{10}$ in. between each turn. A "collector" should be made from two strips of brass mounted on a piece of ebonite, and connected to the aerial and earth terminals of the receiver, the ends of the frame aerial being connected to two plungers taken from a standard lampholder, mounted on a strip of ebonite so that they bear on the brass strips. Of course, no tuning coil is necessary with this type of aerial, and if the set is fitted with one it should be removed. In the case of a simple detector circuit employing a reaction coil, four or five extra turns should be wound on the frame, the junction of these extra turns and the end of the frame proper being connected to the



FIGS. 210 AND 211. *Two further types of frame aerial.*

FRAME AERIAL DATA

Length of Side of Square Frame	*No. of Turns*	*Space between Wires*	*Inductance (Microhenrys)*	*Self-capacity (Microfarads)*	*Natural Wave-length in Metres*
8 ft.	3	½ in.	96	75	160
6 ft.	3	¼ in.	124	66	170
4 ft.	6	¼ in.	154	55	175
3 ft.	8	⅛ in.	195	49	185

earth terminal. The free end of the extra turns should then be connected to the reaction condenser.

The rule-of-thumb data of 75 ft. of wire for the medium waveband will serve in most cases. (See *Aerial.*)

FRAUHOFFER LINES. Are noted when sunlight is seen through a spectroscope; they are seen as a great number of dark lines crossing the spectrum.

FREQUENCY. The number of vibrations or waves per second of any periodic phenomenon. (See also *Musical Frequency, Resonant Frequency, Natural Frequency, Low Frequency, High Frequency, Audio Frequency*, etc. See *Wavelength* for table of Wavelength-Frequency conversion.)

FREQUENCY CHANGER. The part of a superheterodyne circuit which changes the frequency of a received signal in order that it may be amplified by the intermediate-frequency amplifiers. It consists of an oscillating valve and a detector, which may be two separate valves or one valve doing the combined work, and which yields a beat note having a frequency of the difference between that of the received signal and the oscillator.

FREQUENCY-CHANGING CIRCUIT. A circuit, comprising a beat oscillator and a *mixer*, which delivers output at one or more frequencies differing from the input frequency.

FREQUENCY DOUBLER. A circuit used in such a manner that the output is at twice the input frequency. Used in a transmitter to provide an output at varying frequencies with a single crystal or oscillator, and in certain forms of electronic musical instrument to provide octaves of a generated tone. (See also *Frequency Multiplier.*)

FREQUENCY FACTOR, MAXIMUM USABLE. For a single-hop transmission, the ratio of the maximum usable frequency to the critical frequency at the centre of the hop.

The maximum usable frequency factor depends only on the range of the transmission and the vertical distribution of ionisation in the layer concerned, at the centre of the hop.

The term is sometimes used with reference to ranges so long that they involve multi-hop transmission. In such cases the relevant critical frequency would need to be appropriately defined.

FREQUENCY JUMPING. A form of unstable operation of a magnetron in which the frequency remains sensibly constant during a *pulse* but jumps at random from one value to another for successive pulses.

FREQUENCY, MAXIMUM USABLE (M.U.F.). The highest frequency for propagation by ionospheric reflection of radio waves between two specified points.

The maximum usable frequency for a single hop is the product of the critical frequency at the centre of the hop and the maximum usable frequency factor for the distance concerned.

The maximum usable frequency for a path between two specified points involving more than one hop is usually taken as the lowest of the M.U.F.s existing for the separate single hops.

FREQUENCY MODULATION. A system which causes the frequency of the carrier wave to vary in accordance with the applied modulating signal. Unlike Amplitude Modulation, it does not affect the power of the carrier wave; therefore, for any given power rating of a transmitter, the full power is radiated consistently. This results in increased efficiency, reduction of apparatus and operating controls. On the receiving side, it offers a higher degree of fidelity of reproduction freedom from atmospherics and man-made static. It necessitates, for detection or demodulation, the use of three valves in the detector stage, one acting as a "limiter," which ensures that the strongest signal, having a frequency the same as that to which the receiver is tuned, becomes effective; the second valve is called "discriminator," and its function is to reduce or nullify any noise (static) or signal other than that required. The third valve is employed as the actual detector.

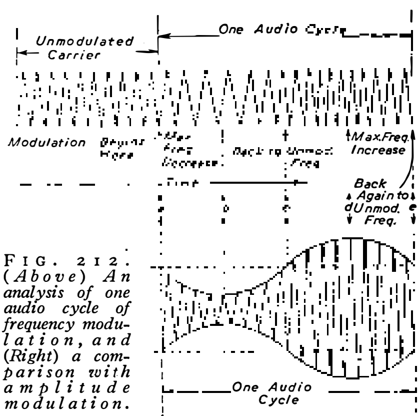


FIG. 212. (*Above*) *An analysis of one audio cycle of frequency modulation, and* (*Right*) *a comparison with amplitude modulation.*

FREQUENCY MULTIPLIER. A circuit used to provide at the output, frequencies at multiples of a single generated frequency. In a frequency doubler (which see) the output is twice the generated frequency, but in a multiplier (which term is equally applicable to a doubler) the output may be three, four or more times the fundamental.

FREQUENCY, OPTIMUM WORKING. The highest frequency at which propagation between two specified points can be expected to be maintained regularly in undisturbed conditions at a certain time on on each day.

The optimum working frequency is determined on a statistical basis, allowing for the expected variations of the maximum usable frequency for a given time on each day during the period concerned.

FREQUENCY PULLING. Change in frequency of a magnetron caused by changing the load impedance, also change in frequency of an oscillator caused by changes in the coupling.

FREQUENCY-PULLING FIGURE. The maximum variation in frequency which can occur when the *standing-wave* pattern in the feeder near to the oscillator is removed through at least half a wavelength, the *voltage standing-wave ratio* in the feeder being maintained at 0·67 in. Care must be taken that the standing-wave pattern is sufficiently near to the oscillator to give a maximum variation.

FREQUENCY PUSHING. Change in frequency caused by change in anode current.

FREQUENCY, RESONANT. The periodicity or number of cycles per second; the frequency of waves or oscillations.

Formula for frequency is : $f = \frac{10^6}{2\pi\sqrt{LC}}$

where L = inductance in microhenrys and C = capacity in microfarads.

$$\text{Frequency} = \frac{300{,}000}{\text{Wavelength}}$$

FREQUENCY SLIDING. Frequency modulation during the *pulse*.

FREQUENCY SPLITTING. A form of unstable operation of a magnetron in which there is simultaneous emission of the energy at more than one discrete frequency during the *pulse*.

FREQUENCY SYNTHESISER. A generator in which a desired frequency is obtained with precision by successive heterodyning of oscillations derived from one stable oscillator.

FRESNEL-ARAGO LAWS. (1) Two rays of light similarly polarised interfere similarly as ordinary light. (2) If polarised at right angles they do not interfere. (3) If polarised at right angles from ordinary light and then directed to the same plane they do not interfere. (4) If two rays obtained from plane polarised light are polarised at right angles they interfere when directed into the one plane of polarisation.

FRINGING COEFFICIENT. This "spreading coefficient" refers to that factor by which a pole face area has to be multiplied in order to get the effective air-gap area.

FRONT-TO-BACK RATIO. The ratio of the field strength of an *aerial* or *array* in the desired direction to its maximum field strength in the rear sector.

FULL-WAVE RECTIFICATION. See *Accumulator* and *Eliminator*.

FULTOGRAPH. Apparatus for transmitting and receiving photographs by wireless. The picture is recorded chemically by a stylus on a rotating drum.

FUNDAMENTAL. The true frequency. This term may be applied to musical frequencies or the frequencies of wireless signals. In music the fundamental note is the true number of vibrations per second, and in wireless it is the actual wavelength. The fundamental is always accompanied by components having a frequency which is an integral multiple of the fundamental. The harmonic which is double the frequency of the fundamental is known as the "second harmonic." (See *Musical Frequencies*.)

FUNDAMENTAL MODE. The *mode* with the lowest *critical frequency*.

FUNDAMENTAL WAVELENGTH. The natural wavelength of a 100-ft. aerial is approximately 120 metres. (See *Aerial, Natural Wavelength of*.)

FUSE. A piece of wire of low melting-point inserted in a circuit so that only a predetermined amount of current can flow. Small fuses for wireless sets should be inserted in the H.T. — lead. Such are inserted between H.T. — and L.T. —.

FUSE VALUES. On the input side to mains receivers at least 1 amp. should be used, and preferably a 1-amp. fuse should be included in each means lead. A ·5-amp. fuse should be included in the H.T. negative lead of the mains section of an A.C. receiver, and in all filament or heater

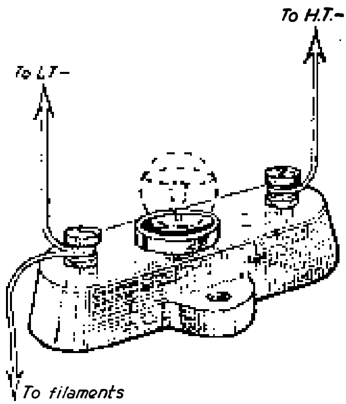


FIG. 213. *Fuse and connections.*

circuits the value of fuse chosen should be such that it will break down before any of the valves. It will vary, of course, according to the method of wiring the filaments or heaters. (See *Colour Code.*)

FUSING FACTOR. That ratio of a minimum fusing current to the carrying current rate of an electrical fuse.

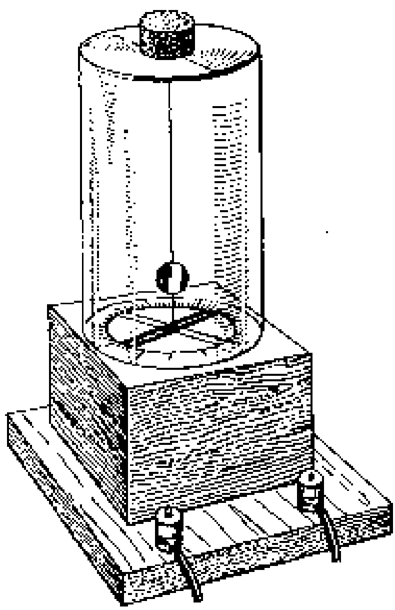


FIG. 214. *A galvanometer.*

G

GABLING. A type of *aperture illumination* in which the intensity rises linearly to a maximum at the centre.

GAIN. (See *Amplification.*)

GALENA. A crystal consisting of sulphide of lead.

GALVANIC CELL. A cell of the voltaic type (*which see*), named after Galvani.

GALVANOMETER. An instrument for detecting the existence and direction of current flow in a circuit. (See Figs. 214-218.)

GAMMA RAYS. The term applied to those frequencies above those of the so-called X-rays. The exact band of frequencies covered by the gamma rays has not yet been defined.

GANG. Any series of similar components joined together and operated by a common control.

GAP. Part of the region between the axes of two *lobes* in the *field-strength diagram* of a radio set, in which the field strength drops below an effective value.

GAP CODING. Subdividing the response of a *transponder* into long and short

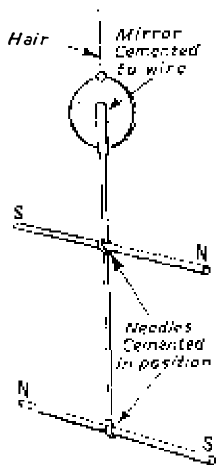


FIG. 215. *Details of the hair, magnetic needles, and mirror.*

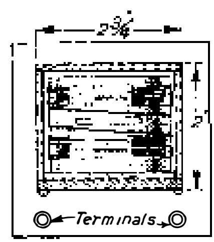


FIG. 216. *A plan view of the cabinet with the top removed.*

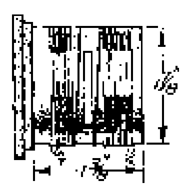


FIG. 217. *The former for winding the coil.*

groups of *pulses* (like Morse), for recognition purposes.

GAP FILLING. The electrical or mechanical rearrangement of an *aerial array,* or the use of a supplementary array, to produce *lobes* where *gaps* previously occurred.

GATE VALVE. (See *Coincidence Valve.*)

GATING. The selection after tuning of part of the received signal either in frequency-range or in time or in some other characteristic.

GAUSS. The C.G.S. electro-magnetic unit of flux density of field strength, named after Carl F. Gauss (1777-1855). In a unit magnetic field a unit pole experiences a force of one dyne. In a field of strength H a unit pole experiences a force of H dynes. A pole of strength m webers in a field of H gauss will experience a force of mH dynes. The strength of the earth's field in a horizontal direction at Greenwich is about 0·17 gauss at present. One gauss equals one maxwell per square cm. 1 gauss = 10^{-4} weber/sq. metre; 10^4 gauss = 1 weber/sq. metre. (See *Maxwell* and *Weber*.)

GAUSS THEOREM. Refers to that charge given to a particle at a particular point in an electrostatic field.

GEISSLER TUBE. A vacuum tube possessing only a moderate degree of exhaustion, so that an electrical discharge taking place in it will be brightly luminous, but broken up by dark spaces. Such discharge is known as a *Geissler Discharge.*

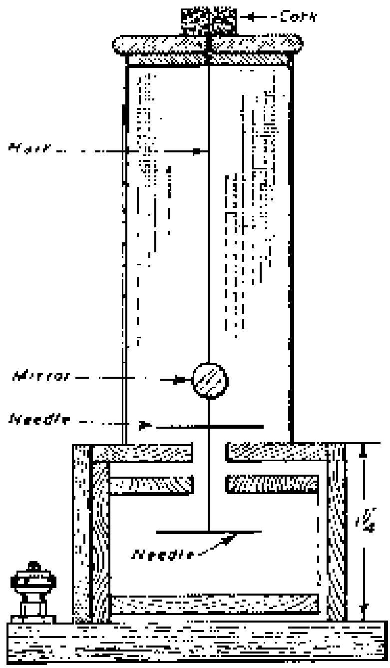


FIG. 218. *A sectional view of the completed galvanometer.*

GEITEL EFFECT. (See *Elster* and *Geitel Effect.*)

GERMANIUM. A mineral used in the manufacture of modern crystal detectors, transistors, etc. A contact is provided and the assembly is sealed, thus providing a reliable R.F. detector which will withstand considerable stress and vibration. (See also *Crystal.*)

GETTER. (See *Valve.*)

GILBERT. One thousand Unit Magnetic Poles (*which see*). 1 gilbert = 0·796 ampere turn, or 10 pragilberts; 1 pragilbert = 0·1 gilbert; 1 pragilbert = 0·0796 ampere turn; 12·57 pragilberts = 1 ampere turn. (See also *Maxwell* and *Weber.*)

GONIOMETER. An instrument for the determination of relative direction of a distant object by means of its radio emissions, whether independent, reflected, or automatically re-transmitted.

GRAMOPHONE PICK-UP. A device so designed that the sound grooves on the record are converted to electrical impulses which may be amplified.

In the simplest form the pick-up consists of a magnet with a moving armature to which the needle is connected. Modifications consist of a permanent magnet with a moving coil operated by the needle; a quartz crystal to which torsional stresses

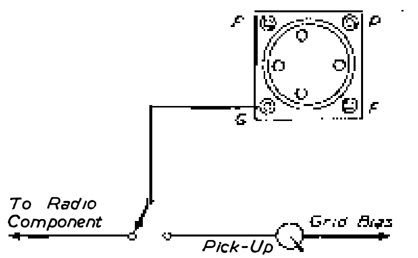


FIG. 219. *Diagrammatic illustration of pick-up switching arrangement without volume control.*

are imparted through the needle and magnetic ribbons, etc. All of these, it will be seen, are similar in construction and operation to loudspeakers, except that they are operated to provide varying currents instead of being operated by currents.

GRAMOPHONE RECORD SPEEDS. Standard speed is 78 r.p.m., but long-playing records (L.P.R.) are now produced which revolve at 33⅓ and 45 r.p.m.

GRASS. Deflections from a cathode-ray tube time base due to electrical *noise.*

GREEK ALPHABET. The Greek alphabet is as follows :

Α	α	(alpha)	Ν	ν	(nu)
Β	β	(bēta)	Ξ	ξ	(xi)
Γ	γ	(gamma)	Ο	ο	(ōmīcron)
Δ	δ	(delta)	Π	π	(pi)
Ε	ε	(epsīlon)	Ρ	ρ	(rho)
Ζ	ζ	(zēta)	Σ	σ	(sigma)
Η	η	(ēta)	Τ	τ	(tau)
Θ	θ	(thēta)	Υ	υ	(ūpsilon)
Ι	ι	(iōta)	Φ	φ	(phi)
Κ	κ	(kappa)	Χ	χ	(chi)
Λ	λ	(lambda)	Ψ	ψ	(psi)
Μ	μ	(mu)	Ω	ω	(ŏmēga)

(See *Standard Theoretical Symbols* pp. xi and xii.)

GREENWICH TIME SIGNAL. (See *Time Signal.*)

GRID. (See *Valve.*)

GRID BIAS (G.B.). The steady continuous voltage applied between cathode and grid to determine the initial operating point of a valve. For instance, in low-frequency amplification it is essential that the grid shall be at a potential of

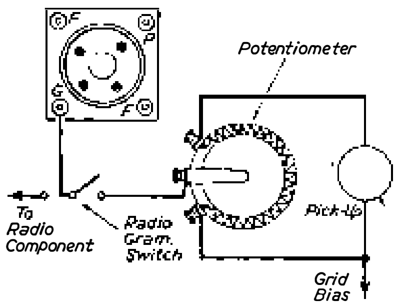


FIG. 220. *Pick-up switching arrangement with volume control.*

such a value that the applied signals will vary an equal amount on the anode curve. Fig. 99 shows a standard grid volts-anode current curve, and at 100 volts H.T. the cente point of the sloping line is directly above the —3V. grid-bias line. Therefore, if a valve with characteristics shown by these curves is employed as a L.F. valve, then a certain bias must be applied in order to bring the working point to the centre of the line. If too much bias is applied, so that the working point is brought to the bottom bend of the curve, the valve will rectify, and this method is known as anode-bend detection (*which see*).

Valves which are employed for H.F. operation sometimes require a positive bias, whilst all L.F. valves require a negative bias. The bias is applied by inserting a small battery between the grid-return lead and the negative L.T. lead. In some forms of mains receivers the bias is applied automatically by the insertion of resistances in the cathode or grid return leads. (See also *Bias* and *Automatic Grid Bias.*)

GRID BLOCKING. Paralysis of capacitance-coupled stages in an amplifier owing to the accumulation of charge on the *coupling condensers* due to grid current passed during the reception of large signals.

GRID CONDENSER. A condenser (usual values ·0003 μF. and ·0001 μF.) used to control the grid potential of the detector valve. Usually has a grid leak of from 2 to 5 megohms connected in parallel with it.

GRID LEAK. A fixed resistance of the non-inductive type (usual value 2 megohms) connected in parallel with the grid condenser.

GRID LEAK AND CONDENSER VALUES. For the average leaky grid detector a condenser of ·0003 μF. capacity and a grid leak of about 2 megohms resistance usually are recommended, while for the low-frequency R.C. stage the condenser may be as great as ·05 μF. or even more, and the grid leak of the order of 250,000 ohms. The function of the coupling condenser is principally to convey the alternating signal to the grid of the valve, while the grid leak acts as a discharge resistance. The reactance, or opposition offered by a condenser to the passage of an alternating current, is high at low frequencies and lower at high frequencies. At the enormous frequencies used for broadcasting, which are of the order of a million cycles per second, a small condenser, of about ·0003 μF., is quite satisfactory over the whole radio frequency range. But in a low-frequency amplifier the ratio between the lowest frequency it is required to pass (perhaps 12 cycles) and the highest (say 15,000 cycles) is in the neighbourhood of 1,000 to 1. If, therefore, the coupling condenser is very small, its reactance at the lower audio frequencies will be so high that the lower notes will be weakened or "attenuated" and serious amplitude distortion will occur.

The grid leak is called upon, in a detector circuit, to discharge the electrons accumulated on the grid during alternate half-cycles, while in the resistance capacity-coupled stage it has to complete the grid circuit of the valve and discharge it continuously and rapidly so that the voltage at the grid at any instant accurately follows the signal voltage fluctuations. Its value, therefore, must be such that the "time constant" of the grid circuit is small compared with the frequency of the incoming signals.

GRID LOCKING. A defect of valve operation in which the grid potential becomes continuously positive owing to excessive grid emission.

GRID STOPPER. A device used to prevent the flow of H.F. currents in the grid circuit of an L.F. valve. The stopper usually takes the form of a fixed resistance having a value of about 100,000 ohms, but an H.F. choke can frequently be employed instead. Stoppers are nearly always desirable in a short-wave receiver.

GROUNDED-GRID TRIODE. A type of triode designed for use in a grounded-grid-triode circuit.

GROUNDED-GRID TRIODE CIRCUIT. A circuit in which the input signal is applied to the cathode and the output is taken from the anode; the grid is at R/F earth and serves as a screen between the input and output circuits.

GROUND RETURNS. *Echoes* received from the ground by an airborne radar set.

GROUND WAVE. A wave which travels virtually along the ground in a manner primarily determined by the electrical constants of the ground (B.S.I.). (See also *Fading*.)

GROUND WAVE (Radar). (a) The direct transference of energy from a radar *transmitter* to its associated receiver. (b) (Loosely). The effect on the *display* of a transference of energy from a radar *transmitter*.

GRUMMET. An eyelet or similar device made from insulating material.

GUIDE WAVELENGTH. The wavelength measured in a *waveguide*.

GUY-LUSSAC'S LAW. States that if the pressure of a gas is constant its volume varies directly with the absolute temperature.

GYRO FREQUENCY.—The natural frequency of rotation of a charged particle under the influence of a constant magnetic field. When used without qualification the term is generally understood to apply to the rotation of electrons under the influence of the earth's magnetic field. The gyro frequency is proportional to the magnetic field intensity and to the charge of the particle, and is inversely proportional to its mass, e.g. for electrons and a magnetic field intensity of 0·5 oersted, the gyro frequency is 1·4 Mc/s.

H

HALF-WAVE AERIAL. (See *Dipole*.)

HALF-WAVE RECTIFICATION. (See *Accumulator* and *Eliminator*.)

HALL EFFECT. If an electric current flows across the lines of flux of a magnetic field, an e.m.f. is observed at right angles to the primary current and to the magnetic field. When a steady current flows in a magnetic field, e.m.f. tendencies develop at right angles to the magnetic force and to the current, proportionately to the product of the current strength, the magnetic force and the sine of the angle between the direction of quantities.

HALYARD. The rope used to support an aerial.

HAND CAPACITY. The name applied to the interference caused when the body or hand approaches a receiver and the high frequencies are transferred through the body to earth. This is most noticeable in short-wave work, when the presence of the hand near the tuning condenser causes all signals to pass to earth. The cure for this form of interaction is to insert a large metallic plate (which is itself joined to earth) between the tuning controls and the operating knob.

HARD VALVE. A valve which has been completely exhausted. This results in a longer life and better qualities. (See also *Soft Valve*.)

HARMONIC. A component possessing a frequency which is an integral multiple of the fundamental. If, for instance, we have a frequency of 100, the second harmonic would have a frequency of 200, the following harmonics having frequencies of 400, 800, 1,600, 3,200, etc.

HARTLEY CIRCUIT. A circuit arrangement in which a centre tap is provided on the grid coil. One half of the coil serves for the reaction circuit and this is completed by a condenser between anode and coil. The main advantage of this type of circuit is its stability, when the proper constants are used for a given size of coil. It will be found ideal for use as a one-valve circuit for battery-operation on the short-waves, and a similar circuit is sometimes used in simple transmitting circuits, either with or without a crystal. Compare Fig. 221 with the Reinartz circuit, Fig. 395.

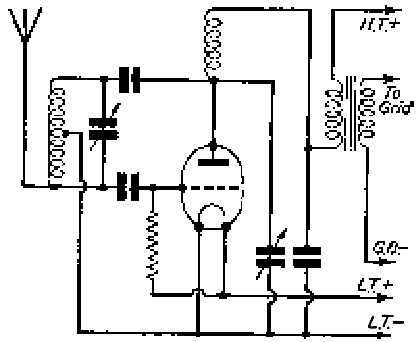


FIG. 221. *The Hartley circuit.*

HASH. Electrical *noise* generated within a receiver, e.g. by a vibrator or mercury-vapour rectifier.

H BEND. A *waveguide* bent so that throughout the length of the bend a longitudinal axis of the guide lies in one plane which is perpendicular to the plane containing the *direction of polarisation.*

HEAVISIDE LAYER. An ionised layer of the atmosphere about forty miles above the surface of the earth. Known as the E layer. (See *Appleton Layer* and *Ionosphere.*)

HEIGHT - POSITION INDICATOR (H.P.I.). A radar *display* which shows simultaneously angular elevation, slant range and height of objects detected in the vertical sight plane.

HEIL TUBE. A type of *velocity-modulation* valve in which the *buncher* and *catcher* electrodes form part of coaxial line, and in which the *drift space* is inside the inner conductor of the coaxial line.

HENRY. The unit of inductance. When a pressure of 1 volt is induced through a coil and changes at the rate of 1 ampere per second, it is said to have an inductance of 1 henry. Named after Joseph Henry. Other units are *millihenry* (one-thousandth of a henry), and *microhenry* (one-millionth of a henry); 1 henry $= 1{\cdot}11 \times 10^{-12}$ stathenry $=$ 10^9 abhenry; 1 stathenry $= 9 \times 10^{20}$ abhenry; 1 abhenry $= 1{\cdot}11 \times 10^{-21}$ stathenry.

HEPTODE. (See *Pentagrid.*)

HERTZIAN WAVES. Ether waves (discovered by Hertz).

HETERODYNE. (See *Beat Reception* and *Superheterodyne.*)

HEXODE. Same as *Heptode.*

H.F. High Frequency (*which see*).

H.F.C. High-frequency Current, or High-Frequency Choke.

HIGH FREQUENCY. Any frequency over 20,000 cycles per second.

HIGH-FREQUENCY AMPLIFIER. An amplifier in which amplification of the received impulses takes place before detection.

HIGH-FREQUENCY CHOKE. A coil of wire having a very low self-capacity but fairly high inductance, which offers a barrier to high-frequency oscillations. Its principal use is to divert the H.F. oscillations of a detector valve for reaction purposes, although it is also used for coupling purposes in H.F. amplifying stages. The ideal choke has the winding wound in sections, a device which reduces the capacity. (See also *Choke, Anti-break-through Choke,* and *Break Through.*)

An alternative method of construction utilises a six-ribbed ebonite coil former. Two kinds are available, one of which is

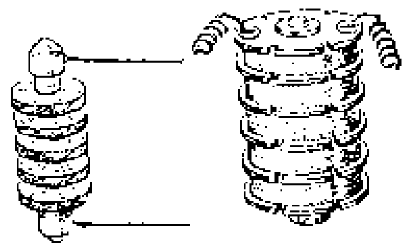


FIG. 222. *Typical short-wave and broadcast-band H.F. chokes with sectional windings.*

solid, whilst the other has a $\frac{1}{8}$-in. diameter hole running through it.

First, a number of slots must be made in the six ribs. For the "reaction" and S.G. chokes these should be $\frac{1}{16}$ in. wide, $\frac{1}{8}$ in. deep, and $\frac{1}{16}$ in. apart; in the case of the mains chokes, however, they should be $\frac{1}{8}$ in. wide, $\frac{1}{8}$ in. deep, and $\frac{1}{16}$ in. apart (see Fig. 223). The former for the S.G. choke will require twenty slots, but the other two will need only ten each. The smaller slots can be made quite easily with a widely set hacksaw, but the wider ones must be formed with a warding file. In winding the "reaction" choke, a total of 1,500 turns of 38-gauge enamelled wire will be used, of which 150 turns are placed in each slot. The S.G. choke is similar, but will have twice as many turns. With regard to the mains choke, this will be wound with 1,700 turns of 28-gauge wire, putting 170 in each slot. Count the turns carefully to ensure that they are equally divided, because unevenness might possibly cause the choke to "peak," or have a "dead spot" at some particular wavelength.

The method of mounting and making terminal connections will depend upon whether or not the choke is to be screened. Assuming that it is not, 4B.A. terminals can be screwed into the ends of the former (they will make their own thread if a little force is used). Soldering tags can be fitted under the terminal nuts and the ends of the winding soldered to these (see Fig. 226). When this method of connection is used, the choke can be suspended in the wiring of the set.

Should it be required to fit a screening box (the chokes described have sufficient inductance to permit of screening), the most convenient method of mounting will be that shown in Fig. 224. The choke, along with a 1½-in. diameter "lid," is attached to an ebonite base by means of a length of 6B.A. rod. Two terminals are mounted on the base, and leads from the winding are brought to these through lengths of insulating sleeving. The screen must, of course, be earthed, and a small terminal is therefore attached to the top of the "box" for this purpose. It is important that the box and lid should be a perfect fit.

An Anti-break-through Choke. An anti-break-through choke can easily be made. The same material will be used for the former, but only three $\frac{1}{16}$-in. slots are required. A winding consisting of 210 turns of 38-gauge enamelled wire is equally divided between the three slots. As can be seen from Fig. 225, the choke

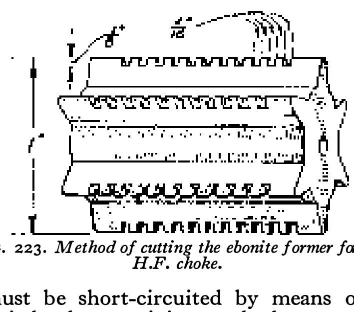


FIG. 223. *Method of cutting the ebonite former for the H.F. choke.*

must be short-circuited by means of a switch when receiving on the lower waveband.

Short-wave Chokes. It is desirable to wind the turns side by side as well as to divide them into sections, and the simplest way of doing this is illustrated in Fig. 226. Ribbed ebonite coil former of 1-in. diameter is used, but the "slots" are only $\frac{1}{16}$ in. deep by $\frac{1}{4}$ in. wide, and are $\frac{1}{8}$ in. apart. To cover wavelengths from 10 to 100 metres, a total of 120 turns of 38 S.W.G. enamelled wire is required, and these are divided into four equal

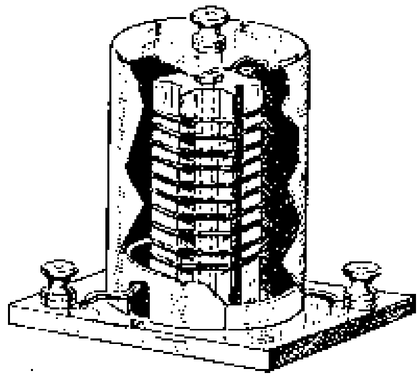


FIG. 224. *Assembly details of screened H.F. choke.*

parts of thirty turns each. No attempt should be made to screen an S.W. choke, since this cannot be done without introducing serious losses.

It is sometimes required to make a set to cover both "broadcast" and short waves, and in that case it is better to use two chokes in series, or to combine both long- and short-wave windings on one former. One end of the short-wave winding must be connected to the anode terminal of the detector valve. With this arrangement there is no need to short-circuit either component, since they will both come into use quite automatically according to the wavelength to which the set is tuned.

Making L.F. and Smoothing Chokes. The essentials of a smoothing choke are: An inductance of not less than 50 henries at the normal working current, a resistance to D.C. current of 2,000 ohms or less, and a safe current-carrying capacity of not less than 20 mA. It is also an advantage, if the choke is provided with a tapping point, to enable alternative ratios to be obtained when it is employed to feed a loudspeaker.

In order to cover all the above requirements with an ample "reserve," the choke described has an inductance of about 50 henries when carrying 25 milliamps. and a D.C. resistance of 1,700 ohms. The winding is centre tapped, and consequently the components can successfully be employed for a wide variety of purposes.

The core consists of about 3½ dozen pairs of No. 5 Stalloy stampings of "T" and "U" shape, whilst rather less than ¾ lb. of 38-gauge enamelled wire is used for the winding. Stampings of the size mentioned can be obtained from certain firms who specialise in the supply of such parts, but, incidentally, this size was employed for many of the better-quality L.F. transformers that were made a few years ago. The dimensions of the stampings are shown in Fig. 227, and by referring to these it will be an easy matter to tell if use can be made of the core of an old burnt-out transformer which may be on hand.

The first thing is to make a winding spool, which may have either a square or circular section "tunnel." If it is square, it should be of the dimensions shown in Fig. 228, and can be made up by bending a strip of stout card in the manner indicated. When the card has been bent to shape it should be fitted with two end cheeks 2 in. square. The latter can be fixed in position with "tacky" glue, after which the complete spool should be given a coat of thin shellac varnish to make it rigid. Before winding is commenced it is a good plan to wrap a layer of insulating tape round the spool to cover the otherwise sharp corners, which might tend to cut the fine wire. A circular spool is somewhat easier to make, but is not quite so efficient. It is built up on a cardboard tube ⅞ in. inside diameter, and fitted with a pair of 2-in. diameter end cheeks, after which shellac is applied as before.

After the winding spool has been made, two small holes should be made near the inside of one end cheek and a short length of rubber-covered flex threaded through these, leaving about 4 in. projecting outside and 6 in. projecting inside the spool. Next carefully solder the bared

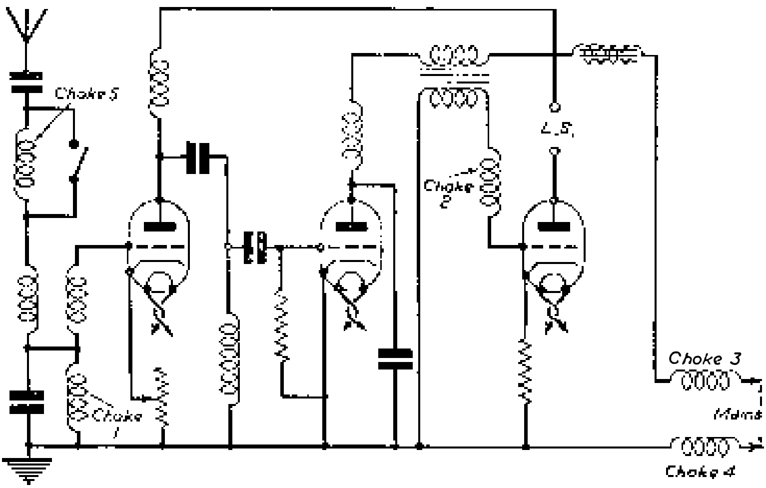


FIG. 225. *Theoretical circuit showing positions of H. F. chokes, and anti-break-through choke in aerial lead*

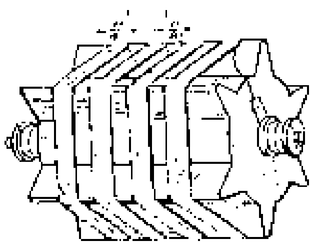


FIG. 226. *An easily-made short-wave H.F. choke.*

end of the 38-gauge enamelled wire to the end of the flex which is on the inside of the spool. It then only remains to wind on the wire.

After winding on one-quarter of the wire the turns should be covered with a layer of insulation, such as waxed paper, oiled silk, or empire tape, and this should be so put on that it will be impossible for later turns to slip past it. The winding should then be continued to 4,000 turns (it is not necessary to count, and an approximation based on the total quantity of wire will suffice), at which a tapping point should be made. Fit another layer of insulation, continue to the 8,000th turn, again insulate, and then complete the winding. Solder a third length of flex to the last turn, pass this once round the spool, and then anchor it in a pair of holes made in a convenient position in the end cheek. The winding should finally be covered with a protecting layer of empire tape.

Once the coil has been wound, the

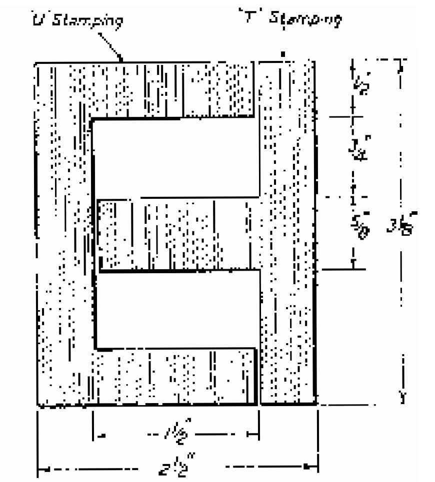


FIG. 227. *Standard "U" and "T" stampings with dimensions for use in L.F. chokes and various transformers.*

stampings can be fitted into the spool. The method of fitting is perfectly simple if it is remembered that "T"- and "U"-shaped pieces are alternated throughout. Another point to remember is that each stamping is insulated on one side, and, to ensure that this shall be effective, the insulated (white or grey) side of every stamping should face in the same direction. The method of assembly is shown in Fig. 229.

It has been stated that the choke described above can be used for various L.F. coup-

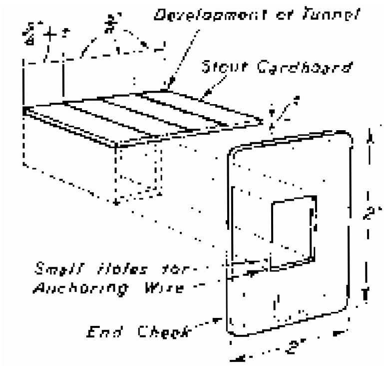


FIG. 228. *How to make the winding bobbin from paxolin sheet for chokes and transformers.*

ling purposes, but it should be added that it is also entirely suitable for H.T. smoothing in mains equipment, where the total current does not exceed about 50 milliamps. When passing the maximum current, the choke will have an inductance of rather more than 30 henrys and will produce a voltage drop of 85. The choke is really most suitable for use in an eliminator supplying about 30 milliamps., and under such conditions its inductance is sufficiently high to give adequate smoothing, while the voltage drop produced will be 51 (a reasonably low figure).

When dealing with currents in excess of some 50 milliamps., it is advisable to employ a smoothing choke of greater dimensions and having a lower resistance to D.C. It is also an advantage to make the component of the so-called constant-inductance type, so that its inductance varies by only the very slightest amount when the current passing through the winding is varied. In order that a choke should show such characteristics, there must be an air-gap in the core; that is, the "T"- and "U"-shaped stampings should not touch each other, but should be arranged with a small gap between them. Particulars will be given of a component of this type which has an inductance of 50 henrys, a D.C. resistance of about 1,300 ohms, and a maximum current-carrying capacity of nearly 100 milliamps.

Six dozen pairs of No. 4 Stalloy stampings are required for the core, and the winding should consist of approximately 1,000 turns, or 1½ lb. of 30-gauge enamelled wire. The winding arm of the core will measure $\frac{15}{16}$ in. by $1\frac{1}{16}$ in. by $2\frac{5}{16}$ in. long, so a spool of these dimensions, and fitted with end cheeks measuring $2\frac{5}{8}$ in. by $2\frac{3}{4}$ in., should first be made. This will be wound in exactly the same

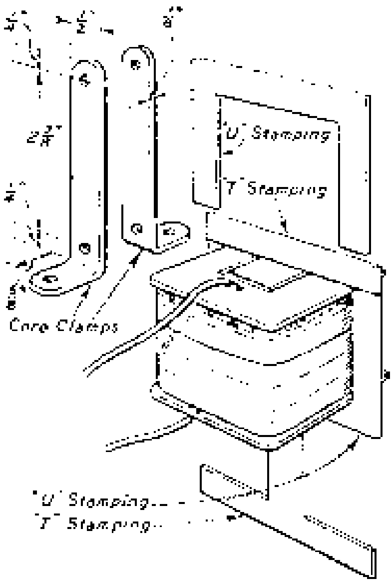


FIG. 229. *Method of constructing supports and assembling the core of an L.F. choke and L.F. or mains transformer.*

manner as was described for the smaller component, taking tappings if desired.

The only real difference occurs when the core stampings are to be fitted, since arrangements have to be made to provide the necessary air gap. This is easily done by fitting all the "T" stampings into the spool from one end, and then arranging all the "U" stampings opposite to them. The necessary gap is fixed by slipping strips of card $\frac{1}{16}$ in. thick between the ends of the "U" stampings and the sides of the "T's." Additionally, to prevent the gap being short-circuited, slips of paper must be placed between the core clamps and the core itself.

HIGH-FREQUENCY TRANSFORMER. A component used for coupling H.F. valves. It consists of two coils coupled together. These two coils are designed so that a step-up in ratio is obtained, and the coupling between the coils is arranged so that tuning one of the windings has the effect of tuning the other. The secondary winding, which is always included in the grid circuit of the following valve, is the one most commonly tuned. If the two windings are arranged so that the coupling between them may be varied, the selectivity of the amplifier may be adjusted.

H.F. Transformer Ratio.

$n^2 = \frac{R}{R_0}$ Where n = ratio.

R being the dynamic resistance of the tuned circuit and R_0 the A.C. resistance of the valve.

Stability in Screen-Grid Stages.

One Stage.

Stable if $\frac{\omega g C_o}{\sigma_1 (\sigma_2 + \sigma_v)}$ is less than 2

Co = residual anode-grid capacity in farads
= $\cdot 001$ by 10^{-12} for Cossor S.G. Valves (all types)
= $\cdot 0045$ by 10^{-12} for Cossor MS/Pen A.

$\sigma_1\ \sigma_2$ ... conductance of grid and anode circuits respectively. In the case of transformer coupling, or its equivalent, replace σ_2 by $n^2\sigma$, where n = transformer, ratio, σ = conductance = $\frac{1}{R}$ of tuned secondary.
= $1/R$ where R = dynamic resistance in ohms σ'' anode filament conductance of valve
= $1/R_a$.

HIGH TENSION (H.T.). The source of power for the output from a valve.

HIGH-TENSION BATTERY. A number of dry (sometimes wet) cells connected in series, used for supplying plate current. There are several grades and prices of H.T. batteries on the market, and it behoves the listener to consider well before buying any but those manufactured by firms of repute. It should be understood that the useful life of the battery is governed by several important points. A battery of 120 volts is made up of 80 cells of $1\frac{1}{2}$ volts each. These cells are connected in series; that is to say, the positive of the first is the positive or + of the battery, the negative of this cell being joined to the positive of the second cell, the negative of which goes to positive of the third, and so on until the requisite number of cells are connected up, the sum of which makes up the voltage required, ending, of course, with the negative or —. It can be seen now how simple it is for the manufacturers to make provision at different points on the top surface of the battery, enabling it to be tapped for intermediate voltages. The larger the elements in the cell the lower is its resistance, which enables the current of the cell to have a greater output. It must stand to reason then that the

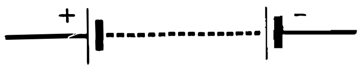


FIG. 230. *Theoretical diagram of a high-tension battery.*

larger these cells are made—and this must consequently increase the overall dimensions of the battery in its cardboard or tin case—the better will the aggregate number of cells stand up to the consumption of the valves. That is the reason why a "triple" capacity battery of the same voltage is bigger than one of the "standard" capacity.

There are three different ratings made, "standard," "double," and "triple" capacities. The following is a list of capacities most economical for the number of valves in a set:

"Standard" capacity for 3-valve sets taking up to 6-7 milliamperes.

"Double" capacity for 4 to 5-valve sets taking up to 10-16 milliamperes.

"Triple" capacity for multi-valve sets taking anything up to 30 milliamperes.

The battery having a "double" capacity does not cost twice as much as the "standard," although if used on the same set will give twice its life. Another good feature of the larger capacity is that its voltage drops more slowly; this means a more uniform output and a better performance of the set.

The active parts of the cell are made up of a carbon rod, positive element, the electrolyte (which is in paste form), and the zinc container or negative element.

The action of the paste—and this is a mixture of sal-ammoniac and certain other ingredients—supplies the electrical current. This action in time tends to eat away the zinc.

HIGHEST USEFUL FIELD FREQUENCY (H.U.F.F.). Equal to 85 per cent. of the *M.U.F.*

HOGHORN. A *primary radiating element* whose essential feature is the smooth transition from a *waveguide* to a *cheese* with a symmetric feed.

HOMODYNE. A system of reception for suppressed carrier systems in which the oscillations of carrier-frequency are provided from a separate source.

HOP. Transmission by a single reflection from the ionosphere. Transmission may be qualified by the number of hops and the layers concerned, e.g. one-hop E (1-E), two-hop F2 (2-F2).

Critical frequency. The frequency of the highest frequency wave which is returned to earth from a particular ionospheric layer at a particular time and place, transmission being at vertical incidence. The ordinary and extraordinary waves have different critical frequencies. The term "critical frequency" when applied without specific qualification generally means the critical frequency of the ordinary wave.

HORIZONTAL FIELD - STRENGTH DIAGRAM. A representation of the field-strength at a constant distance from an *aerial* and in a horizontal plane. Unless otherwise specified, this plane is that passing through the aerial.

HORSE POWER. Electrical equivalent = 746 watts. Mechanical unit = 33,000 ft.-pounds per minute, or 550 ft.-pounds per second.

H. OR T.E. (transverse electric) MODE. A type of *mode* in which the longitudinal component of the electric field is everywhere zero and the longitudinal component of the magnetic field is not.

HOT-WIRE AMMETER. An instrument for measuring in amperes the current flowing in a circuit. It consists of a fine wire which heats up and expands in proportion to the current passing through it.

H.T. High Tension (*which see*).

HUM. (See *Noises* and *Mains Hum.*)

HUM-BUCKING COIL. A coil of wire arranged on a moving-coil loudspeaker or a gramophone pick-up to reduce the interference caused by mains hum. The coil is wound in opposition to the main windings and is of only small dimensions so that it does not affect the proper working of the speaker or pick-up. The hum is balanced out by the passage of the current through the two coils.

HUM-DINGER. A small potentiometer which is wired across the heater supply secondary winding of the mains transformer of an A.C. mains receiver. In place of the usual centre-tap on this winding, the arm of the potentiometer is joined to earth, and it may thus be adjusted to find the electrical centre and thus balance the circuit, with the consequent removal of hum caused by an unbalanced heater circuit.

HYBRID T. A combination comprising a *series T* and a *shunt T* junction at the same point on a *waveguide.*

HYDROMETER. An instrument for measuring the density (the specific gravity) of the electrolyte of an accumulator. (See *Accumulator* and *Areometer.*)

HYSTERESIS. The tendency of a magnetic body to retain any magnetism from a magnetising force, the effect which tends to lag behind a change in the force electrically producing it.

I

ICONOSCOPE. (See *Television.*)

ICONOTOME. A vision pick-up in which the picture is projected optically upon a photo-electric cathode. The resulting photo-electrons are accelerated, focused and deflected in such a way that they impinge in succession on a collecting electrode.

I.F.F. Identification, Friend or Foe: a system using radar transmission to which friendly craft automatically respond, for example, by emitting *pulses,* thereby distinguishing themselves from enemy craft.

IMPEDANCE. The resistance to flow of current offered by a circuit.

For a circuit containing resistance, capacity and inductance $Z = \sqrt{R^2 + (X_l - X_c)^2}$ when X_l represents the reactance of the inductance and X_c that of the capacity.

Impedance Matching:

Transformer. $\sqrt{\dfrac{Z_s}{Z_p}} = \dfrac{N_s}{N_p}$

When Z_s = the impedance of the secondary; Z_p the impedance of primary; N_s = turns on secondary and N_p turns on primary. "Reflected" impedance on primary equals $R_s X \left(\dfrac{N_p}{N_s}\right)^2$ when R_s = Load on secondary.

Tapped Circuits:

$\dfrac{Z_t}{Z} = \dfrac{(X_t)^2}{X}$ when Z_t = impedance between tapping points; Z = total impedance of circuit. X_t = reactance between tapping points, and X total reactance.

Untuned Transmission Lines (two parallel wires).

Impedance (Surge) $= 276 \log \dfrac{b}{a}$ when a = radius of wire and b = spacing of wires.

IMPEDANCE (R_a).

$$R_a = \frac{\text{Change in anode volts} \times 1{,}000}{\text{Change in anode current (mA).}}$$

$$\text{or } R_a = \frac{\text{Amplification Factor} \times 1{,}000}{\text{Mutal Conductance (mA./V.)}}$$

$$\text{or } R_a = \frac{\text{Amplification Factor}}{\text{Mutual Conductance (amp./V.)}}$$

In waveguide technique no single definition strictly analogous to transmission line technique exists; accepted alternative definitions applicable in rectangular waveguides are: (a) The ratio of maximum voltage to total longitudinal current. (b) The ratio of twice the power to the square of the total longitudinal current. (c) The ratio of the square of the maximum voltage to twice the power.

IMPEDANCE FACTOR. The ratio of impedance to resistance in an electrical circuit.

INDUCED CURRENT. When current is passed through a wire which is in close proximity to another wire, currents will be induced in that other wire. The induced current will be in the opposite direction.

INDUCTANCE. The tendency of a circuit to resist current flow and also change of rate of flow. Unit of inductance is the henry (*which see*).

The formula for inductance in microhenrys is: $L = \dfrac{9{\cdot}86 l D^2 N^2 K}{1{,}000}$ where L = inductance, D = diameter of coil in cms.,

Table Showing Value of K

$\frac{D}{l}$	K	$\frac{D}{l}$	K
4·00	·3654	1·25	·6381
3·75	·3743	1·00	·6884
3·5	·3944	·90	·7110
3·25	·4111	·80	·7351
3·00	·4292	·70	·7609
2·75	·4545	·60	·7885
2·5	·4719	·50	·8181
2·25	·4972	·40	·8499
2·0	·5255	·30	·8838
1·75	·5579	·20	·9201
1·5	·5950	·10	·9588

l = length of coil in cms., N = number of turns per cm., and K = a constant. (See table.)

INDUCTANCE AND CAPACITY. The wavelength to which a circuit is tuned depends upon the product of the inductance and capacity of the circuit. Actually, it is equal to the number 1,884 multiplied by the square root of the product of the inductance and the capacity, the former being expressed in microhenrys and the latter in microfarads. Why is it, then, that a tuning condenser of ·0005 μF. is invariably specified for a broadcast receiver? The answer is that considerations of size and overall efficiency more or less settle beforehand the inductance of tuning coils, values of approximately 200 microhenrys for the medium waves, and about 2,000 microhenrys for the long-wave band, having become standard. If a condenser of, say, ·0003 μF. were substituted, the receiver could not be tuned to the higher wavelengths in each band. On the other hand, a larger capacity of tuning condenser would not decrease the wave range of the set.

INDUCTANCE COIL. A coil possessing a high degree of inductance. A choke. Inductances in parallel reduce total inductance, and *vice versa*.

INDUCTANCE OF SINGLE-LAYER COIL.

$$L = \pi^2 n^2 D^2 l K \times 10^{-3}$$

L, in microhenrys; π, 3·14; D, diameter in cms.; n = number of turns to the cm.; l, length in cms.; K, a factor depending upon the length/diameter ratio. (See p. 154.)

Current in Series Circuit at Resonance.

$$\text{I res.} = \frac{E}{r}$$

where r is equiv. series resistance of circuit at wavelength concerned (high-frequency resistance).

INDUCTION. The transfer of energy from one body to another not in contact with it.

INDUCTION COIL. A coil in which voltage is increased by reduction of amperage. (See *Interrupter*.)

INDUCTION MOTOR. A motor consisting of a powerful magnetic field with a disc suspended in the field. The action of the eddy currents in the disc causes rotation of the disc, and by so designing the magnetic poles, the spacing of the poles, the metal of the disc, and the method of suspension, quite a powerful torque is obtainable. This type of motor works from alternating current only, and no brushes are required, consequently there is no interference with radio. This has resulted in the motor being used chiefly for gramophone work.

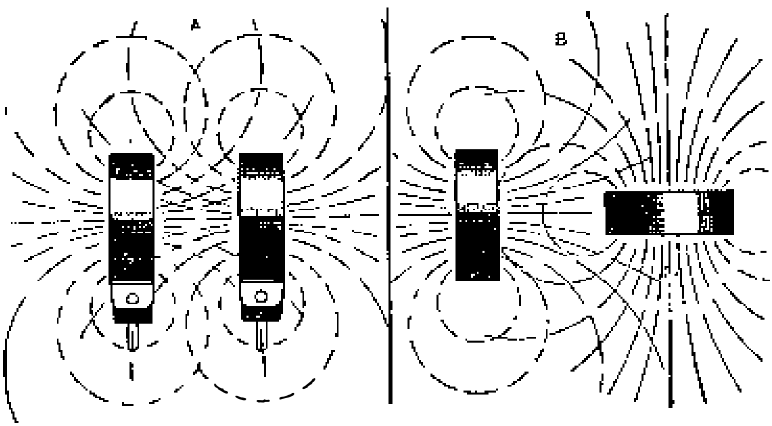


FIG. 231. *Showing the shape of the electro-magnetic field of coils of the simple plug-in type.*

INDUCTIVE CAPACITIVE REACTANCE. That property of a *waveguide* component which results in a reflection whose imaginary part is positive/negative.

INDUCTIVE CAPACITY. (See *Dielectric Constants*.)

INDUCTIVE REACTANCE. Calculated from the formula $2\pi fL$, where f = frequency and L = the inductance.

INKER. A device used in telegraphy for making permanent record of the Morse signals. It consists of a sounder, with a device which is supplied with ink. A roll of paper tape is fixed on this device, and the paper tape is drawn through a gap over which is suspended the inking point. As the armature of the sounder is vibrated in sympathy with the received signals, the inked point makes contact with the tape.

INPUT ADMITTANCE. The reciprocal of impedance. (See also *Miller Effect.*)

INTEGRATING CIRCUIT. A circuit whose output voltage is approximately proportional to the time integral of the input voltage.

INTENSIFIER ELECTRODE. An electrode in a cathode-ray tube which accelerates the electron beam after deflection.

INTENSITY MODULATION. Modulation of the intensity of a cathode-ray *beam* so that signals are indicated by variations in brightness of the *trace*.

INTERACTION. If one compares the average home-constructed receiver with a commercial product of similar size, both for appearance and performance, one will find many differences. On the grounds of appearance, the usual contrast between the two sets is that while the home product looks scrappy the commercial receiver is usually a model of neatness and compact design. Under these conditions the performance is very often equal. When the home-made set is compressed a little, however, and made to look neat, it very seldom works as well. The one word "interaction" goes a long way to explain this phenomenon. While almost anyone with a little knowledge of radio principles can make an untidy set work well, it takes a qualified expert to design the same set in such a way that it still works when it is "tidied up." The fact of the matter is that one cannot take liberties with the placing of the separate components of a set until one understands first principles.

Conventional Layouts. From this reasoning, to make things easier for the home constructor, have sprung certain accepted conventional "layouts," with which one cannot go far wrong.

The main thing to be avoided is interaction between *two tuned circuits.* When a set uses a stage of H.F. amplification the grid circuit of the H.F. valve and the grid circuit of the detector (or the anode circuit of the H.F. valve—really the same thing) will be tuned to the same wavelength.

Any possibility of interaction between these two circuits must be carefully guarded against. Fig. 231 shows roughly the shape of the electro-magnetic field of coils of the simple plug-in type, and it will be readily seen that the "A" arrangement is unsatisfactory while the "B" is considerably better.

Screening. Screened coils and screening boxes for complete H.F. stages make

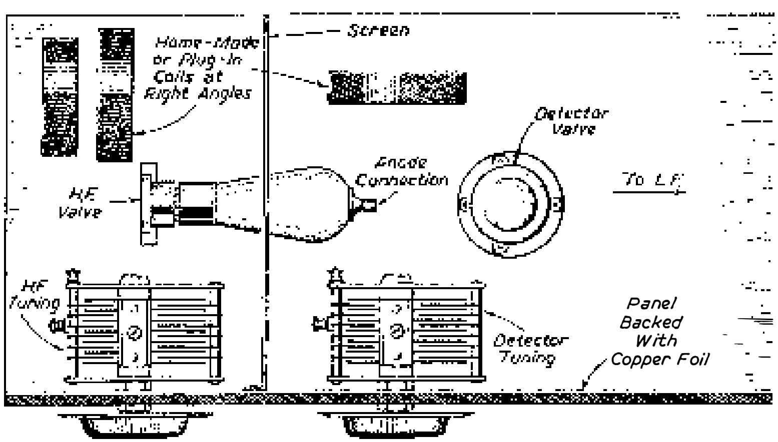


FIG. 232. *A screen the same depth as the baseboard is used for "partitioning off" the H.F. stage.*

things fairly satisfactory nowadays, but if a set is built with plug-in or home-made coils, it is important that the two circuits should be arranged at right-angles, as in Fig. 232, and that a screen should be arranged between them. A small piece of metal, moreover, is not sufficient. A screen of sensible size is well worth any trouble involved in the construction of the set.

Since a tuned circuit consists of a coil and a condenser, it is obviously no great gain to screen the coils from one another while the condensers lie side by side on the front panel. This is one good reason for using a screen of the same depth as the baseboard, and "partitioning off" the H.F. stage altogether (Fig. 232). A metal or metal-backed panel, and a baseboard covered on the underside with copper foil, also help things considerably.

The screened-grid valve was invented to do away with the anomaly that, while it was possible to screen the grid and anode *circuits* of a valve from each other, the grid and anode were still fairly closely coupled together inside the valve. A meshed screen was therefore introduced between them, and the anode lead brought out at the opposite end of the valve from the others. To make the most of the possibilities of a screened-grid valve, see that the grid and anode are screened from one another. The easiest way of doing this is to use a layout similar to that in Fig. 232, mounting the valve horizontally through the vertical screen, so that its anode goes through into the detector compartment, the rest of it being left behind where it belongs, with the input side of the H.F. stage. One can see the screening grid in most modern valves of this type, and the valve should be arranged through the hole in the screen in such a way that the screen is level with the "continuation" of the screening grid.

Interaction between Transformers. The same rules apply to the L.F. end of the receiver. Interaction between two L.F. transformers can produce unsatisfactory effects. If it does not result in audible oscillation, to the accompaniment of anything between a "foghorn" note and a highpitched whistle, it may easily produce a parasitic oscillation above the audible range of frequencies, which will only betray its presence by spoiling the quality of reproduction completely.

Fortunately, most modern L.F. transformers are efficiently screened, but even then it is folly to mount two of them too closely together. The cores should be placed at right angles, and the distance should be as great as can conveniently be arranged. Incidentally, aluminium or copper screening is not of very great use for L.F. work. Heavy iron is necessary to do the job at all well. The average home constructor, however, will not be concerned with amplifiers of such dimensions that screening is necessary. This does not dispose of interaction defects, by any means, by merely dealing with the effects already discussed. Bad wiring alone is often sufficient to cause the ruination of a good circuit arrangement.

Points about Wiring. It may be taken as a general rule, for instance, that any wires leading from the grid and anode of the same valve should not be taken nearer to each other than necessary. Even more important is it that the grid wiring of an early valve in the set should not go near the anode wiring of a later valve. It needs only a very small capacity to start a "vicious circle," resulting in instability and generally bad performance.

The standard layout already mentioned undoubtedly goes a long way towards the prevention of mistakes of this kind; but in a more compact receiver it is not always convenient to adhere to this, and careful screening is necessary.

Yet another point to watch is the screening of the H.F. side of a set from the L.F. side. If, to make the size of the set convenient, the "doubling-back" type of layout is used, it will be found that the input and output ends of the receiver come close together. Screening, as indicated, is necessary

INTERCALATION. Synonymous term for interlacing, used in reference to television scanning.

INTERFERENCE. Two stations "jamming," due to wavelengths being too close. A rejector should be incorporated between aerial and set to reduce this to a minimum. Also due to mains hum. (See also *Noises*.)

INTERMEDIATE FREQUENCY. In a superheterodyne, the frequency produced by the frequency changer before amplification.

INTERMEDIATE-FREQUENCY AMPLIFIER. In superheterodynes, two closed oscillatory circuits. Great selectivity of the detector circuit results.

INTERMEDIATE-FREQUENCY TRANSFORMER. Two coils of wire, coupled together and tuned by pre-set condensers or metal cores to the I.F. and connected between the I.F. valves of a superhet. (See also *Coils* and *Superheterodyne*.)

INTERNATIONAL AMPERE. The practical unit of electric current representing the unvarying current which when passed through a neutral solution of nitrate of silver deposits silver at the rate of 0·001118 of a gramme per second.

INTERNATIONAL CALL SIGNS. The following list of call signs in alphabetical order of call signs and of country has been agreed to by representatives of the Incorporated Radio Society of Great Britain, and the American Radio Relay League.

Prefix	*Name of Country*
(AC3)	Sikkim
AC4	Tibet
(AR)	Syria
CE	Chile
CM-CO	Cuba
CN	Morocco, French
CP	Bolivia
CR4	Cape Verde Is.
CR5	Guinea, Portuguese
CR6	Angola
CR7	Mozambique
CR8	Goa (Portuguese India)
CR9	Macau
CR10	Timor, Portuguese
CT	Portugal
CT2	Azores Is.
CT3	Madeira Is.
CX	Uruguay
D	Germany
EA	Spain
EA6	Balearic Is.
EA8	Canary Is.
EA9	Morocco, Spanish
EI	Eire (Irish Free State)
EK	Tangier Zone
EL	Liberia
EP-E	Iran
ET	Ethiopia
F	France
FA	Algeria
FB8	Madagascar
FD8	Togoland, French
FE8	Cameroons, French
FF8	French West Africa
FG8	Guadeloupe
FI8	French Indo-China
FK8	New Caledonia
FL8	Somaliland, French
FM8	Martinique
FN	French India
FO8	French Oceania (Tahiti)
FP8	Miquelon and St. Pierre Is.
FQ8	French Equatorial Africa
FR8	Reunion I.
FT4	Tunisia
FU8, Y	New Hebrides
FYS	Guiana, French and Inin.
G	England
GC	Channel Is.
GD	Isle of Man
GI	Ireland, Northern
GM	Scotland
GW	Wales
HA	Hungary
HB	Switzerland
HC	Ecuador
HE1	Liechtenstein
HH	Haiti
HI	Dominican Republic
HK	Colombia
HP	Panama
HR	Honduras
HS	Siam
HZ	Saudi Arabia
I	Italy
I6	Eritrea
J	Japan
KA	Philippine Is.
KB6	Baker Is., Howland Is. and Am. Phœnix Is.
KC4	Little America
KG6	Marianas Is., Guam.
KH6	Hawaiian Is.
KJ6	Johnston Is.
KL7	Alaska
KM6	Midway I.
KP4	Puerto Rico
KP6	Jarvis I., Palmyra Group (Xmas Island)
KS4	Swan I.
KS6	Samoa, America
KV4	Virgin Is.
KW6	Wake I.
KZ5	Canal Zone
LA	Norway
(LI)	Libya
LU	Argentina
LX	Luxembourg
LZ	Bulgaria
NY4	Guantanamo Bay
OA	Peru
OE	Austria
OH	Finland
OK	Czechoslovakia
ON	Belgium
OQ	Belgian Congo
OX	Greenland
OY	Faroes, The
OZ	Denmark
PA	Netherlands
PJ	Netherlands West Indies
PK	Java
PK4	Sumatra
PK5	Borneo Netherlands
PK6	Celebes and Molucca Is.
PK6	New Guinea, Netherlands
PX	Andora
PY	Brazil
PZ	Guiana, Netherlands (Surinam)
SM	Sweden
SP	Poland
ST	Anglo-Egyptian Sudan
SU	Egypt
SV	Crete
SV	Greece
SV5	Dodecanese Is. (Rhodes)
TA	Turkey
TF	Iceland
TG	Guatemala
TI	Cocos I.
TI	Costa Rica
UA1-3-4-6	Soviet Union: European Socialist Federated Soviet Republic
UA9-0	Asiatic Russian S.F.S.R.
UB5	Ukraine
UC5	White Russian S.S.R.
UD6	Azerbaijan
UF6	Georgia
UG6	Armenia
UH8	Turkoman
UI8	Uzbek
UJ8	Tadzik
UL7	Kazakh
UM8	Kirghiz
UN1	Karelo-Finnish Republic
UO5	Moldavia
UP	Lithuania
UQ	Latvia
UR	Estonia
VE	Canada
VK	Australia and Tasmania
VK4	Papua Territory
VK9	New Guinea, Territory of
VO	Newfoundland and Lab.
VP1	British Honduras
VP2	Windward Is.
VP2	Leeward Is.
VP3	Guiana, British
VP4	Trinidad and Tobago
VP5	Cayman Is.
VP5	Jamaica
VP5	Turks and Caicos Is.
VP6	Barbados
VP7	Bahama Is.
VP8	Falkland Is.
VP8	S. Georgia, S. Orkney Is., S. Sandwich Is., S. Shetland Is.
VP9	Bermuda Is.
VQ1	Zanzibar
VQ2	Rhodesia, Northern
VQ3	Tanganyika Territory
VQ4	Kenya
VQ5	Uganda
VQ6	Somaliland, British
VQ8	Chagos Is.
VQ8	Mauritius
VQ9	Seychelles
VR1	Gilbert and Ellice Is. Ocean Is.
VR2	Fiji Is.
VR3	Fanning I. (Christmas I.)
VR4	Solomon Is.
VR5	Tonga (Friendly) Is.

Prefix	Name of Country
VR6	Pitcairn I.
VS1, VS2	Malaya
VS4	Borneo, British North (including Labuan)
VS5	Brunei
VS5	Sarawak
VS6	Hong Kong
VS7	Ceylon
VS9	Aden and Socotra Is.
VU	India
VU4	Laccadive Is.
VU7	Bahrein I.
WK	U.S.A.
XE	Mexico
XU, C	China
XZ	Burma
YA	Afghanistan
YI	Iraq
YN	Nicaragua
YR	Roumania
YS	Salvador
YT-YU	Yugoslavia
YV	Venezuela
ZA	Albania
ZB1	Malta
ZB2	Gibraltar
ZC1	Transjordan
ZC2	Cocos Is.
ZC3	Christmas I.
ZC4	Cyprus
ZC6	Palestine
ZD1	Sierra Leone
ZD2	Nigeria
ZD3	Gambia
ZD4	Gold Coast and British Togoland
ZD6	Nyasaland
ZD7	St. Helena
ZD8	Ascension I.
ZD9	Tristan da Cunha and Gough I.
ZE	Rhodesia Southern
ZK1	Cook Is.
ZK2	Niue
ZL	New Zealand
ZM	Western Samoa
ZP	Paraguay
ZS	Union of South Africa
ZS3	South West Africa
ZS4	Basutoland

Name of Country	Prefix
Aden and Socotra I.	VS9
Afghanistan	YA
Alaska	KL7
Albania	ZA
Aldabra Is.	
Algeria	FA
Andaman and Nicobar Is.	
Andorra	PX
Anglo-Egyptian Sudan	ST
Angola	CR6
Argentina	LU
Ascension I.	ZD8
Australia (including Tasmania)	VK
Austria	OE
Azores Is.	CT2
Bahama Is.	VP7
Bahrein I.	VU7
Baker Island, Howland Is. and Am. Phœnix Is.	KB6
Balearic Is.	EA6
Barbados	VP6
Basutoland	ZS4
Bechuanaland	
Belgian Congo	OQ
Belgium	ON
Bermuda Is.	VP9
Bhutan	
Bolivia	CP
Bonin and Volcano Is. (*e.g.* Iwo Jima)	
Borneo, British North (including Labuan)	VS4
Borneo Netherlands	PK5
Brazil	PY
British Honduras	VP1
Brunei	VS5
Bulgaria	LZ
Burma	XZ
Cameroons, French	FE8
Canada	VE
Canal Zone	KZ5
Canary Is.	EA8
Cape Verde Is.	CR4
Caroline Is.	
Cayman Is.	VP5
Celebes and Molucca Is.	PK6
Ceylon	VS7
Chagos Is.	VQ8
Channel Is.	GC
Chile	CE
China	XU, C
Christmas I.	ZC3
Clipperton I.	
Cocos I.	TI
Cocos Is.	ZC2
Colombia	HK
Comoro Is.	
Cook Is.	ZK1
Corsica	
Costa Rica	TI
Crete	SV
Cuba	CM-CO
Cyprus	ZC4
Czechoslovakia	OK
Denmark	OZ
Dodecanese Is. (*e.g.* Rhodes)	SV5
Dominican Republic	HI
Easter I.	
Ecuador	HC
Egypt	SU
Eire (Irish Free State)	EI
England	G
Eritrea	I6
Ethiopia	ET
Falkland Is.	VP8
Fanning I. (Christmas I.)	VR3
Faroes, The	OY
Fiji Is.	VR2
Finland	OH
Formosa (Taiwan)	
France	F
French Equatorial Africa	FQ8
French India	FN
French Indo-China	FI8
French Oceania (*e.g.* Tahiti)	FO8
French West Africa	FF8
Fridjof Nansen Land (Franz Josef Land)	
Galapagos Is.	
Gambia	ZD3
Germany	D
Gibraltar	ZB2
Gilbert and Ellice Is. and Ocean I.	VR1
Goa (Portuguese India)	CR8
Gold Coast (and British Togoland)	ZD4
Greece	SV
Greenland	OX
Guadeloupe	FG8
Guantanamo Bay	NY4
Guatemala	TG
Guiana, British	VP3
Guiana, French, and Inini	FY8
Guiana, Netherlands (Surinam)	PZ
Guinea, Portuguese	CR5
Guinea, Spanish	
Haiti	HH
Hawaiian Is.	KH6
Honduras	HR
Hong Kong	VS6
Hungary	HA
Iceland	TF
Ifni	
India	VU
Iran	EP-EQ
Iraq	YI
Ireland, Northern	GI
Italy	I
Jamaica	VP5
Jan Mayen I.	
Japan	J
Jarvis I., Palmyra Group (Christmas I.)	KP6
Java	PK
Johnston I.	KJ6
Kenya	VQ4
Kerguelen Is.	
Korea	
Kuwait	
Laccadive Is.	VU4
Leeward Is.	VP2
Liberia	EL
Libya	(LI)
Liechtenstein	HE1
Little America	KC4
Luxembourg	LX
Macau	CR9
Madagascar	FB8
Madeira Is.	CT3
Malaya	VS1, VS2
Maldive Is.	
Malta	ZB1
Manchukuo	
Marinas Is., Guam	KG6
Marshall Is.	
Martinique	FM8
Mauritius	VQ8
Mexico	XE
Midway I.	KM6
Miquelon and St. Pierre Is.	FP8

Name of Country	*Prefix*
Monaco	
Mongolia	
Morocco, French	CN
Morocco, Spanish	EA9
Mozambique	CR7
Nepal	
Netherlands	PA
Netherlands West Indies	PJ
New Caledonia	FK8
Newfoundland and Labrador	VO
New Guinea, Netherlands	PK6
New Guinea, Territory of	VK9
New Hebrides	FU8, YJ
New Zealand	ZL
Nicaragua	YN
Nigeria	ZD2
Niue	ZK2
Norway	LA
Nyasaland	ZD6
Oman	
Palau (Pelew) Is.	
Palestine	ZC6
Panama	HP
Papua Territory	VK4
Paraguay	ZP
Peru	OA
Philippine Is.	KA
Phœnix Is. (British)	
Pitcairn I.	VR6
Poland	SP
Portugal	CT
Puerto Rico	KP4
Reunion I.	FR8
Rhodesia, Northern	VQ2
Rhodesia, Southern	ZE
Rio de Oro	
Roumania	YR
Ryukyu Is. (*e.g.* Okinawa)	
St. Helena	ZD7
Salvador	YS
Samoa, America	KS6
Samoa, Western	ZM
Sarawak	VS5
Sardinia	
Saudi Arabia (Hedjaz and Najd)	HZ
Scotland	GM
Seychelles	VQ9
Siam	HS
Sierra Leone	ZD1
Sikkim	(AC3)
Solomon Is.	VR4
Somaliland, British	VQ6
Somaliland, French	FL8
South Georgia	VP8
South Orkney Is.	VP8
South Sandwich Is.	VP8
South Shetland Is.	VP8
South West Africa	ZS3
Soviet Union:	
Armenia	UG6
Asiatic Russian S.F.S.R.	UA9-0
Azerbaijan	UD6
Estonia	UR
European Russian Socialist Federated Soviet Republic	UA1-3-4-6
Georgia	UF6
Karelo-Finnish Republic	UN1
Kazakh	UL7
Kirghiz	UM8
Latvia	UQ
Lithuania	UP
Moldavia	UO5
Tadzhik	UJ8
Turkoman	UH8
Ukraine	UB5
Uzbek	UI8
White Russian Soviet Socialist Republic	UC5
Spain	EA
Sumatra	PK4
Swan I.	KS4
Swaziland	
Sweden	SM
Switzerland	HB
Syria	(AR)
Tanganyika Territory	VQ3
Tangier Zone	EK
Tibet	AC4
Timor, Portuguese	CR10
Togoland, French	FD8
Tokelau (Union) Is.	
Tonga (Friendly) Is.	VR5
Transjordan	ZC1
Trieste	
Trinidad and Tobago	VP4
Tristan da Cunha and Gough I.	ZD9
Tunisia	FT4
Turkey	TA
Turks and Caicos Is.	VP5
Uganda	VQ5
Union of South Africa	ZS
United States of America	W, K
Uruguay	CX
Venezuela	YV
Virgin Is.	KV4
Wake Is.	KW6
Wales	GW
Windward Is.	VP2
Wrangel Is.	
Yugoslavia	YT-YU
Zanzibar	VQ1

INTERNATIONAL COULOMB. Practical unit of electric quantity, representing the quantity of electricity transferred in one second by a current equal to the international ampere.

INTERNATIONAL FARAD. The practical unit of capacity representing the capacity of a conductor which is charged to a potential of one international volt by imparting to it a quantity of one international coulomb.

INTERNATIONAL OHM. Practical unit of resistance, representing the resistance offered to an unvarying current of electricity by a column of pure mercury at the temperature of melting ice having a mass of 14·4521 grammes, a constant cross-section, and a length of 106·3 cms.

INTERNATIONAL VOLT. Practical unit of electromotive force, representing that E.M.F. which when steadily applied to a conductor having a resistance of one international ohm creates in it a current of one international ampere.

INTERNATIONAL WATT. The energy used in one second by an international ampere when flowing at a pressure of one international volt.

INTERROGATOR. A *pulse transmitter* used for exciting a *transponder*.

INTERRUPTER. Mechanism used to break up direct current into a series of impulses, hence producing intermittent current. It is chiefly used with an induction coil. (See *Pulsator* and *Buzzer*.)

INTERVALVE TRANSFORMER. A component placed between the valve stages which amplifies the signal voltages before passing them on to the next valve. (See also *Low-frequency Couplings*.)

INVERSE POWER FACTOR. That reciprocal of power factor applied as a multiplier for changing kilowatts into kilovolt-amperes, this showing the wattless current proportion.

INVERTED AMPLIFIER. This type of amplifier, which has definite advantages at frequencies of 20 Mc/s and upwards, is

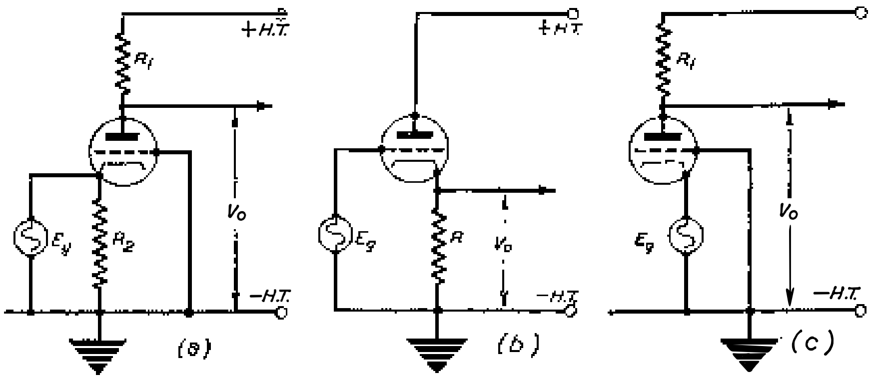


FIG. 233. (*a*) *Inverted amplifier schematic.* (*b*) *Cathode follower. The inverted amplifier is equivalent to a driving e.m.f. Eg in series with the driven stage as in* (*c*), *and the driving source has thus to supply part of the main output power.*

shown, in simplified form, in Fig. 233. With the cathode follower, it has been used to some extent in television circuits and, particularly, short-wave transmitters. The cathode follower is, in a sense, an "inverted" form of amplifying stage, where the output is taken off a load resistance, say, on the cathode side (Fig. 233B). From the H.T. — end of R there is 100 per cent. negative feedback of the output voltage Vo, in consequence of which the overall voltage gain is less than unity. But Fig. 233A shows a stage completely turned "upside down," or inverted.

Then, the input E.M.F., Eg, is applied across a resistance R2, in the cathode circuit.

The anode circuit looks straightforward. The output voltage Vo is taken off the anode end of the resistance R1. In common with the cathode follower, Vo will *not* be phase-reversed as in a straightforward stage with anode load. But, unlike the cathode follower, the overall voltage gain will not be something less than 1·0. Actually, the gain will be a little larger than an ordinary amplifying stage with anode load, even though there is a degree of negative feedback which depends on the internal A.C. resistance of the driver stage. A disadvantage which restricts the use of inverted amplifiers for general purposes is the comparatively low input impedance. The driving stage is shunted by the resistance R2, or, in the absence of this, the internal A.C. resistance of the driven stage. This rules out an inverted amplifier immediately following a high-impedance voltage amplifying stage. But no real disadvantage exists if the driver is a power valve capable of handling the load.

INVERTED INDUCTION COIL. An induction coil which is used for stepping-down purposes.

ION. Any atom of matter which carries an excess of electrons or which is short of its normal number of electrons is termed an "ion." Subsidiary terms are : the triad-ion (one carrying three unit charges), the dyad-ion or divalent (carries two unit charges), and the monad-ion (carries one unit charge). A negative ion is an atom plus an electron, and a positive ion is an atom minus an electron.

IONIC VALVE. The thermionic valve. (See also *Valve*.)

IONISATION. The separation of molecules into ions. Areas of abnormally intense ionisation which occur sporadically within the E layer are variable in time of occurrence, geographical distribution and ionisation density.

IONOSPHERE. Situated many miles above the surface of the earth are layers of ionised gas. The approximate heights of these layers are shown in Fig. 234. For purposes of classification these layers are termed the E, F, and F_2 layers, respectively, as their heights increase. The E layer is also known as the Kennelly-Heaviside layer, after the two scientists who discovered its presence independently and simultaneously. The Appleton layer, again named after its discoverer, comes into existence during the night, due to the fading out of the F_1 layer and the descent of the F_2 layer. The Appleton layer is also known as the F layer.

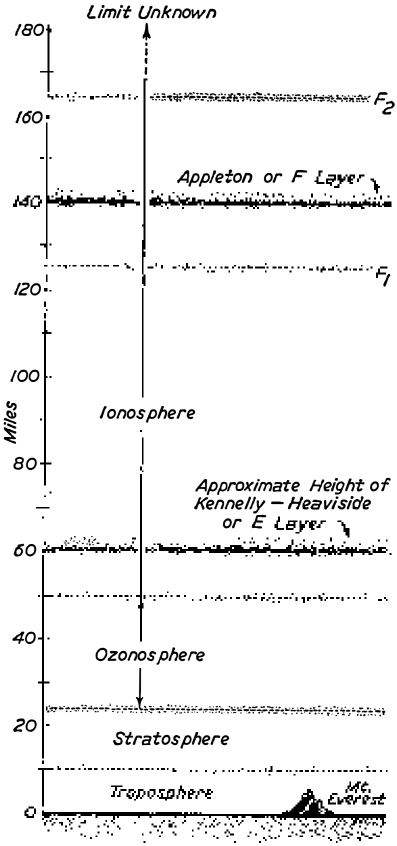


FIG. 234. *Graph showing the various spheres situated above the surface of the earth.*

The gases forming these layers are ionised by ultra-violet rays from the sun, with the exception of the F_2 layer, which, although it has daily and seasonal variations and thus must be effected by the sun, shows itself to be largely affected by other influences, i.e. cosmic radiation. The term layer refers to the region of *maximum electron density* in the gas concerned.

As the height of a layer increases and the rarity of the atmosphere decreases the proximity of atomic particles becomes less with the result that less recombination of those particles (deionisation) is possible.

For the reasons just stated the E layer shows great variations in electron density although the region of maximum electron density keeps at about the same height when night falls. The height of the F_1 layer shows small variation whilst its electron density follows similar variations to the E layer. The F_2 layer's height descends at nightfall, but its *electron* density is very erratic in variation. The electron density of the layers increase with height—as would be expected.

It has been noticed that ionospheric variations follow 27·3 day and 11 year periods; 27·3 days is the period of rotation of the sun, whilst 11 years mark the period of sunspot activity. Also, the appearance of sunspot is usually accompanied with ionospheric storms resulting in the dislocation of short-wave radio services, etc.

IRIS. An adjustable *diaphragm* or *window.*

IRON-CORE TUNING COILS. The inductance of a solenoid is increased when an iron core is included. Ordinary iron is not suitable for increasing the inductance of tuning coils owing to H.F. losses introduced by the iron. A high inductance with a low H.F. resistance is, however, a valuable feature of an efficient tuning coil, and a method of using iron has now been developed. Finely divided iron is used to impregnate paper, ebonite, etc., and this is moulded to form a core over which a small coil is wound. The result is a low H.F. resistance with a high inductance value, giving a coil of extremely small dimensions. (See also *Permeability Tuning*.)

IRON PYRITES. Iron sulphide.

IRON SULPHIDE. A crystal used as a rectifier in connection with a gold or bronze cat whisker.

ISOCHRONE. A line (on a map) of constant time-difference in the reception of navigational-aid pulses.

ISOCHRONE DETERMINATION. Radiolocation in which a position-line is determined by the difference in the transit times of signals along two paths.

ISOCHRONISM. Equality of time; the quality of being done in equal times. Two circuits are isochronous when they have the same frequency.

J

JAMMING. The simultaneous reception of two or more stations.

JAR. Admiralty unit of capacity. 1 jar = 1,000 cm.; 900,000 = 1 μF.; therefore 1 cm. = $\frac{1}{900000}$ μF. (obsolete term).

JELLY ELECTROLYTE. Used in portable receivers. Jelly electrolyte consists of sulphuric acid to which a given proportion of sodium silicate has been added. Jellification takes place at varying speeds according to the proportions in which the two chemicals are mixed. A suitable mixture which jellifies in five or six minutes is—one part of pure sodium silicate (1·200 specific gravity) to three parts of cold sulphuric acid (1·400 specific gravity). As jellification takes place fairly rapidly it is essential to arrange that the entire operation may be carried through without any hitch or delay. The cell to be filled with jelly acid should be given a first charge, using ordinary free sulphuric acid. This acid should then be poured off, and the cell inverted and allowed to drain.

JIGGER. Slang for transformer.

JITTER. Random departure from temporal regularity of repetition.

j OPERATOR. (See *Operator j.*)

JOULE. The unit of energy, and is the quantity of energy developed from the expenditure of one watt for one second. The watt-hour joule = 10,000,000 ergs. The Board of Trade Unit equals 3,600,000 joules, and is known as the kilowatt-hour. Joule's Law states that the heat produced by a current I passing through resistance R for time t is proportional to I^2Rt. 1 joule = 10^7 ergs.

JOULE'S LAW. As a formula this is I^2Rt joules. It refers to that heat developed by the current (I) which is proportional to the square of I multiplied by R and t, letting R = resistance and t = time. If the formula is seen as $JH = RI^2t$ it equals EIt, letting J = joules equivalent of heat, and H = the number of heat units.

K

KATHODE. (See *Cathode.*)

KEEP-ALIVE ELECTRODE. A supplementary electrode in a gas-discharge tube to which a voltage is applied sufficient to keep the gas at or near the point of breakdown by general ionisation.

KEEPER. Term used to denote the bar of iron placed across the poles of a horseshoe magnet to preserve its magnetism.

KELVIN. (See *B.O.T. Unit.*)

KENNELLY LAYER. (See *Heaviside Layer* and *Ionosphere.*)

KERR EFFECT. Illustrates that an angle of rotation is proportional to a magnetisation intensity and applies to the rotation of polarisation plane of plain polarised light as reflected from the pole of a magnet. The number (a constant) varies for different wavelengths and specific materials, making necessary the multiplication of magnetisation intensity in order to find the angle of rotation forming the effect.

KEY. A transmitting key—a form of switch for breaking the primary circuit of a transformer.

KILOCYCLE. A frequency of 1,000 cycles per second. One thousand kilocycles (abbreviated kc/s) corresponds approximately to a wavelength in metres of 300. (The exact relationship is 299·820 metres = 1,000 kilocycles). Therefore to convert kilocycles to metres divide 300,000 by the number of kilocycles; and to convert wavelengths in metres to kilocycles, divide 300,000 by the number of metres.

KILOLINES. 1,000 lines (flux density). (See *Line.*)

KILOVOLT-AMPERE. 1,000 volt-amperes (*which see*).

KILOWATT. 1,000 watts, or 1·34 h.p.

KILOWATT HOUR. 1,000 watt-hours.

KIRCHHOFF'S LAWS. (1) In an electrical circuit, at any junction where circuits

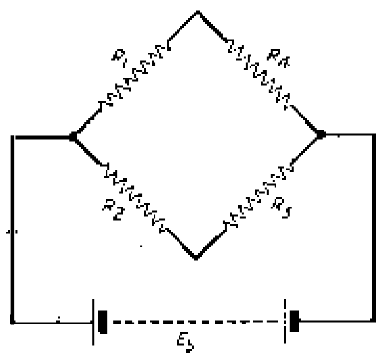


FIG. 235. *A simple series-parallel circuit, involving only an application of Ohm's Law.*

branch, the algebraic sum of the currents meeting is zero. (2) the total e.m.f. in a circuit equals the sum of the resistances of its parts multiplied by the current. Kirchhoff's Laws are in some ways closely related to Ohm's Law, but the former enable us to solve problems which we could not manage with the latter alone. Consider Fig. 235, which shows a battery connected to a network of four resistances. Suppose it is required to find the current delivered by the battery, the currents in each of the resistors, and the p.d. across the ends of the resistors. The problem is a very straightforward one. The resistors are in a simple series-parallel arrangement and the problem necessitates only a systematic application of Ohm's Law and the law connecting e.m.f. and current in a simple circuit to arrive at its solution.

Now suppose that a resistor is added to the arrangement and it is required to find out exactly what is occurring in the network of five resistances shown in Fig. 236. This is not so simple, and, in fact, Ohm's Law and its associated formulæ are not sufficient to cope with the problem. Attempt to work the problem out using the methods suitable for dealing with the arrangement of Fig. 235, and it will soon be found that the fifth resistor connecting the points C and D has complicated the matter far more than an initial comparison of the two systems might suggest.

The problem can be solved by the application of Kirchhoff's Laws.

Kirchhoff's First Law. The algebraic sum of the currents meeting at a point is zero. This is Kirchhoff's first law, and to understand the meaning of this consider Fig. 237, where six conductors are seen meeting at a point. Currents are flowing along the conductors in the directions indicated by the arrows; and these are designated i_1, i_2, etc. It will be seen that the current flowing into the point is $i_4 + i_6$, and this must equal the total current flowing out of the point, $i_1 + i_2 + i_3 + i_5$, or:

$$(i_4 + i_6) - (i_1 + i_2 + i_3 + i_5) = 0$$

If it agreed to distinguish a current flowing into a point from a current flowing out of a point by assigning to the former a positive sign and to the latter a negative sign, then the currents meeting at the point in Fig. 237 are i_4 and i_6 positive, and i_1, i_2, i_3 and i_5 negative. The sum of these six currents is:

$$i_4 + i_6 - i_1 - i_2 - i_3 - i_5$$

and Kirchhoff's first law states that this sum is equal to zero, that is:

$$i_4 + i_6 - i_1 - i_2 - i_3 - i_5 = 0$$

This is the same expression, except that the brackets are removed, as that already obtained by equating the current flowing into the point to the current leaving the point, so that the first law is simply a mathematical way of putting the self-evident fact that when several conductors meet at a point the total current entering the point is the same as the total current leaving the point.

Kirchhoff's Second Law. In any mesh of a network the sum of the electromotive forces is equal to the sum of the products of the resistances of, and currents in, the various parts of the mesh. This is Kirchhoff's second law and to understand its meaning go back to a consideration of Fig. 236. A mesh means a completely closed circuit and in the figure there are five such meshes: BCDB, BDECB, FABDEF, FABCEF and FABDCEF. The last three of these meshes include the battery, so that the total electromotive force in each of them is the electromotive force of the battery, and the other two meshes BCDB and BDECB do not include the battery, and the total e.m.f. in each of them is zero. Kirchhoff's second law applied to the above-mentioned meshes gives the following equations:

For mesh BCDB: $E = I_2R_2 + I_5R_5 - I_1R_1 = 0$

For mesh BDECB: $E = I_1R_1 + I_4R_4 - I_3R_3 - I_2R_2 = 0$

For mesh FABDEF: $E = I_1R_1 + I_4R_4$

For mesh FABCEF: $E = I_2R_2 + I_3R_3$

For mesh FABDCEF: $E = I_1R_1 - I_5R_5 + I_3R_3$

When working round the various meshes in a clockwise direction, a positive sign is affixed to clockwise currents and a negative sign to anti-clockwise currents. A convention of this sort is an obvious necessity; clearly the product I_1R_1 is the potential difference between B and D and, since the current is flowing from B to D the potential of D is lower than the

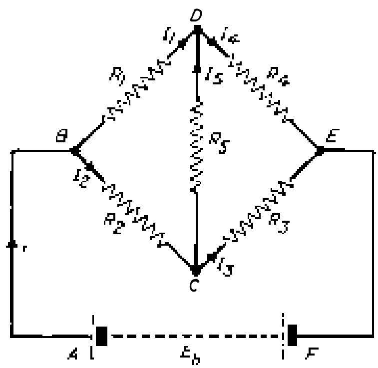


FIG. 236. *The additional resistor R_5 which complicates the circuit of* FIG. 235.

potential of B. The product I_5R_5 is the potential difference between D and C and with the current flowing as the arrows in the figure indicate, the point C is at a higher potential than D. If, then, the change of potential from B to D is given a positive sign, it is necessary to accord a negative sign to the potential change from D to C, since this change is a rise and not a fall of potential.

Having obtained a series of equations similar to those above, it is a simple matter to solve these simultaneously and obtain the currents flowing in the various branches. The solving of simultaneous

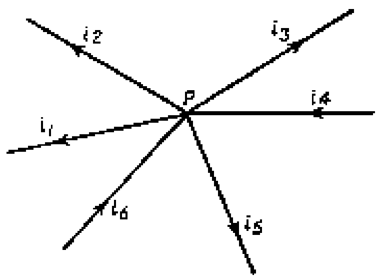


FIG. 237. *Currents flowing to and from a point, demonstrating the first law.*

equations is a laborious though by no means difficult task, and in applying Kirchhoff's Laws to practical problems care should be taken to keep the number of unknown quantities at a minimum. The number of equations required is always the same as the number of unknowns, so that the fewer the unknowns the fewer the number of equations required. Some examples are now given, fully worked out, and a study of these should enable the reader to fully understand the method of employing, and the great importance of Kirchhoff's Laws.

Worked Examples. In Fig. 238 is shown a battery of e.m.f. 10 volts and negligible internal resistance connected to a network of resistances. It is required to find the battery current and the current in the various resistors.

The first thing to do in a problem of this nature is to mark in on the diagram symbols and arrows to denote the various currents. This means an application of Kirchhoff's first law. Let the current from the battery be i, and the current out along BD be x. Then obviously the current out along BC will be $(i - x)$. In the same way let the current out along CD be designated y, so that the currents in CE and DE will be $(i - x + y)$ and $(x - y)$ respectively. These are marked on the diagram. Notice that there are only three unknown quantities, i, x and y, so that only three different equations need be found to provide a complete solution of the problem.

The reader may object at this stage and say that as it is not always possible to tell at sight in which direction a particular current may flow, the arrow indicating that current may be inserted in the wrong direction. This does not matter, however, as the solution of the problem will then show this particular current with a negative sign, indicating an incorrectly marked arrow.

Having now marked off the circuit, Kirchhoff's second law is applied to form three equations from *any three meshes* in this manner:

Mesh BDCB—

$$E = O = 5x + 10y - 5(i - x)$$
$$\therefore \quad 10x + 10y - 5i = 0 \quad \ldots(1)$$

Mesh BECD —

$$E = O = 3(x - y) - 2(-x + y) - 10y$$
$$\therefore \quad 5x - 15y - 2i = 0 \quad \ldots(2)$$

Mesh ABDEFA—

$$E = 10 = 5x + 3(x - y)$$
$$\therefore \quad 8x - 3y = 10 \quad \ldots\ldots(3)$$

These three equations can now be solved simultaneously:

$$10x + 10y - 5i = 0$$
$$5x - 15y - 2i = 0$$
$$8x - 3y = 10$$

Eliminating i from the first and second equations gives:

$$5x - 95y = 0 \quad \ldots\ldots\ldots(4)$$

and combining this with the third equation gives the simultaneous

$$5x - 95y = 0$$
$$8x - 3y = 10$$

Solving for x and y from this equation gives

$$x = 190/149$$
$$y = 10/149$$

and, finally, substituting these values in any one of the first three equations gives

$$i = 400/149$$

The complete answer to the problem is therefore as follows:

Current from battery $= i = 400/149$ amps.
Current in BD $= x = 190/149$ amps.
Current in BC $= (i - x) = 210/149$ amps.
Current in CD $= y = 10/149$ amps.
Current in CE $= (i - x + y) = 220/149$ amps.
Current in DE $= (x - y) = 180/149$ amps.

The solving of simultaneous equations is always laborious, but with care there is no great difficulty in arriving at answer.

Example No. 2 is very similar to the first except that it is now supposed that the

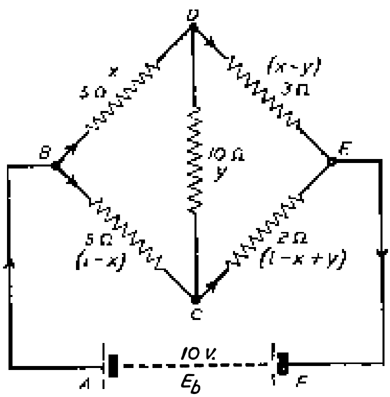


FIG. 238. *The example network solved by the application of Kirchhoff's Laws.*

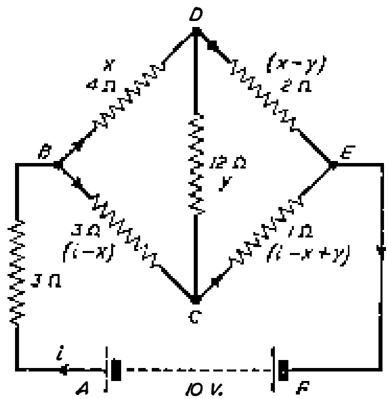


FIG. 239. *An example in which the battery has an internal resistance of 3 ohms.*

battery has internal resistance. The arrangement is shown in Fig. 239, where the internal resistance of the battery is represented by a 3-ohm resistance in one of the battery leads. The procedure of marking in symbols and arrows is just the same as the first example, and three equations are obtained from any three meshes as before.

Mesh DECD

$E = O = 2(x - y) - 1(i - x + y) - 12y$

$\therefore \quad 3x - 13y - i = 0 \quad \ldots\ldots(1)$

Mesh BDCB—

$E = O = 4x + 12y - 3(i - x)$

$\therefore \quad 7x + 12y - 3i = 0 \quad \ldots\ldots(2)$

Mesh FABDEF—

$E = 10 = 3i + 4x + 2(x - y)$

$\therefore \quad 6x - 2y + 3i = 10 \quad \ldots(3)$

Eliminating i from the second and third of these equations gives

$13x + 10y = 10 \quad \ldots\ldots\ldots\ldots\ldots\ldots(4)$

and eliminating i from the first and third equations gives

$15x - 41y = 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$

Solving for x and y from (4) and (5) we get

$x = 510/683$

$y = 20/683$

and substituting these values in any one of the first three equations gives

$i = 1{,}270/683$

The complete answer to the problem is therefore as follows :

Current from battery $= i = 1{,}270/683$ amps.

Current in BD $= x = 510/683$ amps.

Current in BC $= (i - x) = 760/683$ amps.

Current in CD $= y = 20/683$ amps.

Current in CE $= (i - x + y) = 780/683$ amps.

Current in DE $= (x - y) = 490/683$ amps.

A few examples of this nature will soon enable the reader to become fully conversant with the application of Kirchhoff's Laws to complicated networks.

KLIRR FACTOR. Or the Coefficient of Non-linear Distortion, is that ration between root-mean-square values of a fundamental oscillation in wave form to that of the wave harmonics.

KLYSTRON. A type of thermionic apparatus suitable for use as an oscillatory amplifier, or frequency multiplier, in which the Rhumbatron principle is employed to produce velocity modulation of the stream of electrons.

KNIFE SWITCH. A switch having a pivoted arm which wedges between phosphor-bronze spring clips. (See also *Switches*.)

L

LAG. A term used to denote the time lapse between the application of maximum electromotive force and maximum current.

LAMBERT'S LAW of illumination refers to the intensity of light on a surface, from a predetermined source and distance, and is proportional to the cosine of the inclination angle of light on that surface, or that each layer of equal thickness absorbs an equal fraction of the light which traverses it.

LAMINATED. Having a number of thin plates (laminæ) superposed.

LAP WOUND. That style of winding in which the winding is done in loops in such a manner that the connections "lap" towards the commencing back connection.

LAYING OUT COMPONENTS. Bad planning causes trouble that can be divided into two distinct classes; interaction between two stages of a receiver, such as the two coils of the screen-grid set, and accidental coupling between two wires or components in the same stage, such as the grid and anode leads of the detector valve.

Dealing first with interaction between stages, it is quite obvious that the actual shape of the baseboard is a controlling factor of great importance; for example, the square type of layout is to be avoided; it is very unsatisfactory to all but the most experienced, as the proximity of the stages makes fatal stray couplings very hard to avoid. Sets of this type use screened coils, which are often extremely troublesome, as the constructor is misled by assuming that coils in metal "cans" have no field, whereas they have diminished and somewhat localised fields. Screened components are very useful, but they must be treated with respect. It is a great mistake to use a metal baseboard and earth everything to the nearest piece of exposed metal; all high-frequency circuits should, when they are connected to earth, go direct to the earth terminal by means of a wire.

A case may be mentioned of a set of this type which turned out to be extremely unstable until the earth end of the tuned anode coil was disconnected from its "can" and taken straight to the earth terminal. The best form of layout is, without doubt, a long baseboard with each stage following the preceding one in the logical manner; for some unknown reason sets of this type are invariably arranged with the aerial stage on the left; there is nothing against building the set with the aerial tuning on the right-hand side if it is convenient, and sometimes it actually makes the wiring more direct. When a single metal plate is used between two stages as a screen be careful to avoid a component showing round the edge; also keep the coils at a reasonable distance from the screen, as undue proximity will lower the wavelength range. In addition, the fields will not be prevented from reaching the opposing coil. Before leaving the subject of screening, it should be borne in mind that aluminium will not screen low-frequency currents, hence the placing of a transformer near a coil (even if there is a screen in between) is bad (see Fig. 241). The only practical way to keep the transformer field from the coil is to

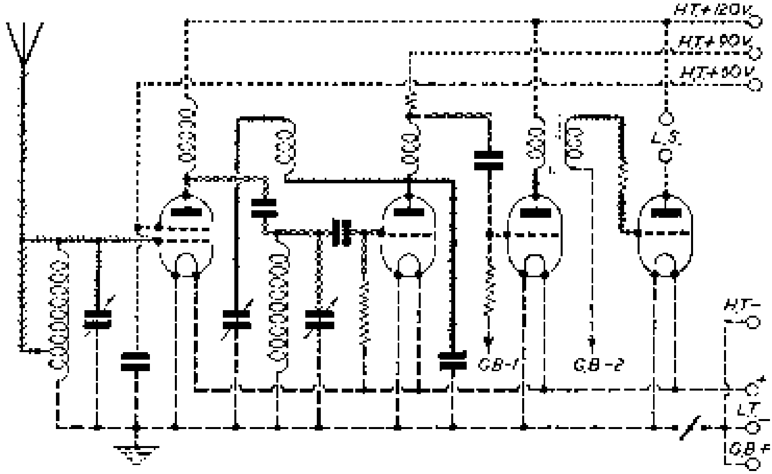


FIG. 240. A circuit diagram of a receiver with the various circuits indicated by different types of line.

leave a generous air space between them. The second type of interaction, i.e. coupling between two parts of the same valve, is not so easy to avoid, but is most important. The most common mistake is that of keeping separate the grid and anode circuits and components of two valves that are connected together: in other words, the anode of the first valve is connected by a fixed condenser and wires, making it quite unnecessary to keep them apart. What should be separated is the grid and anode circuits of valve number one and the similar circuits of the following stages.

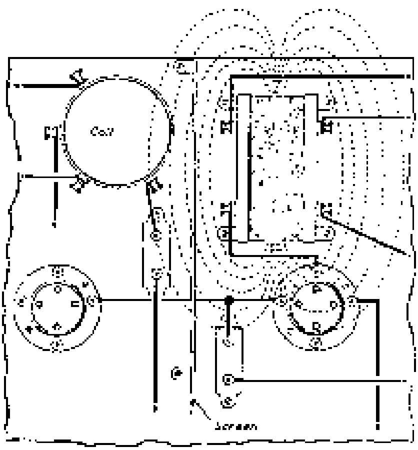


FIG. 241. *The placing of a transformer near a coil (even if there is a screen) is bad.*

Taking an example of a typical screen-grid four, the most important point is to separate the aerial and anode coils and associated components, such as tuning condensers one stage from the other, and it is a minor point if the anode coil and anode lead get tangled up with the grid circuit of the *second* (detector) valve. Fig. 240 shows a circuit with the various circuits separated by different types of lines; all wires drawn in the same manner can be placed close together. Earth wires are shown dotted, and it should be quite understood that these wires are "earth" from the point of high- and low-frequency currents, but may be of any voltage that can be applied from the batteries, which is of no moment from the point of view of wiring. For example, the screen grid of the first valve has a voltage of 60 applied from the high-tension battery, but as it is connected to earth through the 1 μF. condenser, it is at earth or zero voltage as far as high frequency is concerned. Reference to Fig. 240 will show that there are five circuits to be kept free from each other and all free from earth. In addition, there is the loud-speaker circuit, but as the danger here is the actual lead, it does not come into the question of the design of the actual receiver; and it will not be out of place to mention that coupling between speaker leads and the aerial end of the set can be prevented by using flex and keeping the whole apparatus away from the high-frequency side of the receiver.

Different Coloured Wires. The most reliable way of avoiding trouble is by the discriminate use of different coloured wires for the connections: if black is used for the earth and distinct colours for the other circuits, such as red, blue, and yellow, the proximity of two opposed circuits will show up by the obvious clashing of the colours. At the beginning of this section it was pointed out that the best form of set was one using a long, narrow baseboard, partly because it stops interaction between stages and partly because wiring is less complicated, as it is impossible to cramp together wires that are "several steps away." In Fig. 240 one wire, the detector grid lead, is indicated by an arrow, as it is the most troublesome lead in the receiver, and its length should be reduced to the absolute minimum.

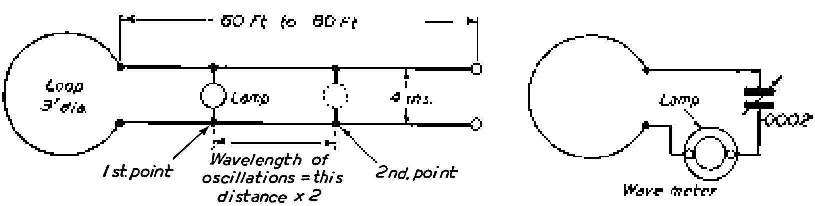


FIG. 242. *The Lecher-wire circuit used for calibration purposes. The upper loop is connected to the oscillator, whilst the lower one is in circuit with a lamp which glows to indicate resonance.*

Wiring can be often simplified and shortened by the study of the terminals on components; this is particularly true of low-frequency transformers, as if put at right-angles, so that each terminal is as near as possible to the point of connection, wiring is as short as practicable.

In the same manner the correct positioning of the valve holder will often completely separate two wires which otherwise would cross each other.

LEAD. Any current-carrying wire.

LEAD-IN. The connection from aerial to receiver. (See also *Aerials.*)

LEAKY GRID DETECTION. A process of rectification in which a condenser is joined between the tuned circuit and the grid. From the grid a high resistance (the grid leak) has to be joined to earth to allow the accumulated electrons to leak away. Hence the term, leaky grid.

LECHER WIRES. Bare wires used in ultra-short wave work, and connected to a valve, generally in the grid and anode circuits. A bridge connects these wires and may be adjusted along them to provide various effects, such, for example, as measuring the actual wavelength of oscillations, etc. For circuit arrangement see Fig. 242.

LECLANCHÉ CELL. A cell of the single-fluid type. In this case, however, the plates are zinc and carbon and the exciting liquid sal-ammoniac (ammonium chloride). By using several carbon plates instead of one, it is possible to increase greatly the strength of the cell. Fig. 243 shows one simple arrangement.

The carbon plates are brittle and should be handled with care, particularly when drilling, etc.

Polarisation is again a great drawback with this type of cell, and many attemps have been made to overcome the difficulty. In the shop-made cell, the carbon plate is placed in a porous pot and surrounded by manganese dioxide. This acts as an oxidising agent, and unites with the free hydrogen to prevent it collecting on the carbon plate.

A simpler method than this is to place a depolariser in the actual solution. Common depolarisers are the bichromates of sodium or potassium, and one of these mixed with the acid in a zinc-acid cell will give it a far longer and more efficient life. A good battery solution may be made by mixing 2 oz. of bichromate, 2 oz. sulphuric acid, and 10 oz. of water (See also *Accumulator.*)

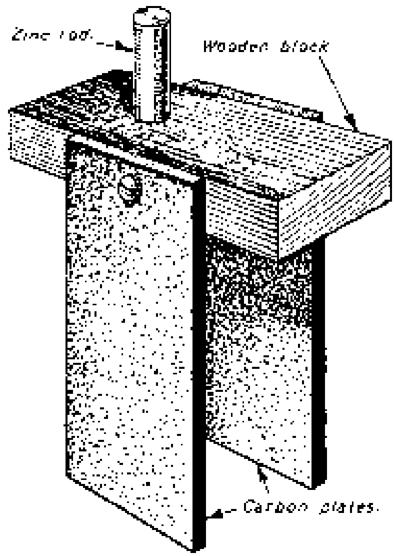


FIG. 243. *The carbon plates for a Leclanché cell.*

LENZ'S LAW. That induced currents have such a direction that the reaction forces generated have a tendency to oppose the motion or action producing them.

LETTER DRILLS. (See *Drills.*)

LEYDEN JAR. A type of condenser consisting of a glass jar, the lower part of which is coated inside and out with tin-foil.

L.F. Low Frequency; audio frequency.

L.F.C. Low-frequency Couplings.

LICENCES. A Post Office licence must be obtained by every listener who is in a position to receive the broadcast programmes. If an aerial is erected a licence is necessary, even although no set is connected to it. The authorities take the view that the intention is to receive the programes, hence the aerial.

The licence covers the use of a portable receiver, but not a car radio which is fixed to a car. Furthermore, it does not cover a receiver in the same house used by another family, even although they may be relatives.

A separate licence is therefore necessary for a car radio and costs the same as the standard licence, namely £1 per annum. For television a further licence is available and costs £2, but includes the standard licence. If, therefore, a standard licence is in force and a television receiver is purchased, a new licence has to be taken out, but a surrender value is given in respect of the unexpired period of the original licence at the rate of 1*s.* 8*d.* per month.

No licence is required for radio equipment used for the radio control of models, but the G.P.O. must be informed that experiments are to be carried out and their permission obtained. There are special limitations as to power and frequencies which must be used.

LIGHTHOUSE TUBE. A type of triode valve for centimetre wavelengths having plane electrodes brought out as disc seals, specially designed for use with coaxial-line resonators.

LIGHT-RAY CONTROL. Apparatus, which depends for its action on the fluctuations in resistance of a selenium cell or "bridge" due to variations in intensity of a ray of light projected on to it. The ray may be used to switch a wireless set on or off, set alarms, shut and open doors; in fact, anything that can be operated by means of a switch.

Today control by light is used to a very great extent in television, which is practically wholly a question of light control. This apparatus is based on what is known as a selenium cell. Selenium is an element with a peculiar property, which was discovered by accident. It was being used as a high resistance in an electrical experiment, when it was found to vary its resistance to an electric current as the light which shone upon it varied in intensity. Thus, this phenomenon led to experiments with selenium cells, ultimately resulting in the production of the modern light-ray apparatus.

It is, in fact, a selenium cell, a compact and easily handled apparatus, having all the principles of the big selenium cell, but far less cumbersome, and of extremely low cost. In its commercial form it is housed in a bakelite case, is easily handled, and has all the properties and

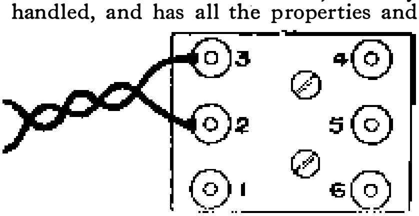


FIG. 244. *The connections to the relay for switching off a wireless set.*

sensitivity to light that modern light-controlled apparatus requires.

The theoretical circuit of this device is shown in Fig. 247, and no difficulty should be experienced in the wiring of the components. There is no soldering necessary, as all wires are connected direct to terminals. Now, in order to feed current to the light-sensitive apparatus, and to supply power to the amplifying valve, two supplies of current are necessary, these being a 2-volt L.T. battery for the valve filament, and a 100- to 150-volt H.T. battery. The valve used is of the detector type, and is recommended because of its extreme sensitivity. Having completed the power supply, and inserted the valve, the apparatus may now be tested.

Remove the H.T. + and tap it on its socket, as this occasional contact releases

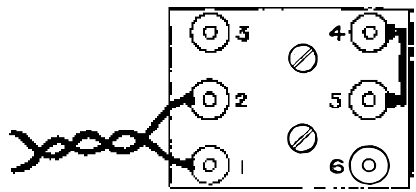


FIG. 245. *The connections to the relay for a burglar alarm.*

the relay, and a click should be heard. This shows that it is operating successfully. Now shine a light on the apparatus, having first turned the variable resistance to approximately the centre of its track, and break the beam of light by passing the hand through it. The relay will then give an instant click, showing that the light acting on the bridge has caused the relay to operate. It is necessary to shade from the sensitive cell as much stray light as possible, focusing on to it only the ray which operates it.

There are a number of different ways in which it will function. They are controlled by the relay on which will be found six terminals numbered 1 to 6. When terminals 1 and 2 are connected to a lamp,

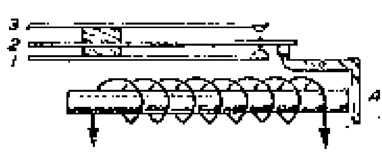


FIG. 246. *Diagram of the switch in the relay.*

the connection between terminals 4 *and* 5 *being removed*, the lamp circuit is normally open. When the light ray focused on the bridge is intercepted, the lamp will light, and will continue to burn until the lamp is switched off, as the apparatus is reset by temporarily shorting terminals 4 and 5 with a piece of wire. It will be seen how useful this connection is for burglar alarms, where it is essential that the resulting alarm can only be switched off by the owner. Another simple experiment is to retain the connections to terminals 1 and 2, and replace the wire connecting terminals 4 and 5 (Fig. 245).

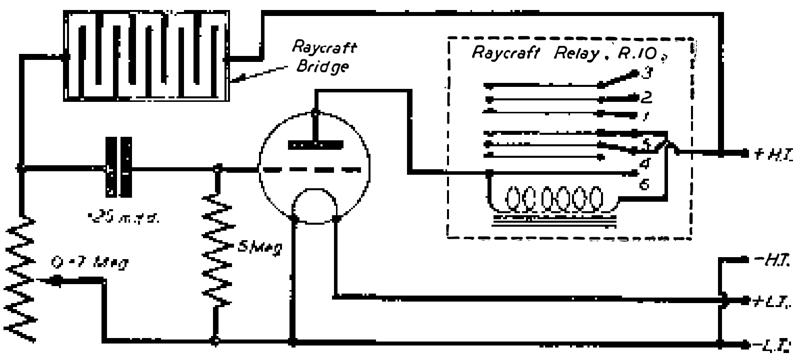


FIG. 247. *The circuit diagram for light-ray control.*

It will now be found that interrupting the ray will light the lamp, but that the restoration of the ray will result in the lamp going out.

Connect the lamp to terminals 2 and 3 on the relay (Fig. 244) and remove the connecting link between terminals 4 and 5. The apparatus will now function in exactly the opposite way to the first experiment. This connection can be used to switch off a wireless set, the electric light acting as the ray. When the electric light is switched off, the bridge will automatically switch off the set (Fig. 246).

LIGHT, SPEED OF. Light waves travel at 186,282 miles per second. This speed is also that of wireless waves.

LIMITER. (See *Frequency Modulation.*)

LINE. It is usual to express field strength as a flux of so many magnetic lines of force, the flux density being the number of lines per square centimetre. The Maxwell (*which see*) is the unit of magnetic flux density. (See also *Kiloline.*)

LINE LENGTHENER. A device for altering the "electrical length" of a *waveguide* or transmission line without altering other electrical characteristics, or the physical length.

LINEAR TIMEBASE. A *timebase* in which the *spot* moves at a sensibly constant speed, in the direction of the time scale, during the useful part of the timebase.

LISAJOU'S FIGURES. Any closed figures traversed by a point moving with the resultant of two periodic oscillatory motions at right angles. Originally applied to certain experiments in connection with pendulums and sound, but now used for a class of records of this nature by such instruments as the Cathode Ray Oscillograph.

LITMUS PAPER. A paper which is used for testing the presence of acids and alkalis. It is turned red by acids and blue by alkalis. Litmus paper is obtainable in red and blue—the red remains unchanged in colour when immersed in acid, but turns blue when immersed in an alkali, changing back to red when reimmersed in acid. The blue remains unchanged when immersed in an alkali, but changes to red when immersed in an acid, changing back to blue when immersed in an alkali.

LITZENDRAHT WIRE. This is a special wire for winding coils and other components which require minimum high-frequency resistance. It consists of strands of insulated copper wire plaited together in multiples of three with silk covering.

LOAD. The amount of energy taken from a battery, motor, etc. The total work to be done.

LOADED AERIAL. An aerial whose frequency or electrical length is varied by the addition of capacity or inductance in series.

LOADING COIL. A coil used to increase the range of an existing coil.

LOBE. (a) The portion of a *field-strength diagram* within a solid angle bounded by a region or regions of minimum radiation. (b) The cross section of a lobe as defined in (a) by any specified plane. (c) The radiation of electromagnetic energy corresponding with the field-strength distribution represented as in (a) or (b).

LOCAL OSCILLATOR. An oscillator, within the receiving equipment, used for generating oscillations which are combined with the incoming signal, as in beat reception.

LOCK. To couple two or more systems so that the recurrence frequency in one system is constrained to be equal to, or a multiple or sub-multiple of, the recurrence frequency in the other.

LOCK FOLLOWING. (See *Automatic Following*.)

LOEWE VALVES. Valves which contained in one glass envelope the electrodes of two or more valves, together with the requisite intervalve couplings. These are resistance-coupled stages, either H.F. or L.F., and the resistances employed for the purpose are enclosed in small sealed glass tubes which are evacuated.

LONG-PLAYING RECORD (L.P.R.). Standard 10-in. and 12-in. gramophone records in which the recording is cut into very small spirals. They are designed to be played at very slow speeds, resulting in considerably greater playing time than with standard discs. The speeds at present in use are $33\frac{1}{3}$ and 45 r.p.m. (compared with 78 r.p.m. for standard records), and special fine needles or sapphire points are needed in view of the fineness of the groove. Greater fidelity is the main advantage of this type of disc, which incidentally is made of unbreakable material.

LONG WAVES (L.W.). Waves longer than 1,000 m.

LOOP. An antinode. The point of greatest amplitude in a wave train.

LOOP AERIAL. American term for frame aerial. A single-turn aerial.

LOOSE COUPLING. When inductive couplings can be varied by changing the relative position of the coils they are said to be loose coupled.

LOSSY ATTENUATOR (in Waveguide Technique). A length of *waveguide* deliberately introducing a transmission loss by the use of some dissipative material.

LOUDSPEAKERS. Although the moving coil is the main type of loudspeaker now in use, there may still be found older speakers which were at one time very

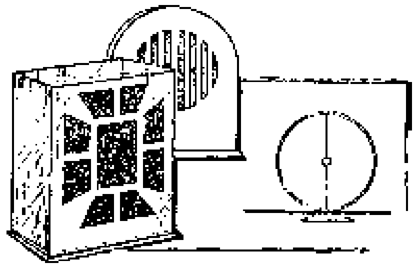


FIG. 248. *Theoretical and pictorial diagrams of a loudspeaker.*

popular. They are the simple cone type; balanced armature and the inductor the dynamic.

The simplest type of movement is the one illustrated in Fig. 249. It consists of a strip of iron, fixed at one end, the free end being above and close to the pole of a small magnet. To the strip of iron, or armature as it is properly called,

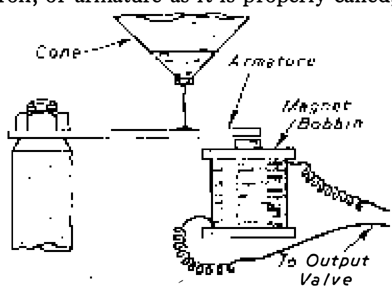


FIG. 249. *The simplest type of loudspeaker movement is the cone type.*

is fixed a thin rod on to which a cone diaphragm may be fixed. The windings of the magnet are connected in the output circuit of the last valve of the set. As the current changes, due to either speech or music passing through this magnet winding, so the pull on the armature is varied, with the result that the vibrations are transferred to the cone, and so the sounds are made audible. It will be obvious that the armature will always tend to return to its normal position, and this natural restoring force gives rise to its first fault, namely, resonance. Again, the current fluctuations due to a very low note, such, for instance, as the beat of a drum, are very great, and should result in a large movement of the armature. As the armature is rather rigidly held, it must be arranged close to the pole piece in order that the weak impulses may affect it.

The Balanced Armature. This was brought out to try to avoid the principal fault of the first type of speaker, namely, resonance.

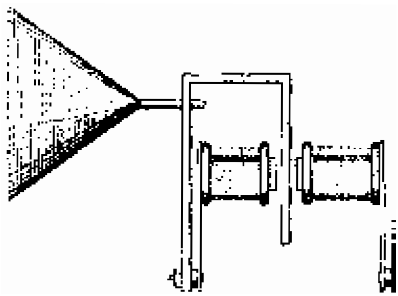


FIG. 250. *The balanced armature. As will be seen, the armature is less rigidly arranged between the two magnets.*

As will be seen from Fig. 250, the armature is now less rigidly arranged in between two magnets. There is therefore an equal pull in each direction, and this tends to make the armature move about a central position, avoiding the natural restoring

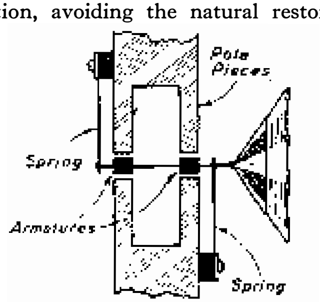


FIG. 251. *The inductor dynamic speaker.*

force which was noticed in the simple type of movement. The gap between the magnets may be fairly large, and so greater signal strength can be handled without the risk of "chatter." This type of speaker is therefore most suitable for receivers employing two or more valves and designed more on "quality" lines than the usual cheap set.

The inductor dynamic is the nearest approach yet obtained to the ideal in moving-iron speakers. In both of the previous movements it is obvious that as the iron armature is fixed at one end, there must necessarily be a certain amount of resistance to overcome in order to vibrate the armature, and the tendency of the armature to return to its position of rest is always present, no matter what

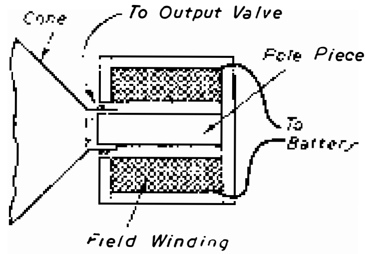


FIG. 252. *Section through a mains energised moving-coil loudspeaker.*

electrical impulses are at work. This prevents the slow oscillation necessary to produce, say, a pedal note on the organ, and, in addition, the cone is not operated in a direct push-and-pull movement. The actual direction of the cone's movement, to produce true tones, should be what might be termed a "piston" movement; that is, it should move in a horizontal plane. Now, as one end of the armature in the speaker movements so far described is fixed, it is obvious that the operating reed is taken through a small arc during

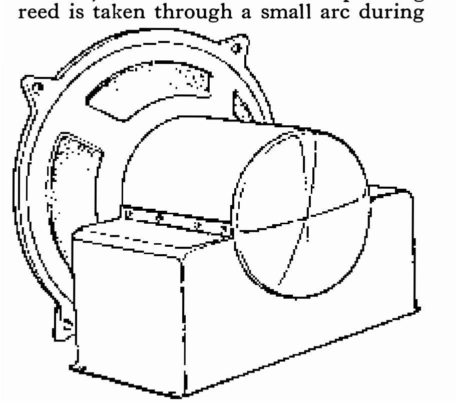


FIG. 253. *A mains energised moving-coil loudspeaker.*

its to-and-fro movement. This gives rise to a form of distortion.

Inductor Dynamic Speaker. To overcome all these defects in a moving-iron loudspeaker the inductor dynamic was produced. The actual arrangement is the subject of Letters Patent, and only a few firms in this country are licensed to manufacture it. Fig. 251 shows the principle on which it works. There are four pole pieces to the magnet system and two armatures. The two armatures are held together by means of rigid, but light, rods, and the armature assembly is held at the *front and back* by very light springs. It is obvious that, by being held in two places, the strength of the springs may be very much weaker than if only one end was held. Furthermore, when the armature is drawn to either side by the signal impulses it must travel in a true horizontal direction, and the restoring force in any direction is equal.

Moving-Coil Speaker. The moving-coil speaker is, of course, the best type of speaker yet designed, and provided one of the best makes is obtained, either permanent magnet or mains energised will give a reproduction identical with the original. As will be seen from Fig. 252 (mains energised type) at the point of the cone diaphragm a light ring of paper is fixed, round which is wound a coil of wire known as the "speech winding." In the mains energised speaker a metal cylinder, having a central rod (the "pot" and "pole-piece"), contains a large winding which has to be connected to some source of direct current. The actual voltage depends on the design of the speaker, and varies in most speakers from 4 volts to 150 volts. The speech winding is supported in a small gap surrounding the pole piece, and this gap should be as small as possible. Usually it is approximately $\frac{1}{8}$ in. When the field is "excited," which means when the current is applied to it, a magnetic field is set up across the gap. The speech coil is connected to the output valve of the receiver, and when the signal impulses flow through this speech winding it vibrates, travelling in and out of the gap. The edge of the cone is supported in some way, either by a ring of leather or rubber, and therefore the cone makes a true "piston" movement, resulting in a faithful reproduction of the received sounds. The only faults with this type of speaker arise from faulty design, and are : too heavy a speech coil and cone; resonance set up by the rubber or leather fixing ring; resonance due to the material of which the cone is made, and one or two other little points.

To get the very best from a moving-coil speaker, a fairly strong signal is desirable, and as it can give such a good performance, the receiver should be designed to give out a signal to justify the use of such a speaker. Particular care should be taken to look after the lower notes in the musical scale, as these can be dealt with so effectively by the moving-coil speaker.

Matching the Impedance. No matter which type of speaker it is intended to use, there is one point which applies to the

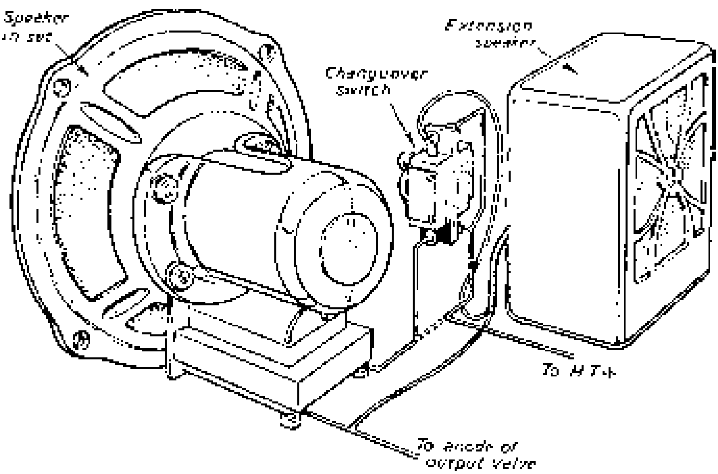


FIG. 254. *A simple method of fitting a switch for changing from a built-in speaker to an external one.*

correct employment of any speaker, and that is, the impedance of the speaker must be matched to the output valve. This means that a certain valve will only give straight-line reproduction with a certain impedance in its anode circuit, and although valve manufacturers give this impedance figure in the leaflets accompanying their valves, unfortunately loudspeaker manufacturers do not always give the impedance of their products. Usually, only the D.C. resistance is given, and this does not enable one correctly to match up the speaker. There are on the market, however, certain output matching transformers which have various ratios, and if the listener desires to get the best from the set, one of these transformers or matching units should be included in the output circuit, and by adjusting it to various values it is possible suitably to match up the speaker. One final word. As the speaker can only reproduce what is fed into it, the choice of circuit should receive as much, or even more, care than the choice of speaker.

Compensated Loudspeakers. Another term for dual loudspeakers (*which see.*)

Dual Loudspeakers. Two speakers, mounted on a single mounting, each of which has different characteristics. In this way a more even response curve is obtained, as the deficiencies of one speaker are covered by its partner. In some matched pairs, one loudspeaker deals with the higher frequencies whilst the other deals with the low notes.

Electrostatic Speakers. The electrostatic type of speaker employs two plates separated by air (in the same manner as a condenser). The differences in potential applied to the two plates produce movement, and by suitable design of the plates, spacing, etc., it is claimed that the reproduction is better than any of the methods described above.

Loudspeaker Horns. Owing to the rapid advances in the design of loudspeaker movements as detailed above, the horn type of speaker has practically disappeared from the market. In spite of this, however, some of the best-known talkie installations employ a horn type of loudspeaker, and this has caused quite a number of wireless amateurs to wonder which is actually the better type—the horn or the hornless. Experts are divided on this question, some holding that the moving-coil speaker, correctly designed, is the best reproducer, and others that the horn type is unbeatable, provided it is of the right shape, and this means that it has to be very large, as the following figures will show. In order that a horn may reproduce *with a perfectly even response* all the notes in the musical scale, it must be of a certain shape and

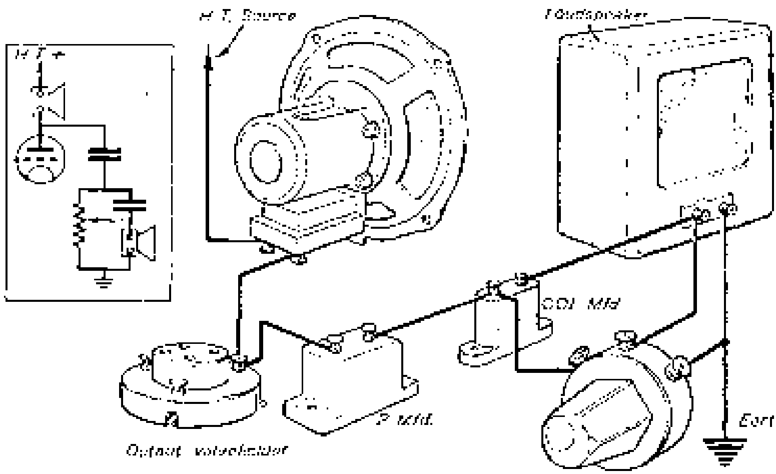


FIG. 255. *A modification of the system illustrated in* FIG. 260 *where a volume control is provided for the extension speaker. In this case both speakers are always kept in circuit.*

of a definite length. The shape will have to follow what is known as the exponential (or logarithmic) law, that is to say, the cross-sectional area of the opening will have to double at equal intervals throughout the length of the horn.

An example will make this clear. Consider a speaker horn, the entrance (or throat) of which has an area of 1 square in. If at 1 ft. along the horn the area is 2 square in., then at 2 ft. it will have to be 4 square in.; at 3 ft., 8 square in.; at 4 ft., 16 square in., and so on. This rate of expansion determines the lowest frequency at which the horn will maintain its straight-line reproduction, or in other words, it governs the "cut-off" frequency. The following table shows these figures :

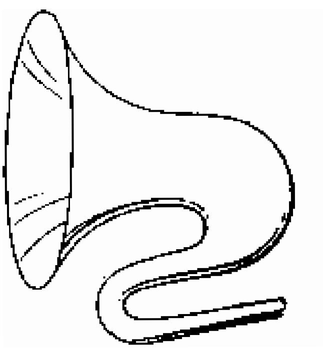


FIG. 256. *A method of forming to avoid bulkiness.*

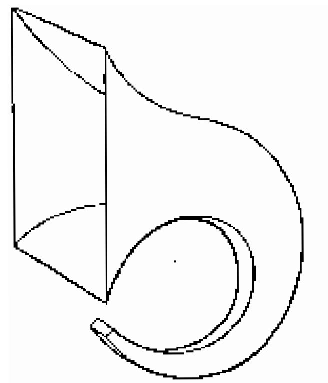
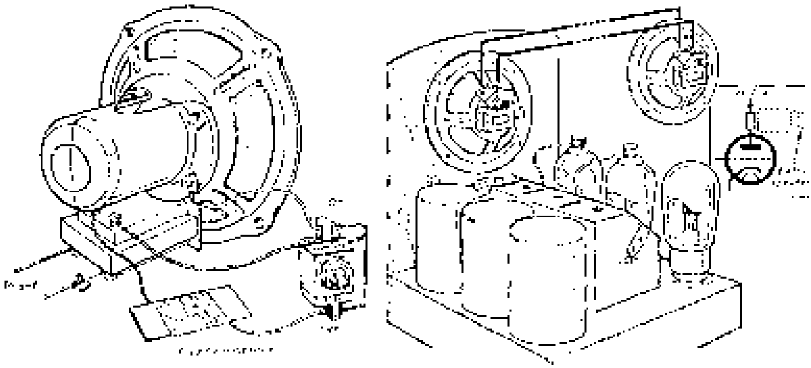


FIG. 257. *A method of curving which avoids bends.*

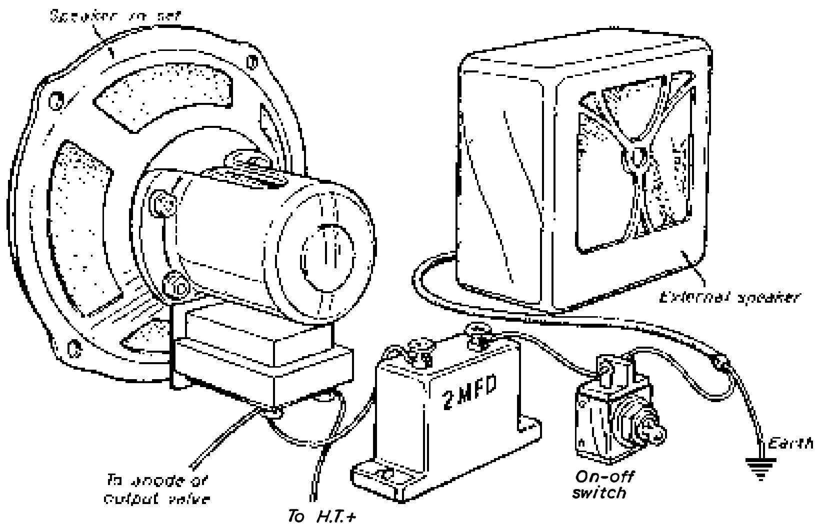
Area doubling every 6 in., cut-off frequency is 128 cycles;
Area doubling every 12 in., cut-off frequency is 64 cycles;
Area doubling every 24 in., cut-off frequency is 32 cycles;
and so on.

To understand what this means, one must remember that the middle note on the piano has a frequency of 256 cycles, and the lowest note a frequency of 26·6 cycles. If, therefore, one wishes the horn speaker to reproduce the lowest note of the piano with the same degree of amplification as middle C, it must double its area every 2 ft. So far the example has decided upon one figure in the design, and it is necessary so as to permit the air column which is standing in the horn from having too great a damping effect on the diaphragm which is actuating it. The most satisfactory size for this opening will be obtained if the diameter is made equal to one-quarter of the wavelength of the cut-off frequency of the horn. This sounds very involved, but it is really quite simple to work out. The velocity of sound in air is 1,120 ft. per second. It has been shown above how to work out cut-off frequency, and therefore to find the corresponding wavelength of this proceed to divide 1,120 by the frequency, and that will give the wavelength in feet. Dividing this by four will give the diameter of the opening, and one must therefore make the horn of such a length that it terminates when that diameter is reached.

Supposing one wishes to construct a horn with a cut-off frequency of 64 cycles, and the unit for the speaker has a fitting with an area of 1 sq. in. The rate of expansion will be every 12 in., and the mouth 4 ft. across. This means that the horn would have to be over 6 ft. long. It becomes obvious from these figures that the old-fashioned type of table loudspeaker was a very poor performer as far as the bass was concerned, and it also accounts for the size of the talkie horns. For those who are interested, here are some hints on construction. In the first place, for simplicity, it must be stated that there is no audible difference, on an ordinary home receiver, between a horn of round or square section. The latter is certainly very much easier to construct. Any wood may be used, and this should, theoretically, be thick to avoid resonance. (Do not employ metal, because of



FIGS. 258 AND 259. (*Left*) *When switching out one of the speakers connected in parallel it is sometimes an advantage to leave the primary winding of the output transformer in circuit. In that case it is well to replace the speech coil by a fixed resistance of similar value.* (*Right*) *Showing the simplest method of connecting an extra speaker; it is in parallel with the "permanent" speaker.*



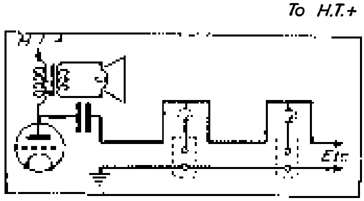


FIG. 260. *A simple method of fitting a switch for changing from a built-in speaker to an external one.*

resonance troubles.) However, plywood ¼-in. thick may be used, and if resonance is noticed, putty pressed on at different spots will damp out the resonance, or at least make it low enough to be unobjectionable. The horn may be curved and

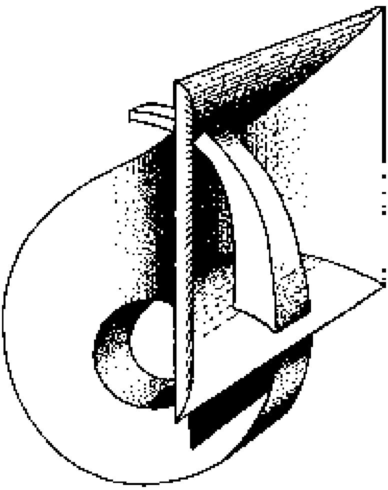


FIG. 261. *How the very large cinema horns are formed.*

bent back upon itself to avoid cumbersomeness, but—and this is important—avoid angular bends. Endeavour, if possible, to get nice steady curves of the swan-neck type to avoid "echoes."

Speaker units for use with this type of horn should be capable of reproducing all frequencies equally.

LOW-FREQUENCY AMPLIFIER. An amplifier which amplifies after rectification of the signal; it calls for low-frequency (iron-cored) transformers.

Strictly speaking, the L.F. amplifier has little or nothing to do with radio, since all *radio* frequencies have disappeared by the time this part of the set is reached. It is really a matter of pure "land-line" technique. But so indispensable a part of a receiver has it become that it is most conveniently taken in with other radio matters.

Consider the working of the three-electrode radio valve for a moment. Put briefly, its action is as follows : a varying voltage applied to its grid will cause similar variations in the *current* flowing through its plate circuit.

When the valve is a detector, the necessary variations in its grid voltage may be supplied by the incoming signal itself, and the valve is so treated that the resulting variations of plate current are "unsymmetrical." That is the principle of rectification.

It is this rectified signal that forms the input to the L.F. amplifier. It has to be converted from the form of a varying *current* in the plate circuit of the detector valve to that of a varying *voltage* ready to apply to the grid of the L.F. amplifying valve.

This may be done in various ways. Fig. 264 shows the most common—illustrating the use of an L.F. transformer. The varying plate current passes through the primary winding of an iron-cored transformer, and causes similar impulses in the secondary winding. As the two windings are arranged to give a "step-up" ratio (by which is meant that the secondary winding comprises many more turns than the primary), the secondary terminals have available a varying voltage which is—if the transformer is well designed—a replica of the varying current. It will be understood, nevertheless, that the grid of the second valve has a rapidly varying potential which will, again, produce a varying *current* in the plate circuit of that valve, although, by this time, the

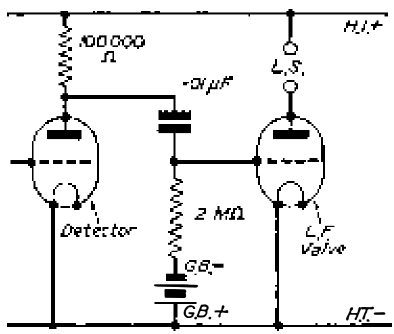


FIG. 262. *"Resistance-capacity" coupling.*

variations will be of much greater magnitude, owing to the amplification that has been obtained through the valve and transformer.

Thus another L.F. amplifier may be added in precisely the same manner. Resistance-capacity coupling is an old favourite that is still greatly used for L.F. amplifier couplings. It will be seen from Fig. 262 that, instead of passing the plate current of the detector valve through the primary winding of a transformer, it is simply passed through a high resistance.

The rapidly varying plate current will undergo a *varying* voltage drop, which is applied to the grid of the L.F. valve by coupling it to the bottom end of the resistance. This is done by means of a fairly large fixed condenser. The only other point remaining is that the grid of the L.F. valve will now accumulate a charge until it "chokes," unless it is provided with a path for the D.C. to leak away to earth. Therefore a grid leak of a high value is connected from the grid to the grid-bias battery.

The fundamental difference between transformer and resistance coupling is that, when the former is used, the total amplification of the "stage" is expressed by the amplification factor of the valve multiplied by the transformer ratio. The common combination of a valve with a "mag." of 10 and a 4 : 1 transformer will thus give a "gain" of 40. On the other hand, when resistance coupling is used, it is the "mag." of the valve only that can be made use of. Luckily, a valve with a much higher impedance—and therefore a higher amplification factor—can be used with this form of coupling, and the "gain" in these cases can be anything between 35 and 60 in ordinary simple sets.

A really good transformer will give just as good quality as resistance coupling, and a *cheap* transformer should therefore be used when there is *one stage only*.

Disappointing results almost invariably come from the wiring up of a set with any odd transformer and the plugging in of any odd valve. A good combination may be found, but the chances against it are about 1,000 to 1.

If a L.F. amplifier is added directly to the detector stage, it is best to choose transformer coupling. In this case the transformer ratio may be anything up to 7 : 1, provided that after a 7 : 1 transformer a bigger valve is used to take the full input without distortion. Always use a good power valve for the stage after a high ratio transformer, even if another valve is to follow.

For the more common plan of using a $3\frac{1}{2}$: 1 or 4 : 1 transformer, a valve of the "first L.F." type may be chosen from the valve-makers' list.

If two stages of amplification are added, it is usually a good plan to use resistance coupling for the *first*. A "first L.F." type valve should still be used to follow the detector. This may then be coupled by means of a transformer, with a ratio up to 4 : 1, to a really good output

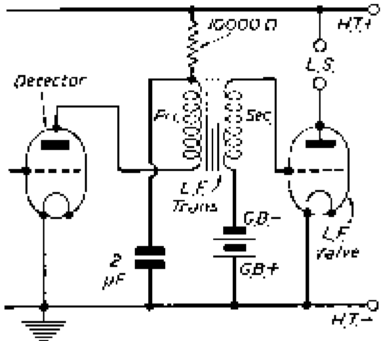


FIG. 263. *Illustrating the use of an L.F. transformer.*

valve. A larger output valve will naturally be needed in this case. It is necessary to pick out individual types of valve. Choose valves to suit the set.

As a final practical point, receivers using two transformer-coupled stages are dealt with. There is nothing whatever against this arrangement, providing that the layout is well chosen, and that too much amplification is not aimed at. True, this particular scheme is more likely to give trouble in the hands of the inexperienced than the previous one, but only because of one or two pitfalls that await the unwary.

Interaction between the two transformers is the most frequent. They should be mounted as far away from each other as is practicable, and their cores should, if possible, be at right angles to each other.

L.F. instability may take the form of an audible whistle, or, more commonly, of severe distortion of music and speech. In the latter case the whistle is probably there just the same, but it so happens that the whole arrangement is oscillating at a frequency well above the audible range.

Such trouble should be cured, if possible, by changing the layout, unless it is found that reversing the secondary leads on one of the transformers puts matters right.

If neither of these devices has any effect, it may generally be cured (at the expense of a slight loss of amplification) by connecting a grid leak of 1 megohm across the secondary winding of one or both transformers.

Finally, it is as well to mention the old pitfall of high-resistance batteries. Nothing is so fatal to a "high-mag." L.F. amplifier as insufficient H.T. voltage and poor batteries. If your set is battery-operated, see that each valve really is getting the voltage recommended by the makers. Also do not omit the "decoupling" unit shown in Fig. 263, particularly in transformer-coupled sets. A resistance of 10,000 ohms and a condenser

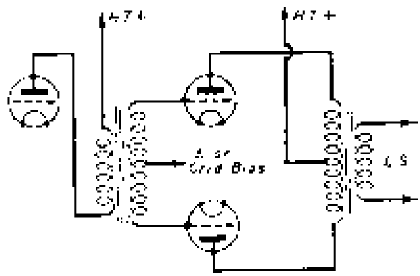


FIG. 264. *Push-pull L.F. transformer coupling.*

of 2 μF., connected as shown, generally make all the difference between success and failure.

When high-power and/or high quality are required the push-pull amplifier is undoubtedly the most desirable arrangement. Apart from the elimination of second harmonic distortion, it is possible to effect certain economies in the mains unit (due to the balancing out of hum), and if really large triodes such as the PX25A are employed, together with resistance-capacity coupling, there is little left to be desired in the way of quality for normal domestic requirements.

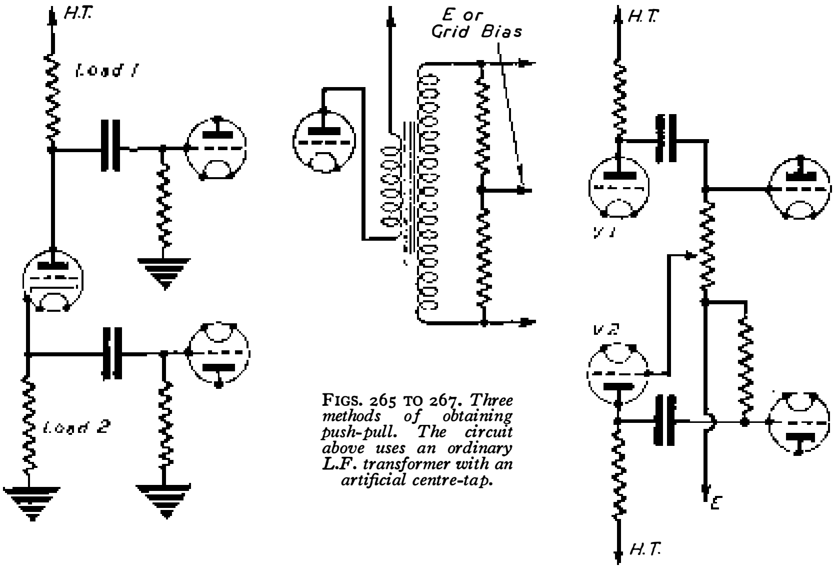
In push-pull working the signal from a given stage is applied across a load, the electrical centre of which is "earthed." This leaves the two ends of the load at high signal potential, but each 180 degrees out of phase with the other. The input to the two push-pull valves is taken to these high potential ends, and, in its original form, an L.F. transformer with the secondary centre-tapped formed the coupling as shown in Fig. 264.

It will be seen from this that the signal developed across the secondary, in the usual way, is applied to the two valves, but the earthing of the centre enables the required out-of-phase signals to be applied to the following grids. This arrangement may be obtained artificially with an ordinary L.F. transformer, by connecting two high-valve resistors across the secondary and earthing their common ends, as shown in Fig. 266. Values not lower than ·25 megohm should be employed, and for the purposes of trying out the arrangement any values on hand may be used. Although, theoretically, they should be absolutely identical, due to their being in parallel with the transformer secondary winding, the usual slight differences found in standard commercial components will not have much effect on the circuit. In the case of battery-operated circuits, the bias should be applied to the junction point, whilst in mains equipment the usual cathode bias should be employed. Normal bias is applied except where one common bias resistor is employed in the heater windings of the two push-pull valves. As in that case twice the normal anode current will flow, the value of the resistor will have to be halved to provide the normal bias voltage. The transformer fitted to most loudspeakers is provided with a centre-tap, and this should be connected to H.T. + and the two anodes joined to the ends of the transformer.

Although it is possible to use quite small transformers on the input side of the push-pull circuit, there is a risk of certain forms of distortion creeping in. On the output side, of course, the removal of direct D.C. from the primary does cut out one of the main troubles of the output stage and there is little risk of saturation causing difficulty. To avoid the cost of high-quality input push-pull transformers, and also to remove certain forms of distortion, it is possible to use resistance-capacity input coupling. This is sometimes known as "paraphase" coupling, "combined cathode-follower coupling," and other fancy names. In general it merely consists of the employment of a resistance as the load, and in some cases two separate triodes (or a combined double-triode) are R.C. coupled to provide the required out-of-phase signal for the output stage, and in others the load resistance is split into two, and one half is placed in the cathode circuit of the input valve. Fig. 267 shows a pair of triode valves V1 and V2 acting as the driver. The output from V1 is fed to V2 as well as to one of the push-pull pair. This means that the output of V2 can then be fed to the other push-pull valve, as it will be 180 degrees out of phase with the output from V1. However, this is not an ideal arrangement as the signal from V2 will be given additional amplification and will thus be stronger than that from V1. Furthermore, the circuit is not symmetrical from an electrical point of view, and whilst it is admitted that it sounds quite good, there are theoretical reasons why it is really unsound. Attempts to balance up the circuit are not very successful, but the inclusion of an oscilloscope in each of the output valve circuits will show that actually there is quite a difference in the signals they each have to handle.

A popular arrangement now being given great prominence is the cathode follower, wherein the load resistance is in the cathode circuit instead of in the normal position at the anode. Again, however, there is quite a difference in the signal available, as, apart from the phase difference, the signal voltages at the anode will be greater than those at the cathode. This may be overcome to a certain degree by using a low value resistance for the load, but there will still be a discrepancy in the types of signal. However, when fed to the two push-pull valves there is no doubt that this scheme does give a signal which is preferable from a musical point of view.

LOW-FREQUENCY CHOKE. A coil of wire having an iron core, and used for smoothing and coupling low-frequency circuits (see Fig. 274). It should have a low resistance to D.C. and high resistance to A.C. (See also *Chokes* and *High-frequency Chokes* and "*Wireless Coils, Chokes and Transformers*" (published separately) for constructional details.)



FIGS. 265 TO 267. *Three methods of obtaining push-pull. The circuit above uses an ordinary L.F. transformer with an artificial centre-tap.*

LOW-FREQUENCY COUPLINGS. The method of coupling L.F. valves together has a great deal to do with both the volume of the output of the wireless set and the quality of that output. As there are several different methods of carrying out this coupling, below is given a brief explanation of each method, together with its advantages and disadvantages.

The most popular method is, of course, the L.F. transformer. This consists of a core of soft iron stampings, around which is wound two separate coils of wire—either side by side or one upon the other (Fig. 268). The ratio of these windings determines the amplification given by the transformer, and thus a 3 to 1 transformer means that the primary is (roughly) one-third the size of the secondary. The primary winding is connected in the anode circuit of the valve, that is, one end of the primary is joined to the anode, and the other end to the H.T. supply. The oscillations in this winding are transferred by induction to the secondary winding, which is connected to the grid circuit of the following valve, and therefore this valve receives similar impulses to those with the exception that they are strengthened by the step-up due to the ratio of the windings. The advantage of this type of coupling lies in this step-up of strength, but there are a number of disadvantages.

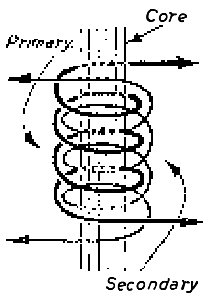
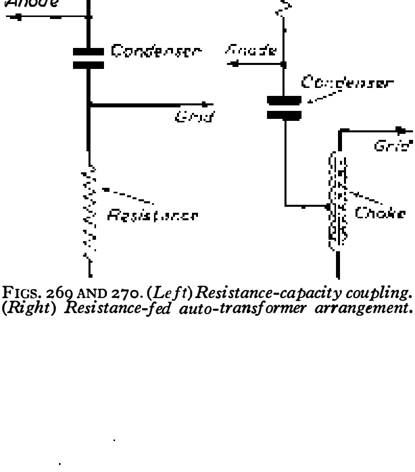


FIG. 268. *Diagrammatic illustration of the L.F. transformer.*

Firstly, the inductance of the primary should be of a certain value dependent on the impedance of the valve in whose anode circuit it is included. As, however, there is a steady D.C. current flowing through it, this impedance is reduced, the greater the current the lower the impedance. Therefore, it is not efficient if included in the anode circuit of a small-power valve passing an anode current of 10 milliamps. or so, unless it is wound with a normal inductance of 20 henrys approximately. This means that the primary would have to be very large, and then when a secondary with the necessary step-up in winding is included, a rather unwieldy component would result. Therefore, generally speaking, the intervalve transformer is equipped with a rather small primary, and will not take more current than 7 or 8 milliamps. without seriously affecting the value of its inductance, and therefore, introducing poor quality. To overcome this defect various schemes have been tried, such as using a core of metal other than soft iron; using different materials for the two windings, etc.

If the D.C. can be kept from the primary, it would obviously improve the working characteristics of the transformer, and that now introduces the next method of L.F. coupling. It is known as parallel feed—which means that the primary of the transformer is in parallel with the preceding valve—and to accomplish this a resistance is included in the first anode circuit (instead of the primary), and one end of the primary is joined to the anode, and the other end to earth (Fig. 271). The quality of the response given by this method is an improvement, but the disadvantage is the same as that occasioned by resistance-capacity coupling, which is dealt with in the following notes.

To get the best response from a valve we must have an impedance in the anode circuit which is as great as possible compared with the actual impedance of the valve. In practice, we choose a value about four times as great as the valve's impedance. Take a standard 2-volt valve with an impedance of 7,000 ohms and an amplification of 5. The impedance to be included in the anode circuit of this valve should be at least 28,000 ohms. Suppose we use 30,000, which is the nearest commercial value made. The anode current of the valve in question will probably be about 5 milliamps. From Ohm's Law, we know that 150 volts are required to pass a current of 5 milliamps. through 30,000 ohms. As the wave requires 150 volts or



FIGS. 269 AND 270. (*Left*) *Resistance-capacity coupling.* (*Right*) *Resistance-fed auto-transformer arrangement.*

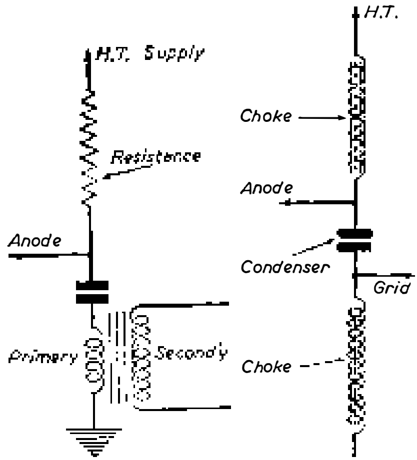
thereabout for H.T., this means that we shall require an initial voltage of 300 volts for the H.T. supply. Here is the disadvantage of parallel-fed transformers or resistance-capacity couplings.

For R.C. couplings an anode resistance is included in the anode circuit of the first valve, the grid of the next valve being joined to this first anode via a condenser, and the junction of grid and condenser being earthed via a resistance (Fig. 269). As there is no iron in this arrangement (and provided good resistances and condensers are employed) this method of coupling should give us perfect amplification. However, in view of the voltage drop described above, a somewhat low resistance has to be employed. This means that the amplification falls below the normal amplification of the valve itself, which, in the case of a standard L.F. valve, is only about 4 or 5. Obviously, then, we shall require three or four R.C. stages to equal in signal strength one good L.F. transformer-coupled stage. Further, the size of the coupling condenser and the grid leak are critical if true straight-line reproduction is required, and all sorts of distortion can be introduced by a wrongly-balanced R.C. stage. If the grid leak is too large, the valve will choke; if too small, the output from the preceding valve will be affected, as the anode resistance and grid leak are virtually in parallel. A small condenser will offer a resistance to the lower musical frequencies, and so on.

The Parallel-fed Auto-transformer. To avoid the effect of the grid leak and to obtain an increase in amplification, the parallel-fed auto-transformer has been introduced. This is a combination of R.C. and transformer coupling, a resistance being included in the first anode circuit; a coupling condenser is used to feed the impulses to an auto-transformer, which steps up the impulses to the grid (Fig. 270). With this method of coupling the condenser should be as large as possible, say 2 μF. or so; to get an improved response from a circuit or speaker which is deficient in bass the condenser may be made smaller, so as to make the coupling a resonant circuit, and so give a bass "boost." The disadvantage here is the anode resistance again, in view of the high initial H.T. required.

It should now be obvious from the foregoing remarks that an efficient choke in the anode circuit, and a choke in place of the grid leak—retaining the coupling condenser—should result in good quality and high amplification, and this method is known as the impedance-coupled circuit (Fig. 272). There is only one commercial form of this coupling on the market. The anode impedance must have a high inductance with a low D.C. resistance, and the grid impedance must also be designed *in conjunction* with the anode impedance, with which it is in parallel, as explained above.

The above remarks should enable the experimenter to carry out alterations in his set to produce perhaps better quality



FIGS. 271 AND 272. (*Left*) *Resistance-fed transformer couplings. A condenser should be inserted between anode tap and primary.* (*Right*) *Choke impedance coupling.*

than that at present obtained, and to enable the non-experimenter to ascertain whether his set is built on the best lines. Connections for a transformer-coupled stage are given in Fig. 275. It will be seen that an earth terminal is provided on the transformer illustrated, but many transformers do not possess this minor refinement. In some cases the same effect can be obtained by taking an earth connection from the metal casing. Again, some transformers having a bakelite case have one of the holding-down screw eyelets connected to the core, so that an earth connection can be made to the screw itself. The connection shown in Fig. 275 relates to the average type of transformer, but some of the older ones have their terminals lettered "I.P.," "O.P.," "O.S.," and "I.S."

A single transformer-coupled stage, if correctly designed, will give all the amplification necessary for most purposes, but when two stages are required a good deal of care must be taken to avoid L.F. instability. The transformers should be good ones of low step-up ratio, and should be mounted with their axes at right angles. Earthing the cores is very helpful, and it is also very desirable to decouple the anode circuits of both the detector and first L.F. valves.

Tone-control Transformers. Transformers of this type operate in a similar manner to ordinary L.F. transformers, but have the added advantage that they can be "tuned." That is, by connecting a variable resistance across two of the terminals the transformer can be made to give emphasis to notes of certain frequencies; when the resistance is removed the transformer functions in the normal manner. The tone-control transformer is especially suitable for use in a very selective receiver in which a certain amount of high-note loss takes place in the tuning circuits. By operating the variable resistance, the high notes can be restored to any desired extent. The method of connecting a transformer of this type is illustrated in Fig. 278, but in this case a circuit diagram is not given, because alternative arrangements are employed by different makers. Generally the transformer and special choke are mounted together in the one bakelite case.

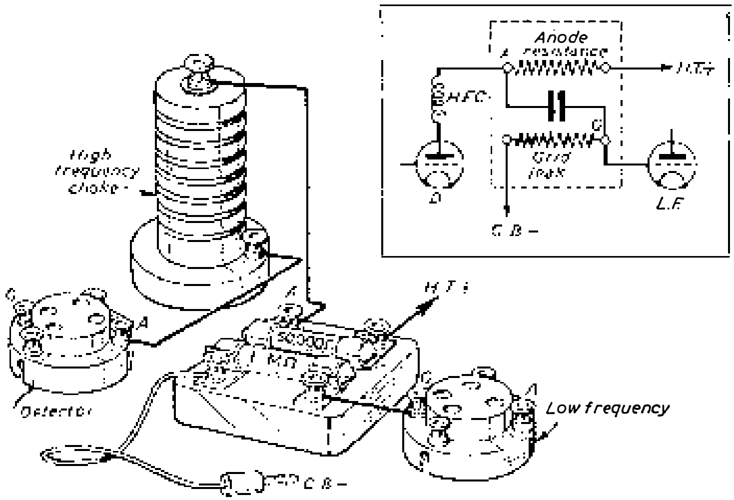
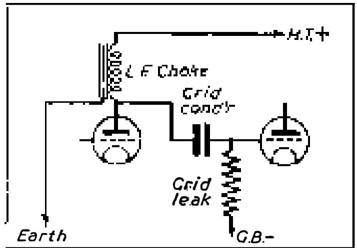


FIG. 273. *Resistance-capacity coupling.*

Push-pull. The push-pull system of L.F. coupling is not very often employed in amateur-built receivers, principally on account of its greater cost, but it can offer very many real advantages in the way of undistorted output at high volume levels. The arrangement of a push-pull amplifying stage is shown in Fig. 277, where it will be seen that two transformers (input and output) are required. The primary winding of the input transformer is connected in exactly the same way as a transformer of the ordinary type, but the secondary has three terminals. Of these, each of the two outer ones feeds a separate amplifying valve; the third terminal, which is really a centre tapping, takes the grid-bias supply for both valves. It will be seen that half the output from the transformer is fed to each amplifying valve, and since the valves are connected to opposite ends of the secondary winding, one receives the negative half of any cycle, while the other receives the positive. The positive half-cycle is the only one which operates the valve, and consequently the two valves work in "turns"; but as one end of the winding is always positive, one valve is always functioning.

The operation can be likened to that of two men sawing through a log with a cross-cut saw; one man pushes the saw, while the other pulls. The men in this the two valves. The correct ratio of this transformer is dependent upon the impedance of the loudspeaker to be employed. It will be seen that the push-pull system



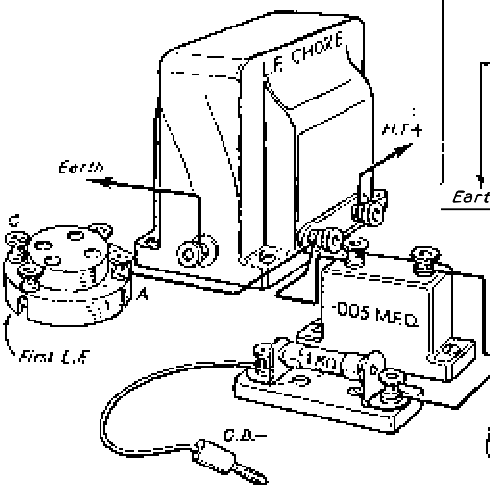
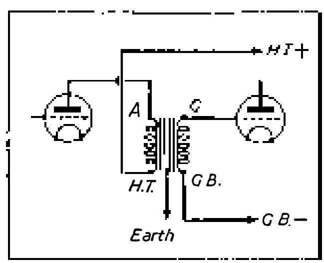


FIG. 274. *Choke-capacity coupling.*

case represent the valves. This analogy is not quite correct, because the man who pulls is actually doing part of the work, whilst it is only the "pushing" valve that contributes towards the output.

Where the Output Transformer Differs. The output transformer is practically the reverse of the input transformer, in that its primary winding is centre tapped and "collects" the output from the anodes of

is more efficient than any other, since it utilises both half-cycles of the signal frequency. A push-pull stage will also handle twice the volume of a single transformer-coupled valve, but as it does



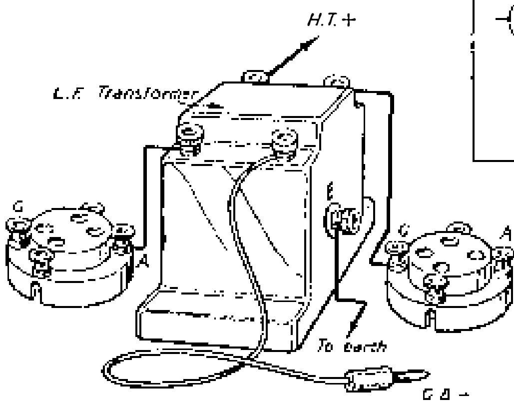
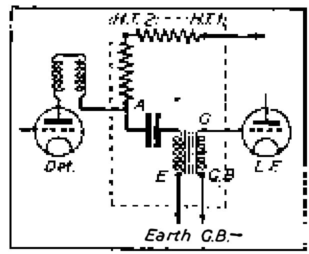


FIG. 275. *L.F. transformer coupling.*

not give any appreciably greater degree of magnification, it cannot provide any greater loudspeaker volume than a single valve unless the input to it is greater.

Even small power valves can be used without overloading, and this makes it possible to obtain good results without the use of excessively high H.T. voltages. Any kind of power valves can be used in push-pull, but the two should have similar characteristics. It should also be explained that the filaments of ordinary directly-heated valves used in push-pull can be fed from raw A.C., without trouble from mains hum.

Decoupling Grid Circuits. To prevent or to cure mains hum and to ensure freedom from certain forms of instability, it is usual, and better, to decouple the grid circuits by inserting a non-inductive resistance of about 100,000 ohms between the transformer secondary and the grid terminal of each valve holder. The



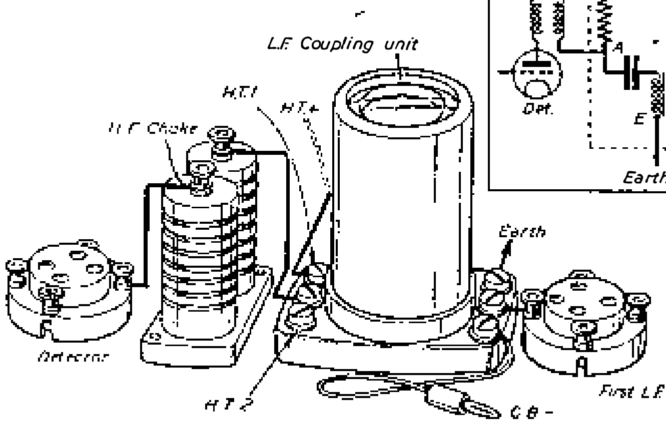
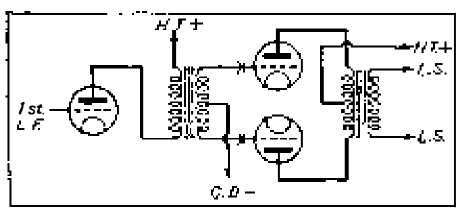
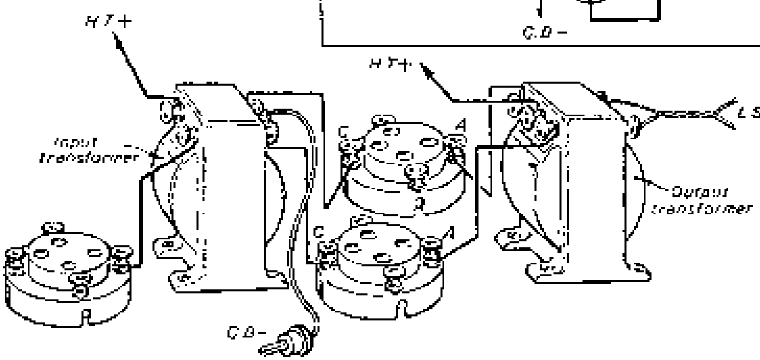


FIG. 276. *Resistance-fed transformer.*

FIG. 277. *Push-pull system of L.F. coupling.*





positions of these resistances are indicated by two crosses in the circuit diagram of Fig. 277.

LOW-FREQUENCY CURRENT. Any current having a frequency of less than 1,000 cycles per second.

LOW-FREQUENCY TRANSFORMER. (See *Transformer.*)

LOW TENSION (L.T.). Low voltage or pressure—usually under 12 volts.

L.P.R. Long-playing Record (*which see*).

LUMEN. The unit of light energy. One lumen is the amount of light energy falling upon 1 sq. ft. of the inner surface of a hollow sphere having at its centre a light source of one candle-power. One candle-power = 4π lumens. (See *Foot-candle, Lux, Micron*, and *Ångström Unit.*)

LUX. A metric unit of illumination. The illumination produced on the surface of a sphere having a radius of one metre by a uniform point source of one candle situated at its centre. It corresponds to a flux density of one lumen per square metre. One lux = 0·093 foot-candle. (See *Ångström Unit, Foot-candle, Lumen, Lux*, and *Micron.*)

M

MAGIC EYE. A small cathode-ray device for indicating visually on a screen the comparative magnitude of a D.C. or A.C. voltage. (See *Visual Tuning Indicator.*)

MAGNETIC FLUX. The number of unit magnetic lines of force traversing a given surface. Unit = Maxwell (*which see*).

MAGNETIC INDUCTIVE CAPACITY. The same as magnetic inductivity. Air is considered as 1. (See also *Dielectric Constants.*)

MAGNETRON. A thermionic valve in which the stream of electrons is controlled by a magnetic field. In large magnetrons producing continuous oscillations, the high-frequency alternating field for the purpose is provided by the filament current and causes oscillations in the anode circuit of twice the frequency without the use of a grid. Such tubes usually deal with powers up to about 1,000 kW., but an improved model, developed for radar, can deal with much higher powers. (See also *Cavity Magnetron.*)

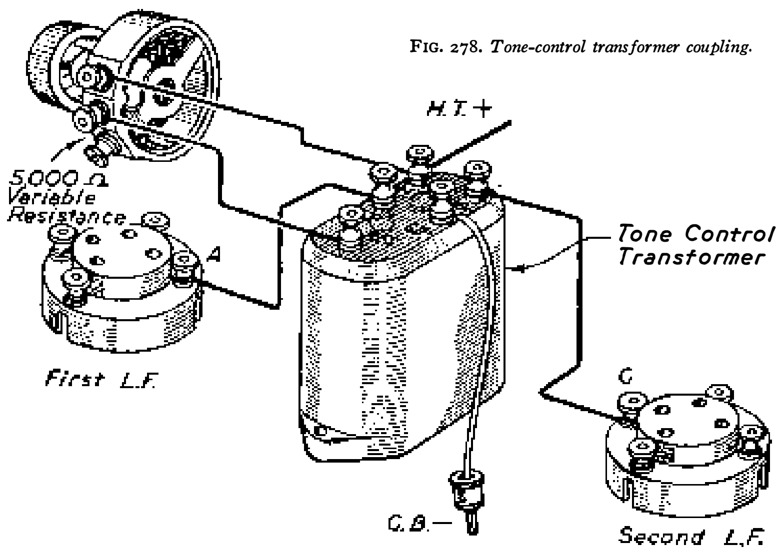


FIG. 278. *Tone-control transformer coupling.*

MAGNETRON EFFECT. That loss of strength of electronic emission due to a magnetic field from filament current, limiting output, especially with large thermionic type valves.

MAGNIFICATION OF TUNED CIRCUIT. $m = \frac{\omega L}{r}$

M'AIDEZ. French S O S, meaning "Help me." Pronounced *Mayday*.

MAIN LOBE. The most important *lobe.*

MAINS ELIMINATOR. (See *Eliminator.*)

MAINS HUM. (See also under *Noises*). The fitting of an additional smoothing condenser in the filter circuit will doubtless improve matters. Rectifier hum can be cured by wiring two ·1-μF. fixed condensers between the two rectifier anodes and high-tension negative (see Fig. 279.) Ripple is caused by inductance of the speaker leads. The leads must be kept as far from the mains side of the set as possible. In some cases the detector valve is fitted too close to the speaker, causing noises which may be taken as mains

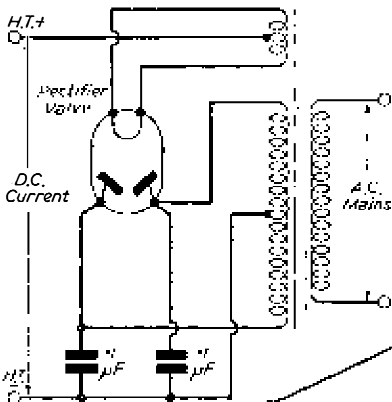


FIG. 279. *Rectifier hum can be cured by connecting two ·1 μF. fixed condensers between the two rectifier anodes and high-tension negative.*

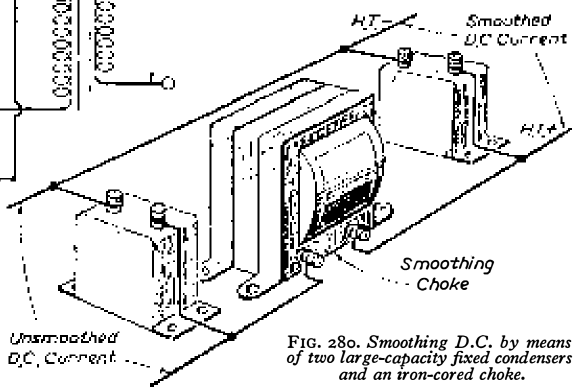


FIG. 280. *Smoothing D.C. by means of two large-capacity fixed condensers and an iron-cored choke.*

trouble. The speaker can be tested by temporarily working it away from the set. With any type of speaker connected to a mains set it is advisable to isolate it from the anode current by either a transformer output or choke-filter circuit. The anode current of the last valve is then prevented from flowing through the windings.

Only the low-frequency signal currents pass through the loudspeaker. This fact not only eliminates all chances of shock if the L.S. terminals are accidentally touched, but also greatly helps in decreasing hum. It may be necessary to alter the position of the low-tension A.C. heater wires which run to the filaments of the valves from the power transformer. They should be kept as far as possible from the grid circuit.

Another point to look for is poor conact at the grid pin of the detector valve in its holder. The grid circuit of the valve is very sensitive, and the pin must therefore make proper contact with its socket; a lower value of grid leak may also be found beneficial.

Using Alternating Current. In utilising alternating current from the mains for high tension, the A.C. has first to be converted to D.C. This is the work of the rectifier. There are two distinct types of this piece of apparatus in use at the present time, one the valve and the other the metal rectifier.

To operate a wireless receiver it must be supplied with a smooth, direct current. Therefore, before the rectified A.C. can be utilised, it must first be filtered, that is to say, smoothed, for, although the rectified current flows now in only one direction, it still is changing in intensity, i.e. pulsating. To eliminate ripple it is made to pass through condensers and a choke. Across the D.C. leads are shunted fixed condensers of several micro-farads capacity. In series with these condensers is a low-frequency choke; this is placed between the first condenser, which is known as the rectifier condenser, and the last or reservoir condenser (see Fig. 280.) The first condenser receives the pulsating D.C. from the rectifier, so that owing to the reservoir action of this condenser the current which flows through to the choke is a great deal more smooth. The choke in its turn does the work of opposing current fluctuations, passing on a still more steady flow to the second condenser; this is the final reservoir from which the high tension is derived for the set. Usually the inductance value of the choke is not less than 30 henries and the capacity of condensers at least 4 μF. each.

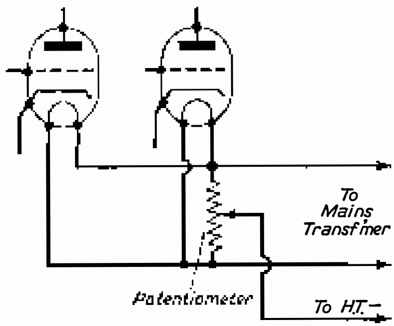


FIG. 281. *A cure for mains hum—a potentiometer is connected across the heater supply wiring.*

Spacing Components in Mains Sets. Great care must be taken, when building a mains set, to see that all of the components are in their correct positions; place the power transformer as far away from the receiving side of the set as possible, also the smoothing choke; in fact, it is better to keep the whole of the mains unit at least 6 in. from the rest of the set, and, if possible, below the baseboard. Often what is supposed to be mains hum is actually L.F. oscillation. Some battery sets work perfectly with dry batteries on voltages in the neighbourhood of 100, but when they are connected to an eliminator giving voltages of 150 to 180, a hum is very noticeable. The obvious cure for this is the fitting of decouplers in the L.F. circuits and possibly in the H.F. circuit as well, especially in the case of a screen-grid valve. Decoupling tends to stop varying current from entering or leaving the transformer and valve circuits, and ensures a steady flow from the supply. It is when the mains are exceptionally noisy that they show up little defects in the wiring of heaters, transformers, etc., and a hum is produced in the speaker. Sometimes, for instance, the set will be perfectly silent during most of the day, but at certain times, usually in the evening, when the generators are working at full load, it suddenly becomes noisy.

A device that is worth trying is the fitting of a 30- or 40-ohm potentiometer across the heater supply wiring. The use of a potentiometer allows the dead-true electrical centre to be obtained. Remember, the *mechanical* centre of the transformer is not always the same as the *electrical* centre. By moving the knob of the potentiometer one way or the other the hum can be exactly balanced out. In making the change, disconnect the wire going to the centre tap of the heater winding of the transformer and join it, instead, to the slider of the potentiometer as in Fig. 281. The tapping on the transformer is left free. A point to remember is to place the potentiometer as near the valves as possible and not actually across the transformer terminals.

MAINS TRANSFORMER. An instrument for stepping up or stepping down an A.C. voltage for the purpose of feeding the heaters and anodes of mains valves. A.C. mains are extremely useful as a source of electrical energy, since the volt-

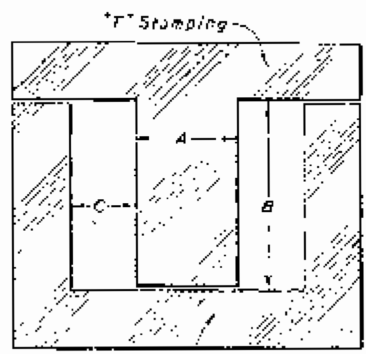


FIG. 282. *Illustration of the transformer stampings to be used in connection with the table on page 192.*

age from them can be changed to any required figure with the greatest ease. All that is needed is a step-up or step-down transformer. Suitable transformers can very easily be constructed. A transformer consists essentially of an iron core, upon which are placed primary and secondary windings. The type of core most frequently employed for small transformers is that consisting of pairs of "U"- and "T"-shaped Stalloy stampings of the kind shown in Fig. 282. When these are assembled they form a semi-solid core with two "windows" and a "winding limb" (see Fig. 283). Assuming that the stampings are of correct proportion (as all those on the market are), the numbers of "turns per volt" for both primary and secondary windings depend upon the cross-sectional area of

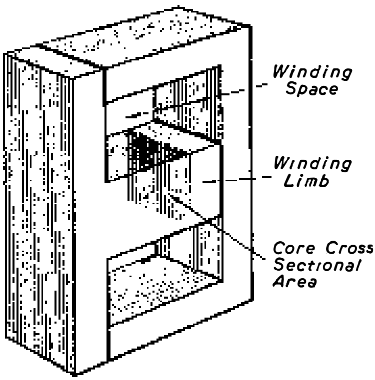


FIG. 283. *Details of the transformer core.*

the winding arm and the frequency of the mains supply. For example, if the area is 1 sq. in. and the frequency 50 cycles, eight turns should be allowed for every volt. If the area were halved, the numbers of turns must be doubled, and *vice versa*; on the other hand, if the frequency were doubled, the turns should be halved, and *vice versa.* This rule is invariable, and forms the basis of all transformer design.

The Stalloy stampings are made in a variety of sizes, some of which are listed in Table I (page 192), where the "A," "B," and "C" dimensions are those defined in Fig. 282. In order to determine the most suitable size of stampings, it is necessary to know the power, in watts, which the transformer has to handle. This is easily calculated by multiplying together the voltage and current (in amperes) of the secondary winding. For example, suppose the transformer had to supply 20 volts at 2 amperes, the wattage would be 20 by 2 = 40 watts. This assumes an efficiency of 100 per cent., but as the actual efficiency is generally about 80 per cent., the result must be increased by 25 per cent., which gives the power to be handled as 50 watts. Reference to Table I then shows that a core consisting of six dozen No. 4 stampings will be suitable.

Once the core size has been determined, the winding data can be compiled. Starting with the primary, which has to handle the total amount of power (50 watts), it will be seen from table, p. 192, that eight turns per volt will be required, so decide upon the gauge of wire necessary to carry the current involved. The current is found by dividing the wattage by the voltage of the supply: for instance, supposing the voltage to be 200, the current would be 50 ÷ 200, or 0·25 ampere. The correct gauge of wire could then be determined by looking up a book of wire tables, but to save this trouble the necessary information in regard to the gauges in most common use is given in Table II, where the smallest possible gauge is seen to be No. 30. As this table is based on a current density of 2,000 amperes per square inch, it is slightly better, where space

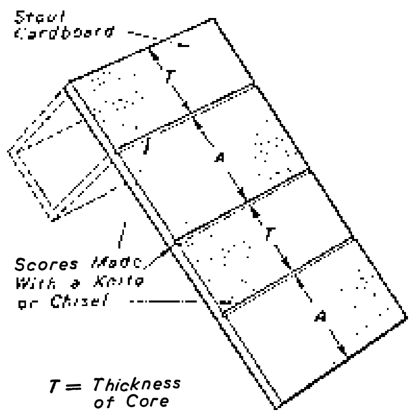


FIG. 284. *Method of marking out and folding the winding spool.*

permits, to employ a gauge of wire one size larger than the minimum shown. The secondary winding will consist of 8 by 20, or 160 turns, and since it has to carry 2 amperes, the wire should be not less than 20-gauge.

In regard to the covering of the wire, this may conveniently be enamel in all gauges less than about 24, but for the stouter gauges it is better to employ double-cotton-covered, since enamel is liable to crack, and so allow turns to short-circuit.

The size of core was provisionally decided on in the first place, but as the winding data are now known, a check should be made by finding the actual "winding area" required. This area can easily be determined by making use of the "Winding turns per square inch" given in Table II. Taking the same example as before, we see that 28-gauge enamelled wire can be wound 3,760 turns per square inch, and therefore our 1,600 turns will occupy rather less than $\frac{1}{2}$ sq. in. The secondary consists of 160 turns of 20-gauge d.c.c. wire, which can be wound 472 turns per square inch, and will therefore take up approximately $\frac{1}{3}$ sq. in. In other words, the total winding area required is $\frac{5}{8}$ sq. in., and as the No. 4 stampings provide $1\frac{1}{2}$ sq. in. winding area, they will be amply large.

The simplest method of making the spool is illustrated in Fig. 284. A square-section cardboard tube is first required and can be made by scoring and bending a strip of stout card of the dimensions shown. Next, a pair of end cheeks must be made to fit tightly over the ends of the tube, and these can be cut out of stiff card or thin plywood and secured by means of strong glue. To make the bobbin more rigid, it should finally be

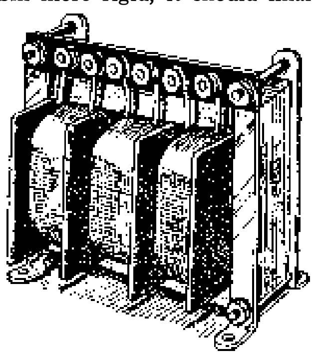


FIG. 285. *In this method the windings are brought out to a terminal strip.*

given one or two applications of thin shellac varnish and dried quickly. To cover the sharp edges of the bobbin, which might cut the wire whilst winding, a few turns of empire cloth or insulating tape should be wound on.

Solder a short length of flex to the end of the 28-gauge wire, anchor this by passing it through a pair of holes in an end cheek and wind on the correct number of turns for the primary. The winding can be done most expeditiously by fitting the spool on to a mandrel, which can be turned in the lathe or a hand-drill gripped in a vice, but it can be done by hand if desired by cutting a handle of wood which is a tight fit in the spool. After every four layers, or

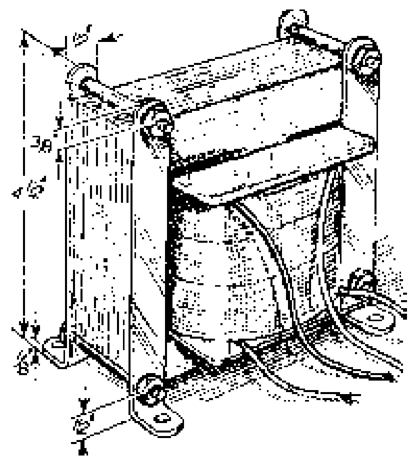


FIG. 286. *Dimensions of supporting foot of transformer and method of finishing off. Flexible leading-out wires are used.*

approximately 500 turns, it is advisable to cover the winding with a layer of empire tape, oiled silk, or waxed paper to avoid the possibility of any two turns at widely differing potential getting close together. Take care that no later turns are allowed to slip past the layer of insulation.

After winding the requisite number of turns a second length of flex should be soldered to the end of the wire, taken once round the spool and anchored as before. Thoroughly insulate the primary by covering it with two or three layers of empire tape, etc., and then continue to wind the secondary, following the same procedure as with the primary. Finally, cover the outer layer with insulating material to ensure that the windings cannot be damaged in any way.

The core stampings must next be fitted, and the method of fitting is clearly shown in Fig. 283. First a "T" and then a "U" are inserted from one end of the

TABLE I
(See Fig. 282 on page 189.)
DETAILS OF STALLOY CORE STAMPINGS

Size No.	Dimensions A	Dimensions B	Dimensions C	Number of Stampings	Approx. Watts	Turns Volt (50 cycles)	Approx. Winding Area
	in.	in.	in.	doz. prs.			sq. in.
4	$\frac{15}{16}$	$2\frac{5}{16}$	$\frac{7}{8}$	6	50	8	$1\frac{1}{2}$
5	[illegible]	$1\frac{1}{2}$	$\frac{3}{4}$	6	30	12	$\frac{3}{4}$
28	$1\frac{1}{4}$	3	$1\frac{1}{4}$	6	250	6	3
29	2	$4\frac{1}{2}$	$1\frac{3}{8}$	6	300	4	$5\frac{1}{4}$
30	$\frac{15}{16}$	$1\frac{1}{8}$	$\frac{7}{8}$	6	45	8	$\frac{2}{3}$
31	1	$3\frac{1}{2}$	1	6	100	8	$2\frac{7}{8}$
32	1	$2\frac{1}{4}$	1	6	75	8	$1\frac{3}{4}$
33	$1\frac{1}{4}$	$2\frac{3}{4}$	1	6	125	6	$2\frac{1}{4}$
35	$1\frac{1}{2}$	$3\frac{5}{8}$	$1\frac{5}{8}$	6	200	5	$5\frac{1}{4}$

This table covers most of the commoner sizes of stampings, but some makers give different numbers to stampings of similar size.

TABLE II
COPPER WIRE DATA

Standard Wire Gauge	Max. Working Current (amps)	Enamelled: Winding Turns per sq. in.	Enamelled: Yards per lb.	Double Cotton Covered: Winding Turns per sq. in.	Double Cotton Covered: Yards per lb.
16	6·5	226	26·3	173	25·5
18	3·6	392	46·9	297	45·5
20	2·0	685	83·3	472	79·4
22	1·25	1,110	137	592	129
24	0·76	1·770	221	977	203
26	0·51	2,560	330	1,280	294
28	0·35	3,760	488	1,630	422
30	0·25	5,370	694	1,990	587
32	0·18	6,890	915	2,550	755
34	0·13	9,610	1,202	3,020	1,024
36	0·10	13,500	1,840	4,100	1,477
38	0·06	20,400	2,810	5,100	2,287

In the above table the "Max. Working Current" (in amperes) is based on a figure of 2,000 amperes per square inch.

spool, after which a similar pair of stampings is inserted from the other end, this process being repeated until the spool is quite full. In order to make the core a tight fit (as it must be to prevent vibration), it might be necessary lightly to tap the last few stampings into position, but undue force must not be used, or else there might be a danger of "bursting" the spool. It will be noticed that one side of each stamping is covered with a white insulating film, and, to ensure that every one shall be insulated from the next, the white sides must face in the same direction.

The last step is to fit suitable clamps to the core to hold the stampings tightly together and provide a simple means of mounting the complete transformer. These clamps can be made from $\frac{1}{8}$ in. thick strip brass or steel, shaped and bent as shown in Fig. 286. They are attached by means of $1\frac{1}{2}$-in. bolts and can be fitted with a terminal strip if desired, or connections can be made directly by means of the flexible leads from the windings. Both methods are shown in Figs. 285 and 286.

All the details given above, although they have been applied to a particular component, are equally applicable to any pattern of mains transformer that the reader may require. In some cases it is more convenient to design the transformer, so that it can be used on any mains having a voltage of between, say, 200 and 250 volts. In that case the primary winding would require an additional 400 (eight 50) turns, and tappings would have to be taken after winding 80, 240, and 400 turns for 240, 220, and 200 volts respectively. The tappings would be made by soldering suitable lengths of flex and passing these out through holes made in the end cheeks. To safeguard against short-circuit between the tapping points, the soldered joints should be covered with a strip of insulating tape, or even with a piece of stamp edging.

When more than one secondary winding is required, such as for H.T. and L.T. supply for a wireless receiver, it is generally most convenient to divide the winding spool into three or more sections by fitting extra cheeks. The position of these will be determined by the area required for winding in the different sections. In order to prevent mains hum it is best to place the L.T. secondary in the centre section, where it will serve as an effective screen between the primary and H.T. secondary windings. With all other kinds of "dual-secondary" transformers the primary winding should be arranged between the other two.

MAINS UNIT. (See *Eliminator* and *D.C. Mains Unit.*)

MAJOR BEND. A rectangular waveguide bent so that throughout the length of the bend a longitudinal axis of the guide lies in one plane which is parallel to the wide side of the *waveguide.*

MANSBRIDGE CONDENSER. A patented form of high-capacity condenser in which the electrodes consist of thin films of metal electrically deposited on the paper dielectric.

MARCONI-STILLE RECORDER. (See *Blattnerphone.*)

MARX CIRCUIT. A voltage-multiplying circuit in which condensers or networks are charged in parallel and discharged in series.

MATCHED TERMINATION. A *termination* which causes no reflection of energy.

MATCHING PLATE. A *diaphragm* used for matching purposes.

MATCHING SPEAKER WITH OUTPUT VALVE. For any given output valve there are certain limits within which the load of the speaker must fall if the full output of the valve and good-quality reproduction are to be obtained. But in the case of a pentode, requiring an anode load of 8,000 ohms, and a speaker the impedance of which is only 2,000 ohms, or a valve the optimum load of which is 2,000 ohms and a moving-coil speaker of low resistance, say, 6 ohms only, it will be wrong to connect the speaker direct in the anode circuit of the valve, as its impedance is far too low. What must be done is to employ an output transformer, so designed that the impedance of the primary (which is connected in the anode circuit of the valve) matches the valve resistance, while the secondary is wound to match the speaker impedance. The correct ratio for such a speaker is found by dividing the optimum value of the load by the impedance of the speaker and extracting the square root.

It should be noted that it is the *impedance* of the speaker, and not its *resistance*, which should be used in this calculation. If this figure is not stated, a fairly accurate approximation can be obtained by using the resistance figure in the case of a moving-iron instrument, or one and a half times the resistance in the case of a moving-coil speaker.

SPEAKER MATCHING TO OUTPUT TRANSFORMER

$$\text{Turns ratio } \frac{N_p}{N_s} = \sqrt{\frac{\text{Optimum Load of Valve}}{\text{Speech Coil Impedance}}}$$

MATCHING STRIP. A metal strip or rod connecting the opposite faces of a *waveguide* and not in contact with the other faces, introducing a desired *reactance.*

MAXIMUM USABLE FREQUENCY. The highest radio frequency at which communication between two points is possible by means of ionospheric waves.

MAXWELL. The C.G.S. electro-magnetic unit of magnetic flux. 10^8 maxwells = 1 weber, or 10^8 lines; 1 maxwell = 10^{-8} webers. (See *Gilbert*, *Weber*, and *Unit Magnetic Pole.*)

MAXWELL'S LAW. (a) Any two circuits carrying current tend so to dispose themselves as to include the largest possible number of lines of force common to the two. (b) Every electro-magnetic system tends to change its configuration so that the exciting circuit will embrace the largest number of lines of force in a positive direction.

MAXWELL'S RULE. Maxwell's *unit tubes* of electric or magnetic induction are such that a *unit pole* delivers 4π unit tubes of force.

MEDIUM WAVES (MW). Waves from 100-1,000 m long.

MEGA. One million.

MEGACYCLES. One million cycles or one thousand kilocycles. This term is used in reference to the frequency of short-wave transmissions. (See also *Frequency.*)

MEGGER. A measuring instrument for very high resistances. The term is really an adaptation of the words Megohm-meter. It is used to ascertain the resistance of bodies which normally should have no electrical contact.

MEGOHM. One million ohms.

METAL - COATED VALVE. A valve sprayed on its outside with metal to act as a screen.

METAL RECTIFIER. (See *Accumulator.*)

METER. An instrument for measuring. In wireless practice meters are used for measuring voltages and currents, and there are several different types of meter in general use. The most common form is known as a "moving-iron" instrument, and consists of a coil of wire inside which is mounted a piece of iron. The indicating pointer is attached to this piece of iron.

The other type of instrument in general use is known as a "moving-coil" instrument, and this consists of a coil of wire which is suspended between the poles of a permanent magnet system, and the pointer is attached to this coil. The passage of current through the coil causes rotation and movement of the indicating pointer in the same manner as just mentioned. The moving-coil type of instrument is very delicate, and the small moving winding has to be wound on an extremely light former in order to respond to small applications of potential. This type has the scale divided into equal sections. Both types are invariably fitted with a small hairspring in order to restore the indicating pointer to zero.

In the more expensive types of instrument two hair springs are fitted, one in front and one at the rear of the moving portion in order to balance the rotation and restoring force.

The moving-iron instrument suffers from a fault which is not very easily remediable, namely, oscillation of the indicator. In other words, when the meter is joined to the circuit to be measured, the pointer swings over right past the correct point on the scale, drops back to a lower reading, swings over again, and so oscillates backwards and forwards several times before coming to rest at the correct reading. This, of course, is irritating when a reading is wanted in a hurry. To overcome this defect a damper is sometimes fitted, and this generally takes the form of a fairly large "fin" to act as a kind of air brake.

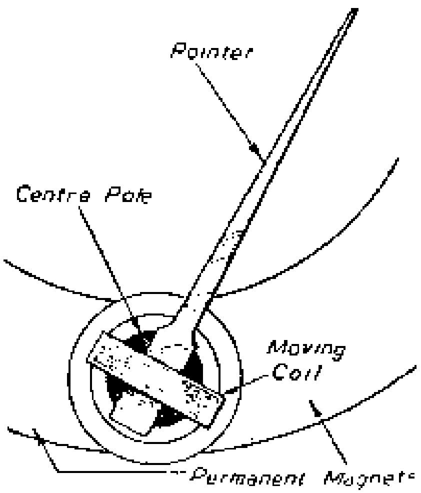


FIG. 287. *A moving-coil instrument with the hair-spring and bearings, etc., removed to show assembly details.*

The moving-coil instrument, on the other hand, moves across to the exact reading in a fairly gentle manner and consequently is known as "dead beat."

Another type of instrument often used for measuring currents is known as a "hot wire" meter. This consists of a thin piece of wire firmly attached at one end, its other extremity being attached to a weak spring. The pointer is attached at the junction of spring and wire, and is pivoted just above this junction point. When a current is passed through the wire it heats up and expands, the spring taking up the slack. This pulls the end

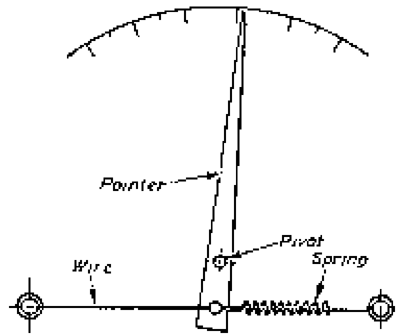


FIG. 288. *Elements of a hot-wire instrument. View showing spring, bearing and method of making connection.*

of the pointer, and by reason of the pivot just above, causes the other end of the pointer to make a radial movement.

A suitable scale enables the degree of expansion or sag—otherwise, the applied current—to be measured. The thermo-coupled type of instrument is not in general use, but is often used in laboratories. In this type of meter two dissimilar metals are attached to each other, and these have different coefficients of expansion and contraction. Arranged near the point of juncture is a heating element, and upon the passage of a current this gets hot and transmits its heat to the junction of the metals. Owing to the variations in expansion a torque, or twist, is developed, and this is transmitted to a pointer traversing a suitably engraved scale.

There are other types of meter which are more or less experimental—but those described above are the types in general use.

For measuring a voltage (or pressure) the meter has to be joined in parallel with the source to be measured, whilst to measure a current (or flow) the meter has to be in series.

All types of meter may be made to indicate a reading higher than that shown on the scale supplied with the meter by shunting (or connecting in parallel) a resistance across the two terminals of the instrument. By suitably choosing the value of the resistance the scale on

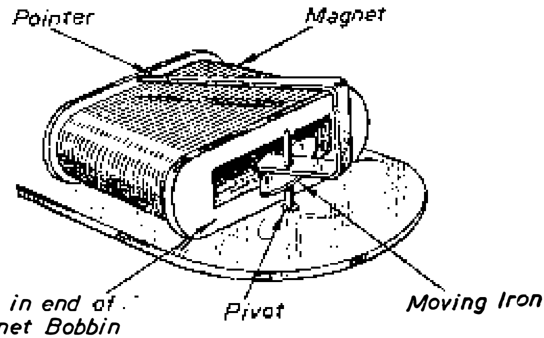


FIG. 289. *A cheap moving-iron movement. The top plate carrying the bearing for the pivot has been removed to enable the movement to be shown.*

the instrument may be made to read double, treble, or even in multiples of ten. The formula for increasing the range is $R_s = \frac{R_m}{(n-1)}$ where R_m is the resistance of the meter; R_s the value of the shunt, and in the number of times the scale is multiplied. The pointers of cheap meters are rather thick, and therefore prevent accurate readings of very fine scales or divisions. The more expensive instruments, however, have a very thin pointer with the

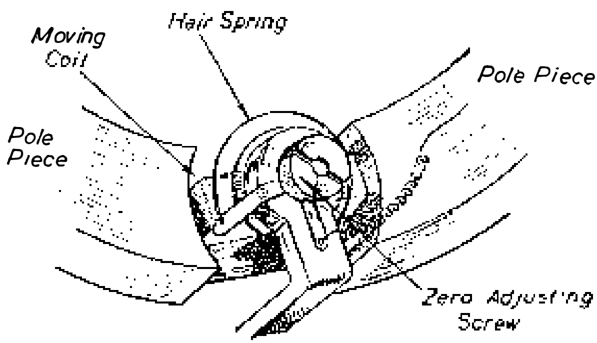


FIG. 290.—*Perspective view of the active elements of a moving-coil instrument.*

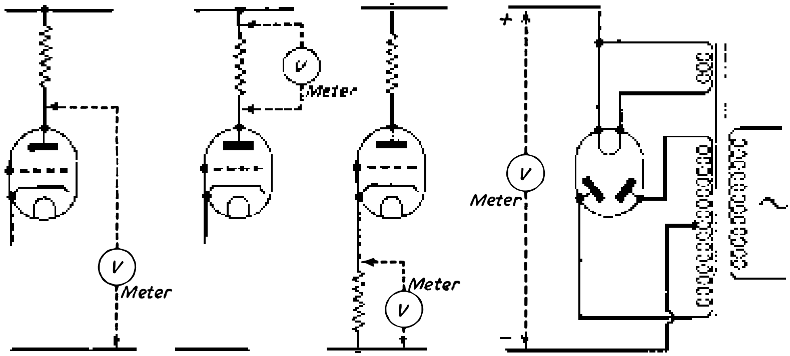
end turned to present a knife edge to view. Where extremely fine readings are necessary, and the indicating scale is divided into very fine divisions, a portion of the scale is made of polished metal, or in some cases a mirror is used, and the true reading of the pointer is obtained when the knife edge and its reflection are in line. (See also *Voltmeter, Milliammeter, Ammeter.*)

METER DISPLAY. A *display* in which the indications are given by one or more pointer instruments.

METERS, INCREASING RANGE OF. The current range of meter can be increased by connecting a shunt resistance across meter terminals. If R_m is the resistance of the meter, R_s the value of the shunt resistance and n the number of times it is wished to multiply the scale reading, then $R_s = \frac{R_m}{(n-1)}$.

METERS USING. To obtain the maximum efficiency from the receiving set it is necessary to apply the correct voltages to the filament, anode, and grids of the valves. Some means of checking these various voltages are essential, and for this reason accurate measuring instruments are indispensable.

The valve makers supply valve curves which state the correct voltage that

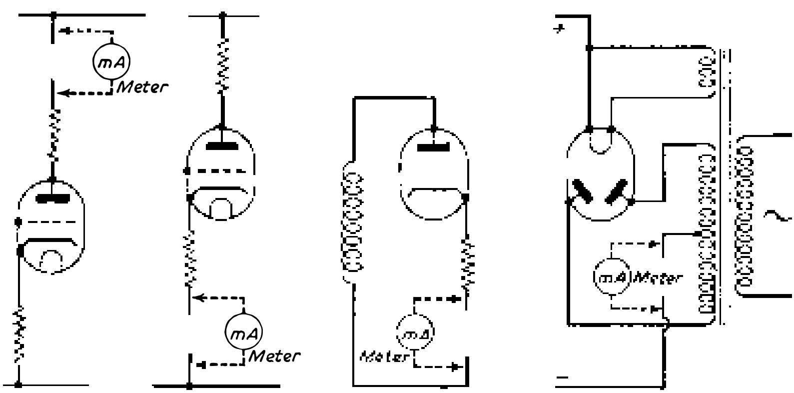


FIGS. 291 TO 294. *Various methods of testing the efficient working of valves. The first three diagrams show different methods of measuring the anode voltage or calculating it by the voltage drop across anode or cathode resistor.*

should be applied to it; and users should endeavour to keep to these values both from an economical point of view and also to obtain the best results. Incorrect grid bias, for instance, will cause distortion, and if not sufficiently high will put a very heavy drain on the high-tension battery. It must first be understood that all meter tests should be made under load, that is to say, when the set is working, so as to allow for the potential drop in the current due to leads to connections, switches, etc.

The two most commonly used meters in radio are the voltmeter, obviously for measuring volts, and the ammeter, which measures amperes. With these two instruments it is quite possible to see distortion in a set, although perhaps even the human ear does not detect it.

Choosing Meters. The greatest care must be taken in choosing measuring instruments, for some of the cheaper grades require more watts to deflect the needle over the dial than the whole current consumption of the set. The most expensive meters take the least current to operate them; it is for this reason, therefore, that a good voltmeter must have a very high resistance, it may be as much as 1,000 ohms per volt, and the current taken would be only 1 milliampere, the best type being the moving-coil pattern. This type operates on the principle of a coil moving in the field of a permanent magnet. It is only suitable for use on direct-current circuits, and being of the polarised type the leads must be con-



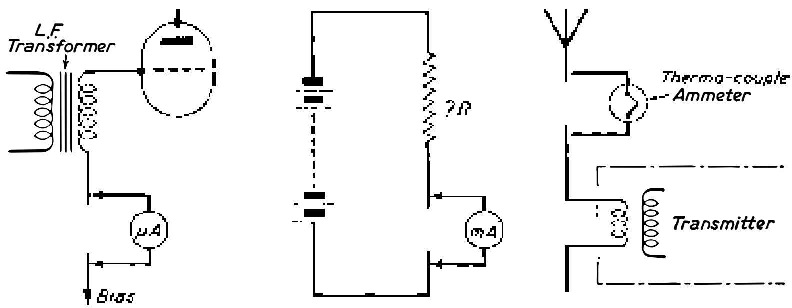
FIGS. 295 TO 298. *Similar methods to those shown in* FIGS. 291 to 294, *but using a current instead of a voltage indication.*

nected up in the correct manner to deflect the needle of the instrument across the dial in the right direction. If the leads are changed and connected the wrong way round then the needle swings over in the opposite direction; although a meter will often stand current in the reverse direction, it may possibly damage the needle by causing it to hit the reverse stop very hard, thus putting a strain on some of the mechanism. Accurate meters are generally fitted with an adjustment which will return the needle to zero, thus enabling it to be brought to exactly o on the scale before the instrument is used.

Voltmeters. Voltmeters can be obtained in various voltage ranges, and also there are those on the market which cover several readings, enabling voltages to be taken of, say, o to 10 volts L.T. and o to 200 volts H.T. The lower readings are suitable for testing filament voltages and low-tension battery voltages when the set is working.

Milliammeters. The anode current taken by the valves in a set is so small that it is very seldom that an ammeter is used. To measure these minute currents a milliammeter is used, which is so arranged that its pointer moves for thousandths of an ampere, or as it is known, milliamperes. In Fig. 303 is shown a milliammeter connected in the anode circuit of a valve, and in Fig. 302 is given the position of the meter when reading the whole consumption of the set in milliamps. The meter should be joined in series with the negative high-tension lead.

When a milliammeter is joined in the anode circuit of the power valve, as in Fig. 303, it is possible and very interesting to test for correct values of H.T. and grid bias, also to see the movement of the needle when the latter is incorrect. The G.B. should be adjusted to that stated by the makers of the valve and the set switched on, it being tuned to a station giving a medium amount of volume. If the biasing is correct the needle will remain steady, and the reading on the dial should be noted. Switch off the set and reduce the bias a little. Switch on again, and it will be observed that not only will the needle no longer be steady, but the current from the H.T. battery will have increased, thus indicating that distortion is occurring, and, as before stated, H.T. current is being used wastefully.



FIGS. 299 TO 301. *The use of a microammeter, milliameter and thermocouple in providing indications of current.*

If the same operation is gone through, but this time increasing the bias on the valve, it will be seen that the needle of the meter tends to kick upwards on strong signals, at the same time the anode current from the battery will decrease, coupled, of course, with distortion. When the needle of the milliammeter kicks both up and down the dial, and no alteration of the grid bias will correct it, it can be assumed that the valve is overloaded, that is to say, that the input to the set is rather greater than the valve can handle. If the power valve is overloaded a more suitable valve must be used in the last stage or the input to the receiver reduced. All that is necessary is to reduce the signal input slightly to that point where it does not result in overloading the last valve.

Testing for Leakages. Tests should be made with a milliammeter in the H.T. circuit when the set is switched off to see if there are any slight leakages through bad insulation or other causes which would put a continuous load on the battery and considerably shorten its life.

Sockets for Meters. It is possible to fit on the panel or on the side of the cabinet sockets, wired from the set internally, enabling plugs attached to voltmeter or milliammeter to be inserted, thus getting over the difficulty of prodding about inside the set with the meter leads. In Fig. 304 is shown the method of fitting these sockets; the plugs are merely banana pins taken from old valve bases and soldered on to the leads which are wired to the instruments. As a milliammeter has to be inserted in series, that is to say, the circuit has to be broken and the meter inserted into the two leads, it means that a connecting piece must be made to remake the circuit after using the milliammeter (see Fig. 304).

Making a Test Meter. In Fig. 305 is shown the theoretical circuit. Since the

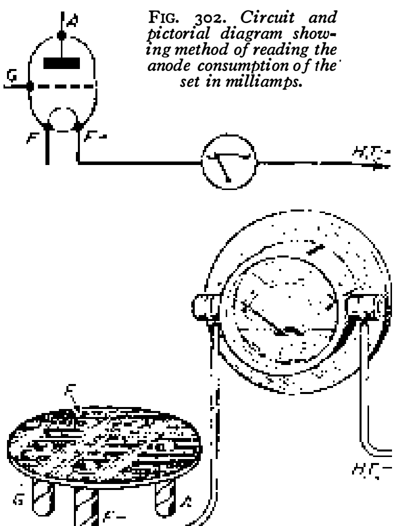


FIG. 302. *Circuit and pictorial diagram showing method of reading the anode consumption of the set in milliamps.*

unit in the main will be employed between the output circuit of the wireless receiver and the input to the loudspeaker, not only are there input and output terminals, but a plug and jack have been incorporated also. In the case of the latter it is necessary with this unit merely to remove the loudspeaker plug from the jack in the set, place it in the jack of the unit, and finally insert the unit's plug into the set. This will interpose automatically the milliammeter in the output circuit, and its variations can be noted and adjustments made according to the information which will be given in succeeding paragraphs. When terminals are in use on the set join the output of the set to the input of the unit, and the loud-

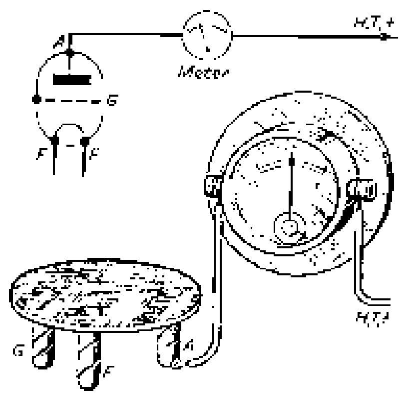


FIG. 303. *Circuit and pictorial diagram showing a milliameter connected in the anode circuit of a valve to determine its consumption.*

speaker to the output of the unit. Although in those cases where the loudspeaker is directly in the output plate circuit it is regarded as conventional to join the long spring of the output jack to H.T. + and the short spring to the valve plate, and correspondingly the ball of the plug to L.S. + and the stem of the plug to L.S. —, there are cases where this scheme is not followed.

To allow for this, a double-pole double-throw change-over switch has been included, so that a positive reading of the instrument is ensured, irrespective of the type of connections.

In addition, a variable resistance has been incorporated, and this is used in conjunction with the milliammeter in a manner to be described later.

To meet those contingencies where the resistance is not required, however, a switch is shunted across the resistance so that it may be short-circuited.

The Components Necessary. A list of the components required for making up the unit is given herewith. Alternatives can be chosen in lieu of those specified, provided the usual precautions are taken to choose

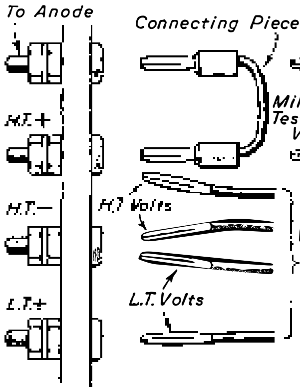


FIG. 304. *Fitting sockets on the panel, enabling the milliameter and voltmeter tests to be made from the exterior of the set.*

variable resistance (wire-wound type), 5,000 ohms resistance; four insulated terminals (engraved), marked output +, output —, input +, and input —; one single circuit jack with terminals; one embossed telephone plug; four cabinet corner cushions and mountings; small quantity of insulated connecting wire, and 3 ft. of red and black flex.

The construction of the unit should be quite a simple matter, even for the novice. Fig. 307 will serve as the panel-drilling

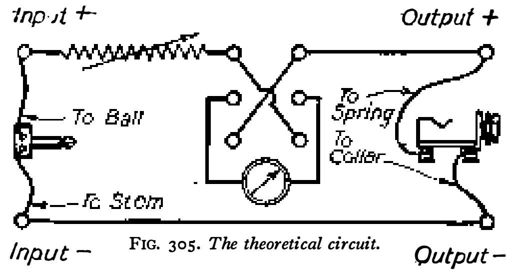


FIG. 305. *The theoretical circuit.*

"quality" products, and ensure that they will fit in the space available. One ebonite panel, 6 in. by 6 in. by ¼ in.; one sloping-deck type oak cabinet to take above panel; one 0-30 milliamp. range moving-coil milliammeter; one double-pole double-throw rotary switch; one single-pole double-throw rotary switch; one

diagram, it being important to remember that all of the holes must be symmetrically arranged. Do not forget to mark out on the back of the panel, so as not to damage the polished face; but owing to complete symmetry in layout no difficulty will arise at this juncture.

Just allow clearance holes for each component, and fix the four terminals, two switches, variable resistance, and meter in place. Figs. 306 and 307 will help with this part of the work.

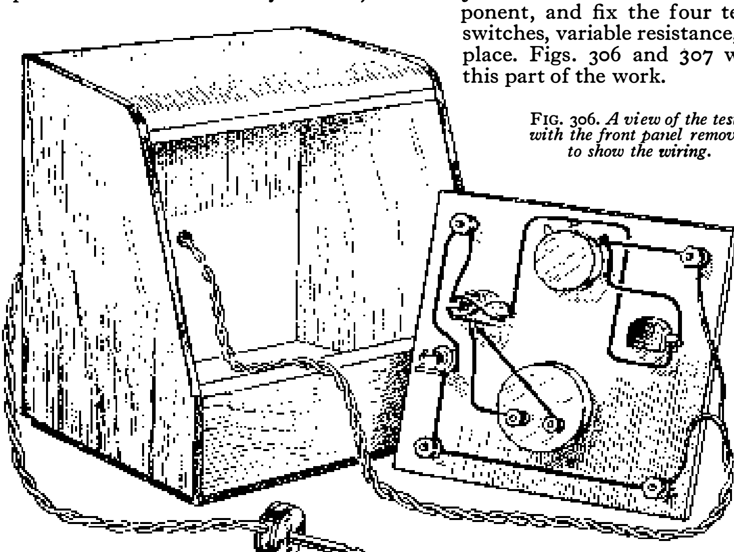


FIG. 306. *A view of the tester with the front panel removed to show the wiring.*

The Wiring. You will notice that the small jack is mounted directly on to the right-hand side of the oak cabinet. Two flexible leads then join the output + and output — terminals with the jack, as shown in the illustrations and diagram. Also the red and black flexible lead which terminates in the plug has its free ends passed through the left-hand side of the cabinet, and is connected to the input + and input — terminals. This completes the construction of the unit, and the panel can be screwed into place in the cabinet.

Provided the L.T. and H.T. sources are quite satisfactory (this is where a voltmeter of dual range is so valuable) under normal circumstances when signals are *not* being received, the needle of the meter will take up a steady reading, the actual milliamps flowing through the instrument being dependent upon the valve employed and its associated filament, H.T. and G.B. voltages. With the reception of signals, however, the plate current naturally varies, and if the variations are symmetrical about the mean value initially registered, then the needle will remain

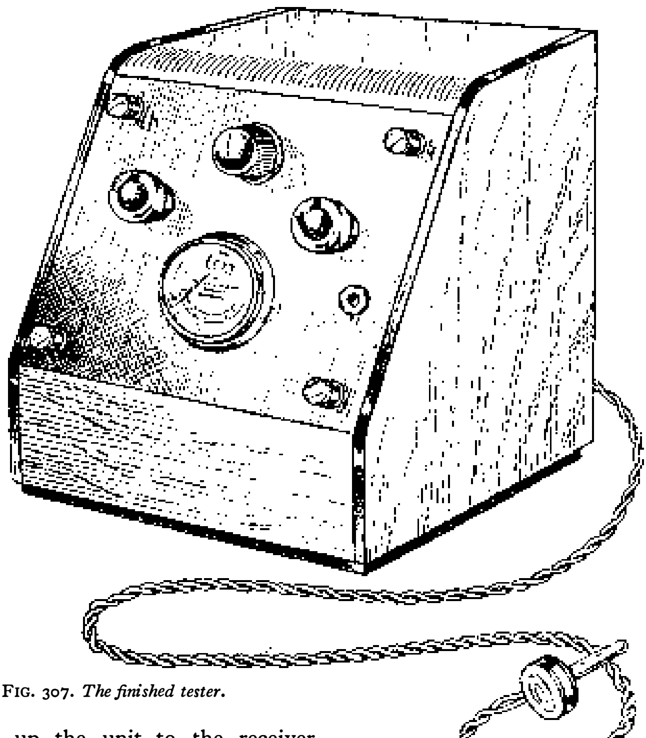


FIG. 307. *The finished tester.*

To join up the unit to the receiver, assuming that the loudspeaker is connected directly in the plate circuit of the output valve, it is necessary only to remove the speaker and join it to the unit's output terminals (or in the jack). Then connect the input terminals (or the plug) of the unit to the vacant loudspeaker terminals on the set, and "short-circuit" the variable resistance so that true current flow can be registered.

stationary, its inertia preventing it from following the rapid current alterations, and distortionless reception is taking place. Should there be any needle "kicks," they will indicate distortion, and alterations and adjustments are called for.

Overloading the Last Valve. If the needle movements are violent, and in any one particular direction, the cause is probably an overloading of the last valve, the two alternatives are open for curing the evil. Either cut down the input to a lower value, or replace the valve with one capable of handling the full grid voltage swing. Of course, there is a possibility that the valve has developed a deficiency, such as loss of emission, but even so, a replacement will be necessary, and this falls within the second category.

Should the needle kick upwards violently and persistently there is probably too much grid bias, and it is necessary either to reduce the value applied or, alternatively, increase the H.T. voltage. Providing there is no overloading, either of these palliatives will cause the needle to cease kicking. On the other hand, if there is a tendency for the needle to kick downwards from its mean position, there is insufficient grid bias, and the cure is obvious. Make a point of adjusting both H.T. and G.B. values so that there is a minimum current flowing consistent with an absence of needle kick, as the drain on the H.T. source is thereby reduced.

Other Uses for the Unit. For additional purposes, it is necessary to bear in mind that connections to the milliammeter itself are provided by the output + and input + terminals, the resistance being short-circuited if accurate current readings are to be determined or, alternatively, left in circuit if the instrument is merely to be employed as a current-flow indicator. Under these circumstances, the milliamp. consumption of individual valves can be ascertained merely by joining up the meter in series with the H.T. lead passing to each valve and noting the reading. If a "break" in a circuit or component winding is suspected, then the meter will prove or disprove the suspicions.

With the resistance switch open circuited, join one end of a 2-volt battery (or higher voltage according to the resistance of the circuit under test) to input +, and then the free ends of individual wires joined respectively to the other end of the battery and output + become the "test leads." If a current flow is indicated by the needle movement, then there is continuity in the circuit, but if the needle refuses to move, a "break" is present. When carrying out these tests always start with all the variable resistance in circuit so as to protect the meter against too high a current flow. Then, if desired, the resistance value can be reduced to give a good needle movement for observation purposes.

METRE WAVES. Waves from 1-10 m long.

METRIC SYSTEM. In the metric system all multiples and sub-multiples are decimal, and multiples are expressed by Greek prefixes and sub-multiples by Latin prefixes.

List of Prefixes

mega means a million times.
kilo means a thousand times.
hecto means a hundred times.
deka means ten times.
deci means a tenth part of.
centi means a hundredth part of.
milli means a thousandth part of.
micro means a millionth part of.

Square Measure

100 sq. metres	=	1 are.
10,000 sq. metres	=	1 hectare.

Weight

10 grammes	=	1 decagramme.
10 decagrammes	=	1 hectogramme.
10 hectogrammes	=	1 kilogramme.
1,000 kilogrammes	=	1 tonne.

Capacity

1 litre	=	1 cubic decimetre.
10 litres	=	1 decalitre.
10 decalitres	=	1 hectolitre
10 hectolitres	=	1 kilolitre.

Length

10 millimetres	=	1 centimetre
10 centimetres	=	1 decimetre.
10 decimetres	=	1 metre.
10 metres	=	1 decametre.
10 decametres	=	1 hectometre.
10 hectometres	=	1 kilometre.
10 kilometres	=	1 myriametre.

Linear Measure Equivalents

1 inch	=	2·54 centimetres, or 25·4 millimetres.
1 foot	=	30·4799 centimetres, 304·799 millimetres, or ·3047 metre.
1 yard		·914399 metre.
1 mile		1·6093 kilometres = 5,280 feet.
1 millimetre		0·937 inch.
1 centimetre		·3937 inch.
1 metre	=	39·370113 inches. 3·28084 feet. 1·093614 yards.
1 kilometre	=	·62137 mile.
1 decimetre	=	3·937 inches.
1 decametre (10 metres)	=	10·936 yards.

METRIC CONVERSION FACTORS

To convert—

Millimetres to inches	× ·03937 or ÷ 25·4
Centimetres to inches	× ·3937 or ÷ 2·54
Metres to inches	× 39·37
Metres to feet	× 3·281
Metres to yards	× 1·094
Metres per second to feet per minute	× 197
Kilometres to miles	× ·6214 or ÷ 1·6093
Kilometres to feet	× 3,280·8693
Square millimetres to square inches	× ·00155 or ÷ 645·1
Square centimetres to square inches	× ·155 or ÷ 6·451
Square metres to square feet	× 10·764
Square metres to square yards	× 1·2
Square kilometres to acres	× 247·1
Hectares to acres	× 2·471
Cubic centimetres to cubic inches	× ·06 or ÷ 16·383
Cubic metres to cubic feet	× 35·315
Cubic metres to cubic yards	× 1·308
Cubic metres to gallons (231 cubic inches)	× 264·2
Litres to cubic inches	× 61·022
Litres to gallons	× ·21998 or ÷ 4·545
Litres to cubic feet	÷ 28·316
Hectolitres to cubic feet	× 3·531
Hectolitres to bushels (2,150·42 cubic inches)	× 2·84
Hectolitres to cubic yards	× ·131
Hectolitres to gallons	÷ 26·42
Grammes to ounces (avoirdupois)	× ·035 o 1 ÷ 28·35
Grammes per cubic cm. to lb. per cubic inch	÷ 27·7
Joules to foot-lb.	× ·7373
Kilogrammes to oz.	× 35·3
Kilogrammes to lb.	× 2·2046
Kilogrammes to tons	× ·001
Kilogrammes per sq. cm. to lb. per sq. inch	× 14·223
Kilogramme - metres to foot-lb.	× 7·233
Kilogramme per metre to lb. per foot	× ·672
Kilogramme per cubic metre to lb. per cubic foot	× ·062
Kilogramme per cheval to lb. per h.p.	× 2·235
Kilowatts to h.p.	× 1·34
Watts to h.p.	÷ 746
Watts to foot-lb. per second	× ·7373
Cheval vapeur to h.p.	× ·9863
Gallons of water to lb.	× 10
Atmospheres to lb. per sq. inch	× 14·7

MFD. Microfarad or μF. (See also *Microfarad.*)

MHO. The unit of conductance (the word *ohm* reversed). The reciprocal of resistance being the conductance of a body having a resistance of 1 ohm.
1 mho $= 9 \times 10^9$ statmhos $= 10^{-9}$ abmho; 1 statmho $= 1{\cdot}11 \times 10^{-21}$ abmho; 1 abmho $= 9 \times 10^{20}$ statmhos.

MHYS. Microhenrys.

MICRO. One-millionth.

MICROAMPERE. One-millionth of an ampere.

MICROFARAD. One-millionth of a farad.

MICROGROOVE. (See *Long-playing Record*).

MICROHENRY. One-millionth of a henry.

MICROHM. One-millionth of an ohm.

MICROLUX. One-millionth of a lux (*which see*).

MICROMHO. One-millionth of a mho.

MICRO-MICROFARAD. $\mu\mu$F. = ·000,000,000,001 Farad, or ·000,001 μF. (See *Picafarad.*)

MICRON. A term signifying a one-thousandth of a millimetre. It is used in expressing the wavelength of light. (See *Ångström Unit, Lux, Footcandle, Lumen.*)

MICROPHONE. A device for converting into electrical currents sounds which are produced in its proximity. The simplest microphone consists of carbon granules bridging two electrical contacts, and sound vibrations vary the resistance of the carbon bridge so made. This results in current variations which may be made to reproduce the original sounds through an amplifier and reproducer. An alternative form of mike has the carbon covered by a disc or diaphragm which provides the necessary movement of the carbon. A condenser microphone consists of two plates arranged very close together, the front plate being flexible. Sounds impinging on the top plate thus vary the capacity between the two plates, and these are part of the grid circuit of a valve, thus giving rise to a means of reproducing the original sounds. A ribbon or velocity microphone consists of a permanent magnet between the poles of which a thin narrow metallic tape or ribbon is suspended. The crystal mike consists of a thin quartz or piezo-crystal, sounds impinging upon which vary its resistance. A moving-coil microphone is similar to a moving-coil speaker, except that the speech coil is actuated by the diaphragm.

MICRO WAVES. Wavelengths of less than 1 metre.

MILLER CIRCUIT. A form of circuit in which the time-constant of a resistance-capacitance combination is multiplied by means of the Miller effect on the capacitance. Named after John M. Miller.

MILLER EFFECT. Implies that the grid input impedance of a valve with a load in the anode circuit is different from its input impedance with a zero anode load. Should the load in the anode be resistance, the input impedance is purely capacitative. If the load impedance has a reactive component, the input impedance will have a resistive component. In pre-detector amplification, with a.v.c. to signal grids, the capacity across the tuned grid circuits tends to vary with the signal strength, evidencing detuning, the effect causing a charge (electrostatic) to be induced by the anode on the grid.

MILLER VALVE. A valve in which the Miller effect is utilised to modify its input admittance.

MILLIAMMETER. An instrument for measuring current in milliamperes. It provides the only certain way of ascertaining whether valves are in good condition; whether they are working in a receiver in the correct manner; whether distortion or overloading is taking place; the drain on an H.T. battery, and any other features which the real wireless man must know if he wishes thoroughly to understand his receiver. A milliammeter inserted in the

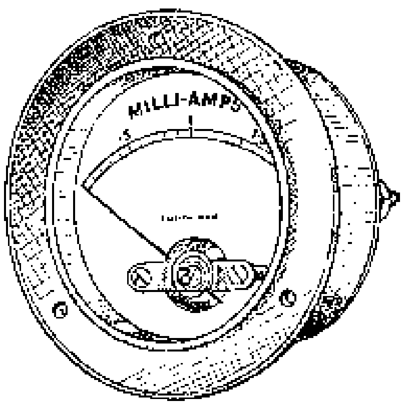


FIG. 308. *A panel-mounting milliameter.*

anode circuit of a valve (that is, between the H.T. positive source and the component in the anode circuit, whether transformer primary, anode resistance, loudspeaker, telephones, etc.) will show the total anode current of the valve.

In theory, the needle of the milliammeter should remain perfectly stationary whilst music is being received. If the needle kicks in an upward direction, it shows that the grid bias applied is higher than is required. If the needle kicks in a downward direction, insufficient bias is applied. Should the needle oscillate backwards and forwards, the valve is being overloaded. Connecting the meter in the H.T. negative lead will indicate the total consumption. (See also *Meter.*)

MILLIAMPERE. One thousandth of an ampere.

MILLIHENRY. One thousandth of a hendry (*which see*).

MILLILUX. One thousandth of a lux. (See *Lux* and *Microlux.*)

MILLIMETRE WAVES. Waves from 1 to 10 mm. long.

MILLIMICRON. One thousandth of a micron (*which see*).

MINOR BEND. A rectangular *waveguide* bent so that throughout the length of the bend a longitudinal axis of the guide lies in one plane which is parallel to the narrow side of the *waveguide.*

MIXER. Controls used to combine output from one microphone with another or other apparatus; also the valve following the oscillator in a superhet.

A device, associated with a beat oscillator, which delivers output at a frequency or frequencies differing from the input frequency.

MKS UNITS. Metre-kilogram-second units.

MMF. Micro-microfarad — one millionth part of a microfarad. A *Picafarad.*

MODE. A definite configuration of the guided or bonded electromagnetic field.

MODE CHANGER. A device for changing from one *mode* of propagation to another, e.g. coaxial to *waveguide*, or H_0 rectangular to E_0 circular.

MODING. A defect of magnetron oscillation in which it oscillates in one or more undesired *modes.*

MODULATION. A process of varying the frequency by introducing into it the frequencies of the matter transmitted. (See *Amplitude Modulation* and *Frequency Modulation.*)

MODULATOR. The circuit used to apply the frequencies of any desired signal to a transmitter.

MOLECULE. The smallest part of matter capable of existing alone.

MOLYBDENITE. (See *Crystals.*)

MONITOR. A device used for checking. It can be a small receiver or similar device for checking output of a transmitter or amplifier.

MORSE CODE. The Morse code (named after Samuel Morse) is as follows :

A · –	J · – – –	S · · ·
B – · · ·	K – · –	T –
C – · – ·	L · – · ·	U · · –
D – · ·	M – –	V · · · –
E ·	N – ·	W · – –
F · · –	O – – –	X – · · –
G – – ·	P · – – ·	Y – · – –
H · · · ·	Q – – · –	Z – – · ·
I · ·	R · –	

1 · – – – –	5 · · · · ·	9 – – – – ·
2 · · – – –	6 – · · · ·	0 – – – – –
3 · · · – –	7 – – · · ·	
4 · · · · –	8 – – – · ·	

Full Stop · – · – · – Comma · · · · · ·
End of Message · – · – ·
Brackets – · – – · –
End of Work (close down) · · · – · –

(See *Tape Machine for Recording Morse.*)

MORSE DRILLS. (See *Drills.*)

MOTOR BOATING. The term applied to low-frequency oscillation. Popping noises, which are of regular period, and hence sound like the exhaust of a motor-cycle or motor boat—hence the name. The cure for this form of instability is to decouple the anode circuits. (See also *Decoupling.*)

MOTOR-CAR RADIO. (See *Car Radio.*)

MOVING-COIL SPEAKERS. (See *Loudspeaker.*)

MULTIVIBRATOR. A *relaxation circuit* which has two unstable conditions and successively passes from one to the other as long as it is operating. The Abraham-Bloch multivibrator is an example.

MUSICAL NOTES FREQUENCY. The frequency of the notes of the pianoforte covers the band from 26 to 4,096 vibrations per second. The lowest note, A, has a frequency of 26, middle C (the centre note of the standard piano keyboard) a frequency of 256, and the top note of the standard piano has a frequency of 4,096. The following table shows the piano notes and their frequencies :

A	26	G	96	F	341	E	1,280
B	30	A	106	G	384	F	1,365
C	32	B	120	A	426	G	1,536
D	36	C	128	B	480	A	1,706
E	40	D	144	C	512	B	1,920
F	42	E	160	D	576	C	2,048
G	48	F	170	E	640	D	2,304
A	53	G	192	F	682	E	2,560
B	60	A	213	G	768	F	2,730
C	64	B	240	A	853	G	3,072
D	72	C	256	B	960	A	3,413
E	80	D	288	C	1,024	B	3,840
F	85	E	320	D	1,152	C	4,096

MUTING CIRCUIT. (a) A circuit which cuts off the output of a receiver when no R/F carrier greater than a predetermined intensity is reaching the first detector. (b) A circuit for making a receiver insensitive during operation of its associated *transmitter.*

MUTUAL CONDUCTANCE (g or "Slope"). The relation of anode current change per volt grid-potential change. Another term for this is "Slope." (See also *Characteristic Curves.*)

$$g = \frac{\text{Change in anode current}}{\text{Change in grid volts}} \text{ expressed}$$

in mhos. when the current is amperes, or milliamperes per volt if the anode current is quoted in milliamperes. For convenience, micromhos are more widely used than the unit mho. There are 1 million micromhos in 1 mho, and 1,000 micromhos to 1 mA./volt.

MUTUAL INDUCTANCE. The result of coupling together two inductances so that a change in the current in one winding produces an E.M.F. in the other.

N

NATURAL FREQUENCY. The natural frequency of a circuit is the frequency with which it oscillates when no external electromotive force is applied.

NATURAL WAVELENGTH. The wavelength of an aerial connected directly to earth (100-ft. aerial = 120 metres).

NEGATIVE FEEDBACK. The fidelity of an amplifier can be improved if a small proportion of the output is fed back into the input so as to be in opposition to it. This is known as degeneration, commonly termed negative feedback.

Consider the simple block diagram of Fig. 309A. If the input to the amplifier can be represented by three lines and the output by 12, then the gain of the amplifier must be four. If a small amount—say one line—is fed back from the output to oppose the input as in Fig. 309B, the effective input to the amplifier now becomes two lines, thus with an amplifier gain of four the output is eight lines of which seven is the useful output.

The overall gain of the stage with feedback now becomes : input three lines, output seven lines, therefore the overall stage gain is two and a half as compared to four before the presence of feedback.

Should we require the output to be 12 lines as it was in the first case, the gain of the amplifier will have to be increased to six and a half, as the total output is 12 plus one which is fed back, making a total output of 13; as the effective input is two, the gain of the amplifier will have to be six and a half. This is shown by Fig. 309C. The total stage gain being four as in the very first case, as the total input is three lines and effective output 12.

The above is a simple explanation of feedback principle, and we can see that if the amplifier gain is not increased when feedback is applied, then there will be a decrease in output. On the other hand, if we wish to have the same output with feedback as we had without feedback, then the gain of the amplifier must be increased. Typical graphs of what may be expected

$$\text{of stage gain} = \frac{\text{Output Voltage(V)}}{\text{Input Voltage (V)}}$$

plotted against frequency are shown in Fig. 310.

Consider the diagram of Fig. 311, showing a feedback circuit. Feedback being

$\therefore$ V = m(v − BV) = mv − mBV or V (1 + mB) = mv.

$$\therefore \frac{V}{v} = \frac{m}{1 + mB} = \frac{1}{1/m + B}$$

As V/v is the overall stage gain of the amplifier the gain with feedback is equal to 1/1/m + B.

If, in the above equation, the gain m of the amplifier is large, then 1/m tends to be very small or approach zero; we can

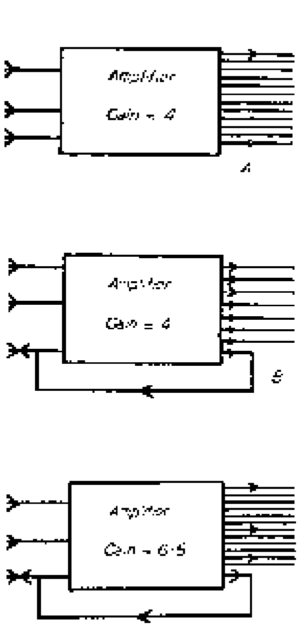


FIG. 309. *A simple block diagram to show the effect on gain.*

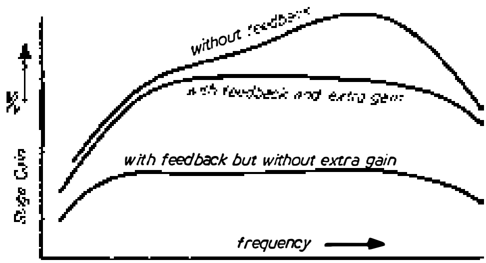


FIG. 310. *Typical curves showing what may be expected if stage gain is plotted against frequency under the conditions shown.*

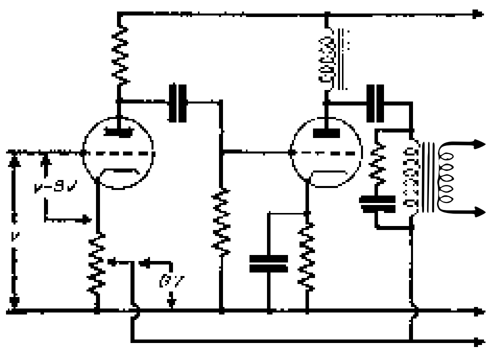


FIG. 311. *The theoretical form of a circuit employing negative feedback.*

obtained by returning the A.C. component of the output valve through all or part of the first valve's cathode bias resistor. The block diagram is represented by Fig. 313.

Let : m Gain of the amplifier.
v = Input to the stage.
V = Output of the amplifier.
− BV = Amount fed back to be in opposition to input.

The input to the amplifier when feedback is applied now becomes v − BV.

The output of the amplifier with feedback will be the product of the input and the gain of the amplifier.

say that the overall gain V/v is proportional to 1/B, that is if 1/50th of the output is fed back the gain is equal to 1/1/50 = 50. In other words, the gain becomes equal to the inverse of the amount fed back. There is one stipulation to the latter statement, and that is for the gain to be equal to the inverse of the feedback, the product of mB must be large compared with unity.

Consider an amplifier first without feedback and then with feedback applied. Suppose we have a 5mV signal and wish to amplify it to 500mV, the gain without feedback will have to be 100.

To provide the same output from the same input with feedback, we shall have to increase the gain of the amplifier; the gain is dependent on B, and assuming we feed back ·008 of the output, i.e. B = ·008, we have:

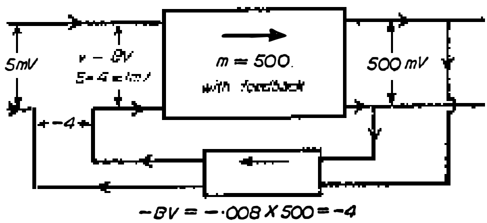
The overall gain has to equal 100 $= \frac{1 + mB}{m}$

or $100(1 + mB) = m$

or $m(1 - 100B) = 100$

$$\therefore m = \frac{100}{1 - 100B} = \frac{100}{1 - 100 + \cdot 008} = 500$$

Therefore to obtain the same output with ·008 feedback the amplifier gain will have to be increased from 100 to 500. The increase in amplification necessary to provide the same output as we had without feedback is the main disadvantage, but in



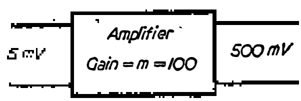


FIG. 312. (*Right*) *Amplifier incorporating feedback and details of a straight amplifier.*

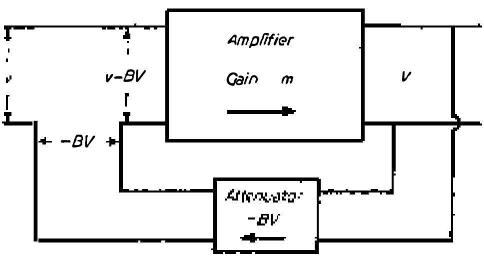


FIG. 313. (*Left*) *The block diagram of the circuit shown in* FIG. 311.

most cases sufficiently outweighs the advantages.

We can prove the above by substituting the figures in the block diagrams of Fig. 312.

The main advantage of a feedback amplifier is the reduction in the percentage distortion. Consider the previous amplifier without feedback, if due to component characteristics, etc., the output increase to 600mV. then we have present a

$$\frac{600 - 500}{500} \times \frac{100}{1} = 20 \text{ per cent. distor-}$$

tion. When feedback is applied a portion of this distortion is fed back to the input to be reamplified so as to appear to cancel out some of the original distortion.

Let: d = amount of distortion appearing at the output without feedback.

D = amount of distortion appearing at the output when feedback is applied.

− BD = amount of distortion fed back.

m = gain of amplifier when distortion is present.

The actual amount of distortion now appearing at the output will be d minus the amplified amount BD,

or $D = d - mBD$

$$\therefore D = \frac{d}{1 + mB}$$

In this case d = 20 per cent., B = ·008 and m = 600 and not 500, as the input to feedback amplifier is 1mV., due to distortion 600mV. appears at the output, therefore the gain of amplifier will be 600 when this distortion appears.

Therefore the percentage distortion when feedback is applied will be:

$$D = \frac{d}{1 + mB} = \frac{20}{1 + 600 \times \cdot 008}$$

$$= \frac{20}{5 \cdot 8} = 3 \cdot 4 \text{ per cent.}$$

or we can say the distortion is reduced by the amount $1/1 + Bm$.

NEGATRON. A four-electrode valve in which a negative resistance effect is produced.

NEON STABILISER. A special neon lamp arranged to be included across the output from a small mains battery eliminator so that it may deliver an even current when used with Q.P.P. or Class B amplification. The sudden high currents taken by the valves working on these principles result, with most mains units, in sudden voltage drops and consequent distortion. The neon lamp, when a large current is taken, has a lower resistance, and consequently tends to even up the load on the unit.

NEON TUBE. A glass vessel filled with the inert gas known as neon, and fitted with electrodes at each end. When a high potential is applied to the electrodes the gas glows with a yellowish red glow.

NEPER. On the Continent the power ratios are generally based on natural or naperian logarithms and the gain or loss of two powers W_1 and W_2 expressed in nepers is given by—

Gain of W_2 on W_1 in nepers $= \frac{1}{2} \log_e \frac{W_2}{W_1}$

It is possible to convert decibels to nepers or vice versa, the proof of this is below The equivalent of 1 db in nepers.

$$10 \log \frac{W_2}{W_1} = 1\ db$$

$$\text{Therefore } \frac{W_2}{W_1} = 10^{\cdot 1} = \cdot 1$$

$$N = \tfrac{1}{2} \log_e \frac{W_2}{W_1} = \tfrac{1}{2} \log_e \cdot 1$$

$$= \tfrac{1}{2} \times 2{\cdot}303 \times \cdot 1 = 0{\cdot}11515$$

Therefore 1 *db* = 0·11515 nepers or 8·686 db = 1 neper.

Therefore to convert nepers to decibels multiply by 8·686 and to convert decibels to nepers multiply by 0·11515 or divide by 8·686. (See also *Bel*, *Decibel*, *Phon* and *Acoustic Watt*.)

NET. To tune the *transmitters* and receivers of a group of stations to a common frequency.

NEUTRALISING CIRCUITS. (See *Neutrodyne Circuit*.)

NEUTRALISING CONDENSER. (See *Neutrodyne Circuit*.)

NEUTRODYNE CIRCUIT. The secret of obtaining successful H.F. amplification is the prevention of "feedback" from the plate circuit of the H.F. valve to its grid circuit. In the modern S.G. scheme this is achieved by very complete screening, not only between external circuits, but between the actual electrodes in the valve itself. With an ordinary three-electrode valve the outside screening may be arranged in just the same way, but, obviously, a certain amount of "feedback" will take place in the valve itself.

The well-known Hazeltine "neutrodyne" circuit obviated this difficulty by arranging that energy should be intentionally fed back from the anode circuit to the grid circuit in such a way as to cancel out the amount of unwanted feedback. This is done by extending the anode coil; the H.T. is tapped on to the centre of the tuned circuit so that both ends of the coil are "live" and at opposite phase. From the end remote from the plate a very small adjustable condenser is used to couple back directly on to the grid of the same valve (see Fig. 314). When the value of this condenser is exactly right, the circuit is perfectly stable.

A screened-grid valve will overload easily, and a signal, straight off the aerial, from a nearby braodcasting station is capable of exceeding the legitimate grid swing. In cases where people want a receiver with rather better distance-getting properties than the conventional "detector and two L.F.," and happen to be situated so near a broadcasting station that a screened-grid valve in the first stage will overload, the neutralised triode forms an excellent substitute for the S.G.

The circuit arrangement shown in Fig. 314 should provide no difficulties, if the anode coil is mounted at right angles to the grid (aerial) coil, and on the opposite side of the screen. A complete suggested layout is shown in Fig. 315.

A general-purpose type of valve—a "HL"—or a "H" type will suit the purpose admirably. If one is very near the local the "HL" is preferable. It should be remembered in such a case, however, that the detector now stands in danger of being overloaded, and that it may be necessary to use a "first L.F." type or even a power valve for that purpose.

Tune the set to the local, bringing it up to maximum volume.

Now remove one filament lead from the terminal on the H.F. valve holder. Leave the valve in position, of course, but with its filament switched off. The local will probably be heard at quite good strength if the neutralising condenser is either "all in" or "all out." Adjust the neutralising condenser until the signal from the local disappears altogether. Having obtained it, move the tuning condensers slightly to make sure that it does not come in again. If it does, readjust the neutralising condenser.

The filament of the H.F. valve should be switched on again, and the set should operate in a stable condition. It should be possible to make it oscillate by means of the usual detector reaction condenser; but when it does so, it should only be the detector that oscillates.

The true setting of the neutralising condenser depends upon the grid-plate

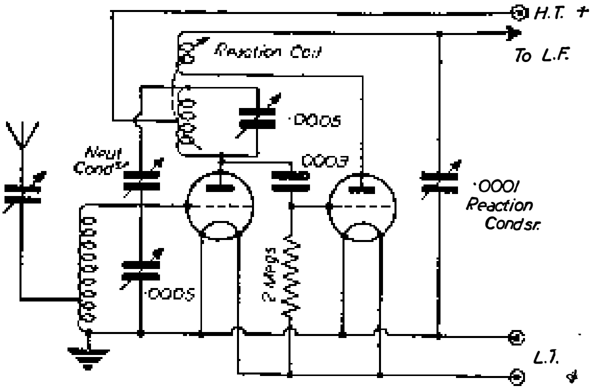


FIG. 314. *The Hazeltine neutrodyne circuit.*

capacity of the actual H.F. valve in use; this implies that if a different valve is used the whole process will probably have to be gone through again.

Tuning should be found to be very straightforward, and simply a matter of keeping the two controls "in step" with each other.

NEUTRON. An uncharged particle of mass equal to a proton which (probably) goes to build up atomic nuclei.

NEWTON. 1 newton = 10^5 dynes.

NICKEL-IRON-ALKALINE ACCUMULATOR. (See *Accumulators*.)

NIGHT ERROR. The error in the bearings given by a radio direction-finder at night time, produced by waves reflected by the Heaviside Layer, especially prominent on short wavelengths. Preferably termed *Polarisation Error* (which see).

NOCTOVISION. A process of television where the object is scanned by infra-red rays. By this means, the object to be televised may be in darkness, but owing to the action of the infra-red ray the television transmitter will receive impulses from the scanned object, and they may thus be transmitted in the same way as when they are placed in bright light. The received image bears all the light and shade of the ordinary method, and it is difficult to tell that the original object is in darkness. (See also *Television*.)

NODE. A point of zero current or potential in an oscillatory circuit.

NODON VALVE. Name given to a form

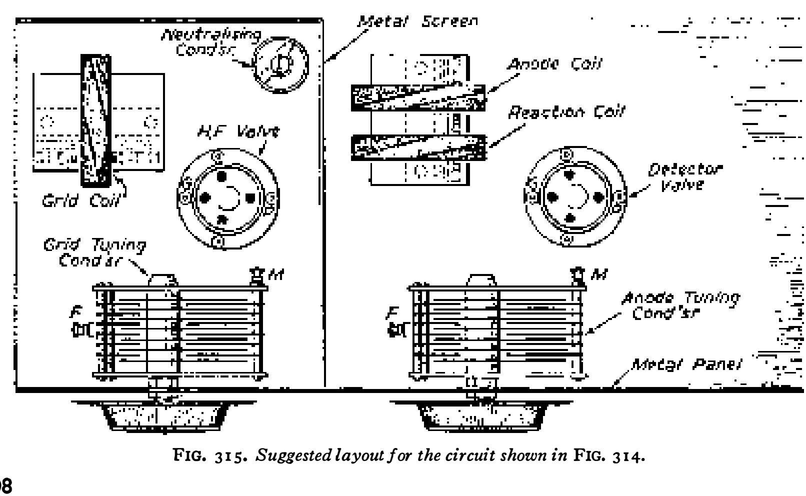


FIG. 315. *Suggested layout for the circuit shown in* FIG. 314.

of chemical rectifier used for accumulator charging; almost obsolete.

NOISE. Unwanted energy (or the voltage produced), usually of random character, present in a transmission system, due to any causes.

Note. In particular applications of the term the noise may be limited to noise of specified origin.

NOISES. Noises may be roughly divided into two classes—those which come from some cause within the set, such as motor-boating, microphonic noises, and certain crackling noises, and those which arrive via the aerial or the mains, such as atmospherics, mains hum, etc. Internal noises will be dealt with first.

Microphonic Feedback. This particularly vicious form of disturbance practically disappeared with the improvement in valves. It is chiefly caused by the sound waves from the speaker impinging on the detector valve. If the electrodes of this are not absolutely rigid, it will act as a microphone, as can be demonstrated by tapping the valve sharply with your finger. A microphonic valve will give out a ringing sound from the speaker. In the same way sound from the speaker itself, on striking the valve, will set it vibrating. This in turn causes the ringing sound in the speaker, and in bad cases this ringing sound gradually builds up to a volume which drowns everything. Flexible mounting of the valve holders is obviously the first step towards a cure. Try also fitting a rubber ring round the bulb of the valve, or placing a jacket of cotton gauze round it. If the trouble still persists, the cause may not lie only with the valve, but may be due to the vibrations from the speaker setting up sympathetic vibrations in the vanes of the variable condensers. In this case the building up usually occurs only when the set is tuned-in to a heavy carrier. Condensers without supports to the tips of the moving vanes are usually the cause, and the remedy lies either in their replacement by more rigid types or the mounting of the speaker or the baffle on felt or sponge rubber pads, as in Fig. 320.

L.F. Howling and Motor-boating. This is usually so low a note that each separate beat can be distinguished, thus producing a regular "plop, plop, plop!" In this latter form it is known as motor-boating. It may be due to a variety of causes, such as interaction between components resulting from bad spacing, feedback caused by a worn-out H.T. battery, overloaded mains unit, etc. Fortunately, it is not difficult to overcome if tackled systematically. One of the oldest and simplest dodges is that of changing over one pair of leads to the L.F. transformer. Simply reverse the connections to either the primary or the secondary, ***but not to both.*** In the case of two-transformer stages, only one should be altered. Failing that, fit a decoupling resistance and condenser in the anode circuit of the detector valve as in Fig. 322. Also try a choke and condenser output filter if one is not already present. This is an almost certain cure where the trouble emanates from the mains unit. Fig. 323 shows the usual arrangement. In the case of receivers which derive their grid bias from the mains, decoupling should be included as is also shown in Fig. 323.

H.F. Oscillation. Unsuitable components, bad layout, and inadequate screening all

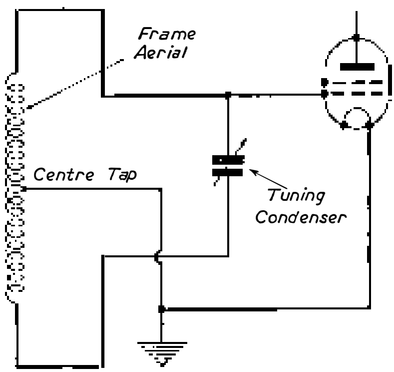


FIG. 316. *Circuit for balanced frame aerial.*

contribute towards instability in the H.F. stages, resulting in uncontrollable oscillation. Of course, with home-constructed sets built up according to the designer's specification the trouble is not likely to occur, since such troubles are cured before the design is offered to the public. Naturally, a few cases do occur when trouble arises through some unseen cause, such as exceptional local conditions or a bad component; but it is more often the set which is not to specification, or has been altered from time to time, which causes most trouble.

As regards a cure, one can only repeat what everyone has heard time and again—namely, pay particular attention to layout and wiring. Unshielded coils should be placed with their windings at right angles to minimise interaction. The same applies to H.F. chokes, which should not be placed with their windings in the same plane as those of an adjacent coil. Non-inductive-type condensers should be used where possible, especially for de-coupling band-pass coils. Keep the connection from the grid of the detector valve to the grid condenser as short as possible, as in Fig. 321. The substitution of metallised valves for ordinary ones in the H.F. and detector stages also helps where screening is inadequate.

Crackling Noises. Some of the causes of intermittent crackling noises produced by

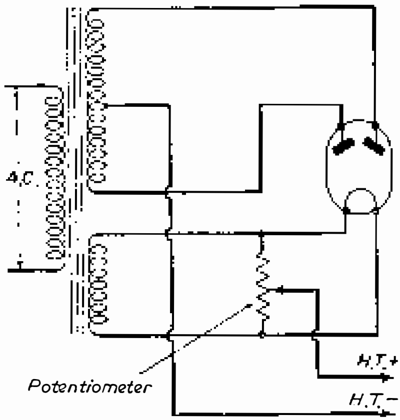


FIG. 317. *A cure for mains hum.*

the receiver itself are as follows: worn-out batteries, bad connections, "burnt-out" transformer windings, and faulty resistances. If it is known definitely that the H.T. battery is the cause, the remedy is obvious, but if this is not certain, the voltmeter will give some idea. Usually, if the voltage has dropped by 25 per cent., the battery has little useful life left in it, and is more than likely to crackle. If the battery is O.K., it is quicker to test the receiver stage by stage than to try to guess the cause. Disconnect the loudspeaker and join it, or a pair of phones would be better, in the anode circuit of the detector valve, as in Fig. 300. If the cracklings are apparent in the phones, then the trouble lies in the H.F. or detector stages. Tighten all terminals and examine all soldered joints very carefully. A soldered connection may be cracked right across without the crack being visible until pulled apart. Test the valves in their holders and open each valve leg slightly to ensure its making proper contact. Short the switch with a piece of wire while it is in the "on" position. If the crackling ceases, the fault lies in the switch.

Test the grid leak in the same way. Here is

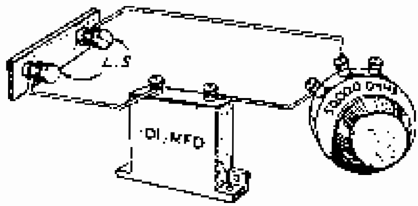


FIG. 318. *A high-note filter—a cure for whistles caused by heterodyning.*

a tip worth while—if one hasn't any spare grid leaks or resistances for comparison when making these tests, one can always borrow one from the idle L.F. stages. The values may not be quite the same, but they will be quite all right for the purpose of locating the crackling.

If no crackling is heard in the phones when placed in the detector anode circuit (across A and B in Fig. 324), alter the connection to include the primary of the transformer. If the crackling appears, the transformer is the cause. If the set is still silent, and there is a decoupling resistance fitted, join the phones across A and E, so as to include the resistance as well. The commencement of crackling would indicate that the resistance is the cause. If there are still no results, pass on to the next stage by connecting the phones (or rather the loudspeaker, as the signals will be louder in this stage) in the anode circuit of the next stage. If this is also the last stage, then, naturally, one will join the speaker to its usual terminals. Now test for loose terminals, faulty resistances, etc., in this part of the circuit, as in the previous stages. In the case of R.C. coupling, the coupling condenser is unlikely to give trouble, but the simplest way to test it is to replace it with another. The same applies to decoupling condensers.

Faulty Mains Unit. In this stage-by-stage test it has been more or less assumed that the set under test is battery operated. In the case of a mains set, procedure is the same except that there is just the possibility of the trouble being caused by a partial breakdown in the mains unit. In this case one would not get beyond the first stage, since, whatever test was tried, the crackling would persist. Fortunately, this is of fairly rare occurrence. The cure

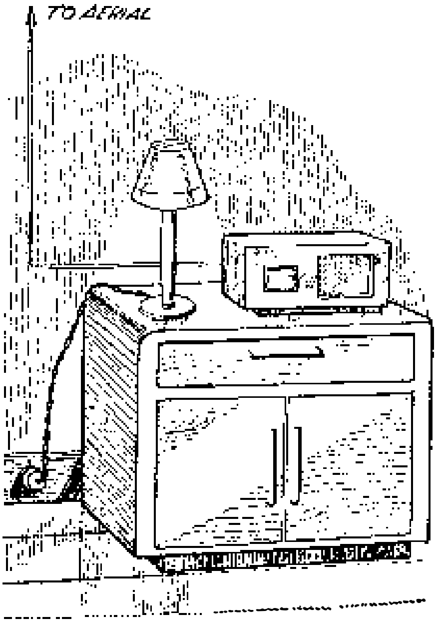


FIG. 319. *One cause of hum is the aerial, earth or speaker leads running parallel to the supply mains.*

is obviously an overhaul of the mains unit and the replacement of any defective parts. Another rather rare cause of crackling noises is due to a defective L.T. accumulator. The positive plates of old accumulators of the block plate type are inclined to break up. Only intermittent contact occurs between the two parts. A broken lug will have the same effect.

Smoothing the H.T. Supply. A potentiometer may also be included with advantage across the filament of the usual full-wave rectifier valve, the H.T. positive lead being taken from the slider instead of from the centre tap of the transformer. This will balance out any hum that would otherwise enter the filter circuit. The connections are shown in Fig. 317. There are several potentiometers on the market suitable as hum eliminators.

The shielding of all heater wiring in earthed sleeving and the use of earthed lead-covered wire from the mains to the set are other well-known dodges for eliminating hum. Take care also that the aerial, earth, and speaker wires do not run close to or parallel with the supply mains.

Tunable Hum. A hum may sometimes be experienced when tuned into a strong transmission like the local station. This must not be confused with the microphonic noise due to vibrating condenser vanes. Tunable hum is usually accentuated, if not caused, by a poor earth connection. Failing a cure when this has been attended to, try the following: connect a ·01-μF. condenser (1,000 volts D.C. test) between one H.T. secondary terminal of the transformer in the power unit and the earth terminal of the set.

Atmospherics. These do not trouble us much in this country except during the few periods of thundery weather experienced each summer. In fact, what is

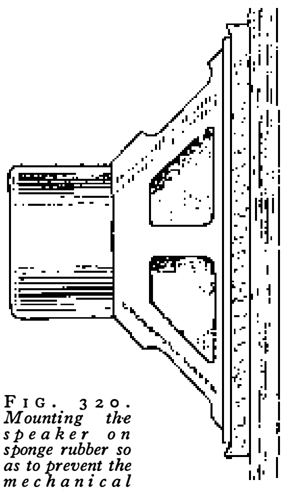


FIG. 320. *Mounting the speaker on sponge rubber so as to prevent the mechanical transmission of vibrations to the set itself.*

often put down to atmospherics is nothing more than crackles caused by a worn-out H.T. battery or some faulty or dirty connection. If there are no doubts as to the cause, disconnect the aerial temporarily. If the crackles cease they are due to atmospherics. A cure is practically out of the question at the present time, but those means herein described for the elimination of electrical disturbances may be found helpful in reducing their effects. One thing to remember is that volume control should never be effected by detuning, since by this method the atmospherics, being untunable, remain at full strength, while the signal is reduced. The

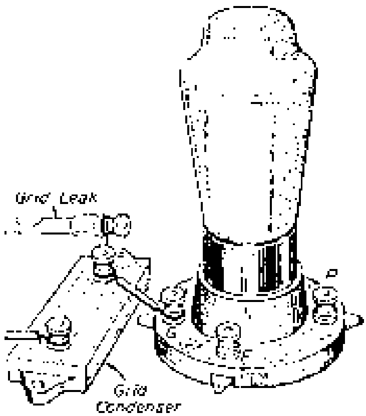


FIG. 321. *By placing the grid condenser close to the valve-holder the lead from the grid to condenser is kept short—which makes for stability.*

best way is to tune in the required station accurately and then reduce it to a workable volume with the reaction or the

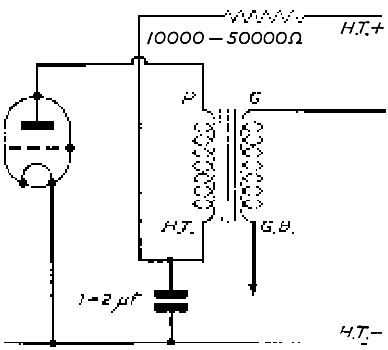


FIG. 322. *How to fit a decoupling resistance and condenser to stop motor-boating.*

volume control. This will at the same time reduce the atmospherics. It is perhaps not quite correct to say atmospherics are untuned, as they will often be found to be less troublesome on the medium waves than on the long. In this case, if there is a choice of using either band for the local programme, as for instance when two stations are giving the same programme, one will naturally tune in to the one which has the least interference.

Heterodyne Whistles. A very shrill whistling sound is sometimes heard above the legitimate signal when tuned to a particular station. This is due to jamming by another station working on the same, or nearly the same, wavelength. It is not uncommon in these days of overcrowding on the broadcast wavebands. First of all make quite certain that it is not caused by the receiver being on the border of oscillation and itself heterodyning the incoming carrier. It is quite possible for this to happen if one is trying to squeeze the last ounce out of the reaction. Again, the trouble may be due to a neighbour's receiver oscillating. Redress here lies with the Post Office. Assuming, however, that the trouble is due to jamming, and if the station affected is a favourite one, fit up a high-note filter. This is shown in Fig. 318.

"External" Noises. Noises which occur from causes outside the set are usually far more difficult to eliminate than those which are caused through some defect in the receiver itself, since it is very rarely that they can be tackled at their source. That the source may be well known is not usually of much help for that reason.

The usual noises experienced are crackling

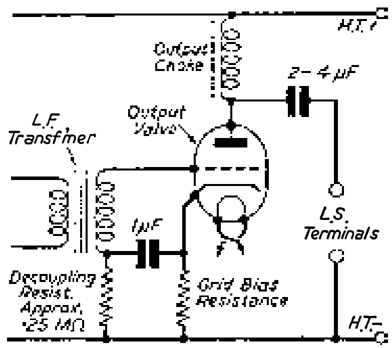


FIG. 323. *The circuit for decoupling by choke-filter output. The output grid circuit is also shown decoupled.*

and similar noises due to electrical machinery, mains hum, atmospherics, and heterodyne whistles.

Interference due to Electrical Machinery. The problem of disturbances due to electrical machinery in the neighbourhood of the receiver is one of the hardest to solve. Amongst the more usual sources are trams, trains, electric signs, automatic traffic signals, charging plants, generators, etc. The radiations are apparently caused by sparking at commutators and switches, etc. These act in much the same way as a spark station, the transmitting aerial being represented by the supply mains which feed the machinery. In the case of trams, the overhead trolley which collects current from the conductor is often a prolific source of crackles and crashes, and even the extent that a properly balanced frame will. The merit of the frame is not due to the fact that it is less efficient than an outdoor aerial, and that therefore it picks up less of the disturbance. If that were so there would be no advantage, since signals would also be reduced in proportion, and any attempt to increase the signal strength would increase the disturbance again. Actually, however, the frame appears to be much more sensitive, at any rate, to the distant broadcast than to the local disturbance.

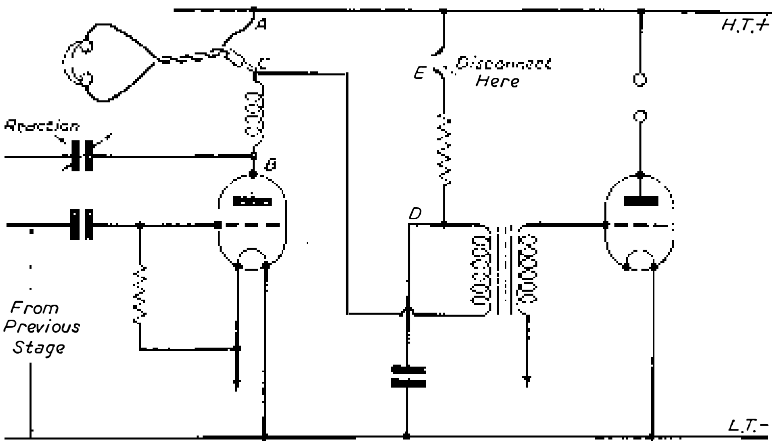


FIG. 324. *How to test for "crackling" noises. To test the H.F. and detector stages disconnect H.T. from E. and join 'phones across A and B. To test H.F. choke join 'phones across A and C. To include transformer join them across A and D. To include decoupling resistance join across A and E.*

the ordinary tumbler switches of the house lighting system cause a click in the loudspeaker every time they are operated. In some of the worst cases a complete cure is often impossible unless the cause is removed. The G.P.O. are, of course, doing much useful work in this connection, but one can often supplement their excellent efforts by approaching owners of noisy plant, such as electric charging systems, sausage machines, etc. Often the fitting of such an inexpensive addition as a good earth connection or a pair of 4-μF. condensers across the brushes, with the centre point earthed, will make all the difference.

Frame Aerial as a Cure. As regards the receiver itself, there are various dodges which may be tried, but probably the most successful of all is the centre-tapped frame aerial. An ordinary frame will generally effect some improvement, but not to The circuit for the balanced frame is shown in Fig. 316. It is similar to that of an ordinary frame, except that the centre point of the winding is earthed. One end of the frame goes to the grid of the first valve in the usual way. The centre tap goes to earth, while the other end is joined to one side of the tuning condenser only. Points to remember in the fitting up of such a frame are : that each half of the frame should be as nearly identical as possible, electrically as well as mechanically. Both the outside leads should be the same length and equidistant from the centre or earthed lead. Naturally, one will need a sensitive receiver with a frame if it is desired to get foreign stations with any degree of volume. A superhet is ideal, but a straight four-valver, with a screen-grid stage, will usually meet all average needs. The placing of the receiver in a metal box, or in some way screening it, will be an advantage when used in conjunction with the frame, although it is unlikely to be of much help with an ordinary aerial.

Using a Counterpoise. The use of band-pass tuning and variable-mu valves is sometimes very helpful in reducing electrical disturbances, as both tend to give a silent background. Another scheme is the use of a counterpoise earth. This has somewhat the same action as the frame aerial, although it is not so effective. In its simplest form it consists of an insulated wire similar to the aerial and placed directly underneath it. This is not always a practical arrangement, but for those who wish to try it the earth terminal of the set is joined to the counterpoise instead of to earth.

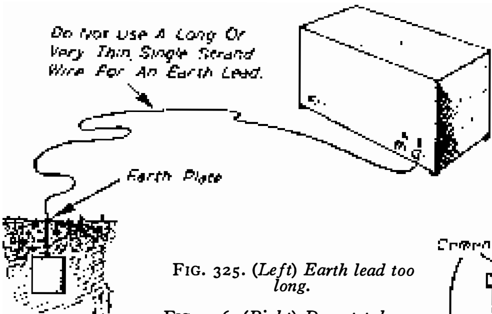
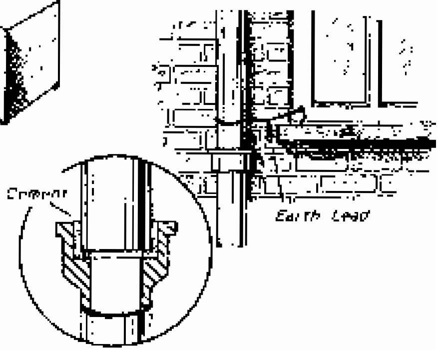


FIG. 325. (*Left*) *Earth lead too long.*

FIG. 326. (*Right*) *Do not take an "earth" lead to a stack pipe as the sections are often cemented together and therefore there is no metallic contact to earth.*



H.F. Interference via the Mains. It sometimes happens that most of the noise arrives via the mains, and not down the aerial. This can be tested by disconnecting the aerial. If the noise continues then one can be fairly certain that the mains are picking up most of the unwanted impulses. Try a good H.F. choke in each lead with a fixed condenser across them. A ·01-μF. condenser (or larger in the case of D.C. mains) will be suitable.

NOISE FACTOR. The ratio of the *signal-to-noise ratio* at the input to that at the output of a receiver, within limiting conditions.

NOISE SUPPRESSION. The action of a device which automatically suppresses the output of a radio receiver until a predetermined input-signal level has been reached.

NOISE TEMPERATURE RATIO. The ratio of the available *noise* power from the component to the available noise power from a perfect resistor at 290° K.

NOMOGRAM. An abac (*which see*).

NON-CRITICAL DIMENSIONS. Any dimension of the cross-section of a *waveguide* which can be varied without alteration of the *criticial frequency* (or wavelength).

NON-DISSIPATIVE STUB. A non-dissipative length of *waveguide* or transmission line coupled into the side of a *waveguide.*

NON-INDUCTIVE COIL. An inductance which is wound back upon itself or otherwise doubled so that the self-induction of each section neutralises that of the other.

NON-INDUCTIVE CONDENSER. A condenser in which the electrodes are so disposed that there is no inductance. A mica and copper-foil condenser is non-inductive, but a paper condenser of the type where a long strip of waxed paper and a long strip of foil are wrapped round and round may be inductive.

NON-INDUCTIVE RESISTANCE. A wire-wound resistance, having the wire element wound back upon itself or otherwise doubled so that the self-induction of each section neutralises that of the other. The term is also applied to a resistance which is composed of some element other than wire, such as a graphite composition. A resistance which possesses no inductance.

NON-OSCILLATORY. A current which commences in a circuit and then dies away without reversal.

NON-SYNCHRONOUS. The same as Asynchronous.

NORMALISED IMPEDANCE. The ratio of an impedance to the characteristic impedance of the transmission line or *waveguide*. An absolute value of the characteristic impedance is not in practice employed in *waveguide* technique and the normalised impedance is then deduced from the formula Z normalised $= \frac{1 + \rho}{1 + \rho}$

NOZZLE. A *primary radiating element* comprising a *waveguide* in which neither dimension increases towards the aperture.

O

OBLIQUE-INCIDENCE TRANSMISSION. The transmission of a radio wave obliquely to the ionosphere and back to earth, as in radio communication over an appreciable distance.

OCTAL. A valve base with eight sockets.

OCTODE. A combined first detector-oscillator valve having six grids in addition to the anode and cathode.

The two sections of the valve appear as an H.F. pentode and a triode.

OERSTED. The C.G.S. electromagnetic unit of magnetising force; 1 oersted $= 10^3$ praoersteds; 1 praoersted $= 10^{-3}$ oersteds; 0·495 oersted = 1 ampere turn/inch = 495 praoersteds; 1 ampere turn/metre = 0·01257 oersted = 12·57 praoersteds.

OFF-CENTRE PLAN DISPLAY. A *display* consisting of a portion of a *P P I* display, not including the centre.

OHM. The unit of resistance defined by that resistance offered by a column of mercury at the temperature of melting ice; 14·452 grammes in mass, and of uniform cross section and with a length of 106·3 cms. When an electrical pressure of one volt is required to force a current of one ampere through a circuit, the circuit is said to have a resistance of one ohm. 1 ohm $= 1{\cdot}11 \times 10^{-12}$ statohms $= 10^8$ abohms; 1 statohm $= 9 \times 10^{20}$ abohms; 1 abohm $= 1{\cdot}11 \times 10^{-21}$ statohms.

OHMMETER. An instrument for giving a direct reading of resistance.

OHM'S LAW. A law which gives the relations existing in any circuit between current, voltage and resistance. The formula is: current = voltage ÷ resistance, which is set down in mathematical form thus: $I = \frac{E}{R}$ (I being the electrical symbol for current, E the symbol for voltage, and R the symbol for resistance). From this equation it is obvious that the voltage can be found by multiplying the current by the resistance ($E = I \times R$), and the resistance is given by dividing the voltage by the current $\left(R = \frac{E}{I}\right)$. In all the above equations the three terms must be in the units of the respective measurements, namely, I in amperes, E in volts, and R in ohms.

Example: If the voltage is 6 and the resistance is 3 ohms:

Current $= \frac{6}{3} = 2$ amps.

Resistance $\frac{6}{2} = 3$ ohms.

Voltage $= 2 \times 3 = 6$ volts.

Ohm's Law for A.C. In an A.C. circuit, Ohm's Law expresses a relation between the circuit E.M.F. or P.D. (E.), the current flowing (I), and the circuit impedance (Z):

$$E = IZ$$

The forms of Z for different H.F. circuits are given below. In the formulæ, L, C, R, and ω are:

L = inductance in henrys.
C = capacity in farads.
R = resistance (A.C.) in ohms.
$\omega = 2\pi \times$ frequency in c.p.s.

I. Resistance and Inductance

In series $Z = \sqrt{[R^2 + (L\omega)^2]}$

In parallel $Z = RL\omega / \sqrt{[R^2 + (L\omega)^2]}$

II. Resistance and Capacity

In series $Z = \sqrt{[R^2 + (1/C\omega)^2]}$

In parallel $Z = R / \sqrt{[1 + (RC\omega)^2]}$

III. Coil (L, R) and Condenser (C)

In series $Z = \sqrt{[R^2 + (L\omega - 1/C\omega)^2]}$

In parallel $Z = \sqrt{\left[\frac{R^2 + (L\omega)^2}{(1 - LC\omega^2)^2 + (RC\omega)^2}\right]}$

The series and parallel cases of **III** are the simple series and parallel tuned circuits. Resonance occurs when:

$$\omega_0 = 1/\sqrt{LC}$$

(An alternative statement of this condition is, $\lambda = 1885 \sqrt{LC}$, where λ is the wavelength in metres and L and C are now in μH and μF.)

In the **series** case the impedance at resonance is:

$$Z_0 = R$$

In the **parallel** case the impedance at resonance is:

$$Z_0 = \sqrt{[(1/C\omega)^2 + (L/RC)^2]}$$
$$= L/RC \text{ approximately}$$

OMNIBUS BARS. Bus bars (*which see*).

OPEN CIRCUIT. A circuit which is incomplete.

OPEN-CORE TRANSFORMER. A transformer in which the two ends of the iron core are not joined.

OPERATOR j. A mathematical symbol used in certain calculations to assist working where roots are involved, which can, of course, be + ve or − ve.

ORTHICON. The special camera used for television. See also *Photicon and Emitron.*

OSCILLATING CURRENT. Alternating current possessing a frequency of hundreds of thousands of cycles a second.

OSCILLATOR. A combination of thermionic valves and resonant circuits for the production of oscillations.

OSCILLATOR COIL. Two coils of wire (one of which is tuned) coupled together and connected respectively in the grid and anode circuits of the oscillator portion of the frequency-changing valve of a superhet. (See also *Coils*.)

OSCILLATOR DRIFT. The slow change in frequency of a thermionic valve oscillator occasioned by changing supply voltages, ageing, and warming-up of the valve and circuit elements, etc.

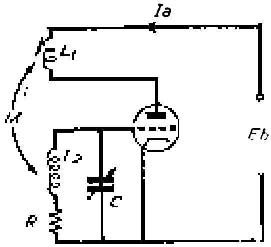


FIG. 327. *The tuned grid oscillator.*

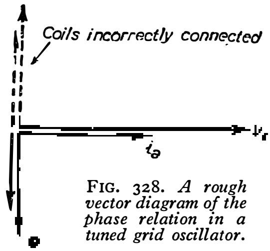


FIG. 328. *A rough vector diagram of the phase relation in a tuned grid oscillator.*

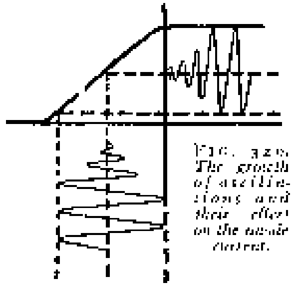


FIG. 329. *The growth of oscillations and their effect on the anode current.*

OSCILLATORS. For any oscillator, mechanical or electrical, it is necessary to have a system consisting of two elements each capable of storing energy and releasing the energy from one to the other at a natural frequency which is dependent upon the magnitude of the elements.

In the case of the electrical oscillator the elements are as follow:

(a) An inductance which is capable of storing energy in its magnetic field, and

(b) A condenser which can store energy in its electrostatic field.

Energy can be released from one to the other at a frequency which, as we saw in the articles on A.C. theory, is given ideally by the equation $\frac{1}{2}\pi LC$. Resistive elements which are, of course, invariably present, slightly modify this natural frequency.

Now a source of energy is also required to provide:

(a) The starting energy, and

(b) Energy to make up losses such as heat losses due to the resistive elements.

Some mechanism is required to ensure that energy is released from the source at the correct moments to maintain the oscillations. In radio circuits this mechanism is generally a valve amplifier. Examine the tuned grid oscillator shown in Fig. 327 where L_1 and L_2 are the anode and grid inductances respectively, the grid coil being tuned in the conventional manner by condenser C.

The operation of this arrangement is no doubt fairly familiar to most readers, but the conditions necessary for the maintenance of oscillations may not be so apparent. Roughly the functioning is as follows:

On switching on the H.T. supply, anode current commences to grow, and the increasing flux in L_1 links with the turns of L_2 so that an E.M.F. is induced in the grid tuned circuit. Thus the grid circuit

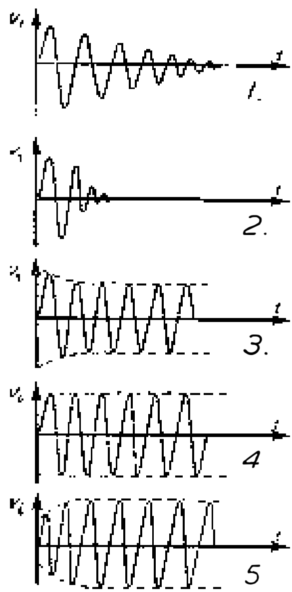


FIG. 330. *The five cases of oscillatory conditions in a tuned grid stage with various forms of feedback.*

absorbs energy which comes originally from the H.T. battery.

Normal oscillation of the grid LC circuit will cause a voltage v_i to appear between grid and cathode which is varying sinusoidally at the natural frequency of the LC circuit.

This will cause corresponding oscillations in i_a, the anode current; hence energy will be transferred to the grid circuit and, if conditions are properly arranged, in such a manner as to assist the original oscillations.

In Fig. 328 is shown a rough vector diagram of the events occurring in the oscillator. Starting with v_i then assuming that L_1 is very small, the anode current is approximately in phase with v_i. (In practice there is a slight lag.) The anode current i_a, in passing through L_1 causes an E.M.F. (e) to be induced in the grid circuit; since this tuned circuit is at resonance the current produced by the E.M.F. will be in phase with e.

The voltage across L will lead this current by 90°, and so will assist or oppose the original v_i according to the direction of the connection of the coils.

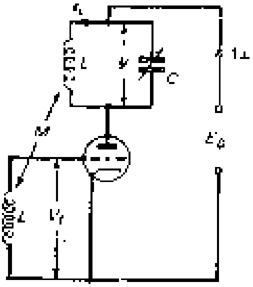
By obtaining this feedback in the correct manner it will be possible to offset the damping caused by the resistance of the grid circuit i.e. the resistance of this circuit virtually becomes zero. The amount of energy fed back will depend upon the value of coupling M.

Maintenance Conditions. Since L_1 is small, the anode load is small, and so : $i_a = g_m . v_i$ (approx.).

In other words, the anode volts V_a are very nearly constant.

We have : $e = M, di_a/dt$.

But if $i_a = i_a \sin \omega t$.



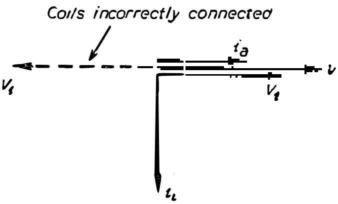


FIG. 331 AND 332. *The tuned anode oscillator and a rough vector diagram of the phase relations therein.*

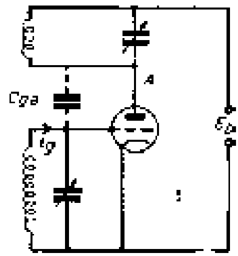


FIG. 333. *The tuned anode-tuned grid oscillator showing the Cga effect.*

$$\text{Then } di_a/dt = \omega i_a \cos \omega t$$
$$= \omega i_a \sin (\omega t + 90°)$$
$$= \omega i_a$$
$$e = \omega M i_a$$

In order that oscillations may be maintained, the power fed back must be greater than or equal to the amount of power dissipated.

$\therefore$ eiL *must be greater than* iL^2R

$\therefore$ e *must be greater than* iLR.

$\omega M i_a$ *must be greater than* $v_i \omega C.R.$

$\therefore$ $\omega M g_m . v_i$ *must be greater than* $v_i . \omega C.R.$

$\therefore$ M *must be greater than* CR/g_m.

This latter is the result of most importance as we shall now see.

Consider the five cases shown in Fig. 330.

Case 1, with no feedback, the oscillations set up by the act of switching on the H.T. supply rapidly die away.

Case 2, with negative feedback, caused by incorrect connection of the coils. This time the oscillations are damped exceedingly quickly, the energy fed back opposing instead of assisting in the maintenance of them.

Case 3, this being positive feedback, but a case where M is less than CR/g_m.

Case 4, again positive feedback, but this time M is equal to CR/g_m. In this instance the feedback is far too critical, for any slight increase in C or R, or a decrease in g_m will cause the oscillations to collapse.

Case 5 is therefore adopted, where M is greater than CR/g_m.

The amplitude of oscillations increases until a condition of stability is reached. Consider Fig. 329 and the growth of oscillations with their effect on the anode current.

Suppose where the oscillations commence to grow, M is set so that it is greater than CR/g_m, g_m being of course, the slope of

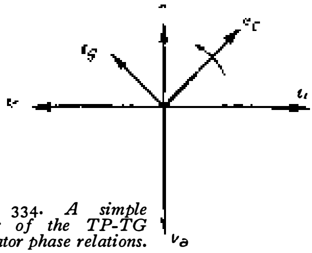


FIG. 334. *A simple vector of the TP-TG oscillator phase relations.*

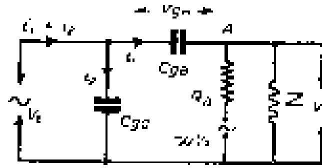


FIG. 335. *Equivalent circuit of* FIG. 333.

the I_a/V_g characteristic.

Now when the amplitude increases to such an extent that the peaks of the cycles traverse the curved portions of the characteristic, then the average value for the slope, i.e. the effective g_m, is decreased. Hence the ratio CR/g_m increases and will so increase until at stability M is just equal to CR/*average* g_m.

If we now suppose that something tends to cause the amplitude to decrease, then the effective g_m will increase and M will again be sufficient to maintain oscillations, i.e. the amplitude remains fairly constant and self-regulation is obtained.

A tuned-anode oscillator is shown in Fig. 331, together with a vector diagram of the circuit conditions.

Starting with i_a, then if the anode circuit is at resonance the voltage v across it will be in phase with i_a. The current iL through the inductive branch lags i_a by 90° approximately, and the E.M.F. injected into the grid circuit will lead or lag i_a by 90° according to the direction of connection of the coils.

This E.M.F. appears between grid and cathode (v_i) and if this is in phase with the anode current, energy is being fed back in such a manner that oscillations can be maintained.

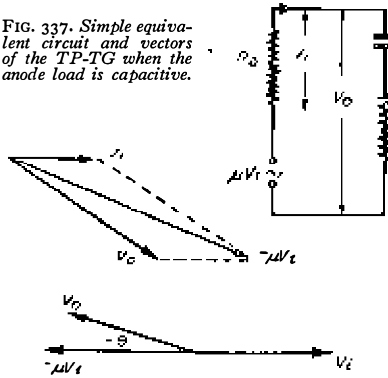
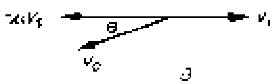


FIG. 337. *Simple equivalent circuit and vectors of the TP-TG when the anode load is capacitive.*

In practice iL lags on i_a by an angle less than 90° and v_i will not be quite in phase with i_a, but it is nevertheless true to say



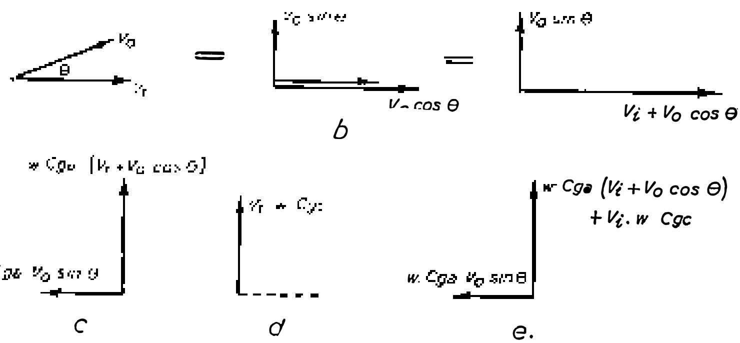


FIG. 336. *The vector conditions existing in the tuned anode-tuned grid stage where the Cga and Cgo are brought into the calculations.*

that it *will* be possible to maintain oscillations if v_i *has a component antiphase to* V_a. Primarily, the working of the tuned-anode-tuned-grid oscillator depends upon the Miller Effect, where feedback from the anode to the grid circuits takes place through the grid-anode inter-electrode capacity C_{ga} and modifies the input impedance of the stage in a manner depending on the nature of the anode load.

In the practical tuned anode oscillator discussed above, the coupling between the condenser (e_g) is very much larger than the induced E.M.F. (e); it is equal to the product of e and the step-up ratio of the grid coil and condenser circuit. The phase of this P.D. is incorrect, however, for the maintenance of oscillations, but it can be shown that if the grid circuit is tuned to a frequency *higher* than that to which the anode circuit is tuned the P.D. developed across the grid condenser is still much greater than e, and that a component is present which is correctly phased.

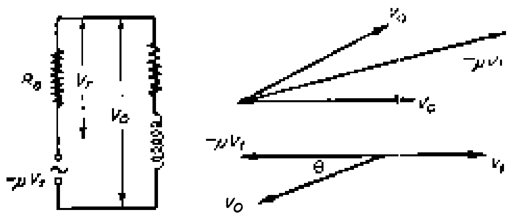


FIG. 338. *As for* FIG. 337, *but in this case with the anode load inductive.*

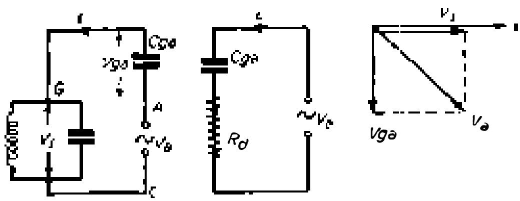


FIG. 339. *With the grid circuit tuned to the operating frequency oscillations cannot be maintained.*

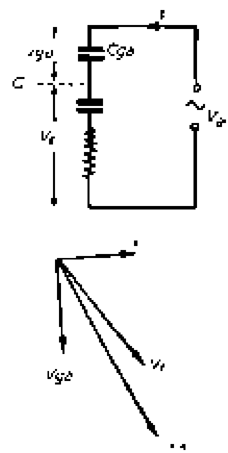


FIG. 340. *Oscillations cannot occur when the grid circuit is capacitive.*

grid and anode coils is generally made variable for reasons of efficiency. In the TP/TG (tuned plate, tuned grid) oscillator, however, these coils are fixed in position and their mutual inductance is constant, the grid coil being this time tuned by a condenser C. This gives the effect of a variable coil coupling as we shall see, although M is not really altered. It becomes possible to vary the potential fluctuations on the grid resulting from any given current in the anode circuit without moving the grid or anode coils in any way.

If we suppose that the grid circuit of Fig. 333 is tuned to the same frequency as the plate circuit and that a current iL is flowing in the latter, then an E.M.F. (e) is induced into the grid coil as we saw in the previous oscillators and a current i_g will flow in the grid LC circuit. As we saw in A.C. theory, the p.d. across the grid

This condition is best explained vectorially. In Fig. 334 is shown the phase relations in the circuit when the grid circuit is tuned above the frequency of the anode circuit. In a case where their frequencies are identical, the vector iL is parallel to the vector of the P.D. across the grid condenser e_g, consequently there is no component of grid potential which is antiphase to the anode potential; this latter condition is essential, as we have seen, for the maintenance of oscillations. Now, as the grid circuit is tuned away from that of the anode circuit the vector e_g will shorten in length (a decrease in magnitude), but it will begin to rotate in an anti-clockwise direction.

When it reaches a position somewhat as shown in the figure it is possible to resolve it into two components, one of these being antiphase to the anode potential V_a, while the other will be at right angles to the anode P.D. It is the former condition which is of importance, and the magnitude of this vector will, of course, depend on the tuning of the grid circuit. By correctly off-setting the grid-tuning condenser the phase and magnitude of the grid P.D. oscillations can be adjusted such that the circuit functions most efficiently and oscillations are maintained.

In a simple tuned-plate oscillator, oscillations die away very rapidly if the feedback between the coils is negative due to incorrect connections. If the grid is tuned, however, by a condenser and this circuit is offset to a frequency *below* that of the

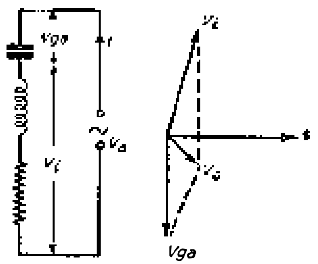


FIG. 341. *When the grid circuit is inductive it is possible for V_a to have a component antiphase to V_i.*

anode circuit, oscillations will be produced and maintained. In this case a vector representation can be constructed as previously, except that in this instance the grid current lags on the induced grid E.M.F. In this simple survey of the TP/TG oscillator the Miller effect has been ignored: actually the C_{ga} coupling does have a great effect on the working of this unit.

The Miller Effect—the feedback from anode to grid circuits takes place through the C_{ga} and modifies the input impedance of the stage in a manner depending on the nature of the anode load. Consider Fig. 333 reduced to its equivalent circuit of Fig. 335, where *Z* is the anode impedance. In Fig. 336A is a vector representation of the phase relations in this circuit, and the arrangement is best considered in this way:

Let θ be the angle by which v_o leads v_i. If in practice v_o lags on—uv_i, then the angle θ would be negative as the vector diagram depicts. By applying Kirchoff's second law round the outside of the complete circuit we have:

$v_i = V_{ga} + V_o$ = vector sum.

$\therefore V_{ga} = V_i - V_o$ = vector difference.

This can be drawn vectorially by constructing a vector v_i and the drawing of a vector v_o in the opposite direction, i.e $-v_o$ and adding this to v_i (Fig. 336B). The current through the grid-anode interelectrode capacity C_{ga} is now given by: $i_2 = V_{ga}\ \omega.\ C_{ga}$, leading V_{ga} by 90° (Fig. 336C) while the current through the grid-cathode capacity, C_{gc} is given by: $i_2 = V_i\ \omega\ C_{ga}$, leading V_i by 90° (Fig. 336D). But the total grid current $= i_1 + i_2$ (Fig. 336E).

Thus the grid current has a component $-v_o.\ \omega\ C_{ga} \sin\theta$ in phase with v_i and a component $(v_i + v_o \cos\theta)\ \omega\ C_{ga} + v_i\,\omega\ C_{ga}$ in leading quadrature with v_i.

Hence the applied voltage v_i will look into an impedance which will be partly resistive and partly capacitive. The stage will

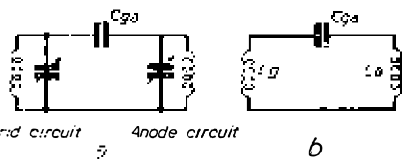


FIG. 342. *By reducing the simple equivalent in this way, the frequency of operation of the oscillator is given by $\frac{1}{2}\pi\sqrt{(1a+1g)}\,Cga$.*

therefore have an input resistance R_i and an input capacitance c_i.

Input Resistance:

R_i = applied voltage/in-phase component of grid I.

$= v_i/-v_o\ \omega\ C_{ga} \sin\theta$.

But v_o/v_o = V.A.F. (*m*)

$\therefore R_i = 1/-m\omega\ C_{ga} \sin\theta$.

Input capacitance:

Quadrature component of $i_g = (v_i + v_o \cos o)\ \omega.\ C_{ga} + v_i\ \omega.\ C_{gc}$

$= \omega.\ v_i\ (1 + m \cos\theta)\ C_{ga} + C_{gc}$.

Input Reactance = applied voltage/quadrature component of I_g.

$= v_i/\omega.\ v_i\ (1 + m \cos\theta)\ C_{ga} + C_{ga}$.

$= 1/\omega.\ C_i$.

$\therefore C_i = (1 + m.\ \cos\theta)\ C_{ga} + C_{gc}$.

We have thus obtained general formulae for both R_i and C_i, and we shall next investigate the forms that these expressions take for the various types of anode load.

Case 1. *Anode Load Resistive.* In this case o is zero and therefore R_i is 1/0, which equals infinity. $C_i = (1 + m)\ C_{ga} + C_{gc}$.

Case 2. *Anode Load Capacitive.* In this case the equivalent circuit of the stage is depicted in Fig. 337, together with the vector representations. Now we have already defined θ as the angle by which v_o leads $-u\,v_i$. In this case v_o lags $-u.v_i$ and hence θ is negative. Thus sine θ is negative though cos θ. Cos θ is still positive.

$\therefore R_i = 1/-m\,\omega\,C_{ga}\,(-\sin\theta)$.
= a positive quality.

Therefore the resistive component of the input impedance is in parallel with the tuned grid circuit. This introduces additional damping so that the energy fed back from the anode to the grid will not tend to maintain oscillations.

Case 3. *Anode Load Inductive.* This time the stage reduces to the circuit of Fig. 338, where again the vector representations are given. This time, the angle θ is positive, and therefore both sin θ and cos θ are also positive.

$\therefore R_i - 1/m\omega.\,C_{ga}\sin\theta\,-$.
i.e. a negative resistance.

Thus, under these conditions the damping of the input circuit may be offset by the energy fed back from the anode circuit and oscillations set up in the grid circuit may be maintained provided the anode circuit is sufficiently inductive.

Hence for TP/TG circuit to oscillate the anode circuit must be inductive, i.e. it must be tuned to a frequency *above* the operating frequency.

We shall now consider the grid circuit.

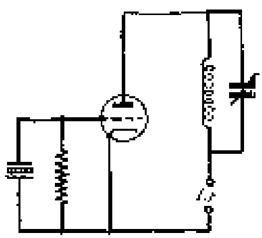


FIG. 343. *The TP/TG oscillator, where a crystal replaces the tuned grid circuit.*

Case 1. *Grid Circuit at the Operating Frequency.* Suppose that the natural frequency of oscillation is that of the grid circuit, i.e. let the grid circuit be tuned to resonance. As we know, for oscillations to be maintained, the anode voltage must have a component which is antiphase to v_i. In the above case as the diagrams of Fig. 339 will point out, this condition is not obtained and consequently oscillations would not occur.

Case 2. *Grid Circuit Capacitive.* This is self-explanatory from a study of Fig. 340. Again V_a has no component antiphase to v_i and therefore oscillations cannot be maintained.

Case 3. *Grid Circuit Inductive.* Fig. 341 shows in this case that it is possible, when the grid circuit is inductive, for V_a to have a component antiphase to V_i. Oscillations can therefore be maintained. The

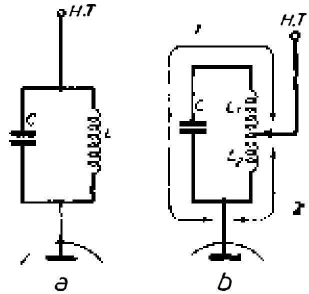


FIG. 343A. *Untapped and tapped tuned anode circuits.*

important result, therefore, is this: the anode and grid coils must be tuned to a frequency *higher* than that of the required operating frequency.

Equivalent Circuits. In Fig. 342A is shown the equivalent circuits connected by the C_{ga} of the valve. So far as total reactance is concerned it can be replaced as shown in Fig. 342B, thus obtaining effectively a series circuit, the resonant frequency of which will be:

$$fo = 1/2\,\pi\,\sqrt{(L_a + L_g)\,C_{ga}}$$

and this is approximately the frequency at which the TP/TG will oscillate. The amplitude of the oscillations depend in a rather complex manner on the ratio of L_a to L_g, hence, for a certain frequency and a maximum amplitude there is only one setting of the anode- and grid-tuned circuits.

The frequency control is usually greater in the circuit having the higher Q.

Crystal Oscillators. The crystal oscillator is a TP/TG oscillator in which the grid-tuned circuit is replaced by a piezo-electric crystal (Fig. 343).

Rochelle salt, tourmaline and quartz crystals exhibit marked piezo-electric effects; that is, if a pressure is exerted between two opposite faces of a slice of such a crystal, P.D. is set up between the faces. If the pressure is changed to a tension a P.D. of opposite polarity is the result. Consequently, if an alternating pressure and tension is applied, an alternating P.D. is produced between the faces. The converse effect can also be produced, i.e. if an alternating P.D. is applied a mechanical vibration tends to occur.

The amplitude of these vibrations is very marked at the natural frequency of vibration of the crystal, and so in this respect the arrangement resembles a tuned circuit. The change in amplitude of the oscillations for a small change in the frequency is very marked; that is, the crystal has, in effect, a very high Q, probably several thousand.

Consider the circuit of Fig. 343. The crystal is included in the grid circuit and a grid leak is provided to allow any D.C. grid current to flow to earth. The crystal has a very much higher Q than the anode circuit and so the frequency of operation will be very nearly that of the crystal.

The natural frequency of a crystal depends upon several things:

(a) The type of crystal—generally quartz is employed for radio work.

(b) The crystal cut—the inclination of the slice to the various axes.

(c) The dimensions of the slice—frequency increases as thickness decreases, the upper frequency limit generally being around 15-20 megacycles per second.

(d) Temperature—the natural frequency normally varies with the temperature, though special cuts can be chosen to give almost zero temperature coefficients.

Effect of Tapping a Tuned Circuit. Tapping points are sometimes taken across part of the anode tuned circuit of oscillators, and the effect this has on various circuit conditions will now be considered. In Fig. 343A is shown the normal untapped tuned circuit, as well as the tapped version.

If we assume that there is no mutual coupling between the two sections of the coil, L_1 and L_2 of this latter figure, then the two circuits may be compared in the following way:

For circuit A:

Resonant frequency $= 1/2\pi\sqrt{L.C.}$

Dynamic resistance $= L/CR$.

For circuit B:

At resonance the reactance of path 1 is equal to the reactance of path 2.

$$\therefore 1/\omega C - L_2 = L_1$$
$$1/\omega C = \omega(L_1 + L_2)$$
$$\omega 2 = 1/C(L_1 + L_2)$$

and $\omega = 1/\sqrt{C(L_1 + L_2)}$
$= 1/\sqrt{LC}$

The resonant frequency of the circuit remains, therefore, unaltered, though in practice the mutual coupling between L_1 and L_2 does have some slight effect.

As regards the dynamic resistance, the capacitance of path 1 is effectively increased, while the inductance of path 2 is effectively reduced: as in the R_D and the selectivity.

The tapping point, therefore, can be adjusted so that the tuned circuit presents the correct load impedance.

OSCILLATORY CIRCUIT. A circuit containing inductance and capacitance in series. Also called *Resonant Circuit.*

OSCILLOGRAM. The graph produced by an oscillograph.

OSCILLOGRAPH. A device for obtaining a visible representation of the oscillations of an alternating current, which are transmitted in the form of reflected light rays to a screen. (See also *Cathode-ray Tube.*)

OSCILLOTRON. Another name for Oscillograph.

OUTPUT TRANSFORMER. It is a prevalent idea that an improvement follows the fitting of a new speaker. Any speaker will function with an efficient receiver *provided that it is connected in a suitable manner.* This is because any valve operates most efficiently when the impedance connected in its anode circuit is of a fairly critical and definite value; this value is called the "Optimum Load," and is measured in ohms.

It is evident that a speaker of different impedance could not be employed for each type of output valve, and therefore some simpler system must be devised. A transformer can be used to "step-up" or "step-down" A.C. voltages, and it is this instrument which is used for the purpose under discussion. If the optimum load required by any valve is known and also the impedance of the speaker to be used with it, a particular transformer ratio can be found with which the valve and speaker will be matched. In the case of a moving-coil speaker the correct ratio is obtained by dividing the optimum load by the speaker impedance and taking the square root of the answer. Stated mathematically, the formula is:

$$\text{Ratio} = \sqrt{\frac{\text{Opt. Load}}{\text{Sp. Imp.}}}$$

As an example, suppose a 7-ohm speaker

is to be used with a power valve such as the well-known 41 MP., having an optimum load of 2,600 ohms. The correct transformer ratio would be $\sqrt{\frac{2600}{7}}$ or approximately $\sqrt{400}$, which is, of course, 20 (to 1).

To use Figs. 344 and 345, first find the optimum load on the horizontal ordinate and take up the vertical line to meet a horizontal one drawn from the position on the vertical ordinate which corresponds to the speaker impedance. The correct transformer ratio is given by the inclined line passing through (or near) the point of intersection. The lines corresponding to the example given above are shown on the graph. In the case of moving-iron and vibrating-reed speakers (most types of cone or balanced-armature instruments come within this class), the calculation is rather different, because the impedance of such speakers increases very rapidly with increase of frequency. To allow for this, "Half the Optimum Load" is substituted

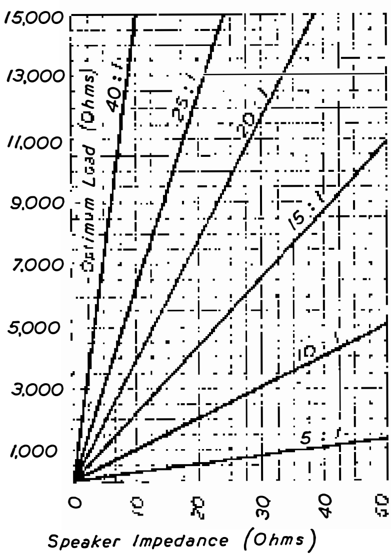


FIG. 344. *Graph for moving-coil speaker.*

in the above equation. The formula thus becomes :

$$\text{Ratio} = \sqrt{\frac{\text{Half Opt. Ld.}}{\text{Sp. Imp.}}}$$

To take another example, suppose one wishes to use a valve like the small power, having an optimum load of 11,000 ohms with a 2,400-ohm balanced armature speaker. The transformer ratio should therefore be $\sqrt{\frac{5500}{2400}}$ or approximately 1·5 : 1. This is shown on the graph in Fig. 345, from which other ratios can

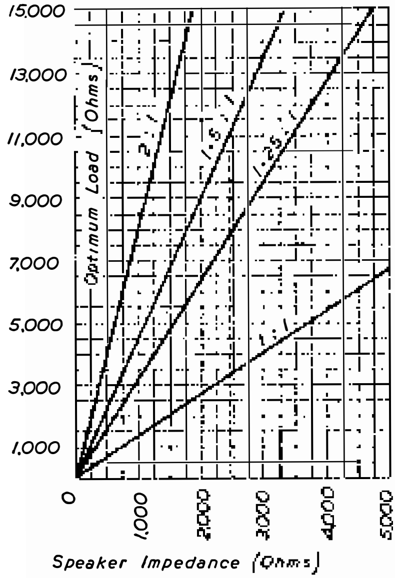


FIG. 345. *Graph for moving-iron speaker.*

be obtained for any particular valve and speaker. Both graphs are equally applicable to either three-electrode or pentode valves, and they provide a very convenient "ready reckoner."

Some manufacturers do not state the optimum load of their valves, but in these cases it will be sufficiently accurate to take it as being twice the A.C. impedance except for pentodes, where no definite ratio exists between optimum load and impedance.

When dealing with moving-iron speakers, their impedance at about 250 cycles should be considered and not their D.C. resistance. Here again one is up against a difficulty, because some makers state only the D.C. resistance of their products. In such cases the impedance can be taken as being one and a half times the resistance. It is safe to assume the impedance of moving-coil speakers to be twice the D.C. resistance when the latter factor only is known.

So far the ratio for output transformers connected as shown in Fig. 347 has been considered, but the same rules apply when a tapped choke is used with a condenser to feed the speaker. The latter arrangement

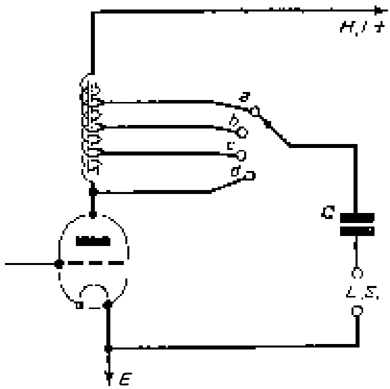


FIG. 346. *Choke-capacity output.*

is illustrated in circuit form in Fig. 346. The tapped choke serves the purpose of what is generally referred to as an "auto-transformer," and gives a step-down of voltage in exactly the same way as does a transformer having both primary and secondary windings.

By connecting the feed condenser C to

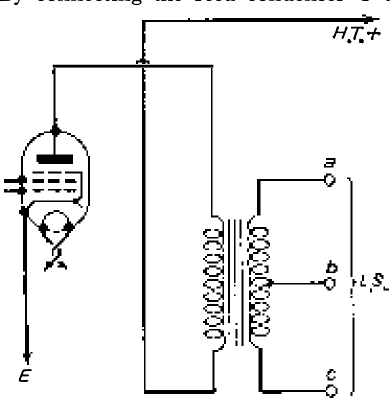


FIG. 347. *Transformer output.*

tappings *a*, *b*, *c*, and *d* in turn, a number of alternative ratios are obtained and the correct one can be chosen as explained above. When C is connected to tapping *d* the ratio is 1 : 1, but when it is taken to a centre tapping at *b* the ratio is 2 : 1. It will be clear therefore that any desired ratio can be obtained by choosing an appropriate tapping point. In practice, however, it is seldom satisfactory to employ a choke for ratios greater than about 4 : 1, so when higher ratios are necessary the transformer is to be preferred.

There are two special cases which require extra consideration. These are : (1) when two or more valves are connected in parallel to enable the output stage to handle more signal power, and (2) when a push-pull output stage is employed. In the former case the *effective* optimum load is found by dividing the O.L. of one valve by the number of valves in parallel.

In the case of a push-pull stage the effective optimum load is twice that of a single valve, since the valves are virtually in series. In other words, the optimum load of two battery P220 valves in push-pull is twice 9,600 ohms, or 19,200 ohms. It is the latter figure then which indicates the correct ratio.

If two speakers are connected in parallel, the effective impedance is halved; in series it is doubled.

OUTPUT TRANSFORMER RATIO. The following formula applies :

$$\text{Ratio} = \sqrt{\frac{\text{Valve Optimum Load}}{\text{Impedance of Speaker}}}$$

OVERTONE QUARTZ CRYSTAL. A crystal driven directly at an integral multiple of its natural frequency.

OZONOSPHERE. (See *Ionosphere*.)

P

PAGE EFFECT. The audible evidence when iron is magnetised or demagnetised, heard as a "tick."

PAINT. To leave a picture on a *long-persistence* screen by the effect of signals on a moving *timebase*, e.g. *P.P.I. display*. Also as a noun, the picture left.

PANORAMIC RECEIVER. A receiver periodically traversing a part of the R/F spectrum and displaying the amplitudes of received signals on a frequency scale.

PAPER CONDENSER. A fixed condenser having a dielectric of paraffin-waxed paper. A Mansbridge condenser. (See also *Condenser*, *Variable Condenser*, *Mansbridge Condenser*, *Billi Condenser*, *etc.*)

PARALLEL. When two circuits are so connected that current flowing divides between the two, they are said to be connected in parallel. The term "shunt" is sometimes used.

PARALLEL FEEDING. (See *Low-frequency Couplings*.)

PARALLEL GATE GUIDE. A region bounded by two parallel plates in which energy can be propagated.

PARAMAGNETIC. Having the property of being attracted by the pole of a magnet, and hence, when suspended or placed freely in a magnetic field, of taking a position parallel to the lines of force. Opposite to *Diamagnetic* (*which see*).

PARAMETER. Where there are three variables, any one of them, called the parameter, may be given a series of fixed values, and two-dimensional curves may then be drawn to show the relationship between the other two variables.

PARAPHASE. A special form of push-pull amplification in which the usual centre-tapped transformer is not used. A second input voltage 180° out of phase with the normal input voltage is obtained by means of a paraphasing valve. The grid is connected in the anode circuit of the valve preceding the push-pull stage.

PASCHEN'S LAW. Related to the length of a spark in gas and states that the required *p.d.* is constant if the product of the gas pressure and the maximum spark length is kept constant.

PASSIVE ELEMENT. An aerial element energised only by radiation which it receives from one or more primary elements.

P.D. Potential Difference. The pressure in volts existing between two parts of a circuit.

PEAK. See *To Peak.*

PEAK SEPARATION (BAND-PASS TUNERS).

$P = \sqrt{\dfrac{\omega^2M^2 - r^2}{2\pi L}}$ cycles (inductive coupling). $\omega = 2\pi f$; M, mutual inductance in henrys; r, equivalent series resistance of tuned circuit; L, inductance in henrys.

$P = \sqrt{\dfrac{\dfrac{1}{\omega^2 C_m^2} - r^2}{2\pi L}}$ cycle (capacity coupling)

C_m = coupling capacity in farads.

PEAK-TO-PEAK AMPLITUDE. The amplitude of an alternating quantity, measured from positive *peak* to negative peak.

PEAK VALUE. The maximum instantaneous value attained by a waveform.

PELTIER EFFECT. That temperature rise and fall on contact between two dissimilar metals by current from applied *e.m.f.* in either direction respectively, as the metal's *thermo-electric e.m.f.* when heated. The coefficient is that energy emitted or absorbed per sec. when unit current, caused by external *e.m.f.*, passes through the junction, this being numerically equal to the *p.d.* at the junction in *electro-magnetic units.* The effect alters or varies according to temperature.

PENTAGRID. The American term for a 7-electrode valve or Heptode. The electrodes consist of cathode, anode, and five grids, and the combination is designed to function as a combined first detector and oscillator in a super-heterodyne receiver. The coupling exists only as an electronic stream. One grid and the anode act as in the ordinary first detector, whilst the remaining grids are employed as oscillator, oscillator anode and screening grids.

PENTODE. The five-electrode valve. (See also *Valve.*)

PERIKON DETECTOR. A crystal detector consisting of zincite in contact with copper pyrites.

PERMANENT ECHO (P.E.) A radar *echo*, at a fixed station, due to any fixed object.

PERMEABILITY (symbol μ) is the ratio of magnetic flux produced by a magnetic force to the magnetic flux produced by the same force in a vacuum. (See also *Iron-core Coil.*)

PERMEABILITY TUNING. Method of tuning by varying the inductance of the coil. This is effected by employing an iron core and moving either the core or the coil in relation to each other. Constant selectivity is obtained by such a scheme.

PERMEANCE. The reciprocal of reluctance (*which see*).

PERMITTIVITY. The ratio between the capacitance of two conductors, when surrounded by the medium, to the capacitance in a perfect vacuum.

PERSISTENCE. The quality of slow decay of the *trace* in a cathode-ray tube.

PERVEANCE (of a Diode). The ratio of the current to the three-halves power of the applied anode voltage.

PHANTASTRON. A valve *relaxation circuit* of the *transitron* type in which the time-constant of the charging circuit is increased by the Miller effect, and the necessary feedback for cyclic operation is obtained by means of a resistance in the cathode circuit.

PHASE. The difference between two identical oscillating currents at any instant is known as the phase difference. If one oscillating current is at zero and another is at maximum, the phase difference is 90°. If both currents are at the same value, they are in phase.

PHASE FACTOR. Expressed as a vector, that quantity by which a maximum *e.m.f.* must be multiplied with an attentuation factor to find the *e.m.f.* on any part of a wave sent along a conductor.

PHASE INVERTER. A stage used to reverse the polarity of a signal.

PHASMAJECTOR. An image emitter providing a standard video signal source to aid television experiments. Actually a "television tuning-in" signal emitter.

PHON. The unit of loudness arrived at by the Ministry of Transport. Some idea of the phon can perhaps be obtained from this noise chart:

Phons—
130—Threshold of feeling or pain.
110–120—Vicinity of aeroplane engine.
105–110—Vicinity of pneumatic drill.
100–105—Vicinity of loud motor horn.
90–95—Interior of tube train, windows open.
80–85—Interior of express train, windows open.
60–75—Conversation (average to loud).
40–50—Quiet street.
20–30—Quiet country house.
0—Threshold of audibility.

(See also *Bel*, *Decibel*, *Neper*, and *Acoustic Watt*.)

PHONES. Telephones.

PHONOVISION. An adaptation of noctovision. Electric current variations are made to operate a special pick-up which makes grooves on a record. A pick-up is used in conjunction with copies of the record, and operates a neon lamp.

PHOTICON. A special television camera. See also *Emitron* and *Orthicon*.

PHOTO-ELECTRIC CELLS. The structure of photo-electric cells is similar to that of thermionic radio diodes, both consisting principally of two electrodes, cathode and anode. The cathode is the electron source; the anode the recipient.

In some designs the cathode consists of a half-cylindrical or rectangular form of suitable metal coated with a specific photo-sensitive material deposited upon the interior of the glass bulb. The anode usually consists of a single rod or rectangular nickel loop, assembled centrally in respect to the cathode. This electrode must be kept extremely small in area compared with that of the cathode, so enabling the even distribution of a substantial amount of radiant energy to the photo-sensitive surface.

Principle Involved. Bearing this in mind, the principle of the photo-electric cell can be understood by referring to Fig. 348 and studying the following description.

If the cathode is subject to a radiated light and the anode is operated at positive potential, an electron current will flow in the anode circuit.

Discovery of this phenomenon was the result of experiments by Hertz in 1887. It can be linked closely with thermionic emission, but a difference is that the latter depends upon temperature, whereas photo-electric emission is the result of light or radiated energy being directed upon a photo-sensitive surface to cause a flow of electrons. These electrons, as in the radio valve, are attracted towards the anode and set up an electron current, the amount that flows depends upon the wavelength, intensity and the colour of the impinging light. From this it will be seen that the sensitivity of any cell depends greatly upon these factors; therefore, cells are designed to operate from

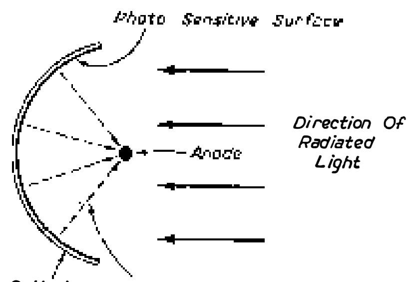


FIG. 348. *The principle of the photo-electric cell.*

different colours of light, this by using different photo-sensitive materials upon the cathode.

Sensitivity Terms. The sensitivity usually is stated in terms of visible radiation, although at various times it is given in microamperes per microwatt of radiant flux; this includes visible radiation, such as light, and invisible radiation, viz., ultra-violet and infra-red. Visible radiation is stated in microamperes per lumen of light flux, which can be defined as the amount of light or radiant energy emitted per unit space angle per second by a source whose intensity is one international candle.

Commercial Designs. Typical designs of photo-electric cells manufactured by the the G.E.C. are shown in Figs. 349 and 350. Those shown in Fig. 349 have a rectangular-shaped cathode and a rectangular wire loop for the anode. By carefully studying these cells it will be seen that the anode area is considerably smaller than that of the cathode.

Fig. 350 shows other types manufactured by the G.E.C. The KMV6 and CMV6 have a cathode in the form of a rectangular plate, centrally sealed in the bulb and brought out to the screw terminal at the top. The anode in these types is a wire mesh covering the internal surface of the bulb and brought out to the anode and grid pins of a standard four-pin base.

The Osram KG7 has a sensitised potassium cathode and is suitable for use in the blue end of the visible spectrum, particularly in the range 4,000 to 5,000 Ångström units. An angstrom is the unit used for expressing the wavelength of light and ultra-violet radiation, i.e. one angstrom equals 10^{-8} centimetres. This cell, therefore, can be used for the detection or measurement of radiation from the already specified end of the spectrum. It is well to mention, however, that the sensitivity of this cell can be secured by increasing the positive potential, though extreme care must be taken not to exceed the value laid down by the manufacturer, otherwise a glow discharge will result and so ruin the cell. Glow discharge is discussed more fully

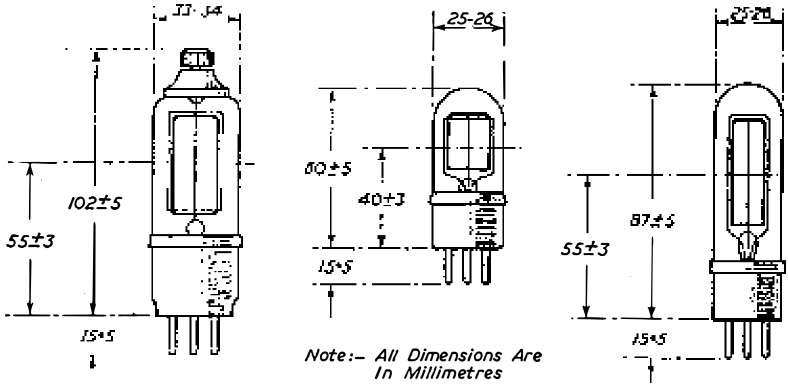


FIG. 349. *Typical designs of photo-electric cell having a rectangular-shaped cathode and rectangular wire loop for the anode.*

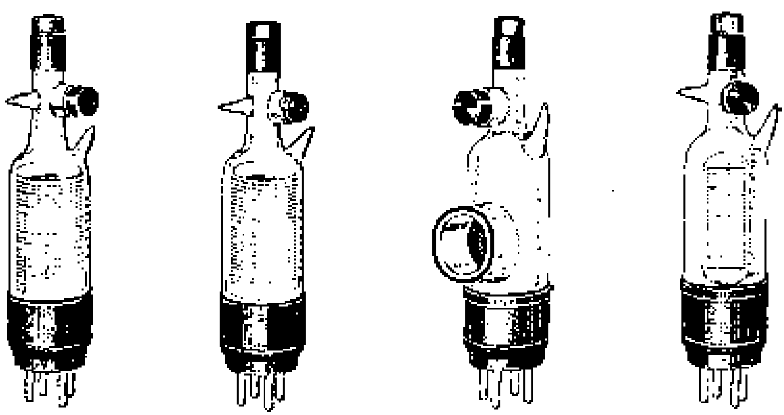


FIG. 350. *Photo-electric cells having a cathode in the form of a rectangular plate centrally sealed in the bulb and brought out to the screw terminal at the top.*

later in this section but it is desirable to mention at this stage that if a gas discharge is allowed to pass for a few seconds the cathode surface will be destroyed.

Curves: Figs. 351 and 352 are typical curves published by photo-electric cell manufacturers. These two curves apply to the Osram KG7 and are self-explanatory. The curve shown in Fig. 351 indicates the gas factor in relation to the applied potential, whereas Fig. 352 shows the average spectral sensitivity curve for an even distribution of radiated energy upon the photo-sensitive surface.

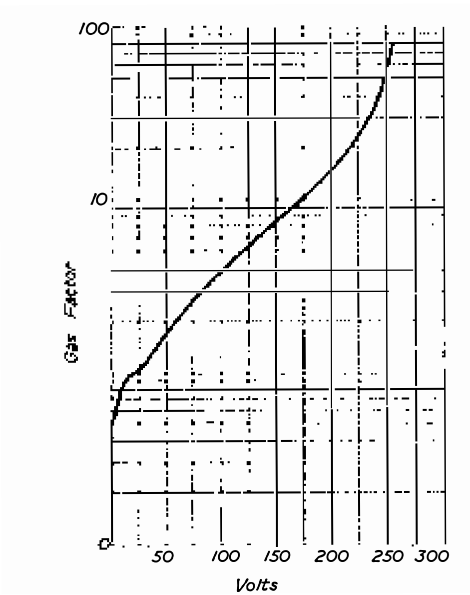


FIG. 351. *Average voltage-current characteristic for Osram type KG7.*

Photo-electric cell KG7 has an anode in the form of a rectangular wire loop. This is sealed centrally with respect to the cathode, which is deposited upon the interior surface of the bulb. By studying the KG7, it will be noted that the cathode covers the interior of the bulb, with the exception of a small clear window which is necessary to enable the radiated energy to reach the cathode without being obstructed by the anode.

Vacuum and Gas-filled Types. Photo-electric cells are made in two distinct groups, namely the vacuum and gas-filled types. The latter were designed originally for sound reproduction, but because of their sensitivity they now are used in many types of relay circuits.

The former type is found in such equipments as the light-operated relays, photometry, colour comparison work and television. This type of cell responds to specific colours in the spectrum, whereas the gas-filled type usually covers a different part of the spectrum.

The presence of an inert gas, such as neon, argon or helium, enables the cell to pass more current for a specified amount

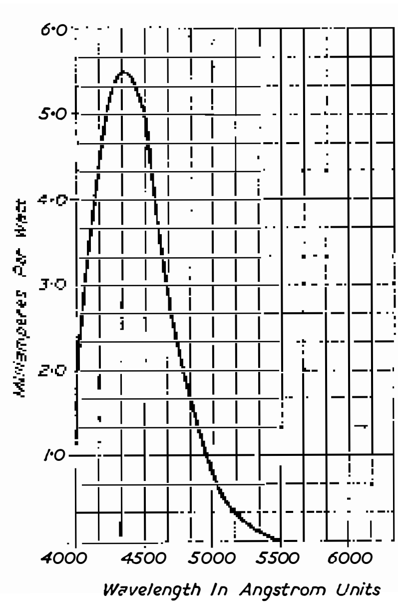


FIG. 352. *Average spectral sensitivity curve.*

of radiated light, thus increasing the sensitivity of the cell.

It is easier to understand why this is so by referring to radio valve practice, where is established the fact that a gas-filled rectifier passes more current than a vacuum type. The reason for this is well known and can also be attributed to the photo-electric cell, as the presence of gas results in a production of ions which cause the cathode electron emission to increase. This phenomena can be explained as the breaking down of the gas molecules by the impact of electrons from the gas molecules—by collision—leaving them positively charged, in which condition they act as conductors of electricity.

Blue Glow. Extreme care should be taken when applying the potential to the anode as excessive voltage will result in a gas discharge, recognisable by a definite blue glow. This glow or discharge is detrimental to the cell and unless the correct ratings are adhered to, permanent destruction of the cathode surface is inevitable. It is well to remember, however, that this discharge should not be confused with the ion production necessary in this type of cell.

In comparison with the vacuum type of cell, the vacuum cell is less susceptible to damage when an accidental overload of anode potential is applied for a short period. Naturally, however, it will destroy the cell if kept on for too long a period.

Applications. The applications of photo-electric cells are many and are well known to those engaged in the radio or electronic industry. Cells today are used for various purposes, such as burglar alarms, smoke detectors, alarm systems, race-track indicators, photometry, television and acoustics, etc. However, whatever the application of any particular cell, the principle is the same. That is by the interruption of the impinging light that is being directed on to the cathode surface a relay comes into operation and either stops or starts the equipment that it controls.

Sound Reproduction and Acoustics. Another application which has become extremely popular in the last few years is to sound reproduction and acoustics. A typical circuit is shown in Fig. 353 and the specific component values are shown below.

C1 C2 = 2 microfarad	V1 = Osram H63
C = ·01 "	V2 = Osram L63
C4 = ·002 "	
C5 = 4 "	
C6 C7 = 50 "	
R1 = 150,000 chms.	R7 = 100,000 chms.
R2 = 50,000 "	R8 = 5 "
R3 = 100,000 "	R9 = 2,000 "
R4 = 25,000 "	R10 = 1 "
R5 = 50,000 "	R11 = 2,000 "
R6 5 "	R12 = 50 "

Suitable photo-electric cells for this type of circuit are the Osram CMG8, CHG22 or CMG25. These cells, when operated at an anode potential of 20 volts, produce photo-electric current more or less proportional to the radiated energy being directed upon the cathode surface. At higher voltages the ratio of the current to the radiated energy increases in respect of the voltage, due to the presence of gas in this type of cell. To prevent a gas discharge taking place in such cells it is recommended that the gas magnification should be in the order of 10. Gas magnification is the increase over the primary photo-electric current, this primary current being the amount obtained when the cathode emission is more or less proportional to the radiant energy. The excess of the gas magnification value results in a gas discharge, a phenomenon already explained.

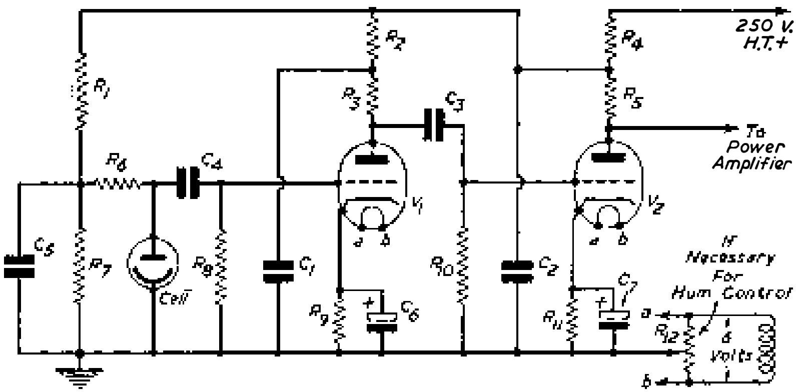


FIG. 353. *Circuit for photo-cell used on sound head amplifier.*

Sensitivities. The sensitivity of the

CMG8, CMG22 and CMG25 exceeds 75 microamps per lumen, the working voltage lying between 80 and 110 volts. It is a good practice when using gas-type cells to incorporate a high resistance in the circuit in order to try to prevent a gas discharge; this resistance will avoid any increase in working volts. Photo-electric cell sensitivities are stated by all manufacturers, who also indicate under what conditions they are taken, as well as the anode potential applied.

Local sensitivity must always be avoided, this usually resulting from insufficient distribution of the radiated energy upon the cathode surface.

Television Cells. An application that is coming back into great vogue is that to television. The cell here is an essential link in the transmission of pictures, its purpose being to convert the light impulses (radiant energy) into electric currents in such a way that, when these currents are received by the television receiver, they are reverted back into the original light impulses and so form the transmitted picture.

Gas-type cells are not recommended for television transmission because they are most reluctant to change their state of rest; this will be appreciable at the very high frequencies that are found in television. It is, therefore, necessary to utilise the vacuum cell for this application, it being essential that the cell selected have a large cathode area.

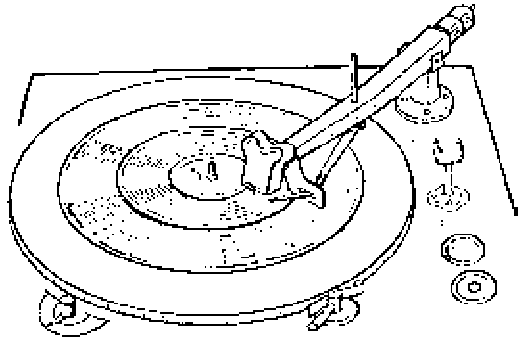


FIG. 354. *The recorder as a reproducer. The tracking arm is out of action, and weights are placed on the back of the arm.*

PICAFARAD. $\mu\mu F$. A micro-microfarad = ·000,000,000,001 farad.

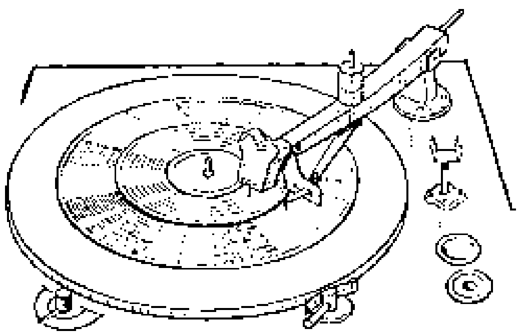


FIG. 355. *The recorder in process of cutting a record.*

PICK-UP, GRAMOPHONE. (See *Gramophone Pick-up.*)

PICK-UP, RECORDING. In order to made gramophone records, a wireless set and a special recorder are needed.

The simplest discs for the beginner are

made of aluminium, and are 6 in. in diameter, but they play for as long as an ordinary 10-in. record.

Fig. 355 shows a very simple home-made recorder mounted on the motor board of a gramophone, and in process of making a record. As can be seen from the illustration, the apparatus consists of a pick-up mounted on a long wooden arm. Fixed to the latter is a small brass arm terminating in a needle holder. To make a record, a tracking disc is placed on the gramophone turntable. (The tracking disc is simply an ordinary record with grooves, but with no sound waves impressed on them.) On top of this is placed an aluminium blank, which is smaller than the tracking disc by about 2 in. all round. A special hard-steel needle is fitted in the pick-up, and a special reproducing needle is fixed in the tracking arm. The pick-up is connected to the output terminals of a wireless set tuned to good loudspeaker strength, the turntable released, and the point of the cutting needle placed about $\frac{1}{8}$ in. from the edge of the aluminium disc. The needle in the tracking arm runs on the tracking disc, making the pick-up arm move towards the centre of the record. Thus the cutting needle makes a spiral groove on the aluminium similar in pitch to the groove on the tracking disc. The speech or music from the wireless set, however, causes the needle in the pick-up to vibrate sideways in the same way as the armature of a loudspeaker. Thus the groove in the aluminium is modulated with minute waves corresponding to the original broadcast.

The record is now cleaned to remove the small pieces of metal which have been left by the cutter. By fitting a fibre needle to the pick-up and connecting the latter to the pick-up terminals of the set the record can be played in the same way as a commercial one.

The Construction. The single recorder may be made as follows: Make the arm first out of a 13-in. length of $1\frac{7}{8} \times \frac{7}{8}$-in. oak. Fig. 356 shows how to mark and cut the wood. Take great care, in cutting the narrower end of the arm, to get the angles of the face correct, as the accuracy of the tracking depends on this.

Fig. 359 gives an enlarged view of the face, and should make the dimensions quite clear.

The thickness of the arm is decreased from $\frac{7}{8}$ in. to $\frac{3}{4}$ in. from the bend to the smaller end, as can be seen in Fig. 356. Round off the top of the arm with chisels and sandpaper to give the apparatus an elegant appearance. Along the centre of the underside cut a channel $\frac{1}{4}$ in. wide and $\frac{3}{16}$ in. deep to hold the flex lead to the pick-up. Drill a $\frac{1}{8}$-in. hole horizontally through the arm $1\frac{3}{4}$ in. from the wider end and $\frac{1}{2}$ in. from the bottom.

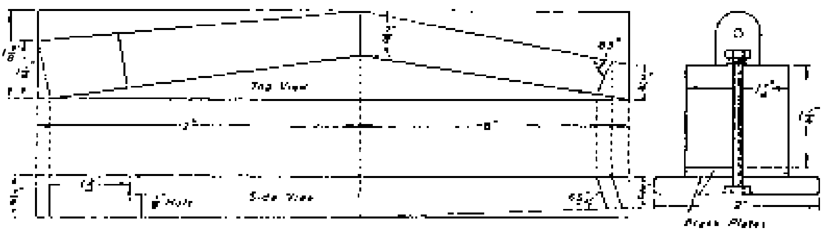


FIG. 356. *Showing how to make the pick-up arm.*

The Pivot and Base. The pivot and base for the arm come next, a section of which is shown in Fig. 356. Cut a 2-in. circle in $\frac{1}{4}$-in. oak for the base and drill a $\frac{3}{16}$-in. hole through the centre. Also drill three equidistant $\frac{1}{8}$-in. holes around the edge of the base about $\frac{3}{16}$ in. Now obtain a round piece of oak or other hardwood for the pillar, $1\frac{1}{4}$ in. in diameter, and $1\frac{1}{4}$ in. long. Drill a $\frac{3}{16}$-in. hole down the centre of this, using a bench drill if one is available, as it is very important to keep this hole upright. Cut two $1\frac{1}{4}$-in. circles from 18 gauge sheet brass, using a coarse metal fretsaw for the job. Drill $\frac{3}{16}$-in. holes also through the centre of each of these, and also two $\frac{3}{32}$-in. holes as shown in Fig. 357. These latter are countersunk. Screw one of the brass discs to the oak base, making the centre holes coincident, and fix the other to one end of the oak pillar. Make sure that the screw heads are sunk well below the brass, as the two surfaces have to run over one another.

The fork on which the arm pivots is

made by bending a ½-in. strip of stiff brass to the shape shown in Fig. 358. Drill the holes as indicated, and screw the fork on to the top of the pillar, using round-headed brass screws.

On the end of a 2-in. length of 2 B.A. threaded rod screw a nut and solder it in position. Push the rod through the oak

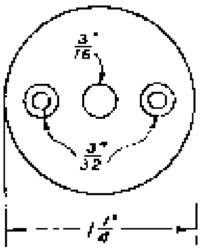


FIG. 357. *Bearing discs for the pick-up.*

base, after having chiselled a recess for the nut. Now slip on the oak pillar complete with the brass fork. Put a spring washer and a nut on the top of the rod, and tighten up sufficiently to prevent any play, but allowing the pillar to revolve freely. A trace of petroleum jelly between the brass faces will act as a lubricant. Mount two small brass terminals on the base for the pick-up connections.

The Pick-up. A pick-up will now be required. If it is mounted on an arm remove the pick-up and fix it to the wooden one just constructed, for the recorder will play commercial records just as well as an ordinary pick-up and arm. If a pick-up has to be purchased one can be obtained without an arm quite cheaply. The method of fixing depends on the type one pos-

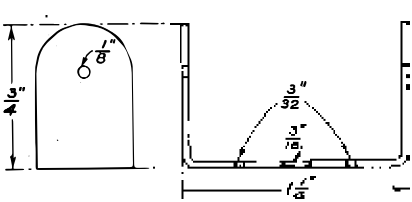


FIG. 358. *The brass fork for pivoting the pick-up arm.*

sesses. The one illustrated is a typical model and is fixed by means of a brass bracket; most others can be fixed in the same way. Make a bracket to fit the smaller end of the arm. Fig. 361 will give the idea. Leave two flanges and drill two $\frac{3}{32}$-in. holes in each for screws to fix into the sides of the arm. The pick-up is fixed to the front of the bracket by two small nuts and bolts passing through the back plate of the pick-up. Screw the bracket tightly to the arm.

The Tracking Arm. The parts for the tracking arm are shown in Figs. 360 and 361. Cut the fixing plate and arm from 18 gauge brass, and drill the holes indicated. The arm is bent approximately as in the sketch and bolted to the fixing plate. Screw the latter to the underside of the wooden arm, so that the ends of the tracking arm come level with the needle holder of the pick-up.

Now obtain the needle holder from an old sound box, and cut it off with a hacksaw as in Fig. 362 (top). Solder it to the end of the tracking arm.

The distance plate (Fig. 360) is cut from 22 gauge brass. Drill three $\frac{3}{32}$-in. holes as shown, and bend the "tabs" back at right angles. The plate is fixed to the pick-up arm by these, just behind the pick-up.

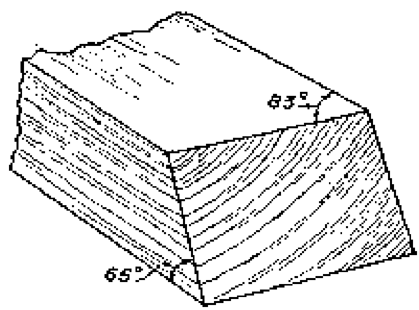


FIG. 359. *The end of the arm is cut as shown here.*

The position of the slot in the plate is dependent on the size and shape of the pick-up, but Fig. 362 shows how to determine it. When the tracking arm is passed through the slot and locked at *x*, the distance between the cutting and tracking needle must be 1¾ in. Cut the slot with a metal fretsaw. The device for locking the tracking arm tightly in position in the slot consists of a cam, fixed just above the arm on a distance plate. When the cam is pushed over towards the pick-up, it presses on the arm, preventing it from moving while a record is being made. The arm can be released and slid to *y* when the recorder is being used for reproducing purposes.

The cam is cut from 18 gauge brass and a $\frac{3}{32}$-in. hole drilled in it, as in Fig. 362.

Fix the cam to the distance plate with a nut and bolt, using a lock nut to prevent it coming undone.

Assembling the Recorder. The recorder can now be put together for a test. Fix the pick-up arm to the pivot by pushing a thin piece of steel wire through it and the brass fork. The wire should be thin enough to allow a little play. Solder the ends of the wire in place in the holes in the fork. It will be found necessary to cut a recess in the underside of the wooden arm to make room for the nut and washer on top of the pillar (see Fig. 363). Just behind the pick-up drill a $\frac{3}{16}$-in. vertical hole through the arm to take the pick-up lead. A small eyelet is pushed in the top of the hole to make it look neat. Bring the lead through the hole and along the groove underneath the arm. Keep it in place by screwing on small brass plates at intervals. Take the lead through the base and solder the ends to the terminals. Chisel two shallow grooves in the bottom of the base, so as to sink the wire below the level of the wood. A piece of green baize glued on the base will protect the leads from damage.

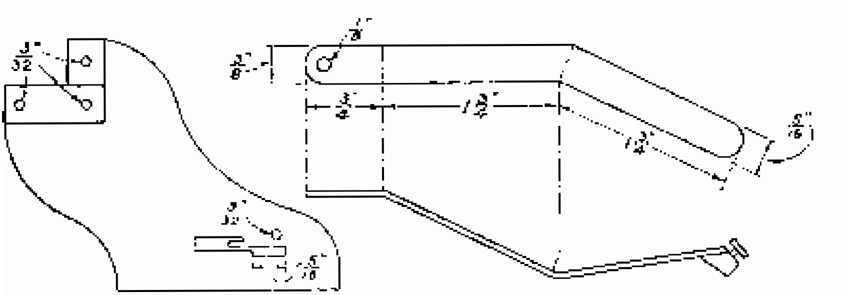


FIG. 360. *Tracking arm and distance plate.*

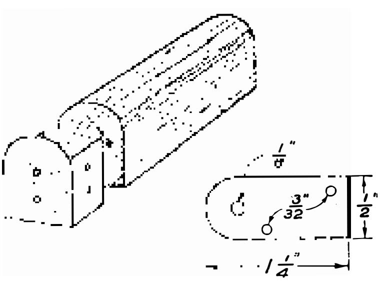


FIG. 361. *Brass bracket for fixing pick-up on end of arm, and fixing plate for tracking arm.*

The Weights. In a piece of $\frac{5}{8}$-in. oak drill a 1-in. hole, and in a small piece of 3-ply fix a piece of $\frac{3}{16}$-in. iron rod. Fix the 3-ply to the oak so that the rod runs down the centre of the hole (Fig. 364). This forms a mould in which to case the necessary weights for the recorder. Melt some oddments of lead pipe in a tin and cast five weights. Dust the inside of the mould with French chalk to prevent the lead sticking to the wood. Clean the rough castings with a file and emery cloth. Drill two $\frac{3}{16}$-in. holes $\frac{3}{8}$ in. deep in the pick-up arm, one in the back end, and the other on top, about 4 in. from the pick-up. Into each of these cement a $2\frac{1}{2}$-in. length of $\frac{3}{16}$-in. steel rod, and bend the back one upwards a little to prevent the weights sliding off when the arm is raised.

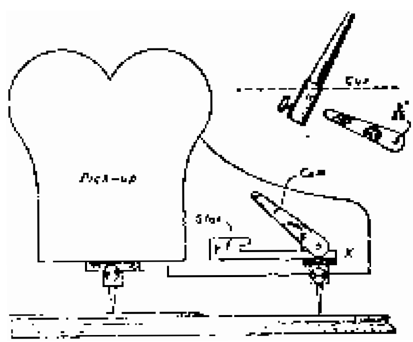


FIG. 362. *Cam for locking tracking arm.*

Recording. Mount the recorder on the motor board of a gramophone. Put a needle in the pick-up and place the point on the central peg of the turntable. Keeping the needle there, find a convenient position for the base and fasten it down with three screws, passing through the holes made for them. Fix a pick-up arm rest on the board to keep the arm raised. Place the tracking disc on the turntable, and on it an aluminium blank. Lock the latter, by giving it a slight twist in an anti-clockwise direction, when the little slots in the blank will engage with the brass studs on the tracking disc. Now put a cutting needle in the pick-up and a special reproducing needle in the tracking arm, taking care that they are locked tightly in their holders. Select a suitable item from the wireless programme to record and tune it to good loudspeaker strength. Connect the recorder across the loudspeaker, and if the pick-up is in working order, you will be able to feel the needle vibrating on holding your finger against it.

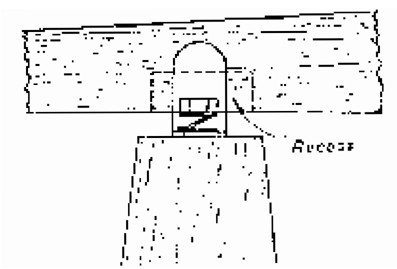


FIG. 363. *Diagram showing recess cut in the underside of arm to clear nut and washer on pivot top.*

FIG. 364. *The mould for casting the weights.*

Wind the gramophone motor fully in order to develop the maximum power (unless an electric motor is used), and place one or two weights on the upright rod nearest the pick-up. Two or more can be placed on, so long as the pressure of the cutting needle does not tend to slow the turntable. A little experimenting will show the best number to use. Now start the turntable, and when it has attained full speed, place the cutting needle on the edge of the aluminium disc. If the needle does not run smoothly, but grates as the record revolves, turning the needle round in its holder will remedy matters. The pick-up will gradually move across the record, cutting a spiral groove as it goes. Do not use the whole of one side of a blank for the first test. About ½ in. of recording should be sufficient to determine whether the first effort has been a success.

Replace the cutting needle in the pick-up with a fibre or special reproducing needle, remove the tracking needle, and transfer the weights to the back of the arm. This is to take the pressure off the needle, otherwise the rather soft point would soon wear away. On no account must a steel needle be employed on an aluminium record.

Connect the recorder to the pick-up terminals of a set, and if the pick-up is a sensitive one, it will be necessary to connect a volume control across it. Before playing the record, clean it with petrol to remove any dirt and grit. Play the record in the usual way.

To obtain the best results with the recorder, a little experience is necessary to determine the best volume at which to record and the number of weights to use, both when recording and playing the discs.

PIEZO-ELECTRICITY. The property possessed by certain substances of forming electric voltages on opposing surfaces when subjected to mechanical pressure. These voltages are of opposing kinds, giving rise to differences of potential. The best-known piezo-electric substances are quartz and Rochelle salt crystals. The latter are now widely used in microphones, pick-ups and speakers. The principle forms the fundamental basis of the Stenode (*which see*). (See also *Bimorph.*)

PI-MODE. A mode of oscillation of a *cavity magnetron* in which the oscillations in adjacent cavities are 180° out of phase.

PINCH EFFECT. Is that magnitude of the up-and-down action or motion of a *pick-up* stylus tip that is caused by the periodic variation of the included angle between the two modulated groove walls on a record.

PIP. A deflection or change of intensity, on a cathode-ray tube *display*, produced as a calibration or *range marker.*

PISTON. A movable short-circuiting plate in a *waveguide.*

PITCH. The highness or lowness of a tone. The distance from the top of one screw thread to the top of another.

PLANCK'S CONSTANT. Quanta of energy radiated when atomic electrons transfer from one state to another, assuming both to be *energy states* with electromagnetic radiation. The constant (h) is given the value of $6{\cdot}55 \times 10^{-27}$ erg second. h is usually coupled to the symbol (v) to represent the frequency of the radiated energy in *c.p.s.* That is, the frequency of the radiated energy is determinable by the relation $W_1 - W_2$, this

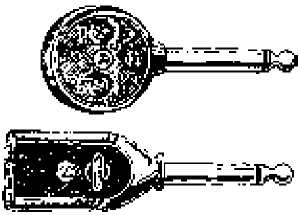


FIG. 365. *Two typical plugs.*

equalling hv. W_1 and W_2 equal the values of the internal energy of the atom in initial and final stages. Some textbooks on radio refer to this constant as the *Quantum Theory.*

PLAN-POSITION INDICATOR (P.P.I.). A radar *display* indicating, as on a map, the relative positions of all *echo*-producing objects within the range of the radar set.

PLANTE PLATES. (See *Accumulator.*)

PLATE CIRCUIT. The part of the circuit of a valve wireless receiver in which the amplified current flows.

PLIODYNATRON. A dynatron, with the addition of plates to control the negative resistance effect.

PLUG. A device used in conjunction with a jack providing two insulated contacts

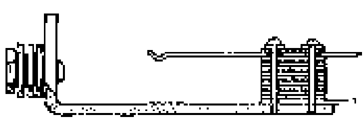


FIG. 366. *Details of a single-circuit jack.*

and hence enabling a circuit quickly to be completed or broken.

Briefly the uses of plugs and jacks are as follow :

(1) They can be used as a convenient means of plugging-in the loudspeaker—either at the set itself or at extensions in other rooms of the house.

(2) The plugging-in of the speaker can be made to switch on the receiver.

(3) They can be used as a means of cutting out the last amplifier valve.

(4) As a means of making a quick change over from speaker to phones when ether searching.

(5) The gramophone pick-up can be easily plugged-in to either detector of L.F. stage, the grid bias being automatically adjusted.

(6) They provide a quick method of connecting or disconnecting the batteries, and even the aerial and earth. (*Note.*—For this latter duty in order to reduce H.F. losses to a minimum special low-capacity jacks should be used.)

Construction of the Plug. Fig. 365 shows two popular plugs. The effective parts are the ball and stem and these are standard as regards size and shape. The only difference between one make and another is in the shape of the body or "shell" of the plug and the method of connecting the leads. Fig. 367 is a sectioned drawing showing the construction of a plug. It will

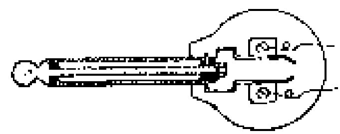


FIG. 367. *Section of plug showing construction.*

be seen that the stem is really a metal tube and that the ball is attached to the end of a rod which passes through the stem. Rod and stem are kept concentric and insulated from one another by means of an ebonite or fibre washer at each end. The rod is not surrounded with ebonite for its whole length, as this is unnecessary and would only add to the self-capacity of the plug. The rod and stem are each connected to a separate terminal or binding screw. In connecting the plug to the speaker or pick-up the two wires forming the leads are joined to the two binding screws and are thus in direct electrical contact with the ball and stem. The body

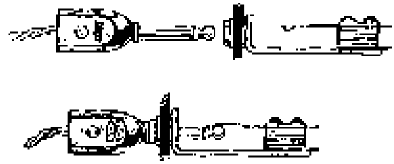


FIG. 368. *How the plug and jack are connected.*

of the plug being of bakelite insulates the hand from any of the metal parts when plugging-in.

Jacks. These vary in detail according to the particular switching they have to perform, but all comprise a socket to receive the plug and one or more insulated spring contacts. Figs. 366 and 368 illustrate a single open circuit jack. The socket which receives the stem of the plug is in the form of a metal bush which screws in to the frame of the jack and also serves as a means of fixing the jack to the panel of the set. The single spring is mounted on a pile of fibre strips which insulate it from the metal frame and at the same time hold it at just the right height to make easy but firm contact with the ball of the plug. The spring is usually of nickel or German silver.

The lower sketch in Fig. 368 shows just what happens when the plug is inserted. The stem of the plug makes contact with the frame of the jack and the ball connects with the spring. This is the simplest switching operation possible with a plug and jack. However, by the multiplication of springs in the jack, other and more varied operations can be performed. For example, the jack shown in Figs. 372 and 373 will complete *two* circuits on insertion of the plug. Here three springs are used, and if you examine the illustrations you will see that normally all three are separated from one another. When the plug is pushed home it not only makes contact with the frame of the jack and with the lower spring, thus completing the speaker circuit, but also in raising the lower spring it connects the two upper ones together. There is a little fibre peg underneath the middle spring against which the lower spring presses when it is forced upwards by the ball; thus the middle spring is also bent upward. It does not actually make contact with the lower spring because the fibre peg is an insulator, but it does connect with the upper one which has a special silver contact for the purpose.

The type of jack previously described with its metal frame and parallel springs is the most common, but is not the only variety obtainable. Notable exceptions are the Midget Jack shown in Fig. 369 and

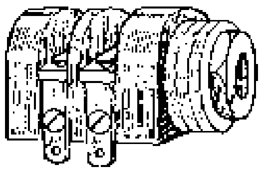


FIG. 369. *A midget jack for use in H.F. circuits.*

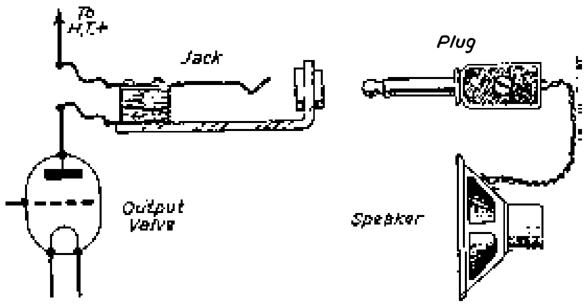


FIG. 370. *Plugging in the speaker.*

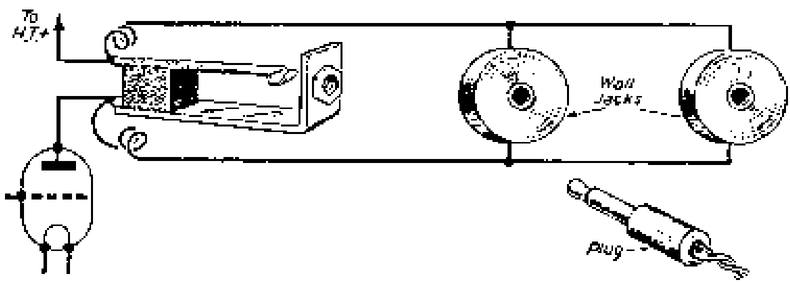


FIG. 371. *Speaker points can be arranged in different rooms by means of wall jacks.*

similar jacks of a small size. The former is specially designed for use in H.F. circuits and one type is of unusual design in that it has a bakelite frame and springs fitted with convenient terminals. Owing to the shape of the springs it does not project so far from the back of the panel, but on the other hand it takes up more room on the panel itself. Another type of jack is the wall jack shown in Fig. 371.

The first use is the provision of a quickly made speaker connection. The circuit is illustrated in Fig. 370. Instead of having two terminals marked "L.S." on the receiver, use a single open circuit jack. The two wires which would normally be joined to the "L.S." terminals are connected instead to the two tags of the jack. The plug is joined to the two leads from the speaker. A further elaboration of this arrangement is shown in Fig. 371. Here, several jacks are connected in parallel. An ordinary jack is fitted to the set and wall jacks are fitted in any rooms where the speaker is likely to be used. Good quality rubber-covered double wire or double flex should be run along the picture-rail or skirting to each point from the set, or from the set to the first point, and from there to the next one, and so on. Use whichever arrangement is most convenient, or that which requires least wire.

A very useful method of switching on a battery receiver is illustrated in Figs. 372 and 373. On plugging-in the speaker the filaments are automatically switched on. The working of the particular three-spring jack which is used has previously been described, and a further study of the illustrations should make the connections quite clear. The two upper springs are connected to the wires which normally go to the filament switch, and the lower spring and the body of the jack are joined to the wires which would otherwise connect to the terminals marked "L.S. —"

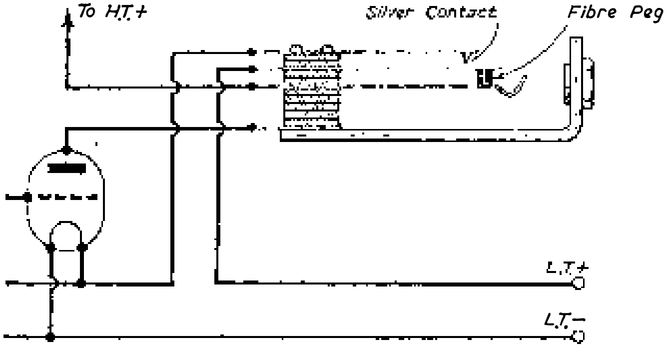


FIG. 372. *How to connect a three-spring jack so as to switch on the set when the speaker plug is inserted.*

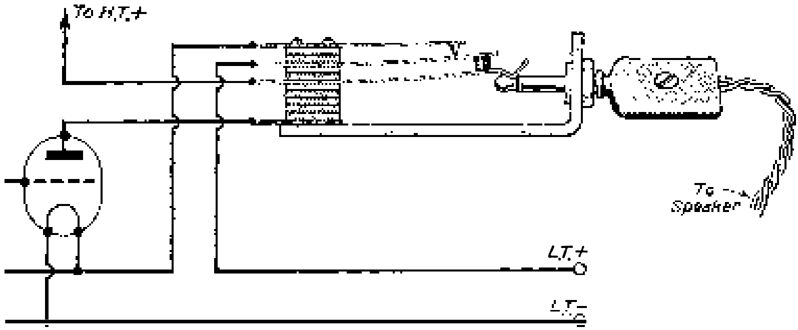


FIG. 373. *How the jack works when the plug is inserted.*

and "L.S. +" on the receiver. The plug is naturally connected to the speaker.

Fig. 375 shows how to cut out the last valve in a transformer-coupled set. The jack on the left, that is the one in the plate circuit of the first L.F. valve, is of the single, closed-circuit type. The one in the output circuit is the same type as that used in Figs. 372 and 373. When the plug, which is connected to the speaker, is inserted in the right-hand jack the receiver works in the normal way, both L.F. stages being used. On taking the plug out, the plate circuit of the output valve is broken and so is its filament circuit. If the plug is now inserted in the other jack it connects the speaker in the plate circuit of the previous valve, the upper spring connecting with the ball and the frame with the stem of the plug. The raising of the upper spring causes it to break contact with the lower one, which is connected to the primary of the L.F. transformer, and thus the transformer is cut out while the speaker is in circuit.

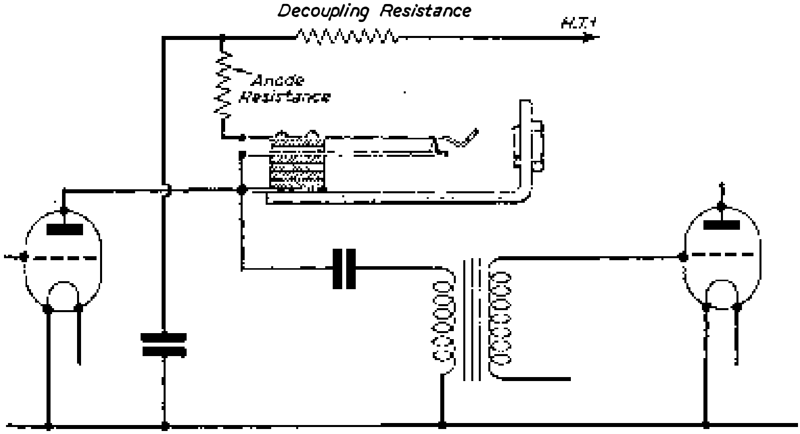


FIG. 374. *The modification necessary to the circuit in* FIG. 375 *when parrellel-fed is used.*

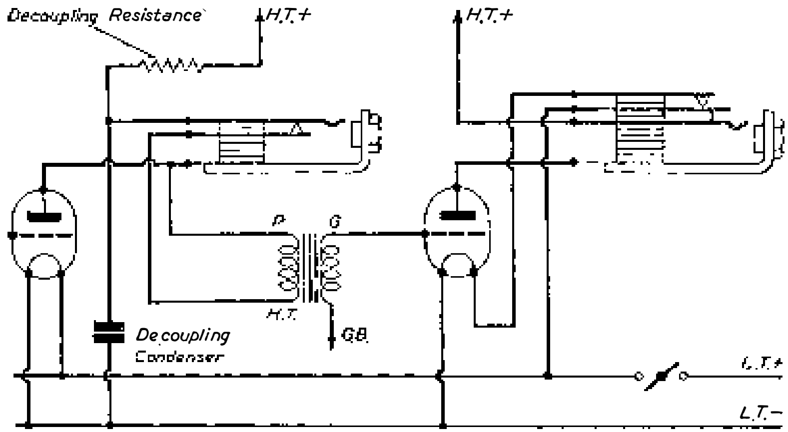


FIG. 375. *One or two L.F. stages can be used at will in this circuit.*

Phones or Speaker. Fig. 375 is the circuit to use when ordinary series coupling is employed, but in the case of a parallel feed it will have to be modified to that of Fig. 374. The resistances in the anode circuit are left connected so as not to disturb the working conditions of the valve. One advantage of the jack method of cutting out the last valve is that by fitting another

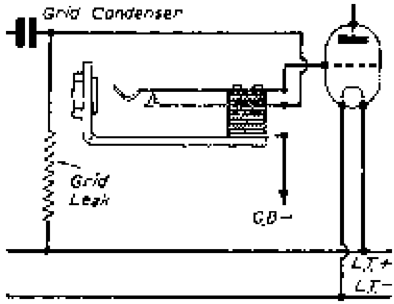


FIG. 376. *An easy way to plug in the pick-up to the detector valve of a battery set.*

plug to a pair of headphones these can be used in place of the speaker. They will very often be found useful for DX work. If necessary, a jack can be fitted in the plate circuit of the *detector* valve, and often ample strength will be provided with the phones plugged-in here. The connections would be substantially the same as those in Figs. 372 and 373.

Plugging-in the Pick-up. One of the chief drawbacks in connecting a gramophone pick-up in the detector circuit of a receiver is that the detector valve has to be biased while the pick-up is in use. Nevertheless, this can be overcome by the use of jack switching. A simple closed-circuit jack is used, as in Figs. 376 and 378. These show the connections in the case of a battery and mains receiver respectively. Grid bias is automatically applied as soon as the pick-up is plugged in. The decoupling resistance, shown in Fig. 378, is optional, and is not included in all sets. If it is not used, the connections from the frame of the jack and from the left side of the decoupling condenser are joined to H.T. –.

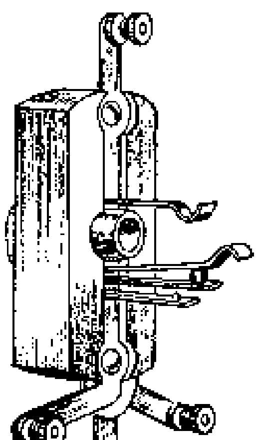


FIG. 377. *A two-circuit jack.*

Where a mains receiver employing resistances for various voltage dropping purposes is in use there are points which must receive attention. Particular reference

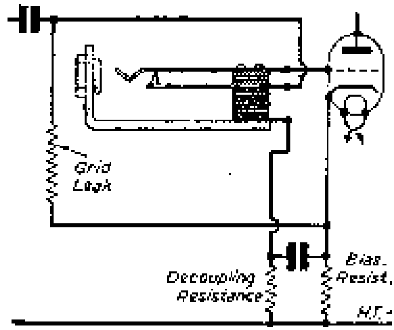


FIG. 378. *The mains version of* FIG. 376. *Note grid bias is cut out when the radio is in use.*

is made to the use of a detector valve as the valve to which the pick-up is joined. If this employs a decoupling resistance in the anode circuit, the voltage drop through this will depend upon the anode current when the valve is in use as a detector. When used with a different bias, there will be a different voltage drop in the anode circuit, and generally speaking this will be greater than when the valve is employed as a detector. It will therefore be necessary to arrange that the value of the decoupling resistance is also altered when the pick-up is plugged into circuit.

P.M.G. AERIAL. The maximum length of outdoor aerial permitted by the Postmaster-General is 150 ft., inclusive of lead-in. The maximum up to May 1937 was 100 ft. It should be emphasised that the wording on the licence refers to "the length of the effective portion of the aerial and the down-lead." A screened down-lead or a special down-lead in which a screened single-core or twin-core flexible cable is connected between the aerial and the receiver by means of impedance matching transformers is not regarded as an effective portion of the aerial and down-lead.

POLAR DIAGRAM. A mathematical term for a diagram using polar co-ordinates. Its colloquial unqualified use is deprecated.

POLAR FLUX. The magnetic field of an electric generator. The magnetic flux produced by the poles thereof.

POLARISATION. A term indicating the changing of the polarity due to bubbles of hydrogen forming on the positive plate. The internal resistance of the cell increases during this action.

POLARISATION ERROR. Error in determining the direction of arrival of radio waves by a direction-finder when the desired wave is accompanied by downcoming components which are out of phase. *Night Error* (which see).

POLARITY. (See *Accumulator.*)

POLARITY OF A MAGNET. The North Pole of a magnet is that which seeks the geographical north. It is, of course, actually its South Pole, as unlikes attract, and likes repel.

POLE-FINDING PAPER. Blotting paper impregnated with neutral salt of sodium and a trace of phenolphthalein. The paper is moistened and the two wires laid on it, when the area in contact with the negative pole turns red.

POLE STRENGTH, UNIT OF. (See *Weber.*)

POLYPHASE. When two or more circuits have a rise and fall of electromotive force which is not in step they are said to be polyphase.

POLYROD. A dielectric rod used as a *primary radiating element.*

PORTABLE ACCUMULATOR. (See *Accumulator.*)

PORTABLE SET. Any self-contained receiver which may be carried.

POSITIVE POLE. A positive pole of an accumulator or cell is that connected to the positive plate.

POTENTIAL. Any voltage above or below zero. (See also *Potential Difference* and under *E.M.F.*)

POTENTIAL DIFFERENCE. The difference in electrical pressure which exists at the ends of an electrical circuit. The voltage drop across a resistance.

POTENTIAL DIVIDER. Another name for a potentiometer.

POTENTIAL RECTIFIER. A type of crystal rectifier requiring an initial current before it becomes sensitive.

POTENTIOMETER. An instrument for measuring potential differences. It should not be confused with an ordinary rheostat or resistance, for it is shunted across the circuit. The potential difference to be measured is balanced against that produced by a current passing through a resistance.

POUNDAL. The foot-pound-second unit of force. The force which imparts to a mass of 1 pound an acceleration of 1 foot per second per second. Its equivalent in C.G.S. (centimetre-gramme-second) units is 13,825 dynes.

32·2 poundals = 1 lb. weight.

POWER FACTOR. In a D.C. circuit, power is measured as a product of current and voltage; for example, if the current through a circuit is 5 amp. and the voltage is 12, the power dissipated is 60 watts.

The same general principle applies in an A.C. circuit, but there is the important

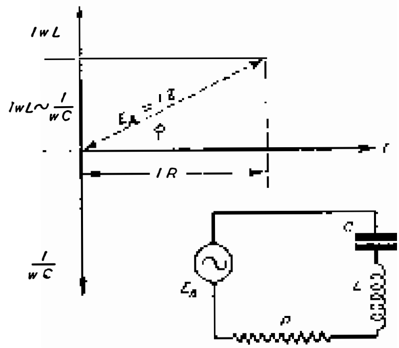


FIG. 379. *A condenser, inductance and resistance connected in series with an alternator. The vector diagram relates to the various factors in the circuit.*

difference that current and voltage are not in phase, when the circuit includes inductance and capacitance, as it generally does. And if the voltage and current are not in phase the power cannot be determined merely by multiplying the two figures together. In fact, the resultant would be simply "apparent" power; this is correctly given in terms of volt-amps.—not in terms of watts.

In order to convert apparent power in volt-amps to actual power in watts a conversion factor must be used. This is described as the power factor, and it varies in magnitude according to the constants of the circuit involved. One method of stating power factor is by the fraction R/Z (resistance divided by impedance).

In Fig. 379 a series circuit is shown, where a condenser, inductance and resistance are connected in series with an alternator. Also, in Fig. 379 is a vector diagram which relates the various factors in the circuit. Inductive and capacitive reactance are measured upward and downward from the horizontal ordinate, as are the corresponding voltages, shown as $I\omega L$ and $1/\omega C$. Since the two oppose, their difference is taken and measured off to a convenient scale on the vertical ordinate. Next, the apparent voltage IR is measured off along the horizontal ordinate. By drawing horizontal and vertical lines to complete a rectangle, we can find the true voltage (E_A) by drawing a diagonal and measuring its length.

It can now be seen that the power factor is equal to I.R. divided by IZ, or R/Z. The symbol for power factor is $\cos\theta$, where θ is the angle shown.

POWER GRID DETECTION. The essential features of this method of detection are large standing anode current, with a good, strong signal applied to the valve so as to produce a drop in current of about 15 per cent. Owing to this large anode current, it is necessary to use a valve with an impedance of between 10,000 and 25,000 ohms, and it is also impracticable to use the majority of L.F. transformers owing to saturation troubles. This means that either resistance-capacity coupling or a parallel-fed transformer must be used, and it is quite obvious that a large current through a resistance to match an impedance of the order stated will result in a very heavy voltage drop. Owing to the convenience of A.C. mains, it is possible to use 400 or 500 volts for H.T., and the drop through a suitable anode resistance still permits the valve to receive its maximum H.T. voltage. An alternative method is to use an iron-cored choke with a very high inductance value. Small values are chosen for the grid leak and condenser, usual values being ·0001 μF. and ·25 megohm. The detector circuit is otherwise standard.

POWER LEVEL. (See *Decibel* and *Phon.*)

POWER OUTPUT. This may be calculated from the formula :

$$\text{Power Output} = \frac{(\text{I max.} - \text{I min.}) \times (\text{E max.} - \text{E min.})}{8}$$

(See *Decibel*, *Neper*, etc.)

PRAGILBERT. See *Gilbert.*

PRAOERSTED. See *Oersted.*

PRECIPITATION NOISE. *Noise* generated in an *aerial* circuit generally in the form of a relaxation oscillation caused by the periodic discharge of the aerial or conductors in the vicinity of the aerial into the atmosphere.

PRE-SELECTOR UNIT. The signal-frequency resonant circuits, with which may be associated an amplifying valve, preceding the *frequency-changer* of a superheterodyne receiver.

PRESSPAHN. A proprietary insulating material manufactured from wood fibre.

PRIMARY CELL. A cell of the bichromate, Bunsen, Daniell, Leclanché, or dry-cell type, producing voltage by chemical action as distinct from a secondary cell or accumulator, which needs to have a current of electricity passed through it, a proportion of which it stores. An accumulator is a secondary cell. (See also page 2.)

PRIMARY CELLS AND SECONDARY CELLS. A primary cell is one in which energy is produced by the chemical action of bichromate and other solutions on two elements such as carbon and zinc. A secondary cell or accumulator will merely *store* an electric current.

PRIMARY CIRCUIT. Any circuit which supplies current to another.

PRIMARY RADAR. The case of radar in which the distant object is passive.

PRIMARY RADIATING ELEMENT. One element of an *aerial* at which radiated energy leaves the transmission system.

PROBE. A conductor, normally a straight rod, projecting through but insulated from the wall of a *waveguide*, for the purpose of coupling to an external circuit.

PROTON. The positive electric charge in an atom; this is neutralised by the negative ions. The fundamental unit of positive electricity. Its mass = $1{\cdot}66 \times 10^{\cdot 24}$ grammes.

PULSATOR. An interrupter or buzzer. (See *Interrupter* and *Buzzer.*)

PULSE. A variation in the value of some quantity as a function of time such that the value departs from a given datum for a time interval and then returns to this datum for a much longer time interval.

PULSE AMPLITUDE. By a process of successive approximation a rectangle is drawn on the graph of a pulse envelope, with its base on the horizontal (time) axis, in such a way that its vertical sides are bisected by the pulse envelope, and that its area is equal to the area under the pulse envelope. The height of the rectangle is known as the pulse amplitude. (Based on R.E.S.P.C. definition.)

PULSE-AMPLITUDE MODULATION. A form of *pulse modulation* in which intelligence is conveyed by varying the amplitude of successive *pulses.*

PULSED-CARRIER MODULATION. Modulation of a pulsed carrier. Pulse modulation.

PULSE-FORMING NETWORK (or CIRCUIT). A network or circuit which serves to produce a *pulse* of the required waveform.

PULSE-FREQUENCY MODULATION. A form of *pulse modulation* in which intelligence is conveyed by varying the pulse-recurrence frequency.

PULSE-LENGTH MODULATION. A form of *pulse modulation* in which intelligence is conveyed by varying the duration of successive *pulses.*

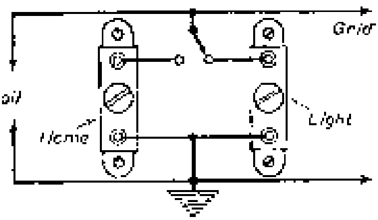


FIG. 380. *Selecting pre-set condensers by means of a change-over switch, for automatic tuning.*

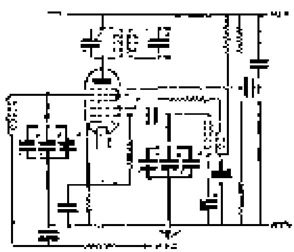


FIG. 381. *In a modern superhet, two tuned circuits may be automatically switched by using two or more pre-sets on the lines shown in* FIG. 380.

PULSE-POSITION MODULATION. A form of *pulse modulation* in which intelligence is conveyed by varying the time interval by which successive *pulses* are displaced from their normal times of occurrence.

PULSE-SHAPING NETWORK (or CIRCUIT). A network or circuit which makes the waveform of a *pulse* applied to the network approach the desired form.

PUSH-BUTTON TUNING. A system wherein station selection is accomplished by pushing button indicators instead of turning a tuning condenser. There are two systems, one of which causes fixed condensers to be included in the circuit and thus to tune to the desired station, and that in which an electric motor is set in motion when the button is pushed. This motor rotates the tuning condenser and it is automatically stopped at a predetermined setting. A large number of buttons may be used and provided with name plates for the most easily received stations on the receiver. The circuit may be fitted with A.F.C. to overcome any slight loss introduced by the motor failing to turn the condenser to the exact setting. (See Figs. 380 to 382 and *Automatic Tuning.*)

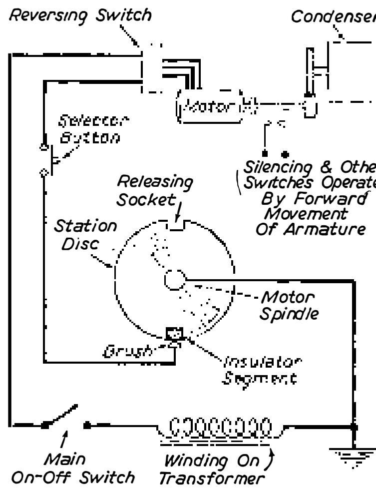


FIG. 382. *Some forms of automatic tuners are motor driven, the basic principle being as shown here.*

PUSH-PULL CIRCUIT. Fig. 383 shows that the coupling of the penultimate stage is by transformer, the secondary of which feeds the grids of two power valves, G1 and G2, in opposite phase, i.e. when the one swings positive the other is negative. The centre of the said secondary is tapped and goes to earth via the grid-bias battery B, which supplies the required bias to both G1 and G2 alike. The anodes of the valves A1 and A2 connect to the terminals of the primary of the transformer, and the H.T. is supplied by centre tapping T.

Firstly, it will be noted that the constant component of the H.T. current is divided and flows equally and in opposite directions round the two halves of the O.P. primary winding. It consequently has little or no effect as inducing magnetisation in the core; and the transformer core is normally without field. Under these conditions the effective inductance is about double or treble. This results in the

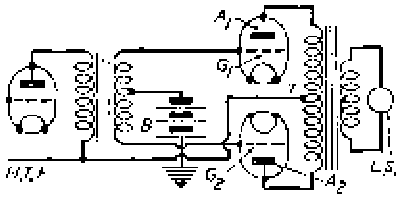


FIG. 383. *Diagram explaining the push-pull circuit.*

low frequencies being more fully transmitted.

Secondly, since one of the power valves is taking more H.T. current when the other takes less, the draft on the H.T. battery is almost constant.

Thirdly, distortion is very greatly reduced; the valves being in opposite phase result in the two correcting one another.

Two valves coupled in push-pull will give far more output. (See also *Class A*, *Class B*, and *Class AB*.)

PYRITES. Mineral disulphide of iron. Chemical formula FeS_2.

PYRON DETECTOR. An iron pyrites crystal. A copper cat's whisker should be used in connection with it.

Q

Q CODE. (See abbreviations, page ix.)

Q.S.A. CODE. (See abbreviations, page x.)

QUARTZ CRYSTALS. Often described as piezo-electric crystals—must not be confused with the detecting or rectifying crystals used for receiving purposes. They are entirely different in every respect, and the name piezo-electric means pressure-electric, the prefix being derived from the Greek. One important property of these crystals is that a potential is developed between two faces if a pressure is applied across those faces. Conversely, if a potential is applied between the faces a pressure of mechanical stress is set up. Thus it is that by applying a fluctuating pressure across the faces, a varying potential or voltage can be obtained. This property is employed for so-called crystal pick-ups and crystal microphones. A suitably-cut crystal is mounted between two metal plates one of which is attached to the stylus or to a diaphragm; as the stylus or the diaphragm is set into vibration a variable voltage is developed which can be applied to an amplifier and thence to a

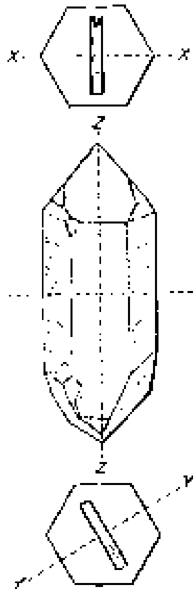


FIG. 384. *The two standard methods of cutting the quartz crystal. It will be noted that the two forms of cut are at right angles and the X cut is less wasteful and is more commonly used by the amateur. The Z cut which is shown on the crystal is not employed in radio work but is only of use for optical purposes.*

transmitter or loudspeaker. It will be seen from this that the crystal behaves in almost the same manner as the electro-magnet of a conventional pick-up or electro-magnetic microphone.

If the crystals are cut in a special manner and to a precise thickness, they have a natural period of vibration. In other words, a crystal can be cut which has, in effect, the same properties as an oscillatory circuit comprising a coil and condenser. By varying the thickness of the crystal the natural frequency can be altered, making it suitable for use in a transmitter.

It is not only in transmitters that the oscillatory property can be employed, for it is possible to use a suitable crystal in a receiver of the superhet type. It is used in such a way that it allows the passage of signals of one particular frequency, while rejecting all others. Consequently, the so-called "crystal gate" is primarily suitable for use at the end of an intermediate-frequency amplifier. The crystal is more accurate in its discrimination than is even a first-class tuned circuit, and by its use it is possible to ensure an extremely high degree of selectivity.

The crystal itself is not actually a crystal

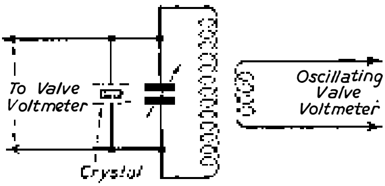


FIG. 385. *Simple circuit for measuring the frequency of a crystal.*

as this term is generally understood, but is a thin slice cut from a quartz crystal, the general appearance of which is as shown in Fig. 384. The slice or wafer which is cut from the crystal is usually somewhere about an inch in diameter or square, although this dimension is not important. After cutting, it is of paramount importance that the crystal wafer be ground and polished so that the faces are absolutely flat and perfectly parallel to each other. It is equally important that the thickness

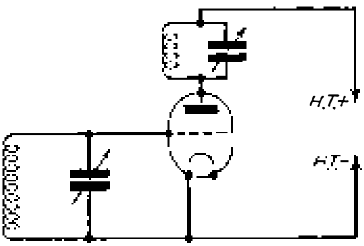


FIG. 386. *Standard oscillator circuit. When the grid and anode circuits are in tune oscillation takes place.*

be exactly in accordance with a figure which can be calculated when it is known to what frequency the crystal should tune and in what manner it was cut from the original crystal.

There are three main axes to consider in connection with quartz crystals, and these are marked X, Y and Z in Fig. 384. The Z axis, which runs from point to point, is called the optical axis (quartz is used for a variety of optical purposes) but this is not of direct importance in radio work. The other two axes are at right angles to the optical axis and run through the corners of the hexagon, and at right angles to two parallel faces. An X-cut crystal is, therefore, as shown at the top of Fig. 384 where the edge of the crystal is shown shaded; a Y-cut crystal is as shown at the bottom of Fig. 384.

Frequency-thickness Calculation. In order to calculate the required thickness it is necessary to know whether an X or Y cut is to be employed. It is then known—as a result of experimental work—that the thickness of an X-cut crystal should be

$$\frac{2{\cdot}86 \times 1{,}000}{\text{frequency}}$$

where the thickness is in mm. and the frequency in kc/s. The calculation is

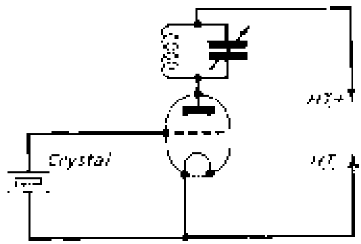


FIG. 387. *A simple oscillator circuit in which the crystal takes the place of the tuned circuit of* FIG. 385.

similar for a Y-cut crystal, except that the figure 2·86 is replaced by 1·96. It will be seen, therefore, that a Y-cut crystal for, say, 3,000 kc/s (100 metres) would require to have a thickness of

$$\frac{1{\cdot}96 \times 1{,}000}{3{,}000}$$

or ·653 mm. approximately.

In practice it is not unusual to employ a cut different from either of the "standard" cuts referred to since there are certain objections to both of these. For example, the frequency of an X-cut crystal becomes less as the temperature rises; the frequency of a Y-cut crystal, on the other hand, increases slightly with a rise in temperature. An advantage of the Y-cut—which is the more widely employed of the two—is that oscillation is more readily maintained with it. Unfortunately, however, this advantage leads to a disadvantage in that the crystal is more liable to parasitic oscillation.

Manufacturers of crystals for radio work have found, from experience, angles of cut which tend to confer the advantages of both of the cuts referred to. Thus, by choosing particular angles in relation to the crystal faces and to the optical axis, they are able to cancel out the so-called temperature coefficient. It is because of the large amount of accurate and painstaking work entailed, and because any crystal having the slightest flaw must be rejected, that the cost of frequency-control crystals is comparatively high.

Having cut a crystal, it is possible to measure its natural frequency by using a circuit on the lines of that shown diagrammatically in Fig. 385. It will be seen that a tuning circuit is coupled to the output from an oscillating-valve wavemeter and is in turn connected to a valve voltmeter; the crystal is in parallel with the tuning circuit. When the tuning circuit and wavemeter are tuned to the frequency of the crystal there is a sharp dip on the scale of the valve voltmeter. This is because the crystal then absorbs energy from the tuning circuit; the electrical energy is used in making the crystal vibrate mechanically.

It is now possible to see how the crystal can be used for controlling the frequency of a transmitter. Fig. 386 shows a simple valve oscillator of the type known in transmitting parlance as tuned-plate tuned-grid, and the valve will oscillate only when the two tuning circuits are brought into resonance. The "reaction coupling" is actually effected by the self-capacity of the valve itself.

Now compare Fig. 386 with Fig. 387. With the exception that the crystal replaces the grid tuning circuit, the two arrangements are the same. It will be seen, therefore, that if the plate circuit is tuned to the crystal frequency the valve will oscillate, but if the tuning is shifted, oscillation will cease. Thus it is that the crystal effects complete control; if tuning were upset for any reason the valve would cease to oscillate and, therefore, transmission would cease. And since the frequency of the crystal remains absolutely constant, to all intents and purposes, the frequency of the transmitter cannot alter.

If it were desired to transmit on any other frequency, a different crystal would have to be fitted in place of that already in use. In practice it is not difficult to use one transmitter for two or three different frequencies by having a suitable number of crystals which can be brought into circuit in turn by means of a rotary switch. Crystals are often made in "plug-in" form so that, in any case, it is simple enough to change from one frequency to another. Another method of working on more than one frequency is by frequency-doublers. It should be mentioned that the simplest method of tuning a transmitter fitted with a crystal is by moving the knob of the tuning condenser until the needle of a milliammeter in the anode circuit of the oscillator valve moves back; a sudden drop in anode current indicates that the valve is oscillating. Another practical point concerning the circuit shown in Fig. 387 is that it would be necessary to use a grid-leak in order to bias the grid of the valve.

Another method of using a crystal control

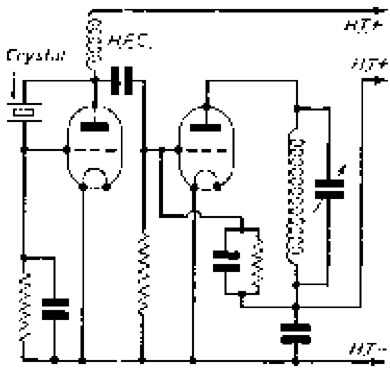


FIG. 388. *An oscillator with an isolating valve.*

in a transmitter is shown in Fig. 388, where it will be seen that the crystal is electrically isolated from the oscillator by means of a valve; it is, nevertheless, virtually in the grid circuit of the second valve shown, which has a tuned-anode circuit. This is a better practical proposition than the simpler arrangement previously mentioned, and is one which is fairly widely employed in commercial radio work.

It is scarcely necessary to mention that crystal control is almost universally employed for telephony transmitters throughout the world, since it is the only ready means of maintaining an absolutely steady frequency regardless of aerial and other conditions. Moreover, the tuning is perfectly sharp without there being any danger of spoiling quality by "losing" part of the side bands.

QUENCHING COILS. These are used in super-regenerative receivers for the purpose of providing the "quenching" oscillations which combine with the signal-frequency oscillations to produce the regenerative effect. The quenching coils can either be included in the grid and anode circuits of the signal-frequency valve (when the circuit includes a single valve) or in the circuits of a quenching valve when two are used.

QUIESCENT PUSH-PULL. A form of push-pull amplifications in which, instead of biasing the two valves at the middle portion of their curves, the bias applied is approximately twice that normally required. This brings the standing anode current down to nearly zero, and the arrival of a signal causes an increase in anode current. When the two valves are correctly chosen the standing current is only of the order of one or two milliamps., and this rises on a loud signal to 15 to 20 m/A. The current varies according to the type and volume of music received. Best results are obtained with two pentodes.

QUIET A.V.C. Also referred to as "Squelch" (*which see*) and "Noise Suppression." An additional valve which renders the L.F. amplifier inoperative on signals below some predetermined strength. The valve is referred to as a "Q.A.V.C." or "Squelch" valve because of its function, and it works by applying an excessive G.B. negative voltage to the grids of the L.F. valves until a signal of "programme" strength is tuned in. (See also *Delayed A.V.C.* and *Automatic Volume Control.*)

R

R CODE. (See abbreviations, p. x.)

RACON (Radar Beacon). A *transponder* used as a navigational beacon.

RADAR. Another name for Radiolocation (*which see*).

The name "Radar" is an abbreviation of the phrase "Radio Detection And Ranging." Long before the era of radar there were systems of radio direction finding. They were used between aircraft and ground stations as well as between ship and shore.

In normal direction finding, however, it is necessary that the object whose direction it is required to determine should be provided with a transmitter, the radiation from which can be picked up at good strength on a direction, or bearing.

Most, but not all, radar devices depend upon the reflection of radio waves. It has for long been known that these waves are subject to reflection by certain objects, and by the Heaviside, Appleton and other ionised layers in the upper atmosphere. They are also reflected to varying degrees by metallic structures, by the ground, buildings and a thousand and one other objects.

If a radio beam is directed on to a church steeple, a ship, an aircraft or a hill, a certain amount of radio energy is reflected (see Fig. 390). Incidentally, the reflection is likely to be greatest at very high frequencies, and it is relatively small at low frequencies. The reflection or radio echo can be picked up by an aerial and detected by a receiver tuned to the same frequency as the transmitter responsible for producing the energy in the original beam. And if we can measure the time which elapses between the initial radiation and the reception of the echo, we can quickly find the distance between the transmitter-receiver and the reflecting object, because we know the speed of radio waves—approximately 186,000 miles a second.

The process is comparable to that of sounding a blast on a ship's siren when the ship is some distance from a cliff side : if the time between the blast and the hearing of the echo is measured, the distance of the ship from the cliff can be calculated from the knowledge that sound travels at a speed of 1,100 ft. per sec. approx. The measurement of time in this case can be made by means of a stop-watch, but the same method is entirely out of the question when radio waves are concerned, because they travel 328 yards in *one-millionth* of a second, or 186 miles in a thousandth of a second.

In order to time radio waves, therefore, we must be able to measure accurately in terms of millionths of a second. That eliminates the more usual timing devices, and introduces the cathode-ray tube as the only known instrument for measuring these almost infinitely short spaces of time with the required degree of accuracy.

Another important point will have emerged from the foregoing simple explanation. It would be useless to emit a continuous signal, just as it would to make a continuous blast on the ship's siren, for the original sound would completely "drown" the echo. With the siren a short sharp blast is required; so with our radar transmitter. Thus the transmitter is made to send out a series of short pulses of energy. The pulses must be of very short duration, and must be so spaced that the echo of one pulse is returned before the next pulse is emitted.

In practice the pulses have a length of the order of two micro-seconds (two millionths of a second) and are spaced by, say, 2,000 micro-seconds. This means that there would be approximately 500 pulses per second or, to use the customary expression, that the pulse recurrence frequency would be 500 per second. This is illustrated in Fig. 391. It should be mentioned in passing that a variety of pulse lengths and pulse recurrence frequencies are employed in radar work, according to the purpose of the particular equipment.

By means of a time-base generator a light spot is made to cross a diameter of the C.R. tube at such a speed that a line of light is seen on the screen. The electron beam moves backward and forward across the tube, but the illumination is blacked out during the backward trace, or fly-back as it is called. The speed of scan of the light spot can be controlled and is known. Suppose that the time taken for the light spot to pass from one end of the trace to the other is 1,000 micro-seconds; the distance travelled by a radio wave in that time is 328,000 yards. But as the wave has to travel from the transmitter to the "target" and back again, 1,000 micro-seconds represents a target distance of just half the previous figure, or 164,000 yards.

If it is assumed that the trace is 10 in. long it can also be seen that a length of 1 in. along the trace represents a radio echo distance of 16,400 yards. Knowing this, we could put a scale on the tube face and mark it off accurately in miles, thousands of yards or any other convenient units. In practice, there are generally two scales, each corresponding with a different speed of trace; this is selected by means of a "speed-range."

Fig. 392 shows the progress of a single pulse when a radar beam is directed on to two aircraft in flight, and also the "picture" produced on the screen of the C.R. tube. Although this picture is seen at any one instant, it represents a series of several hundreds of pulses. It will be seen that there is a large "blip" (as the deflections on the trace are called at the zero end of the scale) and also two smaller blips. The large blip is due to the transmitted pulse, while the smaller blips are the echoes from the two aircraft at different distances from the transmitting aerial. Measurements along the scale are made from the large blip.

When the transmitted pulse "strikes," the first aircraft is reflected The echo is later received back on the receiver and applied to the Y plates of the C.R. tube, where it produces the blip. This is much smaller than that due to the initial pulses, for there is considerable attenuation during the two-way journey.

The transmitted pulse, apart from the small portion which is reflected, proceeds beyond the first aircraft, and is then reflected by the second aircraft, with the result that a third and still smaller blip is produced on the trace.

If both aircraft were close together a single echo blip would be produced, but this would be larger than that from a single aircraft at the same range, and might be split. If there were several aircraft in close formation the blip would be

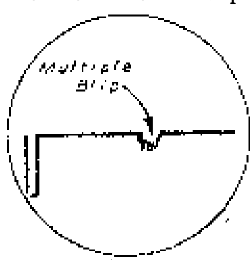


FIG. 389. *This is the form of multiple blip obtained on the range tube when there are several aircraft in company. The individual points generally show a tendency to "dance" due to "beating" of the echoes.*

a multiple one, as shown in Fig. 393. An experienced radar operator would be able to make a fair estimate of the number of aircraft in company by studying the form of the echo blip, however.

We have seen how the range of aircraft is found, and it is pertinent at this point to inquire how the radar operator knows in war-time that the blips on the screen of the C.R. tube represent enemy aircraft. It might be dangerous to send up fighters to intercept our own machines.

Such possibilities have naturally been foreseen and our own aircraft during World War II carried a small automatic receiver-transmitter known as I.F.F. (indicator friend or foe). This compact device is used in conjunction with a short wire aerial and takes its power supply from the aircraft accumulators. It has a motor-operated tuning condenser which sweeps the frequency bands employed for

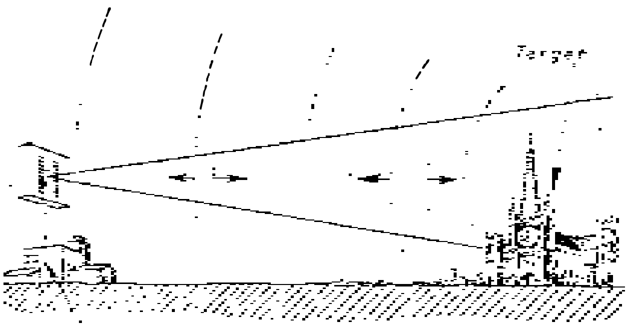


FIG. 390. *How radar pulses are radiated and reflected is shown in this diagram, where the radiated pulses are indicated by full-line arcs and the reflected echoes by broken lines.*

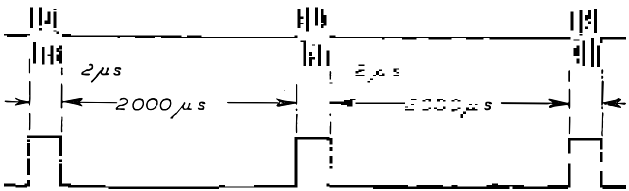
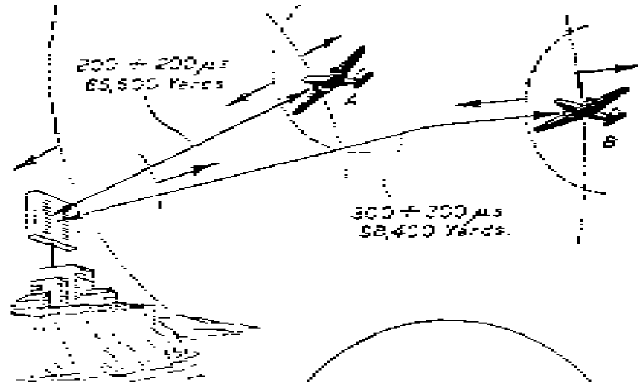


FIG. 391. *The nature of radar pulses. The upper diagram shows the wave form of the transmitter output, while the lower one represents the rectified output from the receiver. The diagrams are not drawn to scale, and it should be understood that the pulse width and spacing varies considerably with different types of radar equipment. In the case illustrated the pulse recurrence frequency is described as 500 per second—one second divided by 2,000 micro-seconds.*



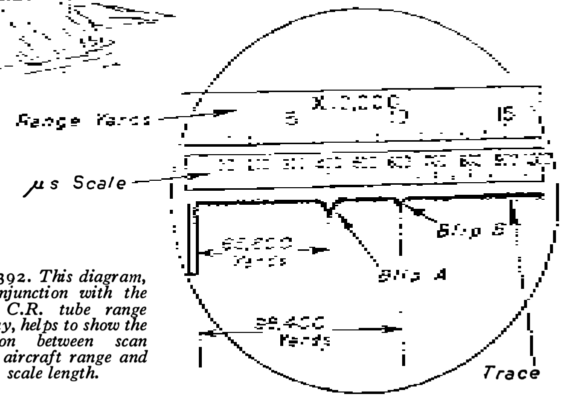


FIG. 392. *This diagram, in conjunction with the inset C.R. tube range display, helps to show the relation between scan time, aircraft range and scale length.*

both coast-watching radars and G.L.s (gun-laying radars). The bands are swept, say, once every 12 seconds and the receiver is so designed that when radar pulses are applied to it the super-regenerative detector "spills over" or squeggs, and so acts as a miniature transmitter. When the I.F.F. is in a transmitting condition the radiation from its aerial is far greater than the reflection of re-radiation from the aircraft. In consequence, the blip seen on the screen of the C.R. tube at the ground radar station is considerably elon-

where it is assumed that a beam aerial system is employed and that the same aerial is used for both transmitter and receiver. In fact, it is customary to employ a single aerial for the dual purpose, as will be explained later. On the other hand, separate aerials can be and are used in some cases; both can be rotated together so that they always face in the same direction.

The aerial array is rotatable about its axis and can therefore be turned so that the centre line of the main lobe of the

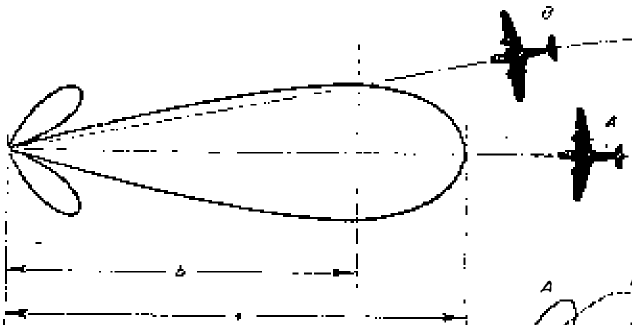


FIG. 393. (*Left*) *In radar direction-finding use is made of the fact that the horizontal polar diagram is in the form of a narrow lobe; there are a few subsidiary lobes with even the best aerial, but these are not normally troublesome. The relative signal amplitudes from two aircraft in and out of line with the lobe are represented by the projected lengths marked A and B.*

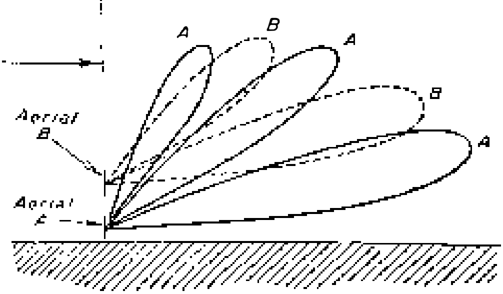


FIG. 394. *In one method of height-finding advantage is taken of the fact that there are gaps between the lobes in the vertical polar diagram of any one aerial. These gaps may be filled by using two aerials at different heights. For height-finding the receiver is switched from one aerial to the other and a note taken in the difference in amplitude of the echo blip. The range being known, the height can then be read from calibration tables.*

gated once every 12 seconds. As a result the operator is immediately able to recognise a friendly aircraft. Similarly, the ground gunner can recognise the aircraft and will withhold his fire. If, however, the crew of the friendly aircraft should fail to switch on their I.F.F., the aircraft cannot be differentiated from a raider and is in danger of attack.

So far we have considered only the method of ranging, or determining the distance of aircraft by the radar station. It is equally important that the bearing and altitude should be ascertained. There are various systems by means of which this can be accomplished, but all depends upon the fact that the echo has a maximum amplitude when the transmitting and receiving aerials are looking straight at the target. This is illustrated in Fig. 390,

polar diagram runs through the aircraft. At this time the echo blip attains maximum amplitude. It will be seen that the accuracy of the bearing obtained is governed very largely by the narrowness of the beam, although a beam width in the region of 10° may suffice. In other systems use is made of twin aerials which produce twin, and partly overlapping lobes. On the aerial mounting there is a pointer which moves over a scale marked off in degrees; the zero line on the scale represents true north. Thus, once the aerial array has been rotated for maximum blip amplitude, the bearing of the aircraft can be read off.

The height of the aircraft cannot be measured as such, but only in terms of the angle of elevation. It is an easy matter, however, to convert the angle of elevation and the slant range of the aircraft into height above ground in feet by means of a graph which can be prepared by the application of simple geometrical principles. There are various methods of finding the angle of elevation, one of which is by using an aerial which can be tilted as well as rotated. In general, this is practicable only on frequencies above, say, 300 Mc/s because a beam aerial array is likely to be rather unwieldy at the lower frequencies. Another method makes use of the "hand of bananas" pattern of the vertical polar diagram. This is explained by Fig. 394, which shows that there are several radial lobes with gaps between them. The angles of the lobes can be varied by altering the height of the aerial. Thus, if two similar aerials were used, the two being mounted in the same vertical plane at different heights, it would be possible to fill the gaps between the lobes. By switching the receiver from one aerial to the other and noting the ratio of the two amplitudes of echo blip, it is possible to determine the altitude.

RADAR CAMOUFLAGE. The art of concealing the presence or the nature of an object from radar detection, e.g. by devising coverings or surfaces which reflect radio energy towards the radar set either inconsiderably or not at all.

RADIAC. Term applied to apparatus for detecting and measuring radio activity.

RADIATION FACTOR. That constant of radiation of an aerial which is divided by the wavelength, being proportional to the square root of the radiated power.

RADIO ATMOSPHERE, STANDARD. For tropospheric propagation: an atmosphere having the standard excess modified refractive index gradient.

Super-refraction. Refraction by the atmosphere exceeding that which would occur in a standard radio atmosphere.

RADIO FREQUENCIES. Frequencies above audio frequencies; any frequency over 20,000 cycles per second.

RADIOGONIOMETER. An instrument which, when coupled to a suitable fixed *aerial-system*, enables the bearing of arriving waves to be determined by rotation of a movable part. (See also *Goniometer.*)

RADIOGRAM. An American term for any message sent by wireless. The English meaning signifies a radiogramophone.

RADIO HORIZON. The locus of the points at which rays from a radio transmitter become tangential to the earth's surface. The radio horizon depends upon the refractive index of the atmosphere.

RADIOLOCATION. (See *Radar.*)

RADIOSONDAGE. System of testing temperature and pressure at high altitudes, by sending up small balloons to each of which is attached a tiny short-wave transmitter, which transmits back to earth every change of the thermometer and barometer. The balloon bursts at a certain altitude, and as the equipment falls a parachute attached opens and brings the equipment safely to the ground. They drop from a height of about 7 miles.

RADOME. A weatherproof cover for a *primary radiating element* or *aerial system*, and transparent to R/F energy.

RAILINGS. Lines, normal to the *timebase* on a *range-amplitude display*, produced by a particular type of jamming.

RANGE-AMPLITUDE DISPLAY. A radar *display* in which a *timebase* provides the range scale from which *echoes* appear as deflections normal to the base.

RANGE-HEIGHT DISPLAY. A radar *display* which shows an *echo* as a bright *spot* on a rectangular field, slant range being indicated along the X axis, height, above the horizontal plane being indicated (on a magnified scale) along the Y axis, and height above the earth being shown by a cursor.

RANGE MARKER. A discontinuity in the range *timebase* of a radar *display* (in the case of a *P.P.I.*, a ring) for measuring the range of an *echo* or for calibrating the range scale.

RASTER. The rectangular picture area built up by the scanning spot on the end of the cathode-ray tube.

REACTANCE. Another term for the resistance or impedance offered to a current passing through a coil and distinct from the resistance due to the current acting back on itself (back electromotive force). The reactance of a condenser is found from the formula: $\frac{1}{2\pi f C}$ ohms, where C is capacity in farads and f = frequency.

Net Reactance. $X = X_l - X_c$

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

or $\omega^2 = \frac{1}{LC}$

Reactance of Coil. $2\pi f L$. π, 3·14; f, frequency; L, inductance in henrys.

REACTION CHOKE. A coil of wire used to prevent the passage of H.F. current into the L.F. amplifier so that it can be used as feedback (reaction) to the grid circuit. (See also *Chokes* and *High-frequency Chokes* for constructional details.)

REACTION CIRCUIT. The circuit of a wireless valve connected so that part of the energy in the anode circuit is fed back and made to react upon the grid circuit.

REACTIVE VOLT-AMPERES. The product of the reactive voltage and the current, or the voltage and the reactive current, in an A.C. circuit. Commonly abbreviated to *Var*.

RECTIFICATION. The process of converting an alternating current into a unidirectional current. In the crystal detector this is carried out by means of a piece of mineral in contact with a metal, or another piece of mineral. The application of an alternating current to this junction results in one-half of the wave being suppressed, and the result is that a direct current is passed on, this current bearing the variations corresponding to the applied signals. The valve is caused to rectify by inserting in the grid circuit a condenser and grid leak, and this acts in the same manner. In anode-bend rectification a large negative potential is applied to the grid, and this results in only the positive half-cycles of the applied signal oscillations being reproduced as changes in the anode circuit, negative applications producing no apparent change in anode current. For power-grid rectification a condenser and leak are employed, together with a large anode voltage. The usual values of condenser and leak for normal rectification are ·0002 or ·0003 μF. with 2 megohms, and for power-grid rectification the condenser is ·0001, with a leak of only ·25 megohm.

RECTIFIER, METAL. (See *Accumulator*.)

RECTIFIER, SELENIUM. (See *Accumulator*.)

RECTIFIER, TUNGAR. (See *Accumulator*.)

RECTIFYING VALVE. A valve having two anodes and a filament, used in an eliminator for converting A.C. to D.C.

REFLECTOR AERIAL. (See *Aerial*.)

REFLECTOR ELEMENT. A *passive element* so situated with respect to its associated primary element(s) that the direction of maximum radiation from the *aerial* is opposite to that from the primary element(s) to the *passive element*.

REFLECTED WAVE. (See *Fading*.)

REFLECTION FACTOR, or the *coefficient of reflection*, is that ratio of luminous flux reflected by a surface to that incidental on it, or it is the total reflection factor or ratio.

REFLEX. A circuit employing a valve for the dual purpose of amplifying at high and low frequencies. The arrangement most commonly employed is to include the secondary of an L.F. transformer in the grid circuit of a valve acting as an H.F. amplifier.

REFLEX CIRCUIT. (See *Circuit*.)

REFRACTIVE INDEX, MODIFIED. For a given height above the earth's surface (sea-level): the sum of the refractive index at the given height and the ratio of this height to the radius of the earth.

If n is the refractive index at height h and a is the radius of the earth, the modified refractive index is $(n + h/a)$.

REGENERATION. Positive feedback.

REGENERATIVE CIRCUIT. (See *Circuit* and *Armstrong Circuit*.)

REINARTZ. A circuit employing a single coil for grid reaction and aerial circuits.

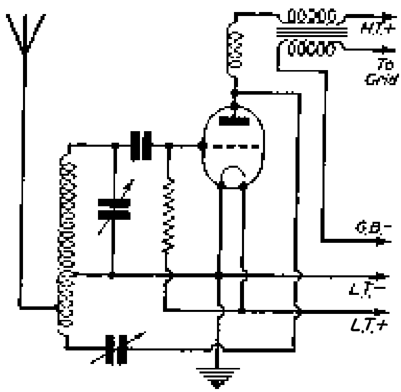


FIG. 395. *The Reinartz circuit arrangement.*

The aerial is tapped into the coil, and the earth is also tapped into the coil at a position between aerial and grid. The reaction is effected by a capacity between anode and one end of the coil.

The Reinartz Circuit is shown in Fig. 395.

REJECTOR CIRCUIT. A tuned circuit which rejects certain frequencies. (See *Wave Trap*.)

RELATIVE INDUCTIVITY. Specific inductive capacity.

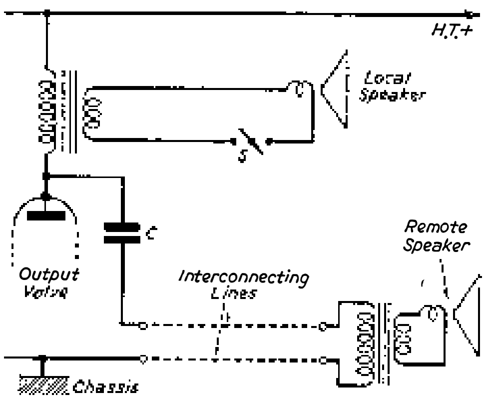
RELAXATION CIRCUIT. A circuit arrangement, usually of valves, reactances and resistances, which has two states or conditions, one, both or neither of which may be stable. The transient voltage produced, or the voltage in a state of rest, can be used in other circuits.

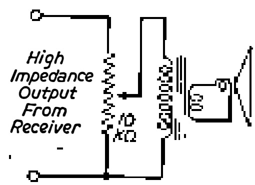
RELAY. A device having a sensitive magnet to which is applied a weak current from one circuit which energises it for controlling another circuit. (See also *Remote Control.*)

RELUCTANCE. The ratio of the magnetomotive force to the magnetic flux produced by it.

REMANENCE. The magnetism retained in iron, etc., after magnetic induction has stopped.

REMOTE CONTROL. When high-impedance moving-iron loudspeakers were in use, the usual method of connecting the external speaker was that shown in Fig. 396, in which the connection is made via the condenser C and earth. If the speaker in the set needed to be silenced the switch S was opened, the primary of the output transformer in the set acting as an anode choke, and the output impedance being developed across the remote speaker. The condenser C should be a paper component having a capacity of at least 4 μF to permit full reproduction of bass.





FIGS. 396 AND 397. (*Left*) *Showing method of connecting extension loudspeaker, using a high-impedance output from the receiver.* (*Above*) *Simple potentiometer volume control for a high-impedance extension speaker.*

Nowadays it is the custom to use a low-impedance outlet to the external speaker, as shown in Fig. 398. This saves both a condenser at the receiver and a transformer at the distant speaker. The internal speaker may be silenced by the switch S if desired. The impedance of the speech coil at the distant speaker should be approximately that of the local one to avoid any serious mismatching. The connection of one of the leads to earth or chassis, (as shown by the broken line in Fig. 398) is not necessary, but occasionally tends to remove any chance of instability, particularly in a T.R.F. set where the extension speaker leads may run close to the aerial. The use of the earthed connection also assists in the wiring of the other control circuits.

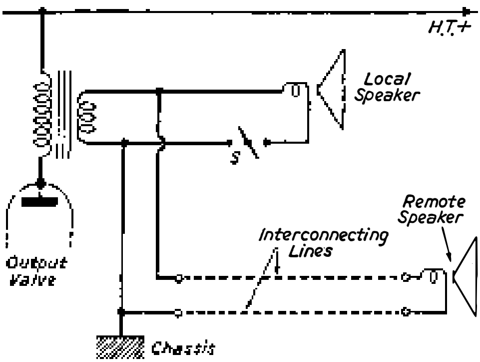
Both methods of connection have their disadvantages. In the high-impedance method of Fig. 396, the resistance of the wires is not of great importance, and ordinary bell wire may be used quite satisfactorily. The capacity between the lines, however, may prove troublesome if long runs are used and will tend to attenuate the higher frequencies. The condenser C has surprisingly high voltages impressed on it during loud passages of music, particularly if there are any resonances in either of the speakers, and should have a working voltage of twice the H.T. voltage of the set. The low-impedance method of Fig. 398, whilst saving the cost of the condenser and speaker transformer, introduces an extra expense in so far as the wire between the two speakers has to have as low a resistance as possible.

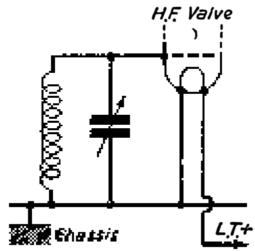
Controlling the Volume Remotely. This may be done at the speaker itself and various methods are used. Fig. 400 shows a good practical method in which the impedance presented to the set and to the speaker remains constant at all positions, thereby eliminating the chance of distortion due to mismatching. Looking at this diagram, it will be seen that a three-gang, six-position switch is used, giving six positions of volume. The direction of the arrows alongside the sliding arms indicates the direction in which they move to reduce the volume. The values given at each resistance indicate its resistance in ohms; the impedance between A and B and between C and D always remaining constant at 3 ohms.

Fig. 397 shows a potentiometer circuit which may be used with high-impedance outlets, as in Fig. 396. This method of connection cannot always ensure consistently good quality, however, owing to the inevitable mismatching which will result.

An alternative method of volume control may be utilised by controlling the gain of one of the receiver valves from the remote point. This can be done quite simply and with the addition of only one interconnecting wire. Fig. 399 shows the grid circuit of an H.F. valve in a T.R.F. (or non-A.V.C.-controlled superhet). If the valve is of the vari-mu type, its amplification factor can be controlled by the simple process of varying the bias voltage on its grid. Figs. 401 and 408 show two simple methods of doing this. The resistance R and the condenser C in these two diagrams are for decoupling the lines and preventing any hum picked up on them from affecting reception. The condenser C in Fig. 408 is used also to complete the tuned circuit. The batteries used for varying the bias are kept at the remote control point. The current taken from them by the volume potentiometer is almost negligible, but it is advisable to switch them off when not in use by the switch S. This switch may be ganged with the remote switch used to switch the set on and off, and which is discussed later. Another method of controlling the bias, particularly when a mains valve is used, is shown in Fig. 403. This system is applicable to mains-type valves only, and has the advantage of not needing the batteries required in Figs. 401 and 408. The interconnecting wire used for the circuit of Fig. 403 should have a fairly low resistance, whilst that used in Figs. 401 and 408 should be well insulated from earth, its resistance not being so important a factor.

If the set in use is a superhet with A.V.C., it is not very practicable to control the volume by altering the bias on an R.F. valve. The control will have to be effected in the A.F. circuits after detection. Fig. 404 shows one way of doing this. An octode frequency-changer, such as the Mullard EK 32, is used as an A.F. amplifier in place of the usual triode after the double-diode. The A.F. voltage is applied to the signal grid, whilst the biasing voltage is applied to the oscillator grid. The values of screen resistor, etc., are shown in the diagram. The valve should be connected immediately after the double-diode, so that the biasing circuit will have the greatest control. Some experimenting may be necessary to find the value of bias battery voltage which gives best results.





FIGS. 398 AND 399. (*Left*) *Low impedance speaker connections.* (*Above*) *Normal grid circuit of battery H.F. valve.*

Control of Tone. A tone control of the top-cut variety may easily be fitted at the remote speaker. If the connection is of the high-impedance type shown in Fig. 396, a circuit as shown in Fig. 405 will meet the requirements, the switch in this diagram connecting the various capacities (or no capacity at all) across the transformer primary and giving varying degrees of high note attenuation. The capacities suggested in the figure will meet most needs, but if additional cut-off is required a larger condenser may be fitted in place of the ·05 μF. condenser, its value being found by experiment.

If a low-impedance circuit (see Fig. 398) is used the tone control presents a slightly harder problem. It is not advisable to connect condensers across the speech coil, and the best solution is to fit another speaker transformer at the extension speaker as shown in Fig. 406. This presents a high impedance at the condenser network, the various degrees of attenuation being "reflected" to the speech coil. An alternative to the condenser switching circuit is shown in Fig. 407. In this circuit, various resistors are switched to limit the effect of the single ·05 μF. condenser. The usual form of tone control which uses a variable resistor, and is shown in Fig. 402, is not of great use in the speaker circuit. This is because the relatively large power that may be developed in the A.F. circuit across the variable resistor is liable to cause arcing between the slider and the track, particularly when the slider is very nearly at the minimum resistance position.

Switching the Set On and Off. Fig. 415 shows the simplest possible circuit in which a relay may be used for switching a receiver from a distant point. It has the great disadvantage that, whilst energised, the battery is continually draining through the coil.

A home-constructed trip-operated relay as shown in Fig. 410 will afford a very useful substitute, however. It is very simple to construct and its operation is as follows: On pressing the remote "On" button the coil A energises, pulling the armature B towards it, thereby making the contacts X. The button is then released and the armature B is held in position by the catch C on the second armature D. When the "Off" button is depressed the coil E is energised; this attracts the armature D, thus releasing the armature B, which springs back to its original position, breaking the contacts X and switching the

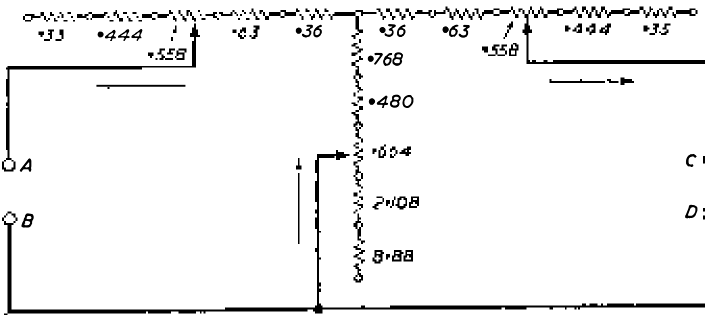
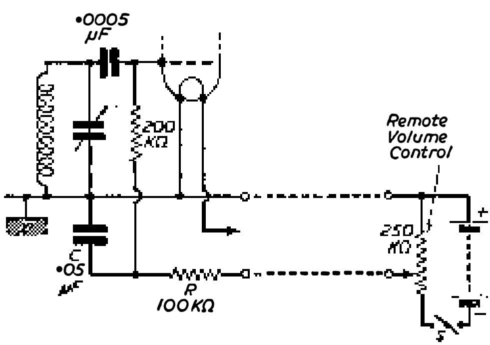
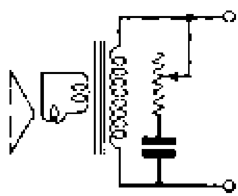


FIG. 400. *Circuit of a constant impedance volume control. The figures indicate resistance value in ohms. The impedance between A and B and C and D both equal* 3 *ohms.*





FIGS. 401 AND 402. (*Left*) *One method of applying bias to the valve of* FIG. 399, *so that its amplification factor may be varied remotely.* (*Above*) *Simple form of tone control for a high-impedance extension speaker.*

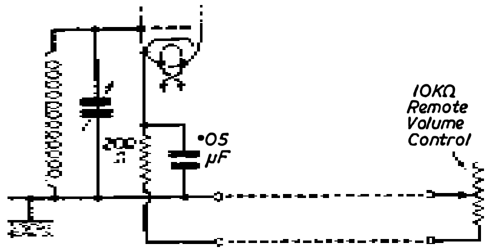


FIG. 403. *An alternative method of volume control. As the external volume control puts more resistance in circuit so the cathode becomes more positive, thus increasing the relative negative bias on the grid.*

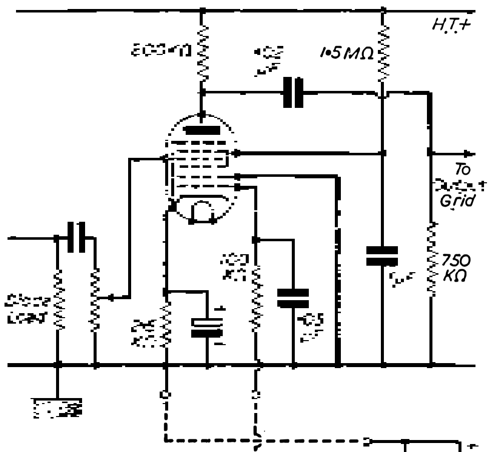


FIG. 404. *An A.F. volume control circuit in which remotely controlled grid bias varies the characteristics of the valve.*

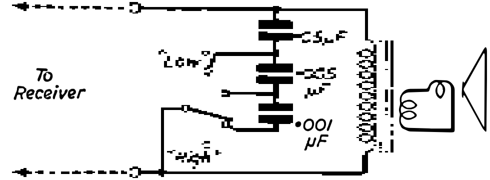


FIG. 405. *A tone control circuit that may be connected at the remote loudspeaker.*

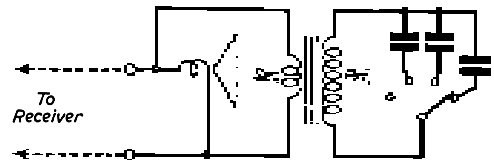


FIG. 406. *How the tone control may be connected if a low-impedance outlet from the receiver is used.*

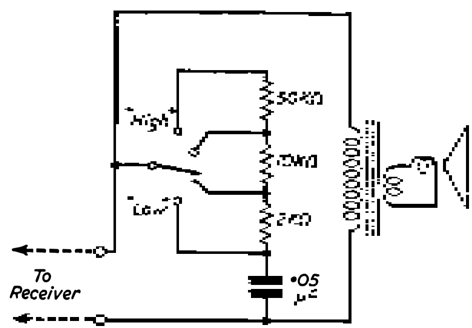


FIG. 407. *An alternative to the arrangement shown in* FIG. 405.

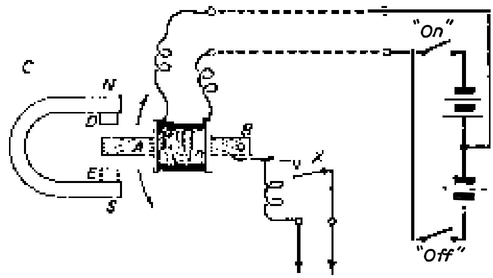


FIG. 408. (*Below*) *Another method of controlling bias remotely.*

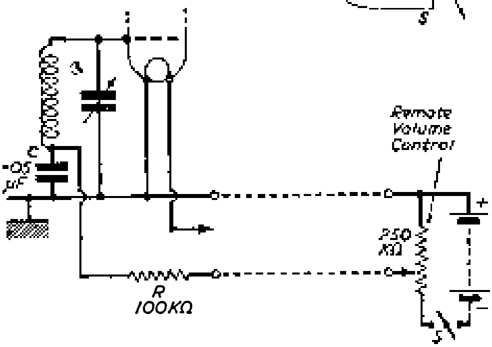
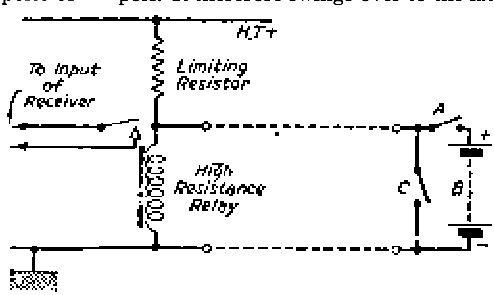


FIG. 409. *A polarised relay which takes current only momentarily from the energising battery and which only requires two leads for interconnection.*

set off again. The "Off" button may then be released, whereupon the whole cycle of operations can be started again.

Another system which uses only two wires between the two points makes use of a polarised relay, which may also be home-made, and which is shown in its essentials in Fig. 409. An armature A is pivoted at B and is free to move between the poles of a permanent horseshoe magnet C as shown by the arrows. When the remote "On" button is pressed the armature is so energised by the coil C that the end adjacent to the magnet poles is magnetised as a south pole. This causes it to be repelled by the south pole of the permanent magnet and attracted to the north pole. It therefore swings over to the latter

FIG. 410. (*Below*) *A trip mechanism for switching a receiver which takes current only momentarily from the energising battery.*



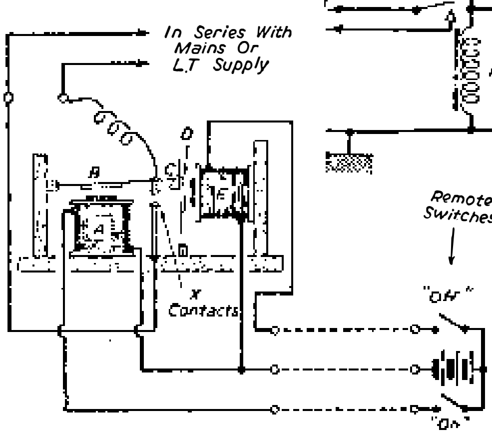


FIG. 411. (*Above*) *A relay circuit which may be used with a mains type receiver where there is no necessity to economise with H.T. current. The limiting resistor should have a value of approximately 40 KΩ and a rating of 5 watts.*

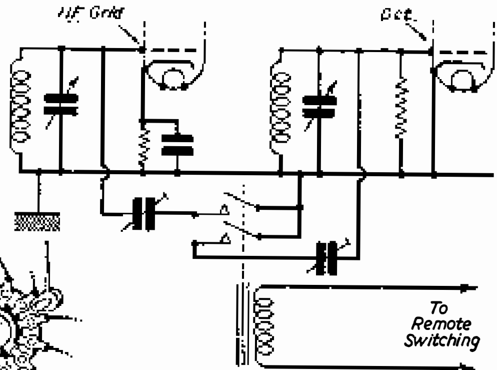


FIG. 412. (*Right*) *A simple method of changing stations using one relay.*

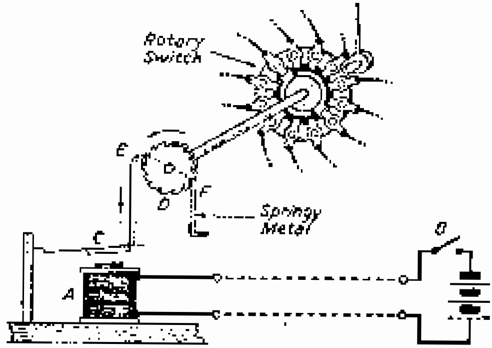


FIG. 413. (*Left*) *A solenoid-operated rotary switch which may be used for station selection.*

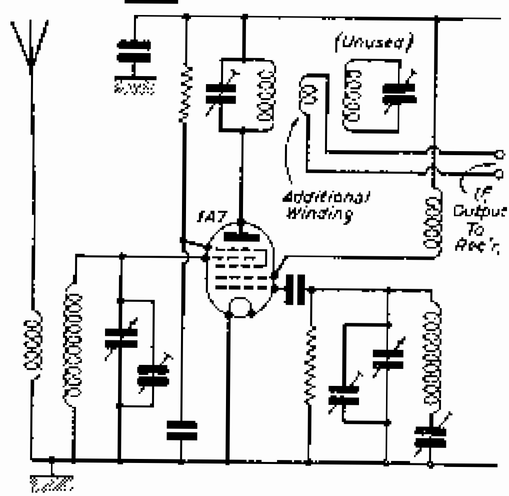


FIG. 414. (*Right*) *A remote tuner unit.*

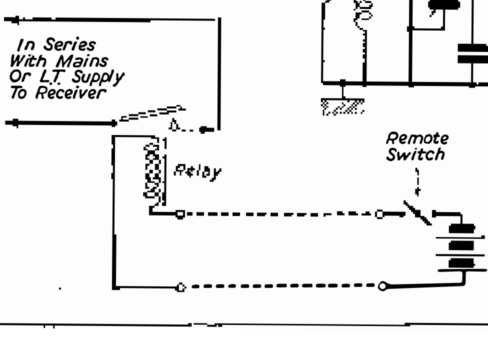


FIG. 415. (*Left*) *Simplest method of remotely switching a receiver on and off.*

pole. This causes the contacts X to be made, thereby switching on the set. The "On" button is then released, but despite the lack of energising current, the attraction between the armature and the magnet pole still holds the armature in position. When the "Off" button is pressed, due to the method of connection of the remote batteries the current now flows through the coil C in the opposite direction and the end of the armature becomes a north pole. This causes the reverse of the previous operation and the armature swings over to the south pole of the permanent magnet, breaking the contacts X and switching the set off. Two brass slugs, D and E, are fitted to the magnet poles to prevent the armature actually touching them as otherwise sticking might occur.

A third and very effective method of switching the remote receiver on and off, and which again only uses two interconnecting wires is shown in Fig. 411. For this circuit one relay only is required. This relay is a high-resistance model having a resistance of some 2,000 ohms or so and requiring 5 milliamps. energising current to close. This circuit is only practicable with mains receivers, mainly because the relay is energised from the H.T. supply, and it would be very wasteful (and expensive!) to use an H.T. battery for this purpose.

The sequence of operations is as follows: When the remote switch A is depressed the batteries B energise the relay which closes, switching on the receiver. After some seconds, the rectifier in the receiver will have warmed up sufficiently to pass H.T. current. The remote switch may then be released, and the relay will remain closed by the H.T. supply of the receiver, via the limiting resistor. When it is desired to switch off the receiver, the button C is depressed. This shorts out the relay winding which then opens. The limiting resistor ensures that no excessive H.T. current is passed. The only disadvantage with this circuit is that the remote battery B needs to have a relatively high voltage for the initial switching on. However, 25 volts is a more than sufficient value and can easily be supplied by means of three 9-volt grid bias batteries in series. It is also important to see that the battery is connected as shown in Fig. 411, as otherwise its voltage, when switched on, will be in opposition to that from the H.T. supply.

Tuning the Receiver Remotely. To obtain complete control of the receiver, the only additional circuit now required is one that will tune the receiver remotely. This is a more difficult task than those previously discussed, and the complication of the circuit required is governed entirely by the number of alternative programmes that are desired.

Taking the simplest instance first, let us assume that only two stations, both on the same wave-band, are required. Fig. 412 shows how switching may be applied to a receiver with two tuned circuits, these being either the R.F. and detector circuits of a T.R.F. receiver, or the aerial and oscillator circuits of a superhet. (If a T.R.F. receiver is used, it may be necessary to screen the two "live" relay contacts from each other to prevent instability.) The receiver is tuned by the normal tuning condenser to that one of the two stations which requires the least capacity in the tuned circuit for resonance (i.e. the station having the higher frequency). When the relay is closed the two pre-set condensers are then adjusted to bring in the second station. When it is desired to listen to the receiver from a remote position the set is tuned primarily to the first of the two required stations. Should the second station be required, the relay is then energised, the required programme being switched on instantaneously. The trouble with this system is that it may be necessary to energise the relay for long periods of time. For the purpose of economy the energising voltage may be obtained from the accumulator in the case of a battery set, or from the H.T. supply (as in Fig. 411) in the case of a mains receiver. In the latter case, incidentally, it is better to employ the "shorting" method of switching the relay on or off as is done by the push-button C in Fig. 411, as this will ensure that the full H.T. voltage does not find its way into the remote control lines, with possible risk of shock or breakdown.

This method of changing stations may be extended, of course, by the simple process of using more relays if a greater choice of programmes is required. A further relay may also be added for wave-change purposes. The whole idea is quite practicable, the only snag being that of battery consumption mentioned above; and it might be well worth while, if the construction of a new receiver is being contemplated, to incorporate a sufficient number of relays into the H.F. and detector (or frequency changer) tuned circuits in the original design.

An entirely different method of tuning the receiver remotely is offered by using a version of the uni-selector. This possesses the advantage that only momentary currents are required for station selection and that only two interconnecting wires are needed. Given sufficient ingenuity a rotary switch may be constructed following the design of that shown in Fig. 413. The coil A, when energised by depressing the remote button B pulls down the armature C. This, in turn, pulls round the ratchet wheel D by means of the hook E. When the button is raised, the coil A is de-energised and the hook springs back to the next tooth of the ratchet wheel, ready to bring it round when required. To prevent the wheel from turning backwards on the release of the hook, a pawl F is fitted, being so adjusted that it just falls from one tooth to the next when the coil is energised. The ratchet wheel is fitted to a spindle, this latter rotating a switch arm designed to make a different contact at each position of the wheel. (If the ratchet teeth are close together, these contacts may be made at spacings of two or three teeth.) When it is desired to set the switch to a different position, the remote button B is pressed the requisite number of times. This, incidentally, is a very simplified version of what occurs when a telephone number is dialled, the button B being replaced by the dial which, among other things, makes and breaks a contact a pre-arranged number of times, that number being proportional to the one dialled.

Using a separate Frequency-changer. Yet another method of tuning a receiver, and one which enables as many stations as are required to be received can be provided by using a separate tuning unit consisting of a frequency-changer with its associated tuned circuits, the intermediate frequency being led to the receiver by means of lines where it is subsequently amplified and detected. Fig. 414 shows a typical example. A 1A7-type valve is used, in common with a small, or midget-size, two-gang condenser. The coils may also be of small dimensions, Wearite "P" coils, for instance, being excellent for the purpose.

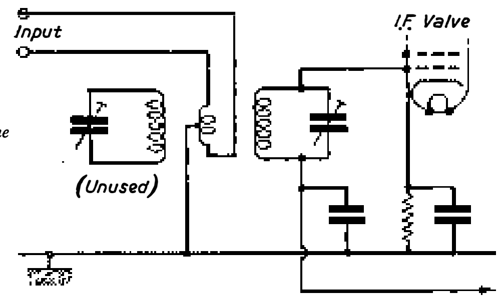


FIG. 416. (*Right*) *Connecting the receiver to the tuner unit.*

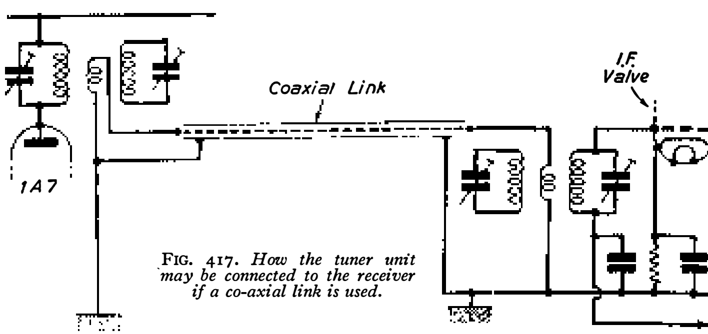


FIG. 417. *How the tuner unit may be connected to the receiver if a co-axial link is used.*

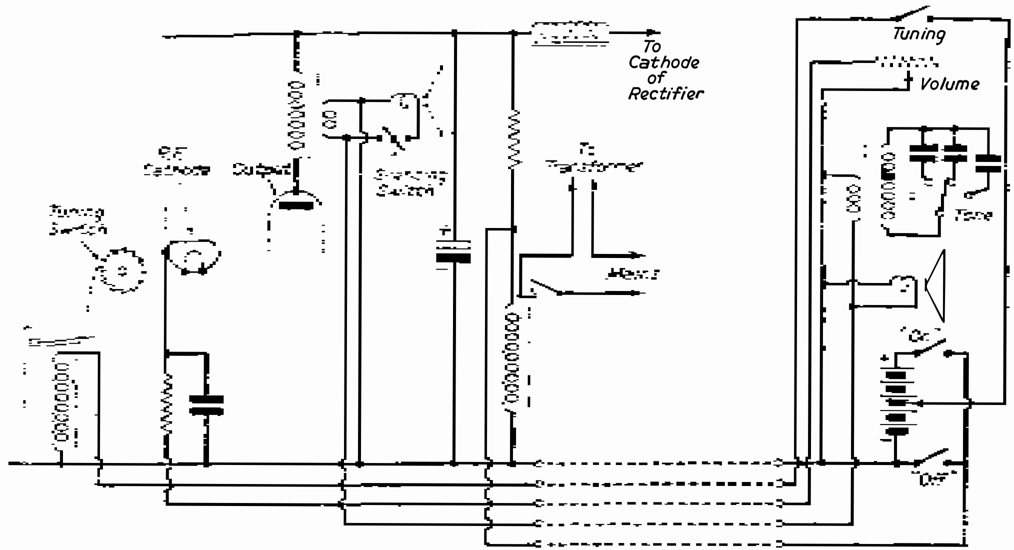


FIG. 418. *Showing how some of the devices described previously may be combined to give complete control of a receiver with the minimum of interconnecting wires.*

The intermediate frequency is fed from the anode of the 1A7 to the I.F. transformer, one coil of which is unused, although it should be tuned to give maximum results if a tightly-coupled transformer is chosen. To obtain a low-impedance outlet to the receiver about 15 turns of thin d.c.c. or d.s.c. wire are wound on the transformer these being connected to the lines to the receiver. Again, about 15 turns are added to an I.F. transformer, but this time care must be taken to see that they are accurately centre-tapped and are physically symmetrical on either side of this centre connection. This is to minimise radiation as far as is possible and ensure that no interference with neighbouring receivers results. For this purpose it is also advisable to use screened wire for the interconnecting link. Alternatively, lighting flex, or similar wire could be used, provided that it runs for all its distance alongside a well-earthed pipe such as a mains conduit, and is actually touching the pipe all the way. This would ensure considerable attenuation of any radiation.

There may be losses in the lead connecting the remote unit to the receiver proper, but these should not be excessive if care is taken. Cotton-covered bell wire would not prove very efficient for this job, owing to its poor insulation and comparatively high resistance. Good quality lighting flex (used as mentioned above) should do quite well in the absence of screened twin cable. Co-axial cable would prove ideal, if the constructor considered the cost was justified. If co-axial were used, the centre-tap at the receiver could be dispensed with, the outer covering of the co-axial cable being earthed at both ends. (See Fig. 417.)

The current consumption of the frequency-changer is not excessive. It can be supplied from small-size batteries, the L.T. consumption for a valve type 1A7 being 50 milliamps. at 1·5 volts and the H.T. consumption being approximately 2·2 milliamps. at 90 volts. Alternatively an A.C./D.C. circuit could be used, H.T. being provided from a small metal rectifier, and care being taken to see that the coupling coil shown in Fig. 414 is entirely free from any connections (to chassis or otherwise) in the unit.

The complete Remote Control System. It will be interesting now to combine all the various devices which have been described and see how they appear in a complete remote control unit. Fig. 418 shows a complete layout for controlling a mains-type T.R.F. receiver. It will be seen that only five leads are employed between the remote control unit and the receiver, whereas all the functions of switching the set on and off, of varying the volume and the tone, and of tuning-in a selection of programmes are offered. The remote switches, etc., may be embodied in the loud-speaker cabinet or a separate unit may be made. If this is fitted with a 5-core flex lead and a plug, it may be plugged in in whichever room it is required to listen. It therefore gives the advantage of enabling a really good receiver to be controlled from, and listened to in any desired room in the house.

(Fig. 418 embodies the various methods shown in Figs. 398, 403, 406, 411 and 413.)

REPAIRING ACCUMULATORS. (See *Accumulators.*)

RESIDUAL CHARGE. The charge remaining in a condenser after its first discharge. It is caused by electric absorption.

RESIDUAL MAGNETISM. The magnetism retained by iron, etc., after contact with a magnet or after the application of a magnetising force.

RESISTANCE. The opposition to flow in an electric current. The resistance of a wire is directly proportional to its length, to its specific resistance and inversely to the area of its cross section. Unit of resistance is the ohm.

RESISTANCE CALCULATIONS. Assume an output valve requires a 100-ohm non-inductive resistance in its anode circuit. It is required to compute the wattage of a resistance. The maximum anode current of the valve is 63 mA. Since it is not possible to apply the formula $W = E \times I$ until the voltage drop across the 100-ohm resistance has been decided, utilise $E = I \times R$, which in this instance will be $E = \cdot063 \times 100 = 6\cdot3$ volts ($\cdot063$ is 63 mA. expressed as a fraction of 1 amp.).

Thus, $W = 6\cdot3 \times \cdot063 = \cdot3969$ watt. From a commercial aspect, a ·5-watt (half-watt) resistance would be chosen, though as surges of current sometimes take place, or as resistances of 100 ohms are rarely available between ·25 and 1 watt the latter would be the wisest choice.

A further example is a power grid detector, with a positive bias of 1·5 volts on the grid. This valve has an applied H.T. potential of 450 volts, which on test shows an anode current of approximately 8 mA. when a 20,000-ohm anode resistance and 15,000 decoupling resistance are employed. We require to know the wattage

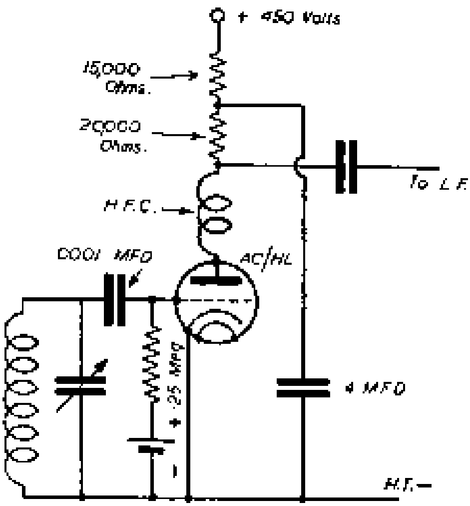


FIG. 419. *The resistances necessary in a power grid rectifier which is also decoupled.*

rating of the resistances, also the voltage on the anode.

By Ohm's Law E = I × R, or, in one case. E = 20,000 × ·008 = 160 volts, and in the other E = 15,000 × ·008 = 120 volts. Ignoring the resistance of the H.F. choke, which is negligible, the voltage drop is 160 + 120 = 280 volts. Subtracting 280 from 450, the actual voltage applied is therefore 170 volts. Reverting to W = E × I, in the first case, W = 160 × ·008 = 1·28 watts; in the case of the decoupling resistance W = 120 × ·008 = ·96 watt. Strictly suitable resistances would be one 20,000 ohms, 2 watts, and one 15,000, 1·5 watts. However, two 2-watt resistances would suit.

From technical considerations it is always advisable to employ an *anode* resistance, of a non-inductive nature, as a wire resistance, wound in the form of a solenoid on a heat-resisting former, invariably possesses inductance and, consequently, a definite self-capacity.

Decoupling resistances can be of any convenient form, so long as they are of suitable wattage. Wire-wound resistances, with adequate ventilation to avoid overheating, are undoubtedly the best, as they are always silent in operation, and rarely change their values under different loads, so long as the maximum ratings are not exceeded.

Metallised Resistances. The metallised resistances are examples of evaporated water colloidal carbon deposits hermetically sealed in practically non-porous porcelain tubes. It is possible to run these resistances at considerable overloads (not that it is advisable or desirable) before any signs of disintegration occur. Another resistance of a highly successful nature is the Loewe, which is a carbon deposit on a glass rod suspended in an exhausted glass tube. The resistance operates on the lines of a carbon lamp, except that it runs at "black" heat. Carborundum compounds, compressed at great pressure, are features of certain other makes, which dissipate heat over their entire surfaces, and which are rated according to their area.

It must be borne in mind that all synthetic compounds, if overloaded, not only disintegrate, but cause "frying" noises in the process. By allowing a generous margin for overload, therefore, no trouble should be experienced; the resistances behave to all intents and purposes as if

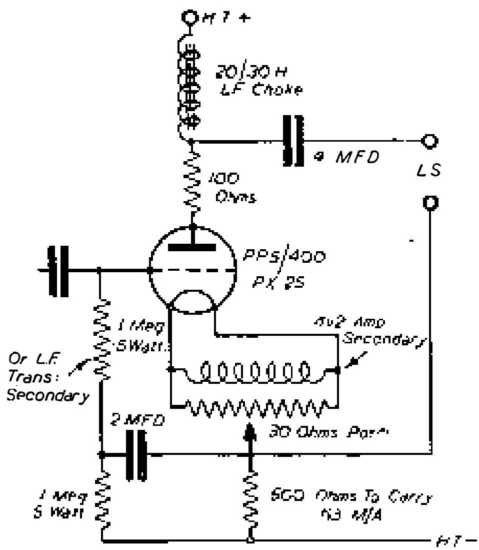


FIG. 420. *An output valve which is mains operated, and the power rating of all resistances which are included in the circuit.*

they were wire wound. The difference lies in their physical properties, wire windings increasing in resistance with increase of temperature, and carbon resistances decreasing slightly in value with similar increases.

For H.F. and detector circuits, ordinary grid-leaks of reputable make can be relied upon not to break down, but for L.F. circuits, particularly in mains sets and in power-valve grid circuits, the ·5-watt type are to be preferred, since occasionally grid current may flow, and the higher rating of the latter type will satisfactorily deal with the momentary loads imposed. Decoupling grid resistances of ·1 or ·25 megohm should always be of the ·5-watt (or larger) type. Automatic grid-bias resistances, as a matter of good practice, should normally be wire wound.

RESISTANCE CAPACITY COUPLING. (See *Coupling*.)

RESISTANCE-CONDENSER BOX. This box provides, always to hand, 36 different condensers and resistances. As is well known, routine testing reveals a large number of condenser and resistance faults. When these are suspected, this test box may be employed to pick out the faulty one. It is invaluable as a substitution in condenser or resistance open circuits and, by moving one prod only, correct values can be ascertained. With a unit such as this speedy service is assured, and in the majority of cases better performance is obtained. Of course, the more accurate the components, the better the unit. Condensers and resistances with a tolerance of one or even the half of one per cent. are available for the serious experimenter.

Construction. The construction is quite simple and straightforward, and should not present any great difficulties even to a beginner. Heavy wire should be used

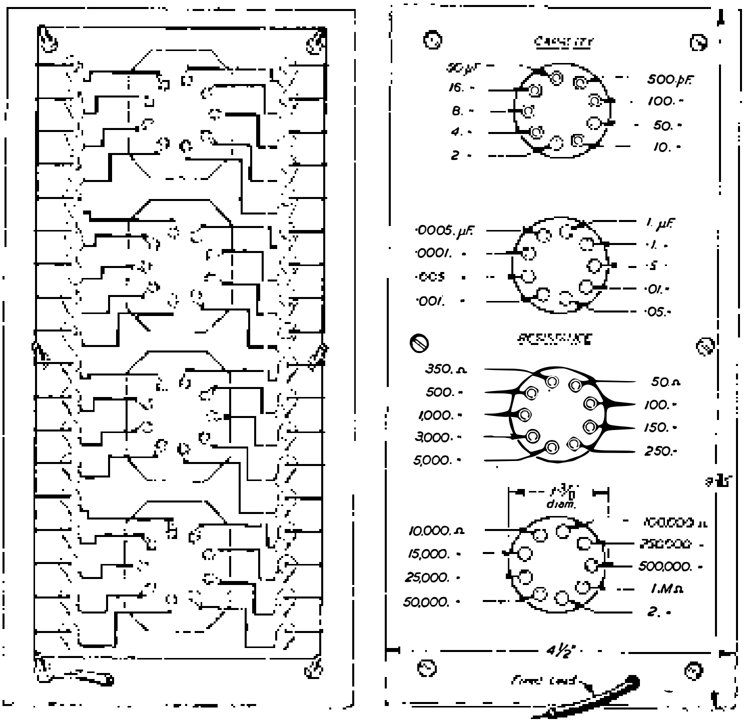


FIG. 421. *Details of the resistance-condenser box.*

(18 s.w.g.), and all joints well and truly soldered. A heavy wire is run round, near the edges of the underside of the panel, and all negatives and one prod are soldered to it. It is supported on six screws bolted to the panel, and soldered to the screw ends. Figs. 421 and 422 explain everything. A unit of this description will become a necessity to the workshop and to the serious electronic worker in the near future, as the modern trend seems to be for greater accuracy and precision. The beauty of this instrument lies in its absence of complicated switching, and also in having only one prod to change.

Using the Box. In use, especially when searching for the cause of hum in a set, always short the prods of the test box before and after each test in order to discharge internal condensers. Failure to do this may result in a nasty shock. If it is decided to fix a crocodile clip on the negative prod, which is very handy, and clip it to the chassis of the set, then shorting the other prod to the chassis will suffice. The 50, 16, 8 and 4 μF condensers in the box are electrolytics, therefore their proper polarity must always be observed. The nine-pin valve holders used have a ring on the underside of each socket, which holds the tips of the sockets together, and thereby ensures good contact, even with the thinnest of prod plugs.

List of Components

1 panel, $9\frac{3}{4}$ in. by $4\frac{1}{2}$ in. by $\frac{1}{8}$ in.
4 valve holders, 9 pin (British).

Condensers				Resistances	
50	μF	50	v.w.	50	ohms.
16	,,	500	,,	100	,,
8	,,	,,	,,	250	,,
4	,,	,,	,,	500	,,
2	,,	,,	,,	1,000	,,
1	,,	,,	,,	5,000	,,
·1	,,	,,	,,	10,000	,,
·5	,,	,,	,,	25,000	,,
·01	,,	,,	,,	50,000	,,
·05	,,	,,	,,	100,000	,,
·001	,,	,,	,,	500,000	,,
·005	,,	,,	,,	1 megohm	
·0001	,,	,,	,,	2 megohms	
·0005				150	ohms.
10 pF.				350	,,
50 ,,				3,000	,,
100 ,,				15,000	,,
500 ,,				250,000	,,

RESISTANCE VALUES IN ANODE CIRCUIT. If the value of the load resistance is made too great, the drop in voltage due to the passage of the standing anode current will be very great, with the result that the working anode voltage will be small, and the valve will not be working under the most favourable conditions.

For low-frequency amplification, the impedance of the external anode load should be from twice to about five times the valve resistance, which will give an overall gain of from two-thirds to five-sixths of the valve's amplification factor. Thus, if a valve has an anode resistance of 50,000 ohms, the resistance employed for a resistance-capacity circuit should be from 100,000 to 250,000 ohms. The higher the resistance, within these limits, the larger the percentage of the valve's amplification factor which can be utilised.

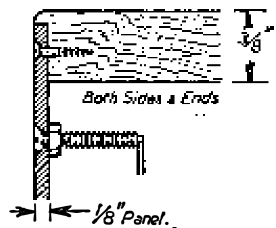


FIG. 422. *Method of fixing panel to the resistance-condenser box.*

RESISTIVITY. Specific resistance.

RESISTOR. Another name for a fixed resistance.

Wattage Rating. If resistance and current values are known, $W = I^2R$ when I is expressed in amps. or :

$$W = \frac{\text{Milliamps}^2}{1{,}000{,}000} \times R.$$

If wattage rating and value of resistance are known, the safe current for the resistor can be calculated from :

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

RESONANCE. A state brought about when the natural frequency of a circuit is of equivalent value to the frequency of the alternating (periodic) E.M.F. created in it, thus inductive reactance will neutralise capacity reactance, and reactance will therefore be at zero. Two circuits are in resonance when they have the same frequency. (See *Frequency*, *Resonant*.)

For formula for current in series circuit at resonance, see page 155.

RESONANCE PEAK. The point in the frequency scale at which a loudspeaker, pick-up, or other component gives maximum response. This point is frequently at the natural frequency of the component.

The name "Resonance Peak" actually applies to the graph upon which response or amplification is plotted against frequency.

RESONANT DIAPHRAGM. A *diaphragm* so proportioned as to introduce no *reactive impedance* at the design freqency.

RESPONSOR. A unit designed to receive the response emitted by a *transponder* after excitation by the interrogating signal.

REVERSED CHARGE. (See *Accumulator.*)

R.F. Radio frequency.

R/F HEAD. That part of a radio equipment containing components concerned in the reception and transmission of carrier frequencies.

R/F PULSE. A train of oscillations whose envelope has the form of a *pulse.*

RHEOSTAT. A variable resistance connected in series to vary the amount of current flowing in a circuit. It differs from a potentiometer which is connected in parallel with the supply.

RHOMBIC AERIAL. A directive *aerial* consisting of wires, long compared with the wavelength, forming the sides of a rhombus, often terminated by a resistor, at the end nearer the distant station, equal to the characteristic impedance of the aerial measured at that point.

RHUMBATRON. An evacuated enclosure of conducting material of special form which enables the electrons in the space within to act as a resonating system.

RIEKE DIAGRAM. A type of circle diagram showing the frequency, anode voltage and power output of a valve as functions of the load impedance.

RING FILTER. A *filter* in the form of a resonant metallic ring or rings.

RING STRAP. A ring-shaped *strap* connecting the ends of alternate segments of the anode of a *cavity magnetron.*

RING SWITCH. A resonant ring located in a *waveguide* system which by rotation controls the flow of energy.

RIPPLE FACTOR. This is that ratio of the *R.M.S.* value of the ripple of a rectified current filter to the mathematical average value of the total $1 \times 2\sqrt{2}$.

RISING-SUN MAGNETRON. A *vane-type magnetron* in which the cavities are alternately shallow and deep, there being two values of radial depth.

ROD REFLECTOR. A system of parallel rods so dimensioned and spaced as to act substantially as a continuous reflecting surface.

ROLLED THROAT. A *parallel-plate guide* system in which the bounding sheets are rolled or bent in such a way that a circular motion of the source or *primary radiating element* is converted into angular movement of the wavefront in one plane only.

RÖNTGEN RAYS. Another name for X-rays, named after their discoverer, Röntgen. The ray is really the electronic discharge from the cathode of a vacuum tube which is directed on to a platinoid plate which radiates waves of extremely short-wave length. The rays are visible on a fluorescent screen.

ROTARY CONVERTER. A direct-current dynamo capable of generating alternating current.

ROTARY TRANSFORMER. A rotary converter.

ROTATING JOINT. A device for permitting one section of a *waveguide* to rotate continuously relative to the other while permitting unmodified transmission of R/F energy.

R/T (RADIO TELEPHONY). Type A3 waves.

S

SAL-AMMONIAC. Ammonium chloride which is used in Leclanché and dry cells.

SATURATION. That state of a magnetic substance when it is impossible further to intensify its magnetism. Saturated solution.

SAW-TOOTH GENERATOR. The production of saw-tooth waveforms is particularly important in television, oscilloscopes, and other small-tube test apparatus. Basically the principle employed is the charge and discharge of a condenser, the comparatively slow exponential rise of voltage across the plates being utilised to draw the light spot across the fluorescent screen, with the sudden discharge allowing the spot to return to its initial position in readiness for the following sweep.

In oscilloscope design one is generally concerned only with a single line time-base, as it is called, the spot sweeping across the same portion of the screen with great rapidity giving to the eye the impression of a straight line without breaks. In television, while the same principles apply, a system must be employed so that the spot does not move along its own track for every sweep, but moves downwards between each line by an amount equal to its own diameter. In this way the complete area of the screen is covered by the spot, giving a continuous patch of light instead of a line to the eye.

This implies the use of two time-base systems, one to move the spot horizontally and the other to move it vertically.

The manner in which saw-tooth waveforms for both these time-bases are produced in television receivers is essentially the same as that employed for saw-tooth production in an ordinary oscilloscope. A condenser is allowed to charge through a resistance from some source of D.C. potential, and on reaching a certain point is abruptly discharged, generally through a saturated valve. An essential of the saw-tooth scanning waves produced (Fig. 423)

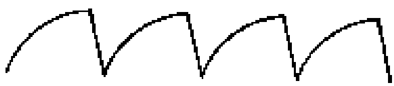


FIG. 423. *Saw-tooth scanning waves.*

is that the portion representing the charge must be substantially linear, otherwise a host of troubles will appear. During the return period, or discharge time, the exact shape is not particularly important, but the ratio of forward time to return time should be as small as possible.

With tubes employing electrostatic deflection a saw-toothed voltage wave is required; with electromagnetic deflection a saw-toothed current wave is necessary. It is customary to use electrostatic deflection for line scanning and magnetic deflection for frame scanning, though this is not absolutely essential. Voltage saw-toothed waves are easier to produce for reasons which will be given later.

A simple voltage wave may be produced by such a means as that illustrated in Fig. 424. The valve V is biased beyond cut-off by the battery B, and remains cut off until a large positive pulse, greater in magnitude than the voltage presented by B, is applied across the resistance R. Starting at the point where the valve is not conducting the condenser C begins to charge up from the battery B1 through the resistance R1, this rise being exponential in form. This build-up goes on until the positive *synchronising* pulse appears across R, when the valve suddenly conducts and discharges the condenser. As soon as the positive synchronising pulse disappears the valve again becomes non-conducting and the cycle of events repeats.

The frequency of the saw-toothed wave produced will depend upon the frequency of recurrence of the synchronising pulse, and is controllable by this means. In a complete, self-contained circuit, the synchronising pulse may be arranged to come from a form of blocking oscillator or a phase reverser controlled by the condenser build-up itself. There are various forms of saw-tooth generators in common use today, including the blocking oscillator, multi-vibrator and Puckle type circuit. The rise of voltage across the condenser may be made substantially linear by utilising only the initial part of the charge cycle or by employing a constant current device in place of the plain charging resistor.

For line scanning where the frequency of the waveform has to be fairly high (number of lines per frame times number of frames per second), saw-tooth generators employ hard valves in preference to gas-filled types, the time lag of the latter introducing distortion unless special precautions are made.

For electromagnetic scanning it is necessary to produce a saw-tooth waveform of current, for the deflection of the electron beam passing along a cathode ray tube depends upon the magnitude of the current flowing in the deflector coils. There

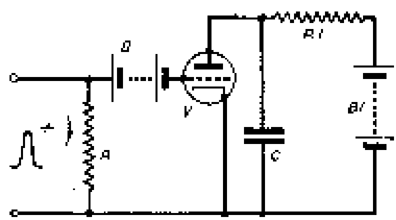


FIG. 424. *Method of producing saw-tooth voltage waves.*

would be no complications about this matter if the deflector coils possessed resistance only, for the application of a saw-toothed voltage waveform across them would result in a saw-toothed current flowing through them. But the coils possess inductance as well as resistance, so that when a saw-toothed voltage waveform is applied to them the resulting current suffers a distortion which destroys the saw-tooth effect. In order to overcome this difficulty it is necessary to so produce a waveform that when it is applied to the deflector coils the desired saw-tooth automatically results. Knowing the inductance and resistance of a particular pair of deflector coils it is a fairly simple matter to calculate the waveform of voltage that must be applied in order to achieve this.

S.B.A. Standard Beam Approach, the initial word relating to Standard Telephones and Cables, Ltd., who pioneered and developed beam approach equipment in this country. The S.B.A. system is developed from the German Lorenz system, which was fairly widely used by the civil air lines before the war. For a time the name Blind Approach was used, but it was later considered that the present name was more appropriate.

S.B.A. depends upon the transmission of an ultra-high-frequency tone-modulated beam within which the aircraft can fly towards the transmitter—described as a main beacon. In addition, there are two so-called marker beacons. These feed into horizontal dipole aerials designed to produce an upward beam. These are situated on the ground at two points along the track of the main beam, and indicate to the pilot his distance from the main beacon. It should be noted that the main beacon is situated at the end of the runway and feeds into a vertically polarised aerial system.

S.C. Silk covered.

SCAN (Radar). To explore a region automatically and continuously by swinging a *beam* of radiation or receptivity (see heading note).

SCANNER. Those parts of the *aerial* which, moving, cause the *beam* to *scan.*

SCANNING DISC. (See *Television.*)

S.C.C. Single cotton covered.

SCHNELL CIRCUIT. A circuit claimed to be extremely selective and to bring in stations outside the range of a normal receiver.

SCOPHONY. A method of television reception.

SCRAMBLE. To transpose and/or invert bands of frequencies, or otherwise to modify the form of the intelligence, at the transmitting end according to a prearranged scheme, to obtain secrecy.

SCRATCH FILTER. A device included in a gramophone amplifier for reducing surface noise. It may consist of a high resistance shunted across the pick-up terminals, or a combination of resistance and condenser employed with the low-frequency transformer. The simplest method is to join a variable resistance of 100,000 ohms across the pick-up, and adjust this to give the degree of noise reduction required. By using this method radio reproduction is not affected. The suppression of the surface noise also results in the suppression of the higher musical frequencies. (See Fig. 425.)

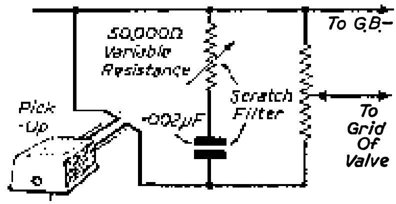


FIG. 425. *Circuit for eliminating scratch.*

SCREEN-GRID CHOKE. Coil of wire connected in the anode lead of a screen-grid valve to offer high impedance to H.F. current. (See also *Chokes* and *High-frequency Chokes.*)

SCREEN-GRID VALVE. (See *Valve.*)

SCREEN SUPPRESSION. (a) Resistance included in series with the second grid of pentode of cathode-injection crystal oscillators to prevent the excitation of low-frequency surface shear crystals in the thickness mode. (b) *Gating* by the application of a negative potential to the screen of a valve.

SCREWS: BRITISH ASSOCIATION (B.A.)

No.	*Absolute Dimensions in Millimetres* — *Full Diameter*	*Pitch*	*Approximate Number of Threads per Inch*	*Approximate Dimensions in Inches* — *Full Diameter*	*Pitch*
25	0·25	0·070	362·8	0·010	0·0028
24	0·29	0·080	317·5	0·011	0·0031
23	0·33	0·09	282·2	0·013	0·0035
22	0·37	0·10	254·0	0·015	0·0039
21	0·42	0·11	230·9	0·017	0·0043
20	0·48	0·12	211·6	0·019	0·0047
19	0·54	0·14	181·4	0·021	0·0055
18	0·62	0·15	169·3	0·024	0·0059
17	0·70	0·17	149·4	0·028	0·0067
16	0·79	0·19	133·7	0·031	0·0075
15	0·90	0·21	121·0	0·035	0·0083
14	1·0	0·23	110·4	0·039	0·0091
13	1·2	0·25	101·6	0·047	0·0098
12	1·3	0·28	90·7	0·051	0·0110
11	1·5	0·31	81·9	0·059	0·0122
10	1·7	0·35	72·6	0·067	0·0138
9	1·9	0·39	65·1	0·075	0·0154
8	2·2	0·43	59·1	0·087	0·0169
7	2·5	0·48	52·9	0·098	0·0189
6	2·8	0·53	47·9	0·110	0·0209
5	3·2	0·59	43·0	0·126	0·0232
4	3·6	0·66	38·5	0·142	0·0260
3	4·1	0·73	34·8	0·161	0·0287
2	4·7	0·81	31·4	0·185	0·0319
1	5·3	0·90	28·2	0·209	0·0354
0	6·0	1·00	25·4	0·236	0·0394

The Committee recommend that for screws less than ¼-in. diameter British Association

Threads should be adopted. It was originally proposed by the British Association in 1884, and finally adopted by them in 1904. It is, however, not yet the usual practice in this country to use the sizes ranging from No. 17 upwards. Moreover, makers of taps, dies, screwplates, etc., usually supply sizes only to No. 16.
(See also *Drills.*)

SEAL (in Waveguide Technique). A gas or watertight dielectric insertion or covering designed to present no obstruction to R/F energy.

SEARCH (Radar). To explore a region by swinging a *beam* under manual control.

SEA RETURNS. *Echoes* received from the surface of the sea by an airborne radar set.

SECOHM. The henry—the unit of inductance.

SECONDARY CELL. Another name for an accumulator. (See also *Accumulator.*)

SECONDARY CIRCUIT. A circuit whose current is supplied by the primary circuit. (See also *Primary Circuit.*)

SECONDARY RADAR. The case of radar in which the distant object co-operates by reinforcing, repeating or otherwise modifying the echo.

SECTOR DISPLAY. A *type A display* used with a radar set whose aerial system is continuously rotating: it is impressed on the long-*persistence* screen only while the *aerial system* is pointing within a narrow arc centred on the target.

SECTOR SCANNING. *Scanning* through a limited angle about any desired axis.

SELENIUM. An element allied to sulphur. It exists as a red powder soluble in carbon bisulphide, as a crystalline grey solid which is insoluble, and as metallic selenium which is insoluble. The resistance of selenium is reduced by light rays. (See also *Light-ray Control.*)

SELF-CAPACITY. A term used in connection with coils to denote the condenser effect of the turns of wire and their insulation.

SELF-INDUCTANCE. In a circuit the inductance caused by the current flowing in it.

SELF-INDUCTION. A back electromotive force is caused when a current changes in a coil. This effect is known as self-induction, and is sometimes referred to as electro-magnetic inertia.

SELF-QUENCHING OSCILLATOR. An intermittent self-oscillator producing a series of short trains of R/F oscillation separated by intervals of quiescence. The quiescence is caused by rectified oscillatory currents building up in some part of the circuit to cut off the oscillations for a given period.

SEMI - BUTTERFLY CIRCUIT. Unbalanced form of *butterfly circuit,* in which the angle of rotation of the condenser plates is usually 180° or greater.

SEPARATE HETERODYNE. A component for generating oscillations of a frequency almost equal to those existing in the circuit in which it is coupled. It is used to give a damping effect.

SEPARATORS. The substance used to separate the positive and negative plates of accumulators. The chief materials used are grooved wood, celluloid and glass. (See also *Accumulator.*)

SEPTATE MODE. A *waveguide mode* which can be propagated along a *septate waveguide.*

SEPTATE WAVEGUIDE. A coaxial transmission line in which a *septum* extends radially from inner to outer.

SEPTUM. A longitudinal metallic plate located inside a *waveguide* or transmission line.

SERIES. A number of cells, coils, components, or instruments connected in such a manner that the current must pass through each unit of the series.

SERIES-PARALLEL. A combination of series and parallel (*which see*). The arrangement can be applied to accumulators, resistors or other components and is generally adopted to enable odd values to be obtained, or to even up current flow without components of correct rating.

SERIES T. A T junction in which the *impedances* in the main guide and side arm are predominantly additive, usually confined to the case of the junction of two *waveguides,* each propagating waves of the *fundamental mode,* when the axis of each guide is parallel to the *direction of polarisation* in the other.

SERVICING. (See *Faults.*)

S.G. Abbreviation for Specific Gravity also Screen Grid.

SHADOW REGION. The region in which, under normal propagation conditions, the field strength from a given *transmitter* is reduced by some obstruction which renders effective radio reception of signals or radar detection of objects in this region improbable.

SHELLAC. A species of resin obtained from the sap of Indian trees. It is soluble in methylated spirit and alcohol, and it is an excellent insulator. Specific inductive capacity is 3.

S.H.M. Simple Harmonic Motion.

SHORT-CIRCUIT. Any circuit having negligible resistance. To cut out a component by connecting its terminals together.

SHORT-WAVE ADAPTOR. A single-valve detector stage which, connected to the L.F. stage of a broadcast set, enables short waves to be received.

SHORT-WAVE CHOKE. A coil of wire offering low resistance to the passage of D.C., and high impedance to H.F. current. (See also *Chokes* and *High-frequency Chokes*.)

SHORT-WAVE COILS. (See *Coil.*)

SHORT-WAVE CONVERTER. A unit for use with a broadcast receiver which has H.F. amplification enabling short waves to be received.

SHORT WAVES. All wavelengths below 100 metres are referred to as "short waves," those below 10 metres usually being referred to as ultra-short waves. These short waves, instead of following the surface of the earth as with higher wavelengths, shoot off into the atmosphere, and are deflected back to earth by the Heaviside layer. The angle at which the signal shoots off varies according to the frequency of the transmission, or in other words, the wavelength. Owing to this "shooting off" and "reflecting back," there are certain areas in which the signals are inaudible, and this is known as the "skip-distance effect." (For *Shortwave Aerial Systems* see *Aerials*.)

SHORT WAVES (SW). Waves from 10 to 100 m. long.

SHOT EFFECT. That small anode current fluctuation in a valve due to irregular emission, caused by the finite charges carried by individual electrons—sometimes termed *Johnson Noise*.

SHUNT. Another term for parallel (*which see*).

SHUNT T. A T junction in which the admittances (reciprocal *impedances*) in the main guide and side arm are predominantly additive, usually confined to the case of the junction of two *waveguides*, each propagating waves of the *fundamental mode*, when the axis of each guide is at right angles to the *direction of polarisation* in the other.

S.I.C. Specific Inductive Capacity.

SIDE-BAND CUT-OFF. The term applied to the suppression of the upper and lower frequencies of a received signal. For good-quality reception a receiver should be designed so that it receives a band of at least 10 kc/s. If a receiver accepts a band of less than 10 kc/s., side-band cut-off occurs.

SIDE BANDS. An amplitude-modulated wave can be considered as a combination of several frequencies. If it is assumed that the modulation is due, say, to an orchestra, a large range of frequencies is obtained, from about 50 to 10,000. We can consider the wave as being built up of many simple ones of frequencies which vary between X −, say, 12,000, and X + 12,000, where X equals the carrier frequency and 10,000 the highest sound frequency emitted. Hence is created a band of audio frequencies extending above and below the carrier frequency.

SIDE ECHO. An *echo* due to a *side lobe* of an *aerial*.

SIDE LOBE. A *lobe* additional to the *main lobe*.

SIGNAL-TO-NOISE-RATIO. The ratio of the available signal power to the available *noise* power.

SILENT ZONE. A region, in relation to a given *transmitter*, in which no signal would be predicted.

SILICON. A mineral used in the manufacture of certain types of crystal detectors for R.F. work. A contact is provided and cemented to the crystal and the assembly is sealed. The combination is not so robust as the germanium rectifier (*which see*).

SKIATRON. (See *Dark Trace Tube.*)

SKIP EFFECT. (See *Short Waves.*)

SKIRT. A thin-walled *ditch* built round the end of a *waveguide* or *flare*.

SLAB COIL. An inductance coil wound in the form of a flat slab. Usually this consists of a length of wire wound in the form of a spider's web, but with adjacent turns touching. Sometimes, however, the turns are wound round spacing pins so that the turns do not lie parallel for their whole length. It has a lower capacity. (See also *Coil.*)

SLICE. To remove those parts of a waveform lying outside two given amplitude limits on the same side of the zero axis.

SLIDER. A moving contact for an inductance, resistance or any similar wireless component which has to be tapped at various points. In the older forms of inductance coil the wire was wound round a cylinder and a brass rod was fixed on the end supports of the coil.

SLOT AERIAL. An *aerial* formed by *slot radiators*.

SLOT RADIATOR. *A primary radiating element* in the form of a slot cut in the walls of a metal *waveguide* or *cavity resonator* or in a metal plate.

SLOTTED SECTION. A length of *waveguide* in the wall of which is cut a non-radiating slot used for measuring purposes

SLUG. (a) A small rod-type iron-dust core; (b) a movable insert forming part of a *transforming section* of a *waveguide*; (c) a device used to increase the time of operation of a relay.

SMOOTHING CHOKE. A coil of wire having an iron core, used in the H.T. circuit to eliminate fluctuations in current and current intensity. (See also *Chokes* and *Low-Frequency Chokes*.)

SNELL'S LAW. If light passes from medium to medium the incident ray, normal to the surface at the incidence point, and the reflected ray are in the same plane. The ratio of the sine of the angle of incidence to the sine of the angle of refraction is constant for the same *two media*, this, however, is dependent upon the nature of the media. Therefore, $\sin i/\sin r = n$ or the *refraction index*.

SNOW. A speckled background on an *intensity-modulated display*, due to electrical *noise*.

SNOW RULE. The deflection direction of a magnetic needle is such that the current flows from *S*outh to *N*orth *O*ver the indicator, the north pole being deflected to the *W*est.

SOFT VALVE. A valve which is not completely evacuated, or which contains a gas. This type of valve is not used at the present day, but was previously used for detection purposes (cf. *Hard Valve*). When electrons are emitted from the filament of a valve they pass outwards towards the anode. If gas is present in the bulb, then collisions take place between the electrons and gas atoms, with the result that the force of impact detaches electrons from the gas atom. These electrons join in the electronic filament stream, and by so doing increase the total anode current. The softer the valve the greater the chance of collisions and therefore the greater the anode current. The disadvantage of this process is that the gas atoms which have been in collision are left positively charged, and these are attracted to the filament, and the attraction is so great that they bombard the filament, eventually breaking it. The soft valve therefore gives a greater anode current for a given potential supply, but has a shorter life.

SOLDERING. Soft soldering is an alloying process, in which the tin in the solder combines with the metals of the joint, so that alloying is obtained; this takes place only if clean metal and clean solder are brought into contact. In normal practice the joint members are often dirty or rusty and may acquire a film of grease through handling; but even if the metal is perfectly clean beforehand, it will oxidise as soon as it is heated.

The colouring of copper or iron on heating is a simple example of the production of oxide films on a metal surface; but the oxide films are also formed during the gentle heating used in soft soldering, although they may be so thin as to be invisible. Nevertheless they form a barrier through which the solder cannot penetrate. The removal of this oxide can be readily obtained by the use of a flux, which combines chemically with the oxide and floats it off the surface; the molten solder is thus able to spread over and tin the clean basis metal exposed. In addition, the flux shields the surfaces against further oxidation during the soldering operation.

These, then, are the two functions of a flux. First, to clean the surfaces to be joined, and secondly to protect them from oxidation.

SOLDERING FLUXES. Soft-soldering fluxes can be divided into three main categories:

(1) Active or chloride fluxes.
(2) Electrical or resin-base fluxes.
(3) General safety fluxes.

Active Fluxes. These are chloride fluxes and are used for most soldering duties. They will remove quite considerable amounts of oxide, rust, or grease from the base metal. Killed spirit has been used in the past, but it is very corrosive and tends to leave a sticky residue in the joint itself. Certain commercial fluxes do not suffer from these disadvantages to the same extent, and are widely used on tinplate, terneplate, iron, steel, brass, copper, bronze, zinc, galvanised iron, nickel, etc. Flux of this nature is supplied in several forms—as a paste flux, as a tinning salt, and as a soldering fluid.

Special tinning salt is very widely used nowadays. It is a highly concentrated powder flux, which readily dissolves in cold or hot water, and should be used to the proportion of 2–4 lb. of salt per gallon of water. A stronger solution of $5\frac{1}{2}$ lb. per gallon is equivalent to A.M. Specification D.T.D.81.

Electrical Fluxes. The safety fluxes are not so rapid as the chloride fluxes and are less effective in removing surface oxide; thus it is necessary that soldering should be done on reasonably clean surfaces. These resin-base fluxes form a protective film over the part, preventing oxidation at the soldering temperature. Such fluxes are available in four forms: (a) paste flux, (b) soldering fluid, (c) solder cream, (d) cored solder wire, and are mainly intended for use on electrical and radio assemblies, where complete freedom from acid or corrosive action is necessary.

Solder Paints, Creams, and Compounds. Reference should also be made to solder paints, solder creams, and tinning compounds, which are widely used nowadays for tinning and sweat soldering. They are mixtures of powdered solder (or pure tin) combined with flux. The creams and paints are applied with a brush to the joint members, and tinning or sweating is obtained by heating with a blowflame, a soldering-iron, on a hot-plate, or by passage through an oven. The flux residue, in the case of the solder paint, can easily be removed, if necessary, by a water wash. The tinning compound is very active and is used, for example, for the tinning of bearings shells.

SOLDER. During recent years, solders with a much lower tin content have been more widely adopted, owing to the necessity for economising in the use of tin. In general, these lower-tin solders have proved in every way satisfactory, although it must be admitted that the pre-war tin-rich solders are quicker in operation and easier to use.

Grade C (40 per cent. tin) is recommended for general hand soldering, while Grade M (45 per cent.) is a more fluid alloy for use on more difficult jobs. Grade G should be used for electrical work. The low tin-content solder, Grade N, is specified for hot dipping work.

In addition there are several tin-economy solders. These solders have a wide field of application, and their use should always be explored in order to minimise the consumption of tin; but they cannot completely replace the normal tin-lead alloys.

Soft solders are normally available in the following forms:

- Tinman's, ½-lb. or ¼-lb. sticks.
- Ingots, nuggets, or blocks.
- Thin blowpipe strips.
- Solid solder wire.
- Cored solder wire.
- Solder tape and strip.
- Solder washers.
- Solder creams and paints.

Solid and Cored Solder Wire. Solders to all specifications are available in wire form.

Solid Solder Wire: All sizes down to 25 S.W.G.

Cored wire
Resin-cored wire
Acid-cored wire } All sizes down to 19 S.W.G.

For electrical and radio work resin-cored solder should be used. It is very much quicker than resin, but just as safe to use.

MELTING-POINTS AND STRENGTHS OF SOLDERS

	Melting-points		*Freezing Range*	*Specific Gravity*	*Tensile Strength tons/sq. in.*	*Elongation, % on 2 in.*
	Liquid	*Solidus*				
Eutectic solder	183° C. 361° F.	183° C. 361° F.	— —	8·42	4·4	32
Grade A 65/35	186° C. 367° F.	183° C. 361° F.	3° C. 6° F.	8·35	4·9	20
Grade B 50/50	205° C. 401° F.	183° C. 361° F.	22° C. 40° F.	8·87	4·4	67
Grade C 40/60	230° C. 446° F.	183° C. 361° F.	47° C. 85° F.	9·33	4·1	63
Grade D (plumber's)	252° C. 486° F.	183° C. 361° F.	69° C. 125° F.	9·85	3·5	70
Grade F 50/50	210° C. 410° F.	183° C. 361° F.	27° C. 49° F.	8·83	3·8	69
Grade G 42/58	233° C. 451° F.	183° C. 361° F.	50° C. 90° F.	9·20	4·16	83
Grade K 60/40	184° C. 363° F.	183° C. 361° F.	1° C. 2° F.	8·46	4·0	52
Grade M 45/55	217° C. 423° F.	183° C. 361° F.	34° C. 62° F.	9·10	4·4	65
Grade N 18/82	278° C. 532° F.	183° C. 361° F.	95° C. 171° F.	10·45	3·5	22

Acid-cored is intended only for special duties and contains a strong chloride flux.

Soldering Zinc. In any soldering operation the molten solder alloys with the base metal and often dissolves some of it. This action takes place rapidly when soldering zinc; this not only leads to contamination of zinc in the solder, which causes sluggishness in running, but also with normal solders leads to the formation of a hard, brittle compound. Successful soldering with a clean smooth finish can be obtained from any of the commercial solders.

Soldering Cast Iron. Cast iron is somewhat difficult to solder owing to the presence of graphite and non-metallic inclusions. Pickling in hydrochloric acid before tinning is sometimes recommended, but this method is dangerous, and not always successful. For many duties good tinning can be obtained, after grinding the surface, with solders to B.S.S. Grades C or M. For the tinning of cast-iron shells, it is advisable to use a tinning compound on account of its increased activity.

Soldering Aluminium. A special technique is required for aluminium. The metal forms an oxide skin on the surface which is not removed by the ordinary soldering fluxes; the oxide must be removed mechanically during the soldering operation. The aluminium solder is melted on the metal to exclude air whilst the surface beneath the molten solder is scraped or rubbed with a sharp tool such as a hacksaw blade or scratchbrush. The amount of scraping should be kept to a minimum; often good tinning can be obtained by rubbing the solder sticks on the heated aluminium. Once a tinned surface has been obtained with aluminium solder, the joint can be completed, if necessary, with ordinary tinsmith's solder. The soldering temperature is in the neighbourhood of 250° C.

Aluminium corrodes readily in moist conditions when in contact with other metals; thus the use of aluminium solder is limited. It is suitable for dry joints, but it is advisable to protect the joint by a coat of varnish or lacquer. Aluminium solders are thus not suitable for kettles and saucepans—welding is the best method of repair.

Solders for Hot Dipping. Hot tinning is normally employed to provide a protective coating. The following technique is recommended:

(1) Degreasing: If the article is greasy, treatment in an alkaline solution or in a trichlorethylene vat is necessary.

(2) Pickling: The surface must be free from oxide. Pickle solutions containing sulphuric, hydrochloric, or nitric acid are used, according to the metal being treated.

(3) Fluxing: After washing, the article is dipped in flux. An active flux is used for all except special purposes.

(4) Dipping in molten solder: The time of immersion should be no longer than that required to bring the articles to the temperature of the solder bath and obtain a clean smooth coating. Usually only a few seconds.

Grade N solder is normally used. The best dipping temperature is about 400° C. Temperature control is important.

Soldering Stainless Steels. The normal tin-lead solders are satisfactory, but Grade M is to be preferred. Most difficulties are due to use of the wrong type of flux. A non-corrosive flux of the phosphate type is frequently satisfactory.

Soldering Tinplate, Terneplate, Brass, and Copper. Generally speaking, these metals are easily soldered. Successful results can be obtained with practically any grade of solder (B.S.S. Grades C, G, or M) and with an active or safety flux. Oleic acid No. 10 is the best safety non-corrosive flux for use on tinplate or terneplate. It is sometimes necessary to carry out preliminary degreasing before soldering, but this is very rare.

Soldering Electro-tinned Articles. Difficulties are often experienced in this operation and are due to two main features:

(1) Insufficient thickness of electro-tin deposit. The minimum thickness should be 0·002 in.

(2) Time lag between electro-tinning and soldering. Soldering should normally be done immediately after or within two days of electro-plating.

Soldering should preferably be done with Grade M solder. Either an active or safety flux is suitable.

Solder Washers. There is an increasing use of solder washers, blanks, discs, ribbon, and strip, which can be supplied to any given size, specification, or shape. The solder is fluxed before location, and jigging and soldering or sweating are obtained on a hot plate or by passing the assembly through a continuous furnace or oven, or by the electrode method.

Soft Solders for Elevated Temperatures. The ordinary soft tin-lead solders commence to melt at 183° C. (361° F.), but as they approach this temperature their strength falls rapidly. The strength of a joint in brass made with ordinary tinman's solder is reduced by 75 per cent. when the temperature reaches 150° C. (302° F.). The loss in strength of soft solders is especially marked at temperatures above the boiling-point of water—100° C. (212° F.).

For soldered joints to withstand stresses at working temperatures of over 100° C., a special high-temperature solder should be used. As an example, ordinary solders often fail at the high temperatures encountered on armatures; this defect is remedied by soldering with a tin-base or lead-base alloy.

JOINT STRENGTH

Shear strength of joints (lap joints in brass)		*L.S.2*	*L.S.4*	*H.T.3*	*Grade B 50/50*
Tons per sq. in. at	18° C.	1·52	1·45	2·63	2·45
	100° C.	1·20	1·14	1·79	1·58
	150° C.	1·01	0·93	1·29	0·68
	200° C.	0·80	0·74	0·52	—

H.T.3 is a tin-rich alloy, free from lead. It is a free-flowing alloy and can be applied by the normal methods.

The Lead-base Solders: L.S.2 and L.S.4, which contain small amounts of silver and other constituents, will resist even higher temperatures than H.T.3. They are not quite so free-flowing as the tin-base solder. With L.S.2 it is necessary to use an active flux to obtain good bonding; with L.S.4, which has better tinning properties, tinning can be obtained with a safety flux.

High-temperature solders are used for armatures, aircraft cooling systems, hot-water appliances, and electrical machinery.

Quality No.	*Alloy*	*Melting-points* ° C.	° F.
—	Tin-lead .	183	361
18	Tin-lead-cadmium	142	288
17	Tin-bismuth .	138	281
15	Lead-bismuth .	124	255
9	Tin-lead-bismuth	93	203
2	Tin-lead-bismuth-cadmium	70	158

Fusible Solders. Alloys with very low melting-points are frequently used for special purposes. Among these may be mentioned solders for work which might be damaged by the temperature of application of tin-lead solders; in safety devices, e.g. for operating alarms or breaking the electrical circuit when the temperature exceeds the melting-point of the alloy; similarly, in fusible plugs for boilers; as fillers for the bending of thin-walled tubes; and setting media for the mounting of punches and dies.

A special bending alloy, melting at 71° C., is used as a filler, providing the internal support necessary to prevent distortion in the bending of thin-walled tubes. The alloy is melted in hot water and poured into the tube, which is plugged at one end. The filling is then chilled rapidly by plunging the tube into cold water. After bending, the tube is emptied by melting out the alloy in hot water.

Matrix alloy is used for setting dies and punches in press tools. The die is placed in position by hand on its backing plate and the matrix alloy poured round it. The alloy expands on solidification, and so holds the part firmly in position. The alloy can be poured at about 200° C., so that the temper of the die is not affected.

Hard Solders. Hard solders were originally brasses containing a high proportion of zinc. More recently it has been found that the addition of silver to brass lowers the melting-point of the solder and gives a better joint. Silver solders are now employed extensively, despite their high cost.

Brazing Solders. These usually contain about 50 per cent. of copper and 50 per cent. of zinc, and the melting-point is in the region of 870° C., i.e. at a red heat. With this alloy it is possible to braze the commonly used brasses which have melting-points of 900° C. or over, and, of course, higher melting-point metals, such as iron and steel.

The British Standards Specification No. 263, 1931, covers three grades of brazing solder:

	Copper	*Zinc*
Grade AA	59-61	Balance
Grade A	53-55	Balance
Grade B	49-51	Balance

Grade AA is intended for solder supplied in the form of wire or slittings.

With these solders, a borax-type flux is generally used.

Silver Solders. These alloys are easier to apply than brazing solders; they have superior fluidity, and give strong, sound joints. Three alloys are specified in British Standards Specification No. 206, 1941.

These solders can be used on copper, brass, bronze, steel, nickel, alloys, etc. Grade A has highest conductivity and is specified for electrical work.

HARD SOLDERS

Grade	*Silver*	*Copper*	*Zinc*	*Cadmium*	*Melting-point, ° C.*
A	61	29	10	—	690–735
B	43	20	37	—	700–775
C	50	15	16	19	595–630

SOLENOID. A coil of wire either wound on a former or air-spaced and self-supporting. When a galvanic current is passed through a solenoid it becomes possessed of many of the properties of a magnet due to lines of force which surround the solenoid. Examples of solenoids in a wireless receiver are: tuning coils, chokes, telephone windings; the speech coil of a moving-coil loudspeaker.

S O S. International distress signal, radiated in Morse. (See also *M'aidez*.)

SOUND, SPEED OF. Sound waves travel 1,142 ft. per second, at sea level.

SOUND WAVES. The vibrations of the air produced by the motion of a body. An example is the beating of a large drum. If the skin of the drum is driven inwards the air will follow the skin, producing a slight rarefaction in that spot. As the skin flies out it will tend to compress the air, and this rarefaction and compression will travel through the air, due to the motion being transmitted from one molecule to another. When it reaches our ear it causes the drum of the ear to vibrate in sympathy with its motion, so reproducing the sound originated by the drum. Sound radiates, that is, distributes its effect equally in all directions, and not in a straight line in one direction only. Consequently, it diminishes in intensity in inverse proportion to the square of its distance. It is possible to control sound waves by means of reflection, inflection, and refraction. In reflection we get "echo"; with inflection we get a bending; and with refraction we get a convergence. Sound waves are divided into two classes: (1) musical sounds, and (2) noises. A musical sound has a regular period of vibration, and a noise has an uneven rate of vibration. Musical sounds are *felt* if they are below 16 vibrations per second. That is to say, no musical note can be heard, but there is a consciousness of sound. Above 20,000 vibrations per second the consciousness of sound ceases.

SOUNDER. A device used in telegraphy for making audible the transmitted telegraphic signals. It consists of an electro-magnet with a heavy armature spring suspended. When a current passes through the magnet the armature is attracted to the pole piece of the magnet, and as soon as the current ceases the spring returns the armature to a contact piece. The "click" produced by the armature hitting the pole piece (or back contact) corresponds with the key depressions of the transmitter, and in this way the signals are read.

SPACE CHARGE. Residual negative electrons which remain in proximity to the filament, and so prevent the full emission to be made use of.

SPACE FACTOR. That ratio of the cross-section of wires in a winding to the cross-section, including insulation and space, of the actual total space taken up.

SPARK. The electric discharge which takes place between two electrodes when the voltage which is applied is sufficient to break down the air resistance separating them. The spark consists of damped oscillations, and these oscillations are transmitted through the surrounding air. It is thus possible to receive the oscillations from even a small spark, such as an electric bell will produce, provided the receiver is sufficiently sensitive. In wireless telegraphy certain transmitters (principally ships and ship stations) employ a spark transmitter instead of telephony. The transmitter employs oscillating condenser spark discharges across an air gap, and the sparks are obtained by the depression of a key in the circuit. In this manner the operator may send the dots and dashes of the Morse code.

SPARK COIL. An induction coil employing a primary and secondary winding, and a vibrating armature. A battery connected across the primary will induce a current into the secondary winding.

SPARK GAP. The contacts across which the spark discharge takes place.

SPEAKERS. (See *Loudspeakers.*)

SPECIFIC GRAVITY. The relative density of a substance, or the weight of a body compared with the weight of another body having the same magnitude. The S.G. of a body is the ratio of its weight to the weight of water it displaces when immersed therein. The ratio of the weight of the material to the weight of the same volume of water.

SPECIFIC RESISTANCE. The resistance of a piece of material which is 1 cm. in length and 1 sq. cm. in cross section.

SPECTROMETER. A test instrument to determine the frequency distribution of the energy generated by any source and to display all the components simultaneously.

SPECTRUM. The term applied to the complete range of light frequencies (known as the "visible" spectrum) and the complete range of sound frequencies (known as the "audible" spectrum). It is appreciated, of course, that in each spectrum there are frequencies which are not normally visible or audible. The complete range of the spectrum may be found under *Visible Spectrum* and *Audible Spectrum.*

SPEECH CLIPPER. A circuit arranged to cut the peaks of the waveform without seriously affecting the intelligibility of the voice. Used in transmitters and amplifiers to avoid certain forms of overloading, and as a result the apparatus may be operated at a much higher level than with alternative arrangements.

SPEECH COIL. The winding on a cone loudspeaker which carries the speech currents. It is usually of low resistance and is fed from the secondary of a transformer, the primary of which is joined in the anode circuit of the output valve. The speech coil is sometimes wound on a cylindrical former of insulating material.

SPELTER. A commercial name for zinc. It is also an abbreviation of the words "spelter-solder," which is a zinc substance for soldering brass.

SPINNER. That part of a mechanical scanner which rotates about an axis, most generally restricted to cases where the speed of rotation is relatively high.

SPONGY-LOOP. A self-oscillator *locked* to a system liable to frequency fluctuation in such a way that the short-period frequency fluctuations of the system cause a negligible change in the oscillator frequency.

SPOT. The point of impact of the electron *beam* on the screen of a cathode-ray tube, whether there be sufficient electrons to excite luminescence or not.

SPOT FREQUENCY. A pre-selected single frequency.

SPOTTING (Radar). Observing radar *echoes* from splashes or ground-bursts made by fall of shot.

SPREADER. The rod or stick used for separating the wires of a two or more wire aerial. Where two wires are employed the spreader should be not less than 3 ft. long for medium wavelengths.

SQUARE-LAW CONDENSER. See *Variable Condenser.*

SQUEEZE SECTION. A length of *waveguide* so constructed that alteration of the *critical dimension* is possible with a corresponding alteration in the electrical length.

SQUEGGER. A *self-quenching oscillator* in which the suppression occurs in the grid circuit.

SQUEGGER OSCILLATOR. In its usual form the squegging oscillator consists of an ordinary feedback valve circuit with a grid leak and condenser, a typical circuit being depicted in Fig. 427. This arrangement will, by a suitable choice of component values, generate anything from continuous oscillation of more or less sine wave form, to short, regularly spaced bursts of oscillation. It is this latter condition of operation, when bursts are produced at a repetition frequency determined mainly by the product CR, that is known as the squegging condition.

The customary explanation of the manner in which this circuit functions is as follows : feedback occurs from L1 to L2, and the valve commences to oscillate at a frequency determined by the grid-tuned circuit L2C1. This oscillation very rapidly builds up and, as it does so, the grid rectification effect of the valve with C and R causes the mean grid potential to swing negative. This effect is cumulative, and after a short while the grid becomes so negative that the valve is carried beyond cut-off and oscillations cease. This condition remains until the charge on condenser C has leaked away through R and L2, when the valve again commences to conduct and the cycle of events repeats itself. The voltage between grid and cathode therefore varies in the manner of the waveform shown in Fig. 426*a*, each cycle consisting of a short burst of oscillation, driving the grid beyond cut-off in the process, followed by a relatively long period of quiescence, during which the grid condenser discharges exponentially through the grid leak.

This squegging condition is achieved by using a much tighter coupling between L1 and L2, and a much higher value for C and R, than would normally be used when continuous oscillations are desired. The form which the oscillating circuit takes is of little importance, and such circuits as the Colpitts or the Hartley may be employed in place of the reaction-coil arrangement of Fig. 427.

Blocking oscillators are generally constructed so that L1, L2 and C1 constitute an iron-cored transformer which may or may not have damping resistances across the primary and secondary. An ordinary, good-quality audio transformer, having a ratio of about 3 : 1 is quite general, the secondary being connected into the grid circuit. In this case C1 does not exist as a separate condenser, but is made up of the self-capacity of the transformer windings.

Consider such a system at an instant when the condenser C (still referring to Fig. 427) is so charged that the valve grid is negative beyond cut-off. This charge commences to leak away through R and L1, and consequently induces a small E.M.F. in L1, such that there is a slight increase in anode potential. This effect continues as C discharges, and at last a stage is reached where the valve begins slightly to conduct. The rising anode current through L1, then induces an E.M.F. in L2 in such a direction that the grid is driven rapidly positive, and in a very short while the valve is fully conducting.

Now as the grid is driven positive, there is a fall in the anode potential due to the back E.M.F. set up in L1, and condenser C is charged by the flow of grid current. L1 thus experiences an additional load due to the grid-cathode A.C. resistance of the valve. This damping effect, together with the fall of anode potential, eventually succeeds in reducing the rate of rise of anode current and hence the grid voltage. Again the effect is cumulative and the anode current falls rapidly, driving the grid negative and carrying the valve beyond cut-off. The grid waveform varies in the manner shown in Fig. 426*b*, the valve cutting off after one-half cycle of oscillatory voltage.

While transformer back-coupled oscillators can be made to function in this manner, actual practice shows that ideal conditions are not easy to obtain due to damped oscillations set up in the transformer windings. A method of overcoming this is to use shunt resistances (the lesser of two evils) across the primary and secondary windings, even though the use of such resistances reduces the useful voltages developed and limits the charge on the condenser. They are also somewhat critical in value.

Another method of achieving the result outlined above is to employ a tuned circuit in place of the transformer, the natural frequency of this tuned circuit being so chosen that the tune for one cycle is equal to twice the period over which the valve will be conductive. The action of the system is then very similar to the transformer-coupled circuit provided that the grid circuit time constant composed of C and the grid-cathode A.C. resistance of the valve is small compared with the period of conduction.

When the grid is carried positive in this case, the precise potential reached depends upon the ratio of the time constant CR_g to the time of one-half cycle of the resonant frequency of the tuned circuit. Taking this ratio to be small, then the condenser C will charge as rapidly as the applied voltage rises, and the voltage across C will be practically equal to the applied voltage. Relative to the cathode the grid potential will be only slightly positive, since it consists of the algebraic sum of the voltages across the coil and the condenser, and these are very nearly equal though opposite in sign (ignoring slight resistive elements). When the voltage across the coil commences to fall the change in grid potential soon carries the valve beyond cut-off and when the voltage across the coil is zero, the grid is negative by an amount equal to the condenser voltage. L2 being part of an oscillatory circuit, the next half cycle of oscillatory voltage carries the voltage across the coil to an amount practically equal to the previous positive swing, though negative in sign. The potential at the grid consequently goes negative by an amount almost equal to twice the condenser voltage already present.

Now, since the conductive grid time constant CR_g is small enough to permit the condenser to charge almost completely during the first positive half cycle of oscillatory voltage, the second positive half cycle will fail to lift the paralysing bias on the grid and the valve will remain cut off. The oscillations will then rapidly die away, and the process will only repeat when the charge on the condenser has leaked through R sufficiently to allow conduction to recommence. The grid waveform for this cycle of events is shown in Fig. 426*b*, already referred to above, where it is seen that the valve is cut off after the first half cycle of grid oscillatory voltage. This is the blocking condition as distinct from the squegging circuit whose grid waveform was shown in Fig. 426*a*. It must not be overlooked, of course, that the blocking oscillator is only a particular form of squegging oscillator, and that all oscillators of this nature are actually squegging oscillators, as was remarked previously.

In order to understand the fundamental theory of squegging oscillators, it is necessary to grasp the implications of the fact that the effective mutual conductance of a valve varies with the grid bias applied.

Mutual conductance is generally defined as the ratio of the change in anode current to the change in grid voltage producing it, infinitesimally small quantities being taken in each case. In the notation of the calculus :

Mutual conductance $g_m = \frac{\delta I_a}{\delta V_g}$, i.e. the tangent to the $I_a - V_g$ curve (Fig. 428) at any particular point.

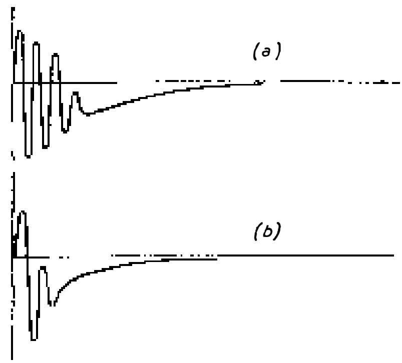
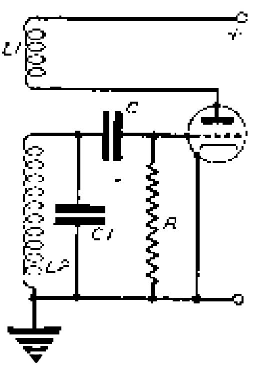
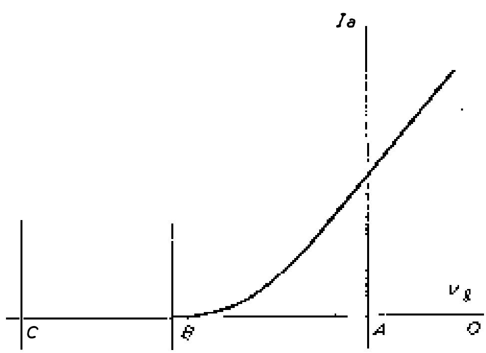


FIG. 426. (*a*) *Grid-cathode waveforms for squegging circuits;* (*b*) *showing the special case of blocking.*

This definition of g_m is not of much value when the amplitude of the input voltage is large, for then the characteristic is curved throughout the working range and the static value of mutual-conductance arrived at by the above method no longer applies. When a relatively large sinusoidal input is applied to the grid,





FIGS. 427 AND 428. (*Left*) *Typical squegging oscillator circuit with reaction coil feedback.* (*Right*) *Typical Ia-Vg curve, showing various points of bias.*

the anode current will fluctuate accordingly, but the anode waveform will not in general be sinusoidal. It may be nearly so, or it may consist solely of short pulses corresponding to the positive tips of the input waveform. It is possible to show, however, that the anode waveform, whatever its variations, can be resolved into a harmonically related series of sine and cosine terms with a fundamental frequency equal to that of the grid waveform. We now define mutual conductance as *the ratio of the fundamental frequency component of the anode current to the grid voltage.*

The manner in which the effective mutual conductance varies with grid bias is quite a simple matter to follow from Fig. 428. When a valve is biased at a point A (about the centre of the steepest part of the curve), the slope and therefore the mutual conductance, has a maximum value g_m. As the bias point is moved back towards B, the slope of the curve becomes less, and g_m therefore decreases. g_m does not necessarily become zero, however, when the bias point is moved beyond the cut-off value of the value at B, for during part of the positive half cycles of input voltage the grid potential may still be carried into the conductive region BO. Only when the grid bias is taken back to a position such as C, where BC is equal to or greater than the peak value $\hat{V}_i$ of the input voltage will the mutual conductance fall to zero. As the grid bias is moved from A in a negative direction towards C, the mutual conductance accordingly falls from its maximum value g_m to zero.

Now also from Fig. 428, taking the characteristic as ideal, that is, ignoring the bottom bend between A and B, we may note the effect of the input voltage amplitude on the mutual conductance. For an applied sinusoidal input voltage of amplitude $\hat{V}_i$ with the valve biased at the point A, the mutual conductance will be constant for all values of $\hat{V}$, from zero up to $\hat{V}_i = AB$. As soon as the amplitude exceeds this value g_m must begin to decrease, for the valve is only conducting over part of the input cycle. As $\hat{V}_i$ becomes greater and greater, g_m becomes smaller and smaller, and eventually reaches a minimum value approximately equal to $\frac{1}{2}g_m$ when AB is small compared with $\hat{V}_i$.

With the valve biased at the point B, g_m becomes independent of $\hat{V}_i$ for the valve is conductive for one-half of each cycle at all times, and its value is then approximately equal to $\frac{1}{2}g_m$.

The third operating point at C gives a mutual conductance which is zero for values of $\hat{V}_i$ less than BC, but which increases as $\hat{V}_i$ increases and eventually reaches a maximum value approximately equal to $\frac{1}{2}g_m$ when BC is small compared with $\hat{V}_i$.

In a practical characteristic curve, where the bottom bend is taken into account, it is a simple matter to see that for a valve biased at the cut-off point B, g_m will increase from zero to a maximum as the input voltage amplitude $\hat{V}_i$ is increased from zero.

As is known from oscillator theory, the conditions as to whether a tuned grid oscillator will generate oscillations or not depends upon the relative values of the conductance of the tuned input circuit M, and the input conductance of the valve M, which latter is dependent upon g_m and may be positive or negative. When M_v is negative and greater than M the circuit will oscillate with increasing amplitude. When M_v is positive, or M — M_v is positive, the valve will not oscillate. Consider the instant when the charge present upon the grid condenser has leaked away sufficiently for conduction to recommence g_m is then finite and its value is increasing as the grid voltage falls. Thus M_v is becoming larger, and eventually a point is reached where its value becomes equal to — M. Oscillation then commences, and as the valve is operating on a curved portion of the characteristic the input voltage brings about an increase in g_m, which in turn increases the value of — M_v and so causes a still further build-up of $\hat{V}_i$. As soon as the oscillation is established, therefore, $\hat{V}_i$ builds up very rapidly, but without an appreciable change in the bias point of the valve. This is due to the failure on the part of the grid condenser to charge at any great speed through the grid-cathode resistance of the valve, despite the rectifying action of the grid circuit. In fact, all that the rectification effect achieves at this stage is merely to prevent the further discharge of the grid condenser through the grid leak.

By the time the grid condenser has charged to any appreciable amount, $\hat{V}_i$ has built up to a very large amplitude. Due to this the bias voltage affects g_m distance beyond the cut-off point. There are then two conflicting actions at work: g_m is tending to decrease as the charge on the grid condenser increases, and at the same time tending to increase as $\hat{V}_i$ increases. If $\hat{V}_i$ is still rising rapidly the grid bias is tending to rise at a similar rate, but with a difference of magnitude which is considerable and very roughly constant. Despite the build-up of $\hat{V}_i$, therefore, as the bias rises, the fraction of the amplitude cutting into the conductive region of the curve will decrease and g_m will begin to grow smaller. The rate of increase of $\hat{V}_i$ will consequently fall off, but the condenser will go on charging all the time the amplitude is sufficient to sweep into the conductive region. As soon as the input peaks fail to carry the valve to the point of grid current, the condenser ceases to charge. At this stage $-M_v$ is less than M; that is, the value of g_m is insufficient to maintain the amplitude; the value of $\hat{V}_i$ therefore falls to zero very rapidly, leaving the valve cut off and the grid condenser charged. As soon as the condenser has discharged sufficiently through the grid leak the cycle of events repeats. It is apparent that as long as the bias point remains on the conductive regions of the characteristic squegging cannot occur. This, however, is not the real distinction between squegging circuits and circuits generating continuous oscillation, for the latter condition is possible even when a valve is biased beyond cut-off. The true conditions under which an oscillator operates depend upon the initial rate of increase of input amplitude; and if this is high the bias voltage lags a considerable way behind the amplitude, and a very large value of $\hat{V}_i$ is reached before the bias can appreciably reduce the value of the mutual conductance.

In any circuit of this nature the input amplitude is always limited by the effect of the increasing bias on the growth of the mutual conductance, itself due to the rise of the input amplitude. If the effect manifests itself before the bias reaches the cut-off point of the valve, squegging does not occur, even though the bias may afterwards exceed this value. If it comes into play after the cut-off point has been passed, squegging necessarily occurs. Summed up, squegging does not occur if the rate of change of amplitude is decreasing at the cut-off point, but it does occur if the rate is increasing at this point.

SQUELCH. Another name (of American origin) for "Quiet A.V.C." (*which see*).

SQUINT. The small angle which may exist between the normal to a broadside *array* (or the axis of an end-fire array) and the actual direction of maximum radiation.

SQUIRREL-CAGE AERIAL. An aerial formed by using circular spreaders at each end. Round the periphery of the spreaders many wires are disposed, so that the result is a cylinder with the wires running from end to end. Another name for this type of aerial is the "sausage aerial."

SQUIRREL-CAGE ROTOR. A rotor formed in the same manner as the squirrel-cage aerial.

SQUITTER (of a Transponder). To produce unwanted self-oscillation owing to incorrect adjustment.

S.R. Specific Resistance.

S.S.C. An abbreviation for Single Silk Covered. A term applied to wire which is insulated by being wrapped with a single layer of silk thread. This thread is wound round and round the wire.

STABILISER. (See *Neon.*)

STABILOVOLT. A multi-electrode gas discharge tube used as a voltage stabiliser and capable of giving a number of constant-voltage supplies.

STABLE TRIGGER CIRCUIT. A *relaxation circuit* which has two stable conditions, and can be made to pass very rapidly from one to the other by applying a suitable *triggering pulse* or signal. The Eccles-Jordan circuit is an example of a trigger circuit.

STACK. A vertical or substantially vertical *array* of aerial elements (B.S.I.).

STAGE GAIN. The amount of amplification which is provided by a complete valve and its couplings. It may be measured by connecting an A.C. generator to the grid circuit of a valve, and measuring the output from the output end of the circuit. (See *Amplification.*)

STAGGER. To adjust, in a regular (not random) manner, the values of a series of circuit quantities so that some or all of them differ slightly from the mean value of the whole series.

STAINING. (See *Polishing.*)

STALLOY. An alloy of steel. This is a proprietary name for a special preparation of steel used for the cores of transformers, etc.

STAND-BI. A nautical term, signifying the position of the tuner where waves of different lengths are received. The term is also employed to denote "wait."

STANDING WAVE. The field configuration corresponding to the stationary wave pattern set up by the combination of a forward *travelling wave* and a portion of this reflected at one or more discontinuities.

STANDING-WAVE RATIO (S.W.R.). The ratio of the difference to the sum of the amplitudes of the direct and reflected waves at a point on a transmission line or in a *waveguide.*

STATAMPERE. (See *Abampere, Ampere.*) 1 statampere $= 3{\cdot}33 \times 10^{-11}$ abamperes.

STATCOULOMB. (See *Coulomb.*)

STATHENRY. (See *Henry.*)

STATIC. Stationary electricity. It is the name also applied to atmospherics, and accumulations of electricity (atmospherics) on an aerial.

STATMHO. (See *Mho.*)

STATOHM. (See *Ohm.*)

STATVOLT. (See *Volt.*)

STENODE. A circuit arrangement in which a piezo crystal is used to obtain selectivity. The varying resistance of the quartz crystal is employed to vary the H.F. by-passing effect, and it is claimed that this results in a degree of selectivity higher than that of a superhet.

STEP-DOWN TRANSFORMER. A transformer in which the secondary winding is smaller than the primary. When a voltage is applied to the primary a smaller voltage is obtained in the secondary.

STEP STROBE MARKER. A form of *strobe marker* in which the discontinuity is in the form of a step in the *timebase.*

STEP-UP TRANSFORMER. A transformer in which the secondary winding is larger than the primary. If a voltage is applied to the primary, a larger voltage will be obtained at the secondary.

STEREOPHONY. A term applied to methods of obtaining depth in broadcast reception. As at present known, the sounds are picked up by a single microphone, which, of course, destroys all sense of "relief," and are relayed from a single point in the room. Experiments in sterophony have consisted of using two microphones arranged at each end of a studio, and relaying the sounds picked up by one from one station, and those from the other microphone from a different station. At the receiving end the two stations are received on separate receivers and two loudspeakers.

STOPPER. A resistor connected next to one of the electrodes of a valve to prevent unwanted self-oscillation.

STOPPERS. Devices used to prevent the flow of currents of some particular frequency. Thus, an anti-break-through choke (connected in series with the aerial lead-in) is used to "stop" the passage of medium-wave signals when the set is tuned to long waves. (See also *Grid Stopper.*)

STORAGE BATTERY OR CELL. (See *Accumulator.*)

STORAGE TUBE. A cathode-ray tube having a special screen used to integrate signals or to store them for scanning.

STRAP. A wire or strip connection between the ends of the segments of the anode of a *cavity magnetron,* to promote operation in the desired *mode.*

STRATOSPHERE. (See *Ionosphere.*)

STRAYS. Another term for "Static," (*which see*).

STROBE MARKER. A small bright *spot,* or a short gap, or other discontinuity produced on the line *trace* of a radar *display* to indicate that part of the *timebase* which is receiving attention. (See also *To Strobe.*)

STROBE PULSE. A *pulse* of duration less than the time period of a recurrent phenomenon used for making a close investigation of that phenomenon.

STROBOSCOPE. A device for determining the speed of rotation of a disc, etc., by means of an interrupted light supply. In its simplest form it consists of a disc of paper or similar material around the periphery of which are arranged an equal number of light and dark segments. When illuminated by a source of light interrupted regularly (for instance, an ordinary A.C. supply) the disc will appear to remain stationary at the correct speed. The formula for determining the number of segments is $\frac{120 \times f}{r}$, where f is the frequency of the lighting supply and r the number of revolutions per minute. A neon lamp gives a more definite image. (See *To Strobe.*)

STUB SUPPORTER. A stub used for mechanical support and producing the minimum electrical disturbance.

SULPHATING. The action of the sulphuric acid upon the plates of an accumulator.

SUN-SPOTS. It has long been known that since the sun emits electro-magnetic waves in the form of light and heat, it must also emit radio waves of extremely weak intensity. Normally, this is so feeble as to be quite undetectable on radio receivers in the 1 to 10-metre band. It has, however, recently been found by a British radio scientist that when there is a big and active sun-spot group on the sun, the solar radio emission can be increased up to one hundred thousand times in the 1-10 metre band, and this radio emission can then be detected by sensitive receivers on the earth's surface. It is natural to assume that these abnormal bursts come not from the sun's disc as a whole, but from the localised active sun-spot area. Many present-day army receivers, particularly those used in radar, are now so sensitive that they detect this abnormal solar emission if their receiving aerials are pointed in the direction of the sun. The effect produced on listening-in headphones or loudspeakers is that of a hissing noise.

In 1946 there was a large and important group of sun-spots on the sun which could easily be seen through smoked glasses with the naked eye. Since the sun itself is rotating (it makes a complete rotation in twenty-seven days) it was calculated that the sun-spot group would cross the meridian on February 5th, 1946, and this was found to be the case, when solar noise from it was detected.

A demonstration of solar noise was arranged by Sir Edward Appleton and the Operational Research Group of the Ministry of Supply, when the solar noise was demonstrated as a disturbance on a cathode-ray screen such as is used for the delineation of radar echoes. It was also demonstrated as an audible hissing noise on a loudspeaker and on a measuring instrument which indicated the strength of the radiation. The wavelength of the receiver used was about 5 metres.

It has long been known that sun-spots affect short-wave radio transmission, because they cause abnormalities in the ionised reflecting layers in the upper atmosphere. We also know that when sun-spots become active first the enhanced radio noise is heard. The radiation causing this noise travels at the speed of light and reaches the earth from the sun in about 8 minutes. Secondly, the radio noise is usually followed by and associated with short-wave fade-outs. These are due to the formation of an absorbing blanket underneath the Heaviside Layer, so that radio waves are strongly absorbed there. This blanket is due to a burst of ultra-violet light and causes a fade-out of from half to one hour's duration. Such fade-outs are observed only on the sunlit side of the earth.

Solar radio noise does not affect ordinary broadcast reception on the long and medium waves. This arises from the fact that just as the atmospheric ionised layers prevent such waves from escaping from the earth's atmosphere, so they prevent medium and long radio waves from being heard. It may, however, drown very weak short-wave signals.

Solar radio noise is of very great scientific interest, and a new field of scientific research was opened up in 1947-48. The discovery of radio noise was made by Sir Edward Appleton and Mr. J. S. Hey. Work on the subject began as far back as 1936, when Appleton analysed reports from a number of wireless amateurs about a curious hiss which they had heard on their receivers. From these reports it was concluded that the noise was due to the emission of radio waves from sun-spot areas on the sun's disc.

Nothing further was heard of this until February, 1942, when Mr. J. S. Hey found that same effect on a number of British Army radar sets in this country, and he was able to prove that the radio noise came from the direction of the sun. He further pointed out that there was a spot on the sun at that time. Since 1942 no further recurrence of the phenomenon had been noted until early in 1946, since when the hiss has been unusually intense, and again the connection with a big sun-spot group has been noted. Once again has the work of the amateur been recognised, for without the careful observation of those who drew the attention of Sir Edward Appleton to the hissing noises, the important discovery might not have been made.

SUPER-HETERODYNE. A method of obtaining high selectivity by converting a received signal into a different, and lower, frequency and then carrying out amplification of this new frequency. The signal is detected, the frequency changed, amplified by two or more H.F. stages, again detected, and passed to the L.F. stages. (See also *Intermediate-frequency Transformer* and *Coils.*)

SUPER-HIGH FREQUENCY (S.H.F.). A frequency between 3 Mc and 30 Mc.

SUPER - REFRACTION. Abnormally large refraction of radio waves in the lower layers of the atmosphere, leading to abnormal ranges of operation.

SUPER-REGENERATIVE. (See *Circuit* and *Armstrong Circuit.*)

SUPERSONIC. Above audibility. Frequencies over 20,000 cycles per second.

SUPPRESSOR GRID. The extra grid which is inserted between the anode and screening grid of a pentode valve. It is generally internally connected to the cathode and acts as a stabiliser by preventing the excessive electrons which are shot back from the anode from interfering with the normal grid-anode electron stream.

SWEPT GAIN. (See *Anti-clutter Gain.*)

S.W.G. An abbreviation for Standard Wire Gauge.

SWING (in D.F.). The arc through which the direction-finder (if rotating) or the *goniometer* search-coil) (in case of fixed *aerial-system*) must be moved to permit the determination of a bearing. The swing is preferably expressed in the form of + half the arc defined above (B.S.I.)

SWINGING CHOKE. Is an ron-cored choke, the inductance of which decreases as the D.C. component flowing through the winding increases. This definition applies equally well to all types of iron-cored inductances carrying D.C. The relationship between inductance and D.C. component is shown in Fig. 429.

The swinging choke is, however, a special case, and this property, which is a disadvantage in an ordinary iron-cored choke, is used to improve the regulation of power supply units called upon to supply widely varying loads. As the name implies, the value of the inductance swings from one value to another, as the D.C. component varies in the winding.

It can therefore be assumed that there will be two limiting cases :

(a) when the choke swings to zero inductance; and (b) when the choke swings to maximum inductance.

In Fig. 431 (a) the choke with zero inductance is represented by R (the D.C. resistance of the winding). In the second limiting case, Fig. 431 (b), the choke is shown as an inductance, L.

Consider first the case (a) where the D.C. flowing in the winding is of such a value that the inductance of the choke is reduced to zero. This leaves only the D.C. resistance of the choke in circuit with a normal condenser input filter, Fig. 431 (a). In practice, R is small, and can be ignored for the purpose of this explanation. The output voltage waveforms of a full-wave rectifier with condenser input are shown in Fig. 430. The condenser C charges up to the peak value of the rectifier output voltage, and tends to remain at this value when the rectifier voltage has fallen to zero. On light load, the condenser discharges into the load circuit comparatively slowly, and its voltage falls only by a small amount by the time the rectifier voltage has again risen to its peak value. When the rectifier voltage falls below the potential of the charge in the condenser, the condenser discharges into the load and maintains the voltage across the load at a mean value, slightly less than the peak voltage of the transformer secondary. The output voltage of a rectifier unit with a condenser input filter is therefore only slightly less than the peak voltage of the transformer secondary, provided the load on the unit is small.

Now to examine the second limiting case (b), when conditions are such that the choke has maximum inductance (when minimum D.C. is flowing). The condenser input filter with an inductance between it and the rectifier valve now becomes a choke input filter, Fig. 431 (b). The inductance of the choke tends to oppose any rapid changes in current through it. For this reason the condenser C never becomes charged to the peak value of the transformer secondary voltage, but reaches a potential of slightly less than the R.M.S. value, as shown in Fig. 430.

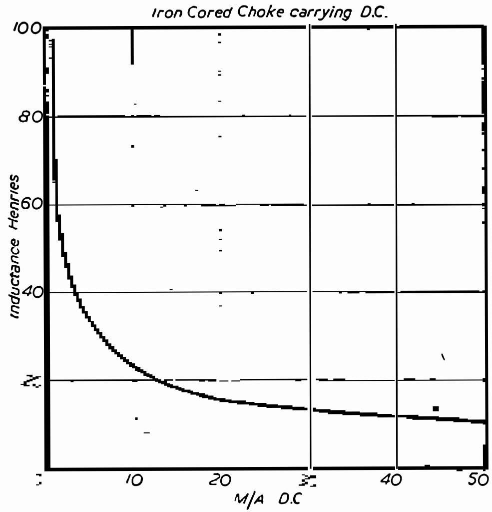
We have therefore two cases :

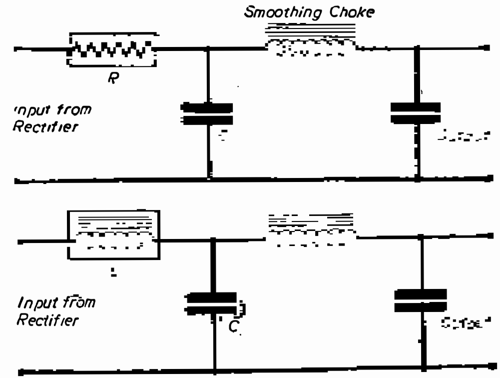
(a) With the output voltage at nearly the peak value, and

(b) with the output voltage at slightly less than the R.M.S. value of the transformer secondary voltage.

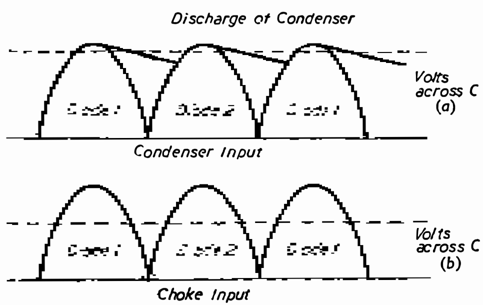
These limits are not reached in practice with a filter incorporating a swinging choke, but the inductance of the choke does vary within certain limits with variations of load.

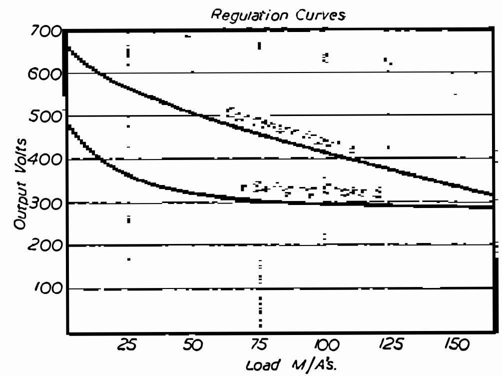
Operation. To sum up, the action of the swinging choke is as follows : On small load, the D.C. component will be at a minimum; the choke will therefore have a high value of inductance and the filter circuit will have the characteristics of a choke input circuit. As the load increases, the inductance of the choke falls, and with the decrease in inductance, condi-





FIGS. 429 AND 430. (*Left*) *Curve showing the relationship between the D.C. component and inductance of an iron-cored choke.* (*Right, top*) *Zero inductance is represented by R—the D.C. resistance of the winding.* (*Below*) *The same choke as an inductance L.*





FIGS. 431 AND 432. (*Left*) *Output voltage waveforms of a full-wave rectifier with condenser and choke output.* (*Right*) *Regulation curves of two types of power pack.*

tions in the circuit approach those of the condenser input filter. Consequently, the voltage across the condenser C will rise. If the values of inductance and capacitance are suitably chosen, the rise in voltage due to the discharge of the condenser into the load will compensate for the voltage drop caused by the increase in load. The circuit then becomes self-regulating.

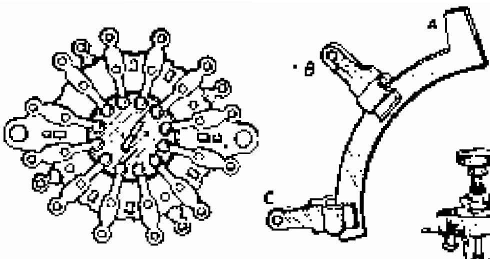
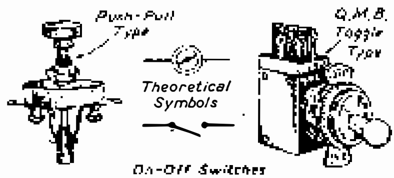


FIG. 433. *A Yaxley type rotary switch.*

FIG. 434. *Theoretical and actual diagrams of an on-off switch.*



Regulation Curves. The curves in Fig. 432 show the regulation of two types of power pack: (a) being the regulation curve of a unit employing a condenser input filter, and (b), a swinging choke. Both the packs are identical, except that the pack (b) incorporates a swinging choke. It can be seen from curve (a) that with condenser input the voltage is high on light load, but falls rapidly as the load increases. By increasing the load from 75 m.a. to 150 mA's a drop of 120 volts takes place. Curve (b) demonstrates the self-regulating effect of the swinging choke. The output voltage falls rapidly to the point X on the curve, but from this point the curve remains almost parallel to the axis. In this case, an increase in load from 75 mA to 150 mA causes a drop of only 10 volts.

In order to make use of the self-regulating property of the unit, it is necessary to operate it on the flat portion of the curve. This is done by connecting a bleeder resistance in parallel with the load, of such a value that a constant load of 75 mA's is imposed upon the unit. Changes in load of as much as 100 m.a. over and above the constant load will have a negligible effect upon the output voltage. A typical case where the use of a swinging choke power unit becomes necessary is the H.T. supply for a class B audio frequency stage, where the load varies rapidly within wide limits. Severe distortion would be experienced if the H.T. voltage fell to any extent when a large, sudden increase in current was demanded by the amplifier. It is therefore essential that the H.T. voltage be maintained at a constant level, irrespective of load.

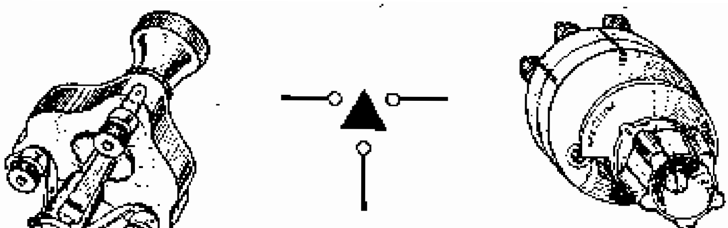


FIG. 435. *Theoretical and actual diagrams of a 3-point wave-change switch.*

The following points should be noted in the choice of components for the construction of a swinging choke power pack:

(1) The transformer must have good regulation.

(2) Mercury vapour rectifiers should be used, as the voltage drop introduced by

this valve is of the order of 15 volts only, and remains reasonably constant, irrespective of load.

(3) The swinging choke must be of good design, with good insulation and low D.C. resistance.

SWITCHES AND SWITCHING. The switch takes the form of a lever, the moving of which "makes" or "breaks" the circuit. Of course, the same result can be achieved by other simple mechanical movements, such as pressing the two wires in contact by means of a "button" or by turning a knob, but in any case the principle is the same, namely, that of connecting and disconnecting two wires. This must have robust non-rusting and non-corroding contacts, and these must be supported in a base which is a good insulator at all times, that is to say, one that will not allow a leakage of current between the contacts when the switch is off. Such switches usually have phosphor-bronze contacts (including the knife arm) mounted on a rectangular base of porcelain. The phosphor-bronze stands up very well to the elements, and so long as the porcelain is cleaned occasionally to prevent leakage of current through any film of dirt, which may otherwise collect on the surface, it will retain its insulating properties indefinitely.

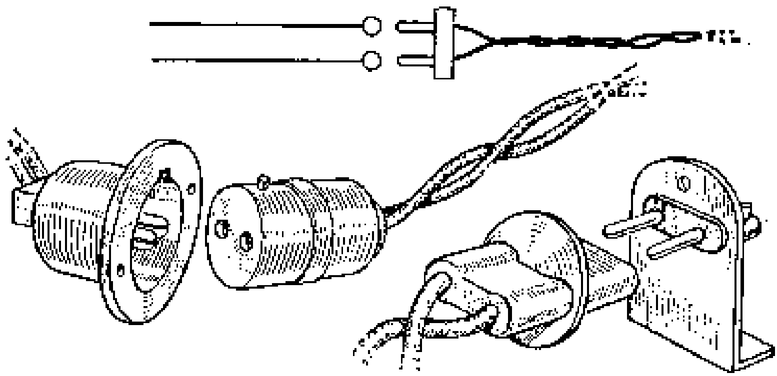


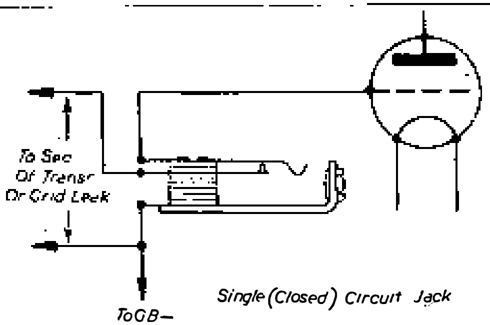
FIG. 436. *Theoretical and actual diagrams of a plug-in connector.*

in fact is the basis of all switches, however complicated they may be. With the more elaborate type it simply means that a number of such connections or disconnections, or both, are made with the one switch.

Single-circuit Types. Figs. 443, 444, etc. show the simple "make-and-break" or "on-off" switch in several patterns. Each pattern is designed primarily for use in some specific place in a receiver—the design being evolved to meet the peculiar requirements of the particular circuit in which it is to be used. Fig. 444 shows a typical circuit with illustrations of the switches used.

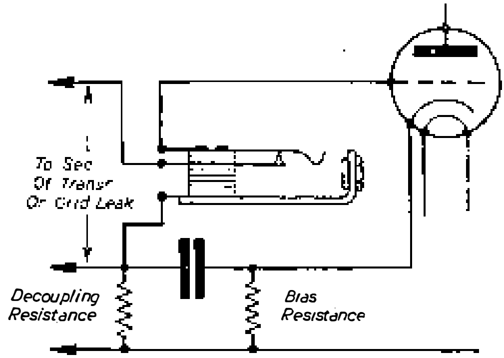
The illustration (Fig. 447) shows a switch designed for use under exacting conditions. It is called a knife switch, since the action of the arm is like that of a knife. It is a double-pole change-over type of switch. As this type of switch is often used out of doors it The switch is operated by swinging the "knife" over from one side to the other. The inset shows how the knife enters the spring contacts. In order to prevent current travelling through the operator's hand an insulated handle is fitted to the knife.

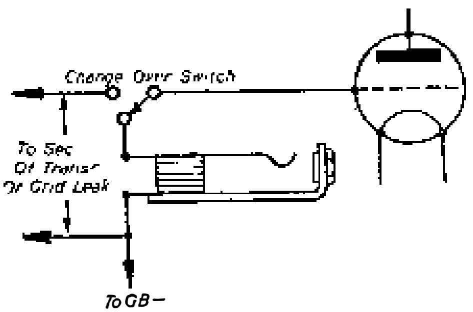
Switches for H.F. Circuits. The switch shown in Fig. 441 is a popular type for use as a wave-change switch. It is used to short-circuit some of the turns of a tuning coil so as to alter its wavelength. This is shown in Fig. 443. It operates on the push-pull principle. When the knob is pushed in as shown the two springs press against the insulated shank of the plunger, but when the knob is pulled out the metal end of the plunger comes between the springs and so connects them together. The qualifications of such a switch must be as follows: definite contact, finest insulation, and low capacity. The first is secured by



← FIG. 437. *A jack arranged for plugging in pick-up to one of the L.F. stages.*

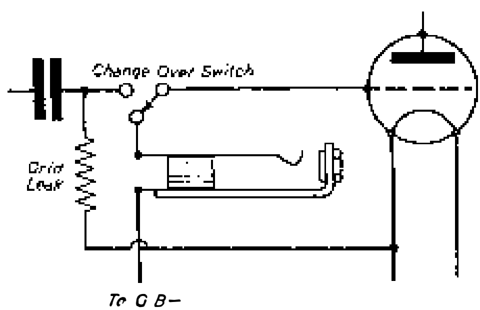
FIG. 438. *A modified version of the circuit shown in* FIG. 437. →





← FIG. 439. *A useful pick-up circuit using a panel switch in conjunction with the plug and jack.*

FIG. 440. *A similar arrangement to that shown in* FIG. 439 *but for use when the pick-up is run from the detector valve.* →



employing strong springs, and by nickel-plating both springs and plunger to prevent corrosion. Good insulation is obtained by using a base made of ebonite (a hard black substance made from rubber and sulphur), or some similar compound such as "bakelite." Low capacity is a necessary property of all switch gear used in high-frequency circuits, such as the aerial circuit of a wireless receiver. It means that the contacts must not be too near together or of too great an area, otherwise they will tend to act as the plates of a condenser and thus allow the H.F. currents to pass from one to the other. Such "leakage" is quite distinct from that caused by bad insulation. It may also lead to the upsetting of the tuning or other function of the circuit in which the switch is connected.

The question of losses due to self capacity only occurs in the design of switches used in high-frequency circuits. With the switch under consideration the self capacity is kept low by keeping the springs fairly wide apart. A similar switch to this one is illustrated at the top of Fig. 444 Here three contacts are employed, the plunger itself forming the third. The use of this switch is clearly shown in the circuit diagram in the centre of the plate. It will be seen that it is used to short-circuit the tuning coils with one movement. It thus replaces two of the single type of switch. It is generally designated "a three-point shorting switch." Other varieties of the same type do not use the plunger as the third contact, but employ three separate springs.

Multiple Types. Much ingenuity has been used in designing switches for more complicated operations in the H.F. circuits of a receiver. It is here that the problem of self capacity becomes really vital, and a compromise often has to be made between efficiency and compactness. It is obvious that there would be no very great difficulty in producing a multiple switch of low self capacity if size were of no account, but more often than not such switches are required for portable sets and where space is restricted. A typical operation which has to be performed is that of changing over the connections from one winding on a frame aerial to the other, and also at the same time switching on and off the current supplying the valves. Figs. 445 and 446 show two efficient switches of the anti-capacity type suitable for such operations and Fig. 453 shows the connections to the frame aerial and filament circuit of one of these "long-wave-off-medium-wave" switches.

Ganged Switches. In many receivers the operation of wave changing where several circuits are concerned is carried out by separate switches which are "ganged." This means that they are linked together, so that they may all be operated by one control. A typical assembly is shown in Fig. 456. In this arrangement all kinds of combinations are available, each unit consisting of from one to four poles and making or breaking up to ten contacts.

These wafer types of switch are referred to as "so-many pole, so-many way"

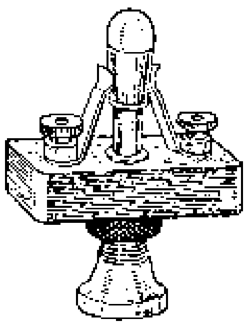


FIG. 441. *On-off switch.*

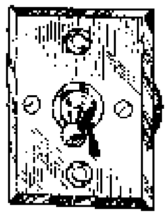


FIG. 442. *Snap switch.*

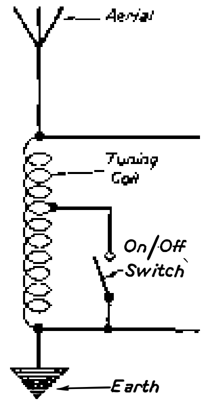


FIG. 443. *On-off switch used for wave changing.*

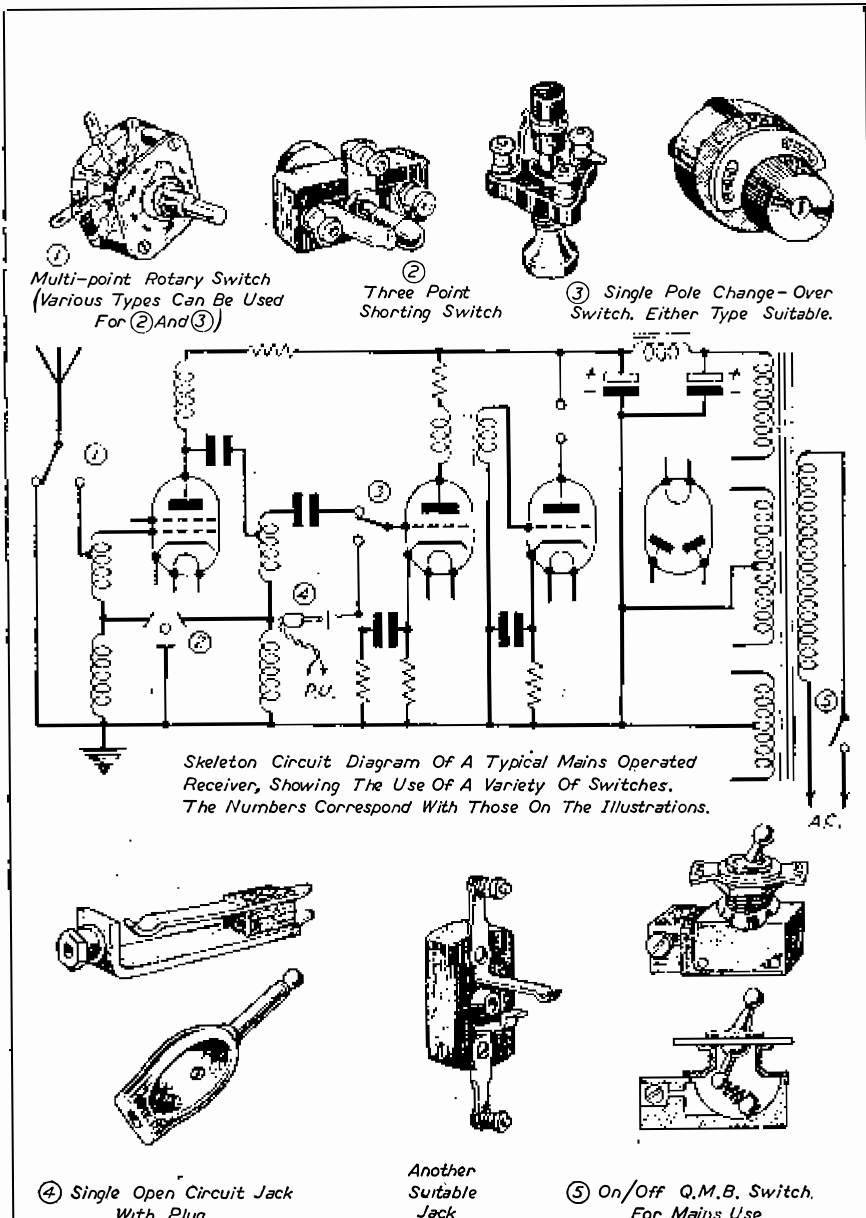


FIG. 444. *Various switches and their use in a standard circuit.*

units, and each wafer is known as a "bank." A single inner contact which passes from one outside contact to another as it is rotated is a "single pole" unit. The inner disc may carry a number of such contacts and may thus be a double-pole, or even a four-pole. The number of outer points to which it connects are known as the "ways"; thus a single-pole three-way would mean that there is a single contact point which makes successive contact with three

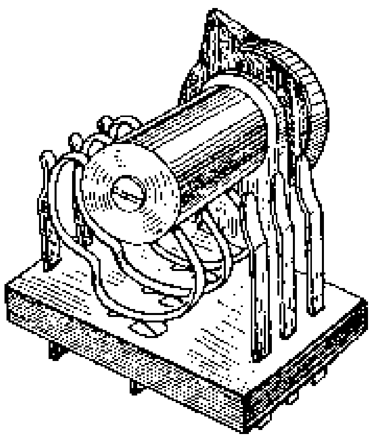


FIG. 445. (*Left*) *A form of low-capacity switch.*

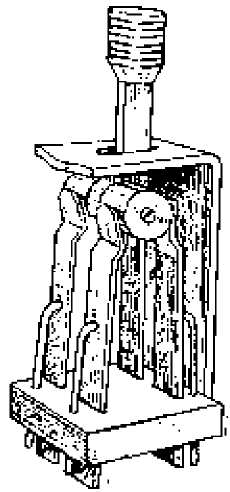


FIG. 446. (*Right*) *Anti-capacity switch.*

outer points. Each of these wafers may be assembled on a length of rod to form any desired number of units, thus enabling one to make up, say, a four-bank, double-pole four-way switch unit, which means you have four separate double-pole switches each capable of making four separate selections.

Filament Switches. These give more trouble than all the others put together. The difficulty is not to obtain low self capacity, adequate insulation, or large current-carrying capacity, but to get perfect contact, not only at first, but after the switch has been in use for years. The fact that most battery valves

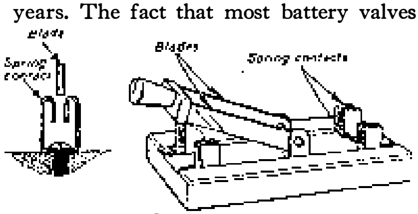


FIG. 447. *Double-pole knife switch.*

require only 2 volts causes the trouble. A slight piece of grit or a few tiny flakes of metal from the contacts is sufficient to raise the resistance of the switch. There is usually, of course, only a slight increase, but as the voltage applied is so low this small resistance has a comparatively large effect, and reduces the current sufficiently to impair reception. What it means therefore is that the contacts must be of generous size, plated to prevent corrosion, and with springs just sufficiently strong to give a firm grip, but not so hard as to cause a scraping away of the contacts.

Two of the many types of on-off filament switch are given in Figs. 441 and 442, while Fig. 455 shows how such a switch is connected.

Jack Switching. A very handy method of switching is provided by plugs and jacks. The plug, a typical example of which is shown in Fig. 451 below, consists of a bakelite handle holding a metal stem which has a small metal ball at one end. The stem is insulated from the ball. The jack is really a socket into which the plug fits. It has one or more springs which make contact with the ball or stem when the plug is inserted. The insertion of the plug causes the springs to bend. In this way a number of circuits can be operated, the bending of the springs causing the breaking and making of the contacts. Fig. 451 shows a multi-circuit jack and what happens when the plug is

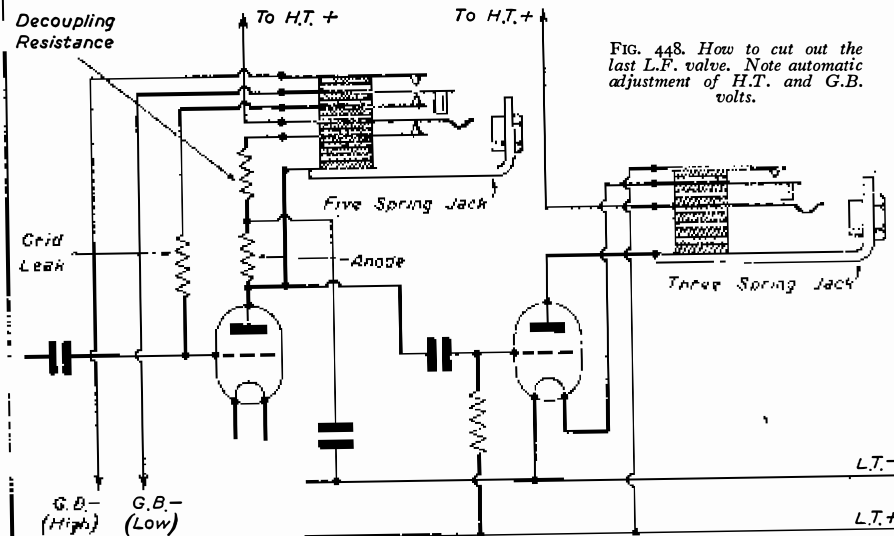


FIG. 448. *How to cut out the last L.F. valve. Note automatic adjustment of H.T. and G.B. volts.*

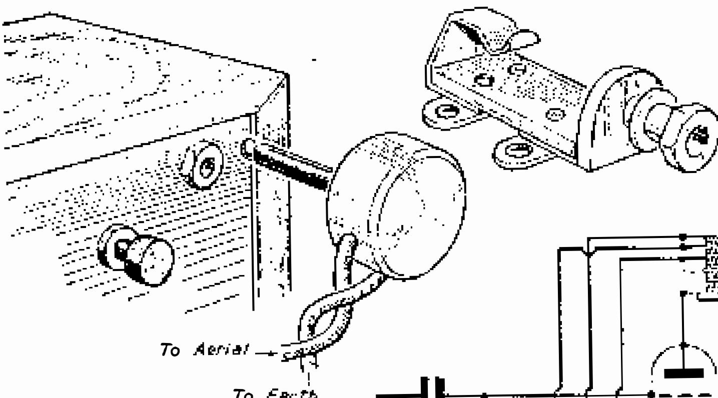


FIG. 449. (*Above*) *A portable set may be quickly attached to an outside aerial by using a plug and jack.*

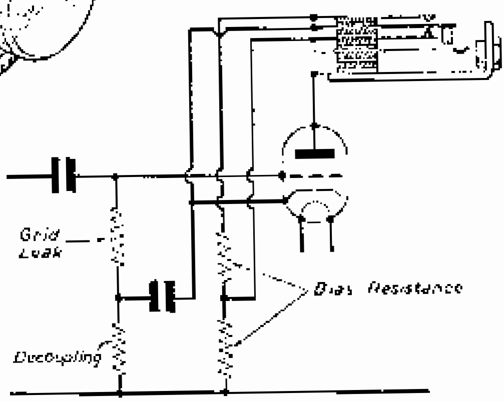


FIG. 450. (*Right*) *How to modify the circuit shown in* FIG. 448 *when using mains valves.*

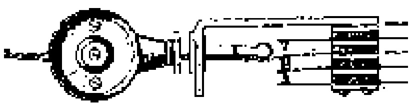


FIG. 451. *Typical plug and jack.*

inserted. In the centre of Fig. 444, a single-circuit jack is used to enable the pick-up which is attached to the plug to be plugged in to the set or removed at will.

Jacks can be obtained which will solve many difficult switching problems, such

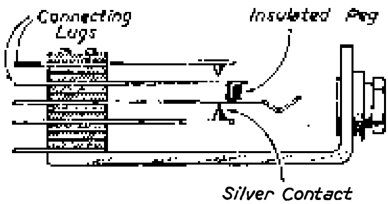


FIG. 452. *Contact points of a jack.*

as cutting out a stage of low-frequency amplification in a multi-valve receiver. The plug is attached to the loudspeaker, and jacks are fitted in the various L.F. stages of the receiver. The speaker is

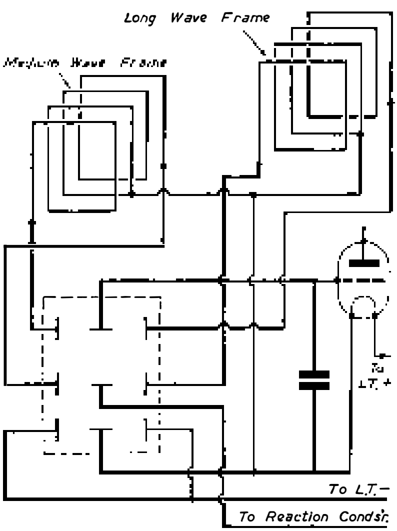


FIG. 453. *Three-pole change-over switch used for wave changing with frame aerials.*

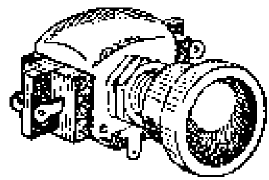


FIG. 454. *Rotary Q.M.B. switch.*

then plugged into the one giving the required degree of amplification.

Unfortunately, owing to the nature of their construction, most types of jacks are unsuitable for inclusion in high-

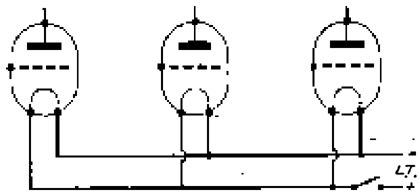


FIG. 455. *An on-off switch and its usual connections.*

frequency circuits as the placing of the springs so close together gives them high self capacity.

Besides the ordinary jacks and plugs there are also what is known as jack switches which embody the same principles. One type is similar to the jack in the middle of the bottom row of switches in Fig. 444, but a plunger takes the place of the plug. The switch is operated by moving the plunger in or out.

Mains Switches. These are small editions of ordinary house switches, working on the tumbler principle. An example is shown in Fig. 442. The essential requirement of a mains switch is that it will make and break the circuit *very quickly.* This is because with the power it is required to handle there is a strong tendency towards "arcing." This is the spark which occurs when a power cir-

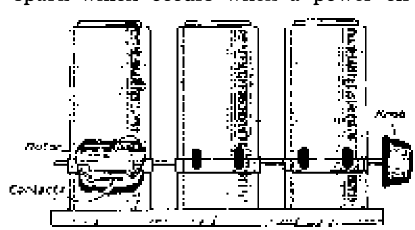


FIG. 456. *Three-gang tuning coil with self-contained switch.*

cuit is broken. If the two contacts of the switch were parted very slowly this spark would continue to bridge the gap until they were some small distance apart, and during that time would badly burn them. If, however, the contacts snap apart quickly the spark is of such short duration as to do no damage.

A very popular Q.M.B. (quick make and

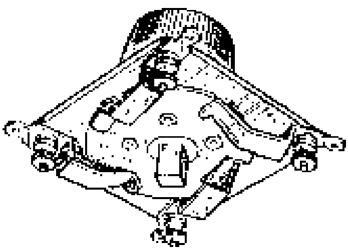


FIG. 457. *Another form of rotary switch.*

break) switch is that shown in Fig. 444, number 5. The lower sketch is a sectional view showing how it works. It is shown in the "off" position. On moving the pivoted toggle arm over to "on," the other end of it which is inside the switch moves over to the right, compressing the spring. When about half-way across the spring is fully compressed. Any further movement then makes its lower end, which is attached to a roller, jump from the right side to the left, so that the positions inside the switch are exactly reversed. This means that the roller is now touching the shaped metal contact on the left. Actually there are two of these, and as the roller touches both they are therefore shorted, and so the circuit is "made." Returning the toggle arm to the right again makes the spring and roller jump back to their former positions. (See also *Plug*.)

SYLVANITE. An ore of tellurium.

SYNCHRONISE. To adjust the periodicity of an electrical system so as to bear an integral relationship to the frequency of the periodic phenomenon under investigation.

SYNCHRONISING SEPARATOR. A circuit, generally in its simplest form a backed-off valve, wherein the line and frame synchronising impulses are separated from the received television signal and fed to the line and frame time bases.

SYNCHRONOUS. In step; occuring at the same time; simultaneous.

SYNCHRONOUS MOTOR. Speed of Rotor = R.P.M. = $\frac{2f60}{n}$, where f = frequency, n = number of teeth on rotor.

SYNTHESIS. The building up of bodies by the direct union of their elements.

SYNTONY. Two tuned circuits are said to be in syntony when they are tuned to the same frequency. Thus a transmitter and receiver are in syntony when the latter is correctly tuned to the former. The word is also used to denote a balance of tone in respect to loudspeaker reproduction. (See also *Resonance*.)

SYSTOFLEX. An insulated tubing used for carrying wires in a wireless receiver. It consists of a plaited cotton fabric which is insulated.

T

T AERIAL. An aerial in which the leading-in wire is taken from the centre of the horizontal portion. It is essential that the lead-in is joined to the *electrical* centre if full efficiency is to be obtained.

T CODE. (See abbreviations, page x.)

TAIL - EATING CONNECTION. The method of connecting two four-wire terminating sets without balance network.

TANK. The term applied to the band-setting condenser used in a short-wave tuner in which band-spread tuning is employed.

TAPE MACHINE FOR RECORDING MORSE. This machine is an aid to the Morse-code learner, for by its aid one is

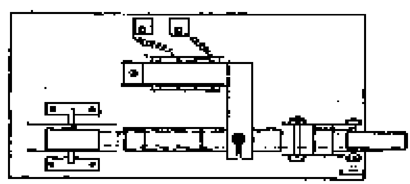


FIG. 458. *Plan view of the tape machine.*

able to send messages and then correct them from the tape. A motor, either clockwork or electric, is required to draw the paper past the brush (see Fig. 459). This can be taken from an old alarm clock, and will serve the purpose admirably.

The balance wheel and escapement should be removed, and the paper threaded between the teeth of the second and third gears. This gives a fairly good speed—the motor running from 4 to 5 minutes with one wind.

The Base. Commence the construction by cutting a base 11 in. by 5 in. by $\frac{5}{8}$ in., and mounting the motor, by means of brackets, as shown in Figs. 458 and 459. The guide tubes through which the tape passes are made by cutting two pieces of

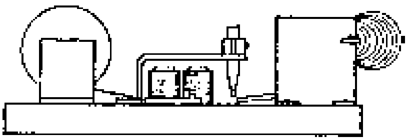


FIG. 459. *Side view.*

sheet zinc, and folding them to the given shape (see Fig. 460). The first piece is mounted so that the paper passes from it and immediately between the teeth of the gears. The second is fixed before the brush and in line with the first. A reel to hold the tape is made by cutting two discs of sheet metal 2 in. in diameter. One disc is fixed to a wooden centre, 1 in.

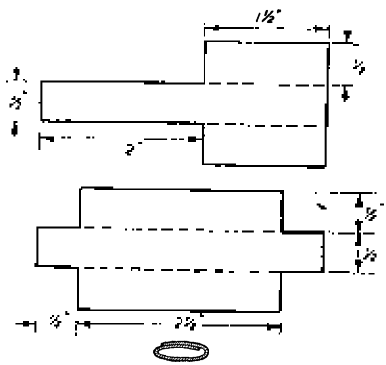


FIG. 460. *Details of the guide tubes through which the tape passes.*

in diameter and $\frac{1}{2}$ in. thick. Two brackets. $2\frac{1}{2}$ in. by $\frac{3}{4}$ in., are cut from mild steel, drilled to take a $\frac{1}{8}$-in. wire axle and fixed on the base with $\frac{1}{2}$-in. wood screws. Each piece of the reel is now drilled to take the axle and mounted between the brackets. A roll of tape is mounted by removing the

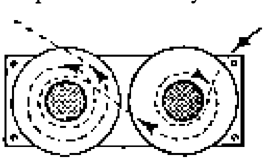


FIG. 461. *Showing how the magnets are wound.*

reel, slipping the paper on to it and replacing; the paper is then threaded through the two tubes and between the gears.

The Coils. Obtain two 1 in. by $\frac{1}{4}$ in, carriage bolts and file the heads flat. Cut two discs of cardboard 1 in. in diameter, put one on each bolt, and press it close up

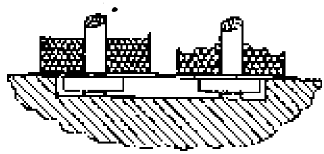


FIG. 462. *The method of mounting the magnets and (right) details of the brush holder.*

to the head (see Fig. 462). For a yoke cut a piece of mild steel 1 in. by $2\frac{1}{2}$ in., and drill two holes to take the bolts $1\frac{1}{4}$ in. apart. Slip this on to the bolts, screw on the nuts, and wind the bolts with 24 D.C.C. wire. The coils should be wound in opposite directions, leaving about 3 in. of wire at each end for connections. Mount the magnets by means of $\frac{1}{2}$-in. nails through the corners of the yoke, cutting a hole in the base for the nuts (see Fig. 461). Connect the ends of the coils to two terminals on the base. The armature is a strip of mild steel $4\frac{1}{2}$ in. by $\frac{5}{8}$ in., drilled at each end to take $\frac{1}{2}$-in. wood screws. The brush holder (see Fig. 462) is a piece of wood $2\frac{1}{2}$ in. by $\frac{3}{8}$ in. by $\frac{1}{2}$ in., fixed on the steel strip. The brush is held in position by means of a $\frac{1}{2}$-in. round-headed wood screw. The armature is bent as shown in Figs. 458 and 459, and mounted on the base so that the hole in

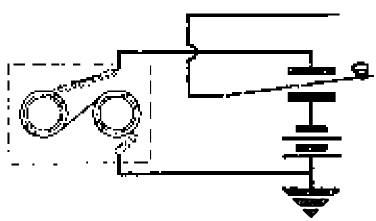


FIG. 463. *The wiring circuit without a relay.*

the brush holder comes above the paper strip. The brush, an ordinary water-colour one with the handle cut off, is fixed in the holder so that, when the armature is pressed down on to the magnets, it just touches the paper. Now make the tapper key, as shown in Fig. 468.

Testing the Instrument. To test the instrument connect it up to two dry cells and a tapper key. Press the key and see that the brush just touches the paper. Ink the brush by transferring ink to it by means of a larger and thicker brush. Wind up the motor and tap out a message, which should come through the machine as a series of long and short marks on the tape. A relay must be used when the wiring

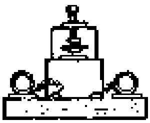


FIG. 464. *The bridge which carries the screw to adjust the tension of the armature.*

exceeds 20 yds. in all; that is both return and line wire. Fig. 463 shows the connections without a relay. Only one station is shown, as the other is exactly similar.

The relay, shown in Figs. 465 and 466, is an instrument by means of which local circuits may be closed from a distance. If the relay described here is carefully made, it will be sensitive to currents of the order of 20 milliamps.

The Magnet. The magnet is a carriage bolt mounted on a $3\frac{1}{2}$ in. by $5\frac{1}{2}$ in. by $\frac{5}{8}$-in. base, as in the tape machine. The top disc of cardboard is $1\frac{1}{2}$ in. in diameter and the bottom metal plate $2\frac{1}{2}$ in. by $1\frac{1}{2}$ in. The magnet is wound with No. 32 S.W.G. wire, the ends of which are connected to two terminals on the base. The armature is a strip of metal, cut from a cocoa tin, $4\frac{1}{2}$ in. by $\frac{3}{8}$ in., with a $\frac{1}{8}$-in. hole drilled in each end. A small nut is soldered over one hole, so that a bolt will easily screw through it. The strip is bent, as shown, and fixed to the base with a small nail and a screw eye to act as a terminal. The bridge which carries the screw to adjust the tension of the armature is a 4 in. by $\frac{5}{8}$-in. strip of mild steel fixed on the base with small wood screws (see Fig. 464). The tension screw is a 1 in. by $\frac{1}{8}$-in. bolt, which screws through a nut soldered in the centre of the bridge. The armature is one terminal of the local circuit and the magnet the other. The bottom plate of the magnet is connected to a terminal on the base.

The Line Current. When a current flows through the magnet coil of the relay, the armature is drawn down until the bolt in the end comes into contact with the magnet. This closes the local circuit.

The relay is connected as in Fig. 466, only one action being shown, as the other is exactly similar. Two dry cells should be used in the line circuit, and two more to operate the tape machine. The tapper key consists of a 4 in. by $\frac{1}{2}$-in. strip of springy brass mounted on a 5 in. by 2-in. base. A bridge is fixed over the key, so that when it is not in use the two make good contact. The end of the key is always connected to the line wire, while the bridge is connected to the instrument, and the lower contact to the battery.

It is possible, by means of remote control relays such as those described elsewhere, to control electrical apparatus from a distance, and the reader will no doubt be able to devise, from the information here given, control relays to suit any particular piece of apparatus he has in mind. Relays, as stated before, are actuated by a weak electric current. (See *Morse Code.*)

TAPER. (i) The relation between an electrical quantity and mechanical position, e.g. the shape of the curve expressing the relation between the setting of the knob of a potential divider and the fraction of the impedance on one side of the moving contact.

(ii) A continuous change of cross-section of a *waveguide.*

TAPPER. The key used for transmitting Morse signals by completing the circuit. Usually consists of a solid brass bar furnished with a substantial ebonite knob. It is pivoted towards the centre, and the rear is held down by an adjustable spring. A contact is fitted below the knob, and upon depressing the knob the circuit is completed, or if desired, the circuit may

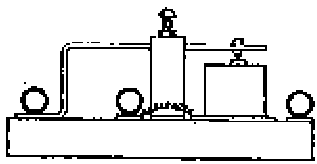


FIG. 465. *Side view of the relay instrument.*

be continuous, and the depression of the knob may break the circuit. The spring pulls the arm up when pressure is removed, and by this means the dots and dashes of the Morse code may be transmitted, a sharp thrust downwards producing a dot, and a slightly sustained pressure producing the dash.

TAPPING. The introduction of a lead into a coil, resistance, etc. Wherever a current is flowing, and a lead is introduced to provide an alternative path, a tapping is made. Examples are in the introduction of the aerial lead into a tuning coil; insertion of plugs into a battery which is provided with sockets at different points;

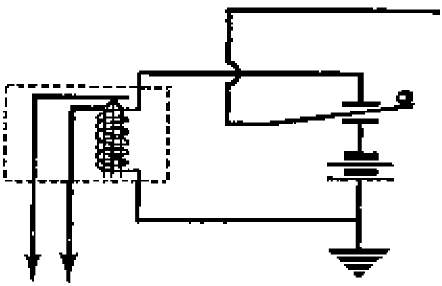


FIG. 466. *The wiring circuit showing how the relay is connected.*

the moving arm of a filament resistance or potentiometer; the centre-point of a push-pull transformer.

TELEARCHICS. The science of the distant control of mechanisms by light-rays, or by radio.

TELEFUNKEN. The abbreviation or trade name of the large German wireless concern, the full name of which is Gesellschaft für drahtlose Telegraphie m.b.H. The name is composed of the words "Funken," which is the German plural of "Funk," a spark, and "Tele," which has the same meaning as the English, namely "afar" (from the Greek *tele*).

TELEGRAPH. Any method of communicating intelligence to a distance.

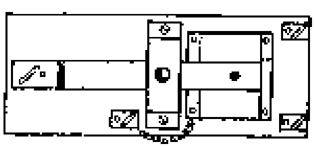


FIG. 467. *Plan view.*

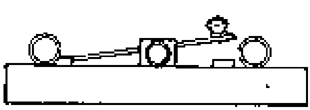


FIG. 468. *The tapper key.*

(From the Greek *tele* = afar; *grapho* = to write.) The methods of so communicating a message may be divided into three classes—audible, visible and tangible. The electric telegraph may be audible or visible. In the first category we may employ a sounder or buzzer (*which see*), or other device; and in the second category one may employ a lamp or similar device.

TELELOGOSCOPY. The transmission, by television, of writing or written lines.

TELEPHONE. A device for transmitting sounds over a distance. (From the Greek *tele* = afar; and *phone* = a sound.) It consists of an electro magnet, with a disc of soft iron fixed just in front of the pole piece of the magnet. The speech is uttered close to the iron disc (which is known as a "diaphragm"); it vibrates, and so produces variations in the magnetic field. These variations may be conveyed along a wire and passed through a similar electro magnet at the other end. The variations in the magnetic field at this end will vibrate the diaphragm, and in so doing will reproduce the sound. Philip Reis was undoubtedly the first inventor of the electric telephone (1861). Graham Bell perfected the device. A modern form of telephone employs, instead of the electro magnet, a carbon-granule microphone, in which granules of carbon are caused to vibrate by the speech sounds.

TELEPHONE TRANSFORMER. A transformer included in the anode circuit of an output valve for matching the impedance of the telephones. The ratio is designed so that normally high-resistance phones may be employed.

TELETRON. Another name for a cathode-ray tube.

TELEVISION. The process of being able to see (through the medium of electrical methods of transmission) the reproduction of images of moving, living or stationary objects.

Briefly, the English system of television consists of the radiation of the vision (on a frequency of 45 Mc and sound on a separate frequency of 41·5 Mc. The scenes in the studio are translated into electrical impulses by means of an Iconoscope (*which see*). These impulses are converted in the transmitting apparatus into a modulated wave upon which are superimposed synchronising impulses so that the receiver may be kept in step with the transmitted picture and thereby correctly proportioned. At the receiving end the impulses are picked up, usually by a fixed-tuned receiver, and applied to a cathode-ray tube. At the same time part of the received signal is applied to a circuit known as a synchronising separator which is coupled to a time base which causes the scanning beam of the C.R. tube to cover the picture area at the correct speed. The beam is controlled by the received picture modulation and thereby the image is recreated on the end of the cathode-ray tube.

The English system provides a picture composed of 405 lines consisting of $202\frac{1}{2}$ lines interlaced at a frame frequency of 25 pictures per second. The aspect ratio is 4 : 3, and the maximum band-width for vision is 5 Mc.

TELEVISION AERIALS. (See *Aerials*.)

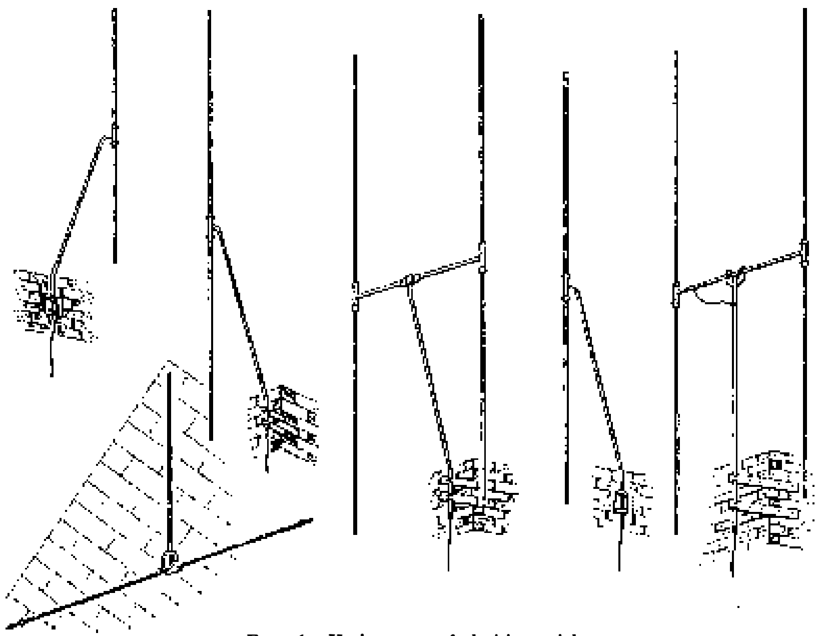


FIG. 469. *Various types of television aerials.*

TELEVISION RECEIVER. The television receiver here described has been built up with the following points in mind :

(a) Comparative ease of construction.

(b) Adaptability of the vision chassis for different ranges of reception and vision frequency.

(c) Adaptability to experiment.

(d) Keeping the cost as low as possible without sacrifice of reliability.

(e) Ease of alignment.

In order to comply with the first point a unit system of construction has been adopted, and the receiver consists of five separate chassis, interconnected by cable. These chassis are as follows :

1. *Vision chassis,* a 10-valve unit giving two outputs, one to modulate the tube grid, the other to feed the synchronising circuits.
2. *Sound receiver chassis,* a 5-valve unit feeding a normal speaker output.
3. *Synchronising and time-base unit,* a 6-valve chassis, feeding line and frame-scanning coils.
4. *Tube unit,* housing the C.R.T. and all scanning and focus components.
5. *Power unit,* a 2-valve (rectifiers) chassis supplying normal H.T., extra H.T. and all heaters.

The total number of valves used is 23, which may seem excessive, but in certain areas this number is essential, while in others it can be slightly reduced, as will be shown later.

To meet the requirements of point (b), a superhet circuit was chosen for the vision receiver, since this is most easily converted to another vision frequency, as all I.F. circuits (where the bulk of the amplification is carried out) then require no modification. Again, it is much easier to get stability with plenty of gain from a row of valves operating at a comparatively low intermediate frequency than it is from an equivalent number of R.F. stages all working at 45 Mc/s.

The cost of the receiver has been kept down by the use of ex-W.D. valves as far as possible. These valves work perfectly provided they are bought unused, and by this means one of the main money-swallowing items in any television receiver is considerably reduced.

Vision Receiver Theory. The valves used mainly in the 10-valve vision chassis are S.P.61's, the Service equivalent being V.R.65. These are high-slope television pentodes with top-cap grid connections and Mazda-Octal bases.

Referring to the circuit (Fig. 471), this may at first glance appear to be a little "crowded" with components, but in theory and actual construction it works out very easily and conveniently. The aerial feeder (which must be 80 Ω co-axial type) is coupled to the first tuned circuit L1 by a $1\frac{1}{2}$-turn loop, the main coil being damped by R1 (4 kΩ), and the whole circuit being tuned to cover both *vision and sound* frequencies, about a mean 43 Mc/s. V1 provides initial R.F. amplification; but in view of its low anode load R3 (2 kΩ) this does not exceed three or four times, and R3 damps, in addition, the second tuned circuit L2, this also being tuned through both vision and sound frequencies. The sound signal is taken from this coil by means of a single-turn loop, of which more will be said later. V2 provides further amplification, and the vision signal is tuned by L3 to provide the input signal to the frequency-changer stage V3. This valve is a triode-hexode type ECH 35 (or V.R.99A), and its oscillator section operates at 58 Mc/s, thus giving an I.F. output of 13 Mc/s. Circuit values here are critical and should not be altered

V3 provides practically nothing in the way of amplification, and it is sufficient if it does not attenuate. The I.F. output appears across R13 in the anode of the hexode section, and is passed through C15 to the first I.F. tuning coil L4. Variable bias on V2 and V4 by means of VR1 (contrast control) prevents overloading of the I.F. stages, the bias on the suppressors of these valves being varied in addition to that on the grid (in the ratio of R21 to R22), so that there is negligible change of input capacity with change of grid bias—remembering that the valves are non-variable-mu.

V4, V5 and V6 are the three I.F. stages, and are "stagger-tuned" to provide an adequate band-width for good definition. The mean I.F. is 13 Mc/s, as has already been mentioned. The output from V6 is developed across the last I.F. coil L7 and is rectified by V7, a television type diode. The rectified output is developed across R30 (2·2 kΩ) and is filtered by L8 and L9 before being passed to the grid of the video-amplifier valve V8.

V8 receives a negative-going signal from V7 and consequently is arranged to have a very small bias so that the maximum swing of the grid in the negative direction can occur before serious over-loading sets in. C31 is merely included to bolster up the high-frequency response of the amplifier by preventing feedback at the highest modulation frequencies. A compensating choke (L10) has also been included in the anode circuit of this stage for the same purpose.

V9 is a D.C. restoring diode, and V10 is a phase-splitting stage that provides signals in opposite phase for feeding the tube grid with a positive signal and the synchronising circuits with negative signals.

Construction. The actual design is a little unorthodox.

The valves are connected base-to-cap all along the line. This form of construction is very suitable for the valves used, where the top cap is the grid connection, for then the lead from the preceding anode is kept as short as possible, and further, the screening is extremely complete between the stages.

The chassis is built up from three pieces of aluminium, the general shapes being given in Fig. 470. It is advisable, when marking out the holes for the valve-holders, to mark out first one strip only, as shown in the figure, then to arrange for the holes in the opposite strip to fall between them. This method thus allows for any slight inaccuracy which might result if separate marking out is attempted. Then again, although there is plenty of room between the chassis for the easy insertion of the S.P.61s and the solitary E.F.50 (V.R.91 Service), the frequency-changer is somewhat taller and may not "go." This matter of height must be checked before the chassis are bolted to the back plate, for if the frequency-changer is too tall, a further large hole must be cut in the opposite strip to allow for the projection of the top cap. All other grid leads go through grommets to their respective top caps. All other holes are drilled in the most convenient places, as dictated by the components.

Referring to Fig. 470, this diagram is designed to show which components are to be wired into the separate compartments into which the strip chassis are divided. These partitions are made up from thin copper (aluminium will do), and bent to fit closely across the chassis, reaching completely to the bottom and coming up to the level of the side flanges. The screens between the valves are similarly made up. Inside each compartment the components are wired as conveniently as possible, care being taken particularly in the two R.F. and mixer compartments. This latter section is very important. The valve-holder is a ceramic type, and the oscillator coil is a Wearite type PA4. This coil is prepared by stripping off the small coupling winding which consists of a few turns of very thin wire wound at the end of the thick main winding. It must be completely removed, and the tags to which it was attached should be cut off short so as not to interfere with the other parts. The main winding is now wired directly to the oscillator tuning condenser, which is a 20 pF maximum ceramic trimmer, air-spaced type. It *must* be insulated completely from the chassis.

The following points are of extreme importance and *must* be observed completely:

Certain resistances pass *through* the dividing screens, and these are: R5 from compartment 1 to 3, R9 from compartment 2 to 4, R17 from compartment 3 to 5. Resistance R20 also passes through from compartment 4 to compartment 2, where it connects with R10 and then passes out through the back plate to VR1 and the associated resistances. The contrast control is mounted on a small component bracket, and an extension spindle is later fitted so that control can be easily effected from the end of the chassis.

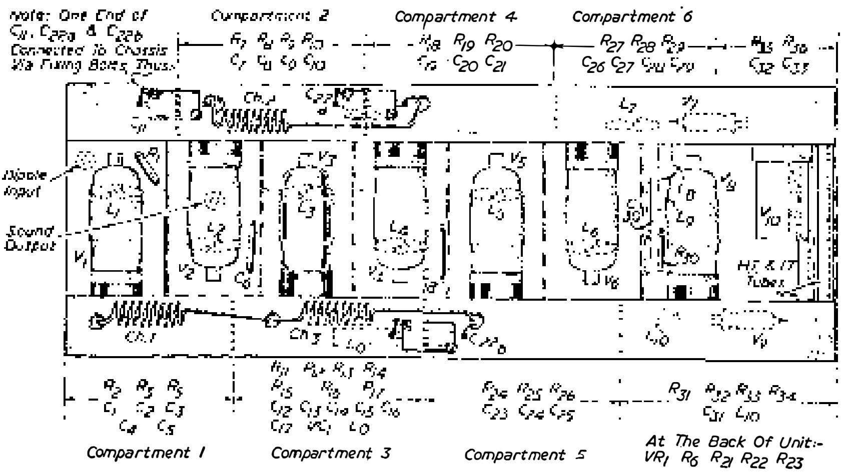


FIG. 470. *Chassis layout of the vision section showing components wired in the separate compartments.*

The heaters of the first three valves have chokes included in their wiring, these chokes being situated on the outside of the strip chassis. These are wound from 20 S.W.G. enamelled copper wire, 14 turns each on an ordinary pencil shaft, afterwards being pulled out to a length of about $1\frac{3}{8}$ in. They are then wired through grommets to the heater pins of the valves concerned. Note carefully that C22 is shown in Fig. 470 as *two* condensers, one on the upper and one on the lower strip chassis. Each has

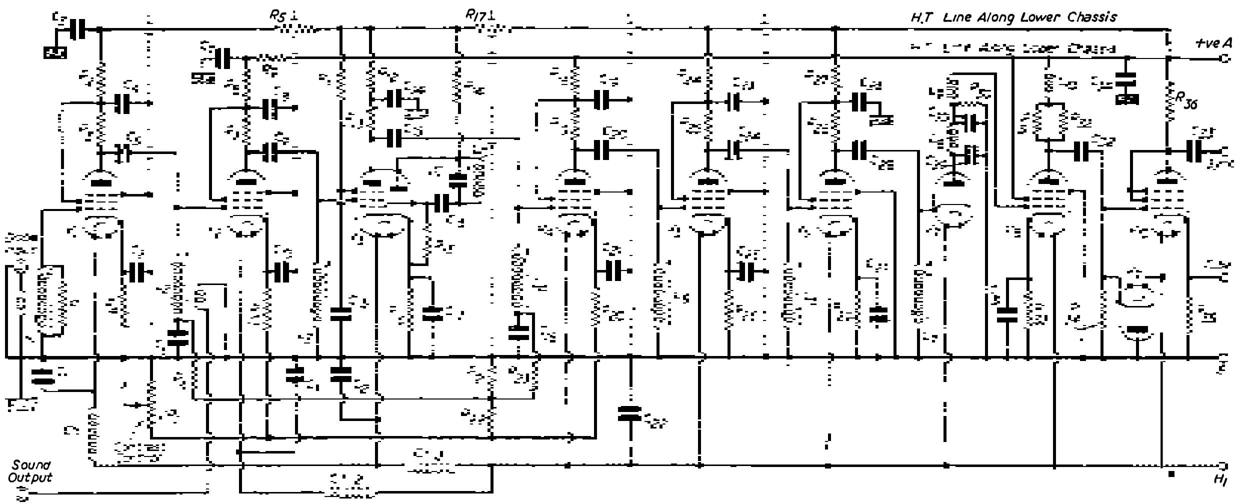
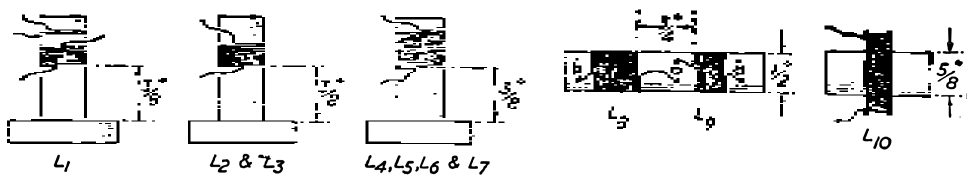


FIG. 471. *Theoretical circuit of the vision unit. A list of components will be found on page 301. Coil winding details are given below.*



L1	L2 & L3	L4, L5, L6 & L7	L8 & L9	L10
L1 {Main: 6 turns. Coupling: 1½ turns. (Coupling spaced 1/16 in.)	L2.—6 turns. L3.—5 turns.	L4, L5, L6.—16 turns. L7.—18 turns.	L8.—55 turns. L9.—25 turns.	L10.—55 turns pile-wound between card-board cheeks. 3/16 in. apart.
34 S.W.G.	34 S.W.G.	36 S.W.G.	38 S.W.G. enamelled.	34 S.W.G.

Note.—All coils, with the exception of L10, are close-wound, the wire being enamel/single-silk covered except where otherwise indicated.

a value of 500 pF though on the theoretical diagram only *one* C22 is drawn. The other heater by-pass condensers not located on the outside of the chassis with the chokes are C1 and C12; these are wired directly from the appropriate heater pins to earth inside the compartments. The other sides of all heaters are tied directly down to chassis.

The detector valve V7 is mounted horizontally in compartment 6 along with the last I.F. coil L7. The rectified output passes through a grommet to chokes L8 and L9 and the diode load R30 and by-pass condenser C30. The D.C. restorer diode is mounted similarly near the base of the video-amplifier V8, the compensating coil L10 also being mounted at this point. There is nothing about this part of the circuit that requires lengthy description, apart from the fact that the H.T. and heaters supply are fed from the upper chassis to the lower through a ⅜-in. diameter aluminium tube connecting both chassis, and the grid lead of V10 is brought up similarly through another tube, the self-capacity being kept as *low as possible.* H.T. leads and outputs are brought to a 5-way tag-strip at the end of the upper chassis. The actual connections are seen on the right of Fig. 478, the letters used for designation being similarly marked on the other chassis to which connection has later to be made.

The Tuning Coils. Tuning in the receiver is carried out by iron-plungers, circuit capacity being kept at a minimum.

List of Components

R1, R35—4 kΩ; R2, R12, R24, R27—470 Ω; R3, R13—2 kΩ; R4, R26, R29—160 Ω; R5, R9—1 kΩ; R6, R19, R22, R23, R25, R28—4·7 kΩ; R7—8·2 kΩ; R8, R18—3·3 kΩ; R10, R20—100 Ω; R11—40 kΩ; R14—27 kΩ; R15—47 kΩ; R16—220 Ω; R17—1·5 kΩ; R21—68 kΩ; R30—2·2 kΩ; R31, R32—6·4 kΩ; R33—30 Ω; R34—1 MΩ; R36—7·5 kΩ.

Erie Ceramic, etc.

(*All resistors ½-watt type except R*31 *and R*32, *which are each* 1 *watt.*)

C1—·0003 μF; C2, C4, C8, C10, C13, C14, C17, C19, C21, C23, C25, C26, C27, C31—·01 μF; C3, C5, C6, C7, C9, C15, C18, C20, C24, C28—·001 μF; C11, C12, C22—·0005 μF; C16—15 pF; C29, C30—10 pF; C32, C33, C34—·1 μF.

T.C.C. mica, silver-mica, etc.

(*All condensers up to V*8 *are moulded mica or silver-mica.*)

VR1 (contrast control): 10 kΩ wire-wound.

Oscillator tuning condenser: 3-20 pF air-spaced ceramic trimmer.

Oscillator coil, Lo.: Type PA4, Wearite.

Valve-holders: 6 Mazda Octal, paxolin; 1 International Octal, ceramic; 1 Belling-Lee B9G; 2 midget diode type.

Coil Formers (plain or wound): Midco Radio, Wellingborough.

Valves: 6 SP61 (or VR.65); 1 ECH35 (or VR.99A) (mixer); 1 EF50 (or VR.91); 2 E.A.50 (or VR.92).

Co-axial Plugs: 2, Belling-Lee type L604P.

Co-axial Sockets: 2, Belling-Lee type L604S.

Theoretical Details. We now turn to the unit which, apart from the vision chassis, is probably the most important part of a complete television receiver, namely, the time-base chassis, shown in theoretical form in Fig. 474.

The unit in the present receiver is a 6-valve section, V11 to V16 inclusive, the first pair of valves constituting the synchronising separator and limiter stages. V13 is the line discharger valve with V14 as line amplifier, and V15 is the frame discharger valve with V16 as frame amplifier. The amplifier valves feed the deflector coils with correctly-shaped pulses to build up the raster on the screen of the cathode-ray tube.

Turning to details, V11, which is an EF50 (VR91) strapped screen to anode, operates as the synchronising separator proper by working with a very low anode voltage which brings the working point of the characteristic on to the bend of the curve. The vision signal which is applied from the anode of the phase-splitter V10 in the vision unit is negative-going in sign, with the result that only the synchronising pulses carry the valve into the conducting regions of the characteristic and the output from the anode thus consists only of negative-going synchronising pulses freed from the vision signal itself. Fig. 473 (a) shows the actual oscillogram on the anode of V11. This output is applied to the grid of V12 through the normal RC network of C2 and R4, and V12 itself functions as a straightforward amplifier and inverter, producing at the screen and anode positive going sync. pulses for triggering the line and frame thyratron discharger valves.

The output from the anode is applied to a short time-constant differentiating stage consisting of C7 and R11. C7 is a home-made component and is illustrated in Fig. 472. The construction is in no way critical, and with care can be made in a couple of minutes. Good insulation is the main item of importance. R11 is 270 kΩ in value, and in conjunction with C7 splits up the positive sync. pulse of Fig. 473 (b) into a series of alternate positive- and negative-going spikes of extremely short duration. The positive spike is used to trigger the line thyratron V13 and so synchronise the picture with the transmitter. (Fig. 473 (c)).

The line thyratron valve is the Mazda T41, a reliable and popular discharger for this sort of work, and in the unsynchronised condition, i.e. in the absence of a signal, is a free-running saw-tooth oscillator working at a frequency between 9 and 11 kc/s. C8 is the actual charging condenser which charges through R13 from the H.T. line, and VR2 is used to control the frequency by the simple method of adjusting the cathode resistance. The synchronising pulses from C7 when applied lock the frequency very firmly to that of the transmitter (10,125 cycles per second), and so ensure a steady picture on the screen.

The saw-tooth output at line frequency from V13 is fed to the line amplifier valve,

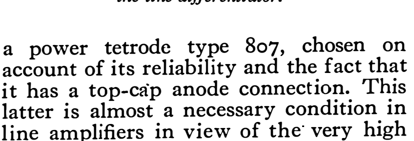


FIG. 472. *Stages in the making of a low-capacity for the line differentiator.*

a power tetrode type 807, chosen on account of its reliability and the fact that it has a top-cap anode connection. This latter is almost a necessary condition in line amplifiers in view of the very high voltage appearing at the anode during the line fly-back. In single-ended valves spark-over troubles are almost inevitable if used as line amplifiers. The gain of the stage, and thus the width of the picture, is controlled by VR1, which is a pre-set control of 250 Ω value and functions by virtue of varying the negative feedback on the stage. This form of control tends to improve linearity, for which reason R14 is also included in series with the charging condenser. The output from the anode is shown in Fig. 473 (d) and although this looks

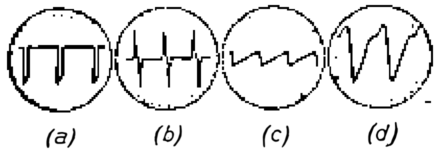


FIG. 473. *Typical traces obtained on the oscilloscope at various points in the time base.*

terrifying, it is quite suitable for feeding the line deflector coils which modify it through their self-inductance. T1 is the line transformer, a very important component. This has a ratio of 4·5 to 1 and is made so that the connection to the top-cap of V14 is direct and well insulated. It is specially matched to the deflector coils.

List of Components

RO, R12, R24—3·3 kΩ; R1, R4, R17—1 M Ω; R2—27 kΩ; R3—110 kΩ; R23—470 kΩ; R6, R8—47 kΩ; R7, R9—25 kΩ; R10—4·7 kΩ; R11—270 kΩ; R13, R25—220 kΩ; R5, R14—470 Ω; R15—2·5 kΩ; R16, R29—1 kΩ; R18—160 Ω; R19—47 Ω; R20—200 kΩ; R21, R22—100 kΩ; R26—1·5 kΩ; R27—0·5 MΩ; R28—200 Ω; R30—3·5 Ω.

Erie Ceramic, etc.

(*All resistors ½-watt type except R15 which is 1 watt and R30 which is 15 watts.*)

C1—4 μF; C2, C12, C14—·1 μF; C3, C4, C13—·5 μF; C5—25 μF (25-volt working); C6—·005 μF; C7—See text; C8—·002 μF; C9—·01 μF; C10, C11—·001 μF; C15—·0005 μF; C16—16 μF electrolytic (500-volt working).

T.C.C. mica, etc.

(*All condensers above 0·005 μF should be of the 500-volt working type, except where otherwise stated, and those of 0·005 μF and below are of mica.*)

VR1 (width) : 250 Ω.
VR2 (line hold) : 2·5 kΩ.
VR3 (frame hold : 2·5 kΩ.
VR4 (height) : 0·5 MΩ.

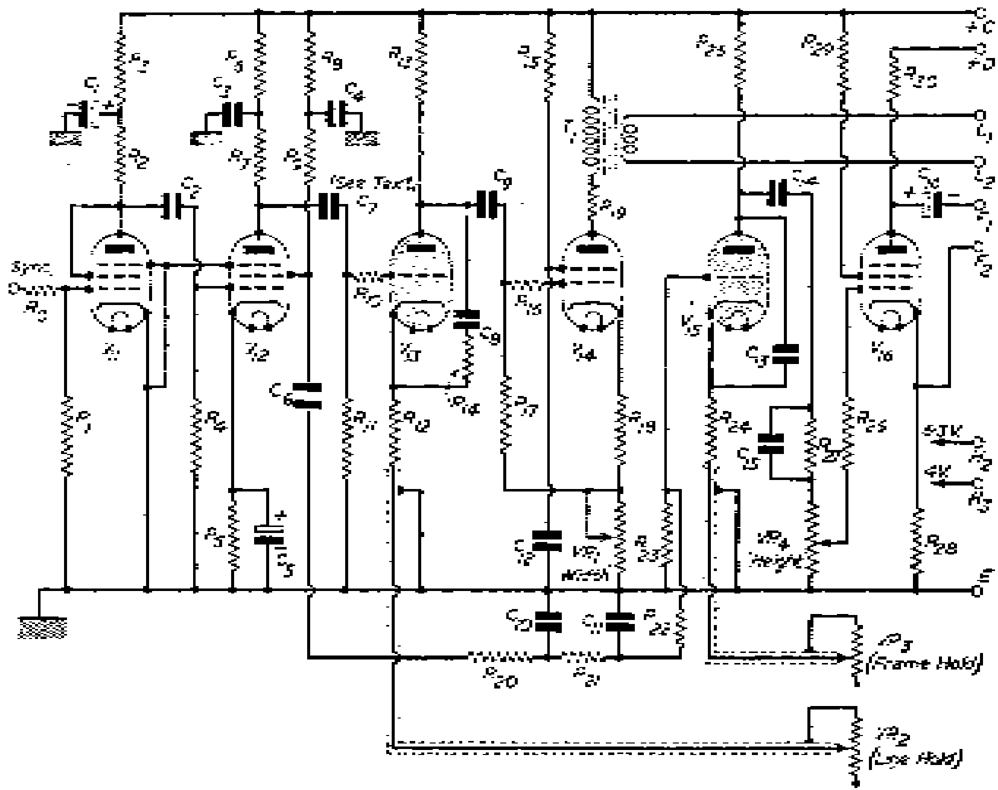


FIG. 474. *Theoretical circuit of the synchronising separator and time bases.*

Valve-holders: 2 Mazda Octal, paxolin; 2 Belling-Lee, B9G; 1 International Octal; 1 5-pin U.X. type.
Valves: 2 EF50 (V.R.91); 2 T41 Mazda; 1 807; 1 EL33.
Line transformer: 4·5 to 1 (Midco Radio, Wellingborough).
Chassis: 12 in. × 6 in. × 2 in.
Wire, sleeving, nuts and bolts, tag strips.

Going back now to V12, at the screen the sync. pulses (similar to those appearing at the anode) are fed to a frame integrator network consisting of R20, R21, C10 and C11. This layout works in a manner opposite to that of the differentiator circuit, in that it "bunches" the frame pulses at the end of each half-frame into one long pulse, at the same time destroying completely the high-frequency line pulses. The frame discharger valve V15, which otherwise functions in exactly the same way as V13, is thus only triggered at the end of the half-frames, with the result that the generated saw-tooth has a frequency of 25 cycles per second. When the stage is free-running in the absence of a signal, the frequency is variable by VR3 and may be anything between 20 and 100 cycles per second, the charging condenser in this case being C13. When the stage is synchronised the saw-tooth output is locked to the transmitter just as the line thyratron is locked by the line pulses.

The output at frame frequency from V15 is fed to the frame amplifier through C14, and a correcting network C15 and R27, and the gain of the amplifier V16 (EL33), is adjusted by VR4, which thus varies the height of the picture. The

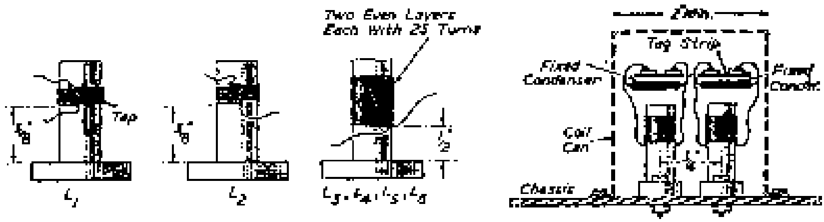


FIG. 475. *Details of the coils used in sound unit.*

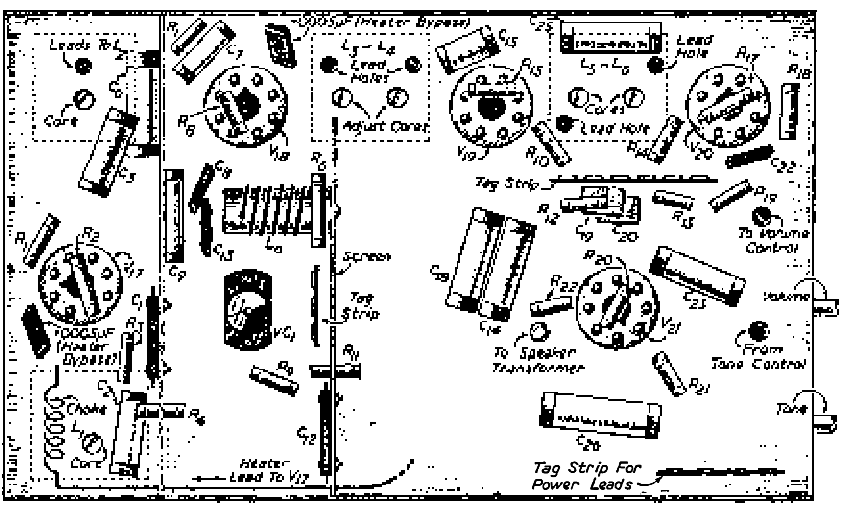


FIG. 476. *Layout for the sound receiver. R11 and R4 pass through the screens as shown. Above the chassis are VR1, VR2, C21, R16, C24, C27 and the O/P transformer. VC1 must be completely insulated from the chassis.*

cathode resistance R28 is unbypassed to assist linearity, and the output appearing across R30 (a 15-watt resistance), is passed through C16, a 16 μF electrolytic, to the frame deflector coils. These coils, together with the line coils, are, of course, located in the tube unit, and will be described later.

There are two heater inputs to this unit, one of 6·3 volts at 3 to 4 amps., and one of 4 volts at 3 amps. The other side of all heaters returns directly to chassis.

Construction. The chassis size is 12 in. by 6 in. by 2 in. deep, and is made from heavy gauge aluminium. A larger chassis size may, of course, be used if one is conveniently to hand, provided the general layout remains the same. Tag strips are used wherever junctions have to be made, otherwise resistances and condensers are wired directly from pin to pin. There is nothing particularly critical about the actual building of this unit, but good separation of line and frame input pulses to the thyratrons should be aimed at (physical separation, that is) to avoid any unwanted interaction.

VR1 and VR4, respectively the "Width" and "Height" controls, are pre-sets and are mounted at the side of the chassis. Once set during test they need be touched no more. VR2 and VR3, on the other hand, are respectively the "Line Hold" and "Frame Hold" controls and must be made available for setting up at the beginning of each programme. They are accordingly brought away from the main chassis through about 18-in. lengths of screened lead (the thin type of co-axial cable is admirable). Later, if and when the whole set is fitted into a cabinet, these controls can be conveniently mounted on to the front panel. The self-capacity of the lead is not critical, and the screening is used as the earth return.

The anode resistance of the frame amplifier, R30, is a 15-watt resistance of value 3,500 Ω. This is mounted above chassis next to the line transformer, and no heat is thus generated unnecessarily below chassis. The line amplifier also has a high-voltage protective top connector included, in which is the 47 Ω stopper resistance, though such a connector is not absolutely necessary. It is, however, advisable, in view of the flyback voltage developed at this point.

The line and frame outputs are brought out through a 4-way cable to an 8-pin Octal plug, alternate pins being those used. The cable length depends on how far away the tube unit is going to be, but 18 in. should prove adequate for most cases. The heater and H.T. inputs are brought through a similar length of 5-way cable, fairly heavy leads being used for the earth and heaters. All leads, both those going to the deflector coils (L1, L2 and F1, F2), and those coming from the power supply (+ C, + D, E, H2 and H3), connect to the main chassis on tag strips mounted along the far edge.

The only other points of importance are: all earth connections should be short and well made, components should be rigidly mounted, and a substantial gauge of aluminium used for the chassis itself.

All resistances are rated ½-watt except R15, which is 1 watt and R30 which, as previously mentioned, is 15 watt. Note carefully that C16 is an electrolytic (500-volt working), and that if a metal-cased component is used it *must* be carefully and adequately insulated from the chassis. A few turns of insulating and Empire tape between the can and the clip are essential, and insulation should be checked before H.T. is applied to the unit. The positive terminal goes to the valve anode.

All condensers must be rated with regard to working voltage, depending upon their position in the unit; C1, C2, C3, C4, C6, C8, C9, C12, C13, C14, should all be 500-volt types, and those of value below 0·005 μF. of the mica type. Other condensers not listed above should be of the mica type, except C5, which is an ordinary 25-volt bias electrolytic.

Sound Receiver. The theoretical circuit diagram of the sound receiver is shown in Fig. 477. It consists of a five-valve chassis, wired as a superhet, and comprises R.F. amplifier, frequency-changer, I.F. amplifier, second detector, A.V.C. and first audio-amplifier, and output pentode.

V17 is a pentode type SP61 (VR65) working as a wide-band R.F. amplifier. Its input is derived from the vision chassis previously described, and the first valve stage of the latter chassis is common to both vision and sound signals. The sound signal is taken from the second coil on the vision receiver by a single turn coupling loop and fed through a short length (1 ft. to 2 ft., or less, as convenient) of coaxial cable to L1 of the sound receiver, where it is correctly matched by being tapped one turn up from the earthy end of the coil. The anode load of V17 is R2, a

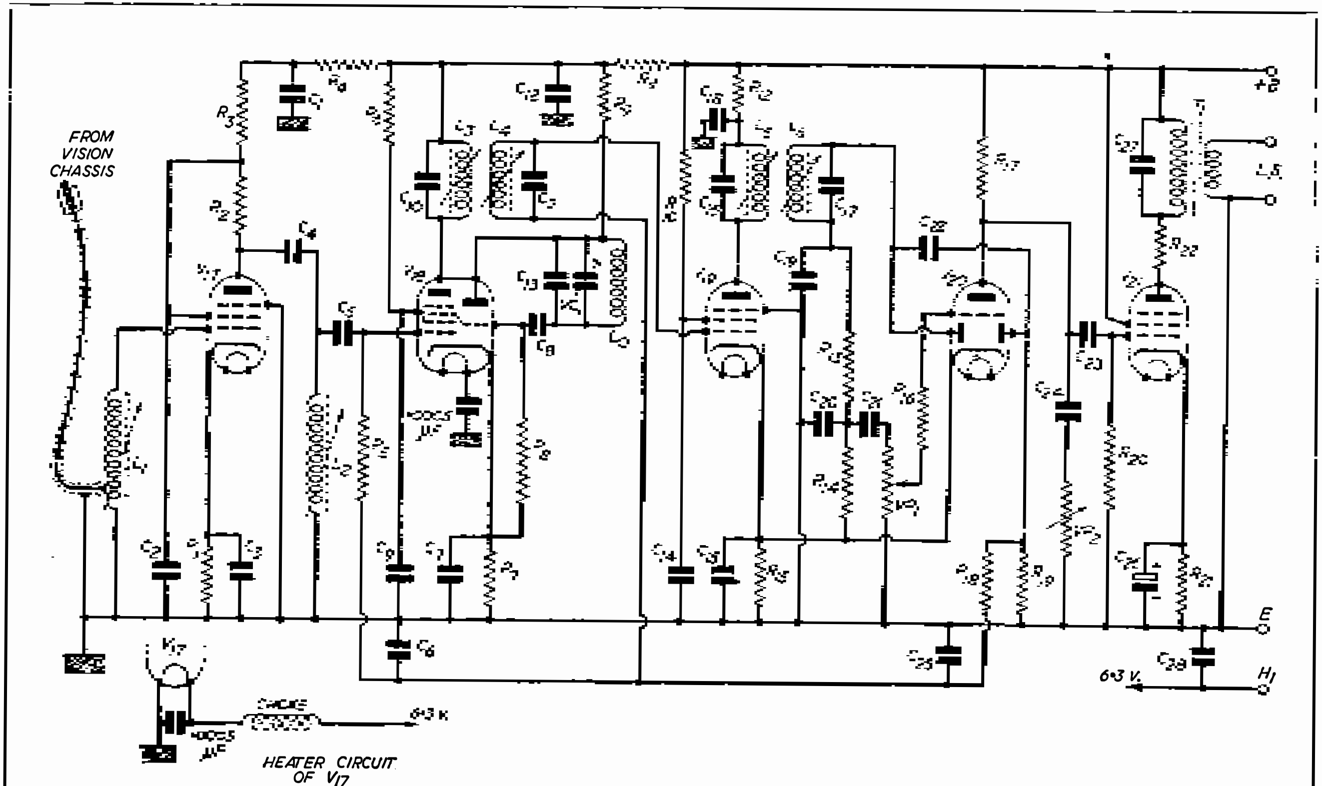


FIG. 477. *The theoretical diagram of the sound receiver. It is a five-valve superhet, and the IF is 3 Mc/s.*

resistance of 7,500Ω, which permits an appreciable gain to be obtained from the stage while retaining adequate bandwidth to do justice to the quality of the television sound signal. R3 and R4 in conjunction with C1 and C2 decouple the stage from the rest of the receiver.

V18 is the frequency-changer (ECH35) and is very similarly wired to the equivalent stage in the vision receiver. A.V.C. is applied to the control grid through R5, and C5 serves to prevent it being shorted through L2 to earth. The oscillator section is a Hartley circuit with VC1 as trimmer-tuner, L0, the oscillator coil, being a Wearite type PA4 with the coupling winding stripped off exactly as was described for the vision frequency-changer. C13 is included to make up the tuning capacity and so make the adjustment of VC1 less critical.

In the choice of intermediate frequency there are conflicting factors to consider, but there is little object in having an I.F. of 13 Mc/s. or more as was the case in the vision receiver. There, a bandwidth of at least 2·5 Mc/s. was aimed at; in the sound receiver a bandwidth of 20 to 50 kc/s. is perfectly adequate, and in practice an I.F. of 3 Mc/s. was suitable.

The I.F. transformers are hand wound and are perfectly simple to make. Details are given later. For the present, L3 and L4 form the first I.F. transformer, tightly coupled in the anode circuit of V18, tuned by iron plungers and fixed condensers C10 and C11. The tuning is quite flat and there is no difficulty in setting up the I.F. coils during alignment.

V19 is the I.F. amplifier EF39 (VR53) and is quite conventional. Its output is tuned by the second I.F. transformer L5-L6, and passed on to the detector, one diode of V20, which is valve type EBC33 (VR55). R13, C19 and C20 form an I.F. filter, and R14 is the diode load across which the rectified signal appears. This is applied via C21 and the volume control VR1 to the grid of V20, where A.F. amplification takes place. A.V.C. voltage is derived from the detector anode through C22, rectified by the second diode, and so applied to V18 and V19 through the filter R18 and C25. Note that C6 and C25 are actually in parallel; C6, however, is wired close to the mixer end of the A.V.C. line to give decoupling at this point, C25 providing decoupling at the detector end. Note also that V19 and V20 have a common bias resistance R15 and this is decoupled by a midget 0·5 μF. condenser.

After V20 there is a tone control VR2, and the output valve is an EL33 conventionally wired. The output transformer should suit the valve, and its primary is shunted by C27. A 6F6 may be used as output valve provided R21 is increased to 400Ω.

Construction Details. Fig. 476 shows the under-chassis layout, and this should be closely followed, particularly in those parts associated with V17 and V18.

Aluminium is a suitable chassis material, and the size is 12 in. by 6 in. by 2 in., although slight variations are permissible. Two aluminium screens divide V17 and V18 from each other and the rest of the circuit, and R4 and R11 pass through these screens as shown. This kind of construction is essential if stability is to be maintained. Notice also the heater choke in the heater feed to V17. This consists of 12 turns of 22 S.W.G. enamelled wire wound on a pencil shaft and then slightly expanded to become self-supporting.

The coils and I.F. transformers need some discussion as these are home-made components, and some little care is required in their construction. First, the tuning coils L1 and L2 : these are wound on the small formers as used in the vision receiver, and are very similar. L1 consists of seven turns of 34 S.W.G. enam./S.S.C. wire tapped up rather more than one turn from the earthy end. Fig. 475 shows the dimensions to be followed. L2 consists of an untapped coil of six turns wound in the same manner, the wire used being as for L1.

All coils, including the I.F. transformers, in this receiver are canned. Any suitable screening cans may be used, though nothing less than 2 in. square should be used on account of increased circuit capacity. The height is not so important. L1 and L2 are bolted down to the chassis, a hole being provided in the latter so that the iron core may be adjusted from below, and the can is then fitted over them. A small tag strip may be used close to the coils so that the grid lead which emerges from the top of the can is firmly anchored within; the free end of the coil which is thin should not be brought out through the can, either above or below the chassis, but heavier leads should be attached to a tag strip conveniently fitted inside the can close to the coil former. In the can with L2 are mounted the following: C4, C5 and R5. Fig. 475 shows the layout of the I.F. transformers inside their cans. Both are identical. The formers used are the same as those for L1 and L2, two being used in each can. The actual coils are wound as shown in Fig. 471, four in all being required. With care it is a simple matter to get two perfectly even layers of wire, each layer consisting of 25 turns, on each former, as shown. The ends should be fixed with a little wax, and the whole coated with a dope such as polystyrene solution, and allowed to dry hard for a few hours before fitting to the chassis. (This also applies to L1 and L2.) The coils are then mounted side by side on the chassis, the latter being drilled so that the iron cores may be adjusted from below. The dimensions are given in Fig. 475 and are not critical, though they should be adhered to as closely as possible. Inside each can are mounted the fixed tuning condensers associated with the coils, i.e. C10, 11, 16, 17. These are silver-mica components of 70 pF. capacity, tolerance 2 per cent. A tag strip is used in each I.F. transformer can to provide anchorage for the coil ends and the heavier outgoing leads. The connections to the ends of the coils are immaterial. When the formers are fitted to the chassis, and the downward coils leads have been passed through, the screening cans are fitted overall, the grid lead to V19 coming through the top of its can.

Turning now to the oscillator circuit, the layout as shown in Fig. 476 should be closely followed. The trimmer VC1 is a small air-spaced ceramic insulation variable condenser of maximum capacity 25 pF. and it must be completely isolated from the chassis, that is, from the point of view of both fixed and moving vanes. The parallel capacity C13, which is a 20 pF. silver-mica component, is included to make the adjustment of VC1 less critical; the oscillator operates at a lower frequency than the signal circuit, that is, at 41·5—3 Mc/s. = 38·5 Mc/s., and so the adjustment is much easier than the corresponding case in the vision receiver where the oscillator frequency is 58 Mc/s. The lower frequency is chosen instead of the higher (which would be 41·5+3 = 44·5 Mc/s.) on account of the proximity of the latter to the vision signal on 45 Mc/s. The higher frequency results in the destruction of the picture on the tube due to feedback into the vision channel. The lower frequency overcomes this difficulty and there is no interaction whatever between vision and sound. The coil Lo, as already stated, is a Wearite PA4, and the coupling winding is stripped off exactly as was described for the vision oscillator. The coil should be mounted so as to clear the chassis by at least ½ in. It does not matter which way round it is wired.

Outgoing power leads are taken from the receiver, and will later be connected to the power unit as marked.

List of Components

R1, R16—160Ω; R2—7·5 kΩ; R3, R11—470 Ω; R4—1,500 Ω; R5—200 kΩ; R6—40 kΩ; R7—250 Ω; R8—68 kΩ; R9—30 kΩ; R10—100 kΩ; R12—3·3 kΩ; R13—22 kΩ; R14—270 kΩ; R15—270 Ω; R17—47 kΩ; R18—470 kΩ; R19—1 MΩ; R20—330 kΩ; R21—200Ω; R22—47 Ω (*Erie Ceramic, etc.*).

(All resistors ½-watt type, but ¼-watt could be used if desired for bias and A.V.C. circuits.)

C1, C4—·001 μF.; C2, C7, C9, C21, C23, C24—·01 μF.; C3, C6, C27—·005 μF.; C5, C19, C20—60 pF.; C8—30 pF.; C10, C11, C16, C17—70 pF. (± 2 per cent.); C12, C28—·002 μF.; C13, C22—20 pF.; C14, C18—·1 μF.; C15—·5 μF.; C25—·05 μF.; C26—25 μF. Electro.

Two at ·0005 μF. for heater by-pass on V17 and V18 (*T.C.C., etc.*).

(Condensers in R.F., Mixer and I.F. stages should be mica or silver-mica.)

VR1 (volume)—·5 MΩ; VR2 (tone)—·25 MΩ.

Valves: One SP61 (VR65); one ECH35 (VR99A or ARTH2); one EF39 (VR53); one EBC33 (VR55); one EL33 or 6F6.

Valveholders: One Mazda Octal; four International Octal.

Six Coil Formers with cores (plain or ready wound).

Oscillator coil: Wearite, Type PA4.

Oscillator tuning: Ceramic air-spaced 25 pF. max.

Chassis and dividing screens: 12 in. by 6 in. by 2 in.

Coil cans: Four, minimum 2 in. square.

Output transformer: To suit output valve.

Tube Unit. There is no metal chassis to be made for this unit, the construction being almost entirely in wood. A general sketch of the finished part is shown in Fig. 479, where all the necessary dimensions are also shown. These dimensions will be discussed in more detail a little later on, since the unit may be used without component alteration for either a 7-in. or a 9-in. cathode-ray tube. Both tubes specified are of the magnetically-focused and deflected types, and the focus and scanning coils used are perfectly suitable for either.

Theory. The scanning coils, which are built up as a single unit by the manufacturer, are fed with correctly shaped pulses from the time-base amplifiers through terminals L1, L2, F1 and F2 shown on the left of the theoretical circuit diagram in Fig. 478. These leads terminate from the time-base unit in an International Octal plug, and on the tube unit an International Octal valveholder is mounted as shown in Fig. 479, to receive the plug. From the valve-holder, leads are taken up to the scanning coil terminals which are plainly marked by the makers.

The centre tap of the line coils (marked L.C.) is earthed, although if no centre tap is provided this makes no difference to the performance. On some coils a centre tap is also provided to the frame windings, this should be left free.

Across the line coils is wired a damping circuit consisting of C1, R1 and VR1 in series. The reason for this is to provide damping of the line transformer secondary circuit and so allow a linear scan to take place across the screen. VR1 is accordingly designated "Linearity" and its setting irons out the kink which would otherwise appear in the line scan. This control is rated 3 watts, wire wound, and R1 is rated at 3 watts also. They are mounted in the positions shown in Fig. 479. The focus coil which is mounted round the neck of the tube is energised from the main H.T. supply through the focus control VR3, which is a 5-watt wire-

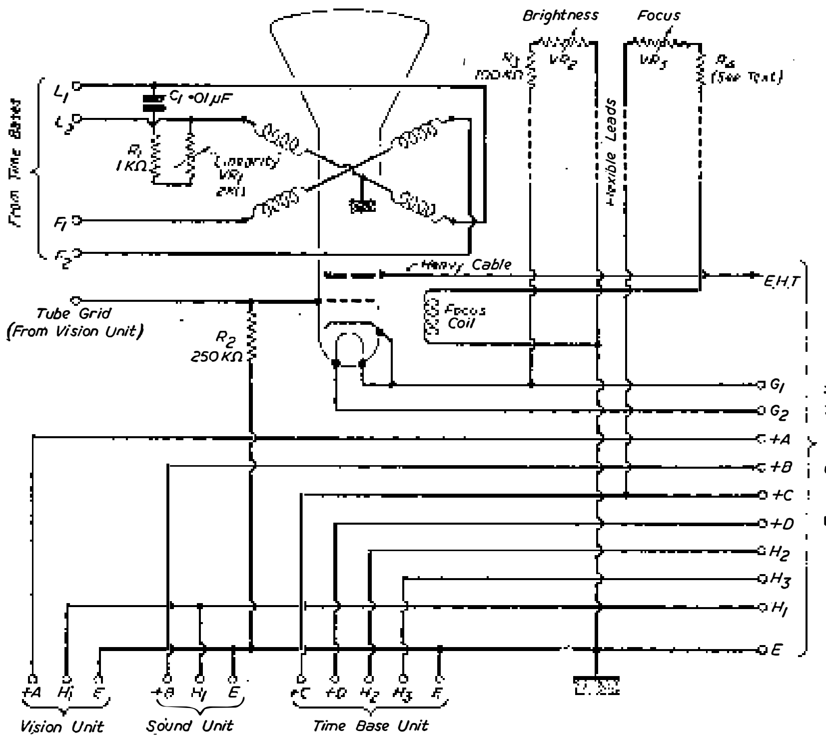


FIG. 478. *Theoretical circuit of the tube unit and distributor strip.*

wound resistance. The value of this resistance is 5 kΩ, and in series with it is a fixed component R4, rated 3 watts. The value of this resistance is 2 kΩ for the specified 7-in. tube, but this must be increased to 3 kΩ for the specified 9-in. tube. No other changes are necessary in the entire receiver, since the scanning and focus coils fit either tube, and their base connections are exactly the same.

The grid of the tube is fed with the video-signal from the cathode of V10 in the vision receiver. The grid is returned to the cathode through R2, a ¼-watt resistance of value 250 kΩ, though any value up to 1 MΩ is suitable. It simply acts as a grid return in the event of the vision receiver not being connected; in practice it is shunted by R35 (4 kΩ) in the cathode of V10. The lead from the vision chassis to the grid is *not* screened, and on account of the low output impedance of V10 at this point its length is not particularly important; however, it should in any case be no longer than is strictly necessary, and preferably it should be kept clear of the vision and sound chassis. The cathode of the tube returns to the one side of the tube heater (a separate 2-volt winding) and thence to earth through the brightness control VR2 which has a value of 0·25 MΩ. R3, in series with this control, limits the maximum brilliance and so protects the screen of the tube. Its value is 100 kΩ, rating ½ watt.

Construction. Returning now to the dimensions of Fig. 479, these are calculated for the Mullard 7-in. tube, and some slight alterations are required for the Mazda 9-in. tube. The best plan for the constructor is not to stick to hard and fast measurements, but to get his tube and build the wooden frame to suit it. The base of the tube need project from the rear wooden upright only enough to plug into the Mazda Octal valve-holder, for which a small aluminium bracket may be made. The scanning coils are slid over the neck of the tube and pushed as far forward as they will go. A trace of cotton-wool carefully pushed between them and the tube neck will suffice to hold them firmly in position. The hole for the tube neck in the rear upright is cut slightly larger than the neck diameter (35 mm.) and is lined out with a piece of soft material, such as felt, so that the tube neck just makes a tightly sliding fit. The hole in the front upright through which the large end of the tube projects is cut so as to allow the screen to lie about 2 in. to 3 in. in front of it, and a rubber mask can then be fitted later. For the 7-in. tube, a hole 6 in. diameter is suitable; for the 9-in. tube an 8-in. hole is required. The wooden stand has a base of such a length that the whole assembly is firm, and the tube is comfortably accommodated. The front tube hole is lined with thin felt.

The focus coil is a heavy all-metal affair and must be mounted in such a manner that it does not touch or bear on the tube neck. If it is forced in any way, or allowed to drop, the tube neck may be fractured. The simplest manner of mounting it is by using the three fixing lugs already fitted to it, and extending these with short lengths of threaded studding. Three holes are then drilled in the rear wooden upright and the three threaded lengths are passed through so that the focus coil is exactly in line with the small hole for the tube neck already cut in the wood. The focus coil should be maintained in this position by the threaded rods firmly, yet at the same time it should be possible to move it slightly backwards and forwards, and also tilt it through a few degrees upwards and downwards and sideways. The threaded rods may be locked to the wooden upright by nuts on either side. Later on, when setting up the receiver on a signal, the focus coil will have to be adjusted (mechanically) to centre the raster; until that time it should be locked centrally and firmly around the tube neck. The coil yoke only clears the glass by 1 mm. or so, so great care must be exercised in this part of the construction. Mount the coil so that its centre lies about 3 in. from the base of the tube.

List of Components:

Cathode-ray tube Mullard 7-in. MW18-2, or Mazda 9-in. CRM91. Premier Radio Co.

Resistances: R1—1 kΩ, 3 watt; R4—2 kΩ or 3 kΩ, 3 watt (see text); R3—100 kΩ, ¼ watt; R2—250 kΩ, ¼watt; VR1 (Linearity)—2 kΩ (wire wound); VR2 (Brightness)—250 kΩ; VR3 (Focus)—5 kΩ (wire wound).

Scanning and focus coils: Midco Radio, Wellingborough.

Condenser: 0·01 μF mica.

One International valve-holder.

One Mazda Octal valve-holder.

One 10-way tag strip.

Leads, screws, etc.

Now, as an examination of Fig. 478 will reveal, the tube unit also acts as a distribution panel for all H.T. and heater leads coming from the power unit to the various separate chassis making up the complete receiver. A 10-way tag strip is accordingly mounted along the rear of the tube unit and 10 leads from the power unit are connected to it. They are brought through a length (about 2 ft.) of 10-way cable (or 10 separate leads bound into a form), and are shown numbered and lettered on the right-hand side of Fig. 478. All these letters *must connect to corresponding lettered points in the power unit*, and so leads of different colours should be used in the 10-way line. A wrong connection at this point might well prove disastrous. The line bringing the E.H.T. (about 4 to 5 kilovolts) to the tube anode—which is a side cap connection—is quite separate and is a length of ignition cable to withstand the voltage. It connects to the tube anode cap by way of a small ceramic insulator (see Fig. 479) so that no sudden tug can break the tube cap.

From the 10-way tag strip cable forms lead off to the various units, supplying them with H.T. and heater voltages. The earth lead is common to all and should be of *very heavy wire* since the total current flowing through it consists of heaters as well as H.T. points. The wire should be stranded type, suitably insulated.

To the time-base unit, a 4-way cable form is taken off, as shown, to the sound receiver, a 2-way cable form, and to the vision receiver, a 2-way cable form. The lengths of these feed lines are immaterial, but they should be as short as possible, and their final length should be left until the complete receiver is ready for test.

The letters as marked on the leads in this tube unit are the same as those already marked on all chassis previously described, and there should be no difficulty, therefore, in getting the connection correct the first time.

There are no other points of great importance to be mentioned in the building of this unit, and each constructor can adjust the actual design to suit himself. The tube should not be mounted until everything else is ready; it can then be inserted from the front by pushing the neck through the scanning coils, the focus coil, and the rear wooden upright in that order, into the valve-holder mounted at the rear. The scanning coils may then be soldered to their appropriate leads coming up from the valve-holder socket.

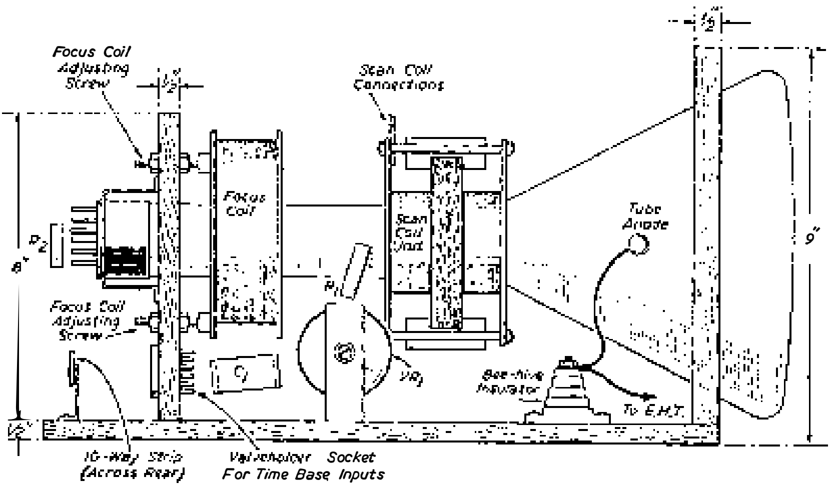


FIG. 479. *Pictorial diagram of the completed tube unit.*

Power Unit. the power unit which is now to be described completes the actual constructional work on the television receiver, and after it has been built nothing remains to do but to connect the various sections together and align the vision and sound receivers.

Basically, the power unit is perfectly conventional as the circuit diagram of Fig. 482 reveals, but in construction it is a comparatively heavy and unwieldy piece of equipment demanding a solid chassis construction coupled with care in wiring and insulation requirements. It consists of two mains transformers, three smoothing chokes, five smoothing electrolytic condensers, and various bleeder resistances, dropping resistances, etc. Such a large number of chokes and condensers may seem unusual when judged by ordinary power unit standards, but this is true of the whole of a television receiver, and in the present instance every component is absolutely necessary. Mains hum and power unit coupling must be avoided at all costs if worthwhile pictures are to be obtained, pictures, that is, which are free of wavy edges and dark hum bands. It is true that the frame locks in at the mains frequency when the set is operating, but a wavy edge and a black band across the picture are still possibilities even if they are stationary.

There are several important points to be dealt with first with regard to the circuit shown in Fig. 482. First, the mains transformer supplying H.T. and heaters to the vision, sound and time-base units already described; it is unlikely that a mains transformer will be available giving exactly the output voltages specified, namely, 350-0-350 volts at 250 milliamps, 6 volts at 8 amps., 6 volts at 3 amps., 4 volts at 4 amps., 2 volts at 2 amps., and 5 volts at 3 amps. Certain changes are, however, possible. The specified rectifier valve V22 is a 5U4G operating at 5 volts 3 amps. heater; a 4-volt valve may be used instead if the 5-volt winding is not available, and

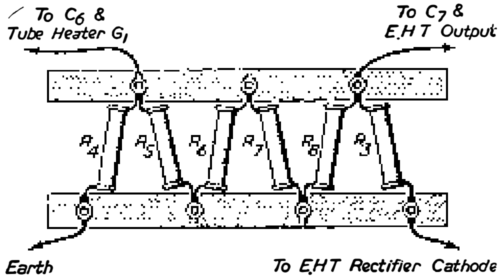


FIG. 480. *How to arrange the E.H.T. bleeder to provide a long leakage path.*

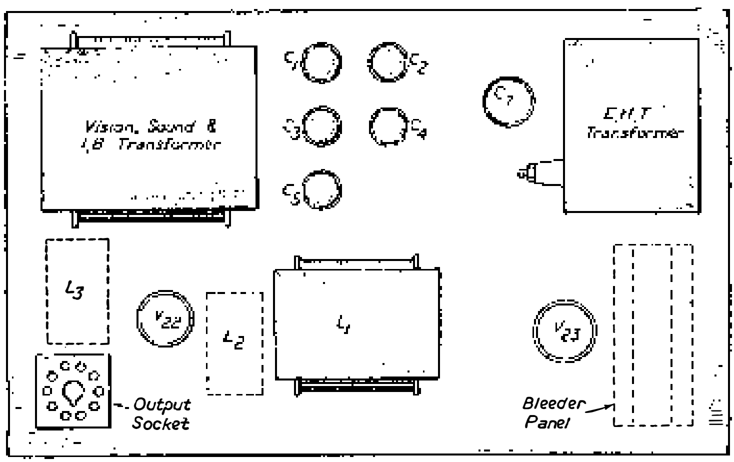


FIG. 481. *Layout for the principal components of the power unit.*

suitable valves are the Cossor 451U or Mazda UU8. Alternatively again, two ordinary 120-milliamp. rectifiers may be wired in parallel. Second changes that are practicable are combination of the two 6-volt windings into one winding of 6 volts, 10 amps., or failing this, a separate heater transformer may be used for one or more of the required heaters. The 2-volt tube winding should, in any case, be isolated as shown, not taken from a tap on one of the earthed windings. The reason writer stripped his transformer of iron—which did not prove so troublesome as the size of the thing indicated—and wound on an additional 2-volt winding for the tube, and increased the 4-volt winding to 5 volts for the available rectifier. Turns per volt are very low on these transformers and can be determined from the windings already wound; there is also plenty of room for the additional turns of wire.

The specified amperages of the windings shown in Fig. 482 are the theoretically

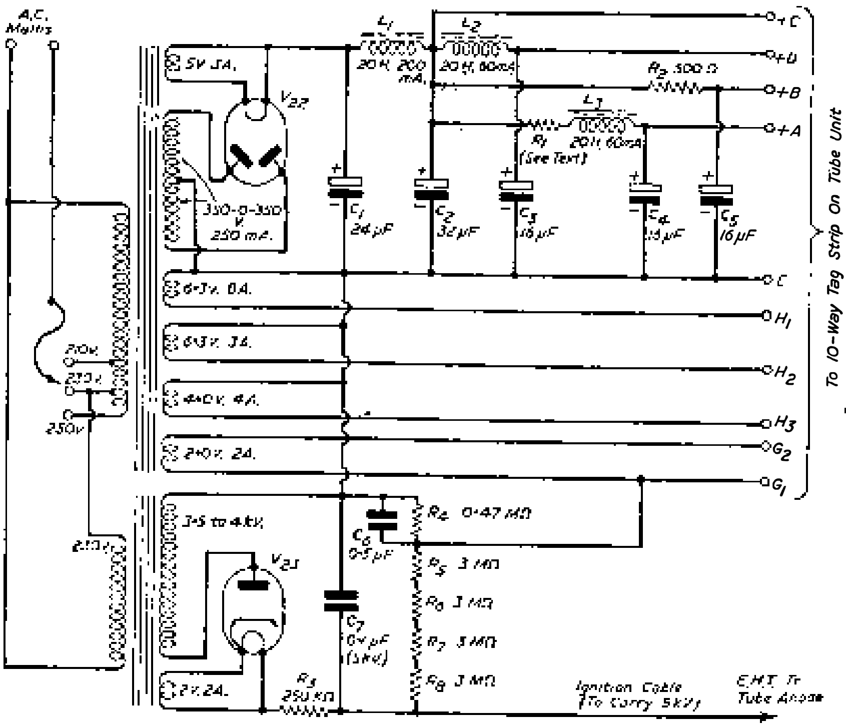


FIG. 482. *Theoretical circuit of the power pack, with terminal references.*

for this is not connected so much with tube heater-cathode insulation as the desirability of connecting the tube cathode directly to its heater to prevent possible trouble from hum. In this case a transformer having the following heaters was used: 6-volt at 6 amps., 4-volt at 8 amps., 6-volt (tapped at 2-volt) at 2 amps., and 4-volt at 3 amps. Such transformers having the correct H.T. winding are plentiful at the present time. The correct ones therefore, and are *not* those actually in use in the power unit. The 6-volt 6-amp. winding supplies the required 7 amp. to 8 amp. demanded by the vision unit without trouble; the tapped 6 volts 2 amps. supplies the time-base chassis. The 4-volt 8-amp. winding easily supplies the two gas valves with their 2 amps. and there is no voltage rise because of this. This matter of heaters is one for the individual ingenuity of the constructor, but it is not a serious point and is easily overcome with a little thought and attention.

Turning now to the extra H.T. transformer, this is an easily obtainable component, and is a transformer rated at 3·5- to 4-kilovolt H.T. with a 2-volt heater for the rectifier valve. This latter is a Cossor SU2130 (the Service equivalent is the VU120), or alternatively a Mazda U22 is suitable. Great care must be taken with the insulation of the heater winding and wiring of this valve, and a long-leakage path-type valve-holder should be used. The smoothing chokes and condensers are normal components and can be readily obtained. Heavy duty ex-Government chokes can be obtained cheaply for L1 : for L2 and L3 normal-type smoothing chokes as used in radio receivers are suitable, although "midget" components must be avoided. All the electrolytics are rated at 450-volt working, and the larger values such as 24 μF. and 32 μF. may be made up out of paralleled components. C1 may be raised to 32 μF. if desired.

C7 is the smoothing condenser for the E.H.T. and must be chosen with regard to its working voltage accordingly. 0·1 μF. rated at 5 kilovolt working is suitable, and ex-Government components may be used. A larger capacity, provided the working voltage is not below 5 kilovolts, may, of course, be used. C6 is simply a decoupling component and has the usual 350-volt rating.

Construction. Fig. 481 shows the layout, from above chassis, of the power unit, but some modification may be necessary to suit the components actually used. However, no drastic changes need be necessary even if a separate heater transformer is used, for this can be accommodated below the chassis. The chokes L2, L3 and all the resistances are below chassis, their positions being indicated by the broken lines. A 10-pin socket (heavy type) is used to bring the outputs to a point, and the 10-way lead from the tag-strip on the tube unit is terminated by a 10-pin plug. The order of connections is left to the constructor and is not important, but it is *absolutely essential* to ensure that the plug wiring mates with the socket wiring. Very careful checking is necessary at this point as a mistake is so easily made. The lettered points on the right of Fig. 482 correspond to the lettered points on the circuit of the tube unit previously described, and these particular letters are used throughout the circuit. There should, therefore, be no error with regard to them, and although the number of interconnections seems alarming on paper, in practice a few neat cable forms can be made up to connect together the various units.

The E.H.T. output is *not* brought through any plug or socket, but is led directly from the smoothing condenser C7 to the tube anode through a length of ignition cable. It is essential to take care over the wiring of the whole of this part of the power unit. The heater leads to the rectifier should be heavily insulated and, if possible, kept clear of the chassis by ½ in. or so. The smoothing resistance R3 should be mounted on a tag panel with the bleeder chain R4 to R8, the whole panel then being mounted well clear of the chassis and all other parts and leads. The bleeders should be mounted, as shown in Fig. 480, so as to give as long a path for leakage as possible. R3 is ½-watt rating, R4 to R8 each 1-watt. The bias for the tube is obtained from R4, and the brightness control is actually wired in parallel with it, as a check through to the tube-unit circuit diagram will show.

There is nothing of great importance to be said about the wiring of the remainder of the circuit, and it may be carried out as the individual constructor desires. The rating of R2 is 5 watts, as is R1. The value of this latter resistance is chosen to make the total resistance of both L3 and itself in series up to 500 ohms, and is not critical. The chassis size is, in the writer's case, 14 in. by 9 in. by 3 in., but this is not a hard and fast affair, and the constructor may buy one to suit his components. Nothing much smaller than the above, however, is recommended. Make all earth returns of very heavy wire, especially those associated with heater wiring, and the earth pin on the 10-pin socket must be very heavily anchored.

List of Components

Mains transformers (see text).

1 20 H. 200-milliamp smoothing choke (low D.C. resistance).

2 20 H 60 milliamp smoothing chokes.

1 32 μF. 500-volt working electrolytic condenser.

1 24 μF. 500-volt working electrolytic condenser.

3 16 μF. 500-volt working electrolytic condensers.

1 0·1 μF (or larger) 5-kilovolt working condenser.

1 0·5 μF. 350-volt working paper condenser.

1 Belling-Lee 10-pin plug and socket.

Resistances, etc., as specified in the text.

TELLURIM. An element of rare occurrence found in a few minerals in association with gold, silver, and bismuth. Symbol—Te. It possesses many of the characteristics of a metal, but bears so close a resemblance to selenium in its chemical properties that it is generally placed in the sulphur group. It is used in conjunction with another crystal as a rectifier. (See also Crystals.)

TEMPERATURE COEFFICIENT. The proportional change of resistance in a conductor per one degree of temperature. This is positive for metals and negative for carbon. It is approx. constant for pure metals only.

TERMINATED FOLDED DIPOLE. A *folded dipole* having a resistor, equal in value to the average characteristic impedance of the *aerial*, connected across those inner ends which are not fed.

TERMINATION (in Waveguide Technique). The point at which energy flowing along a *waveguide* continues in a non-waveguide *mode* of propagation.

TESTING A RECEIVER. Although elaborate test equipment is normally desirable for servicing receivers, simple tests may be carried out at home. In the case of a simple battery receiver, it may be tested without any instruments in the following manner. Assume that the L.T., H.T. and G.B. batteries are in order. Disconnect the wire which is joined to the detector valve-holder terminal lettered "A" or "P." Connect up one lead to a pair of headphones to the terminal, and take the other lead straight to H.T. positive 60. Switch on the set and see if signals come through. If there are no signals tap the glass bulb of the valve lightly with the tip of your finger. If no noise is heard the valve is broken. To ascertain this simply remove the valve and plug one of the other valves from the set in its place. Supposing that no matter which valve you plug in you can still hear nothing. Remove the wires which are connected to the "F" terminals of the valve-holder, and obtain two new pieces of wire and attach them to the "F" terminals, and straight on to the accumulator. If the valve now works, then the filament wiring in the set or the leads from the terminal strip down to the accumulator are at fault.

With all leads of the flexible variety having clamped-on spade connectors or similar devices, it often happens that the wire gets broken, but the connector is held in position by the cotton covering.

Now that leads have been checked over and found correct, there only remain the connections from the L.T. terminals on the set to the valve-holder and the terminals on the valve-holder itself.

Supposing when joining the accumulator direct to the valve-holder nothing is heard in the phones. The only lead left which can cause this trouble is the H.T. negative lead, and if this is joined to the set to one side of the fuse only, look at the fuse. If this is in order, remove the H.T. negative lead from the terminal strip and join it to the L.T. negative terminal.

Now take the case where on connecting the phones no signals can be heard, but the valve "pings" on tapping it. This shows that filament and anode circuits are correct and the trouble must lie in the tuning arrangements. Try a different coil, or if some complicated switching arrangement is used in the set, wind or obtain a simple 60-turn coil and connect one side of it to aerial and one side to earth. Disconnect the aerial terminal to the tuning coil, and also the lead from the tuning coil and/or condenser to the grid condenser. Join the aerial terminal to the grid condenser, and again observe whether signals come in. If they do, then the tuning coil is at fault. Supposing you hear nothing with this simple coil, then the grid condenser is broken inside.

The reaction circuit consists of only a reaction condenser and coil, so that one can soon find any fault arising here, and the absence of reaction, when the maximum H.T. is applied to the valve, will show that the reaction circuit is faulty.

Now pass on to the first L.F. stage. If, when one attaches the phones to the anode terminal of the detector valve, the signals are heard, proceed as follows: Remove the lead joining the anode terminal to the second valve, and join the phones to this as before described, taking one side of the phones direct to the H.T. battery in order to eliminate any decoupling resistances or other parts included in the anode circuit of the valve. If signals are still quite in order pass on to the following valve, and so on. If, however, nothing can be heard, the first thing to do is to test the valve. If it is correct, then the only components used to couple the detector valve to this one are the L.F. transformer or an R.C.C. unit. Substituting new components is the easiest way of finding out what is wrong. If one cannot obtain substitutes, the primary and secondary windings of the L.F. transformer may be tested for breaks in the following way. Disconnect all leads from the transformers and then join one primary terminal to the positive socket of a grid bias or pocket-lamp battery. To the other primary terminal join one side of the phones. Now join the other lead of the phones to one side of a high resistance—such as a grid leak—and the other side of the resistance should be carefully touched on the 1½-volt socket. If a scratching sound can be heard in the phones then the primary is unbroken. If, however, nothing can be heard, try the 3-volt socket and gradually work upwards. Do not omit the resistance, and do not apply too high a voltage. If nothing can be heard at 12 volts or so, then the primary is broken. Test the secondary similarly.

With a simple voltmeter and/or milliammeter, the receiver may be tested at each stage by including the meter or meters as shown on page 196. Fig. 291 shows how the voltage at the anode of a valve may be obtained by connecting a voltmeter across the valve. This will sometimes give a false reading in certain cases owing to the shunting effect of the resistance of the meter. However, if the voltmeter is connected across the anode load resistance the voltage drop which is given will enable the anode current to be calculated by the simple application of Ohm's Law, as also if it is connected across the biasing resistor. Alternatively, if the anode circuit be opened and a milliammeter be joined in series (either at the H.T. or cathode end) the current indicated will enable the resistance values to be checked (knowing the voltage applied). Fig. 294 shows how the output from a mains rectifier may be read, whilst Fig. 298 shows how the current output may be checked.

A microammeter in series with the grid of an L.F. valve will check whether or not the valve is running into grid current. If a resistance is to be checked it may be connected in series with a battery and milliammeter as shown in Fig. 300 and its value calculated in the absence of an ohmmeter.

TETRODE. A 4-electrode valve. The screen-grid valve is a tetrode, having filament, screening grid, control grid, and anode.

THEREMIN PRINCIPLE. This is the principle upon which the production of electronic music is based. This name is derived from the musician Theremin. (See also *Electronic Music.*)

THERMAL NOISE. (Johnson noise.) The E.M.F. generated by the thermal agitation of electrons.

THERMAL TUNING. Adjusting the frequency of a *cavity resonator* by varying its shape by thermal expansion.

THERMION. Another name for *Electron* (*which see*). (Also see *Valve.*)

THERMIONIC VALVE. (See *Valve.*)

THERMISTOR. A device in which use is made of the large negative temperature coefficient of resistance of certain substances, e.g. for measuring small R/F powers in radio technique.

THOMPSON EFFECT. That reversible thermal effect produced when current flows in a conductor having unequal heat. With copper, heat is absorbed when current flows from a cold portion to a warmer one in it.

THREE - ELECTRODE VALVE. (See *Valves Explained.*)

THROAT. That part of the flare or tapered *parallel plate guide* immediately adjacent to and connected to the main run of *waveguide.*

THYRATRON. A gas-filled triode, used for rectification, and in connection with television time-base generators. It is a registered trade-name owned by the B.T.-H. Co., Ltd.

TIME BASE. A circuit which employs either a gas discharge or a normal hard valve to provide a periodic voltage or current for application to the deflector plates of an electrostatic cathode-ray tube, or the deflection coils of a magnetic tube. For further details of time base circuits, of which there are several types, see a companion work entitled *Television Principles and Practice*, obtainable from the publishers of this volume.

TIME SIGNAL. The official Time Signal is that which is received from Greenwich Observatory. This is accurate to $\frac{1}{20}$th of a second, and Greenwich Mean Time is denoted by the *last* of the six pips. With the Big Ben signal, the *first* stroke indicates the hour.

TO PEAK. To adjust a tuned circuit to optimum performance.

TO STROBE. To select on a recurrent *time base* a portion of the output signals.

TONE CONTROL. The pentode output valve, the Class B stage, and the Q.P.P. arrangement all need some form of tone correction in order to give a pleasing tone to the reproduction. Dealing first with the pentode, it may be stated that this gives over-emphasis to the higher notes, with the result that the tone sounds too shrill. Consequently we need a high-note cut-off to balance the reproduction, but as certain types of orchestral music need more cut-off than speech, for instance, the control should be variable so that it may be adjusted according to the item being received. The usual tone control for this type of valve is shown in Fig. 483, and it will be seen to consist merely of a fixed condenser in series with a variable resistance, both being joined across the output circuit. In this connection it should be remembered that the H.T. positive side of the speaker or output transformer is at earth potential in relation to the anode, and accordingly it is quite in order to join the tone control components between the anode and earth as shown in Fig. 484.

The Q.P.P. arrangement utilises either a double pentode or two separate pentodes in a push-pull circuit and accordingly a similar type of tone corrector may be employed. This should be joined across the two anodes, which is, of course, across the output circuit, as shown in Fig. 485. The resistor may be fixed or variable. In some cases it may be found that it is desirable to connect a fixed condenser permanently across this type of output stage and use the tone control arrangement already referred to as an addition. In Fig. 486, therefore, I show this arrangement, and values suitable for the pentode tone corrector may be stated to be as follows. For the fixed condenser some value between ·001 and ·05 μF. is generally suitable, and for the resistor from 20,000 to 100,000 ohms. The shunt condenser in Fig. 486 should not generally

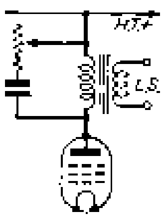


FIG. 483

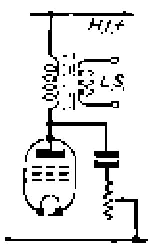


FIG. 484

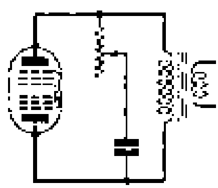


FIG. 485

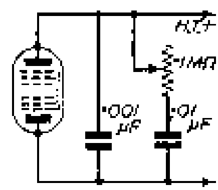
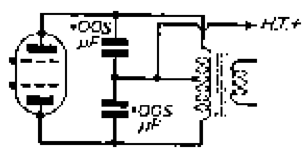


FIG. 486

FIG. 487



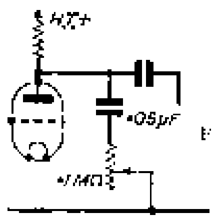
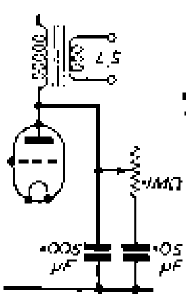
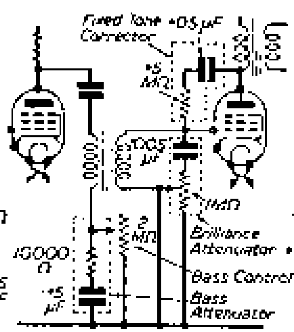
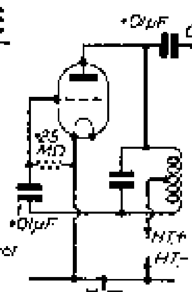


FIG. 488

FIGS. 483 TO 492. *A variety of tone control circuits suitable for all types of receiver.*







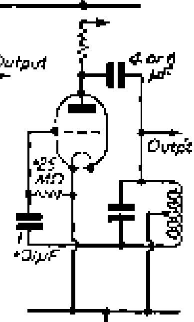


FIG. 489 FIG. 490 FIG. 491 FIG. 492

be greater than ·001 μF. In the Class B circuit such a comprehensive tone control is not needed, and generally the tone is sufficiently well balanced if a fixed condenser shunts each anode. A value of ·001 μF. up to ·005 μF. will generally be found satisfactory, and they should be placed as shown in Fig. 487. The use of resistors on the input side is sometimes recommended with the Class B arrangement, but, generally speaking, if the L.F. circuits are properly designed, a condenser filter alone is adequate.

Many modern receivers are provided with a tone control across the first L.F. stage. This usually takes the form of a condenser and resistance arrangement (similar to that used in the pentode circuit), joined between the anode of the L.F. valve and earth. The general principle is shown in Fig. 488, where it is used in conjunction with the standard resistance-capacity circuit. Suitable values will depend upon the valve and the R.C. components, and again, up to ·05 μF. and up to 100,000 ohms are generally suitable. A more comprehensive arrangement for use in this stage is seen in Fig. 489, where, in addition to the usual resistance and condenser, a fixed condenser is permanently joined between anode and earth. This follows on the lines of Fig. 486, and a suitable value for the additional condenser is ·005 μF.

All of the circuits so far described merely control the high notes, or, in other words, the brilliance, but a circuit of great interest is seen in Fig. 490, which is the arrangement employed in an H.M.V. receiver. In this, provision is made for bass attenuation, brilliance attenuation and, in addition, a fixed tone corrector is employed. As will be seen, the bass attenuator consists of a fixed resistor and condenser in series between the anode of the penultimate stage and earth, and shunted across these two components is a variable resistor. The brilliance attenuation is effected by a fixed condenser and resistor across the grid circuit of the output valve, and the resistor is of the variable type to effect the degree of brilliance attentuation desired.

The fixed tone corrector in this circuit is a fixed condenser and resistor coupled between the grid and anode of the output valve. The separate circuits are indicated by varying line thickness in Fig. 490, and the values used by H.M.V. are given.

In addition to the usual arrangements shown, it is possible to employ chokes and other components in special circuits, and in this connection it should be remembered that there is a special tone control choke consisting of a tapped winding with a total inductance of 3 henrys. This inductance naturally varies according to the current flowing through it, and to preserve the maximum value it should be so arranged in circuit that no D.C. flows. This may easily be done by using the normal filter circuit arrangement. In this choke tappings have provided to give inductance values of 0·5, 1, 1·5, 2, and 2·5 henrys, and the resonant frequency of the choke with various values of condenser are shown in the accompanying table.

Capacity μF.	*Frequency Cycles*
0·1	500
0·07	600
0·052	700
0·04	800
0·031	900
0·025	1,000
0·011	1,500
0·0063	2,000
0·0041	2,500
0·0028	3,000
0·0021	3,500
0·0016	4,000
0·00125	4,500
0·001	5,000

Suitable circuit arrangements are shown in Figs. 491 and 492, and it should be noted that when the condenser is in parallel with the choke the circuit is of the rejector type, and when it is in series with the choke the circuit is of the acceptor type. For the benefit of those to whom these terms are not clear it may be explained that a rejector circuit provides maximum voltage at the resonant frequency, whilst the acceptor gives minimum voltage at the resonant frequency. Thus to eliminate needle scratch, for instance, an acceptor circuit would be needed, and 4,000 cycles is generally regarded as the frequency of needle and surface noise, which means that an acceptor circuit made up from the complete choke winding and a ·0016 μF. condenser would be needed.

TONIC TRAIN. A process of signalling in which interrupted continuous waves are employed. The interruptions are generally provided by using a valve fed with an interrupted source of high tension. Obsolete.

T-R SWITCH. A device used to prevent energy reaching the receiver during transmission. It may be used in radar sets employing either separate or common transmitting and receiving *aerials*.

T-R UNIT. A device which incorporates a *T-R switch* and a *transmitter blocker* (if fitted). It is used only in sets employing a common transmitting and receiving *aerial*.

TRACE. The pattern appearing on the screen of a cathode-ray tube.

TRANSCEIVER. A combined *transmitter* and receiver in which part of the circuit is used both for transmitting and receiving.

TRANSDUCER. A device by means of which energy may flow from one or more transmission systems to one or more other transmission systems. The energy transmitted by these systems may be of any form (for example, it may be electrical, mechanical or acoustical), and it may be of the same form or different forms in the various input and output systems.

TRANSFORMER. A combination of two inductances so arranged that alternating currents in one will induce currents in the other winding. There are three principal types of transformer employed in wireless receivers: high-frequency transformers, low-frequency transformers and mains transformers. High-frequency transformers consist simply of coils of wire, of which either the primary or the secondary may be tuned. The coupling is so tight that the effect of tuning one circuit is the same as tuning both. The relation between the windings, or, in other words, the ratio, is governed by the type of valve with which it is used. The low-frequency transformer consists of a similar arrangement, with the inclusion of a core of iron to increase the inductance. The two windings may be wound one on top of the other or side by side. The mains transformer consists of a similar arrangement, except that the primary is wound for inclusion in the A.C. mains circuit, and in place of one secondary, several secondaries are employed, to give voltage supplies for heating the heaters of indirectly heated valves. One secondary winding is provided for the purpose of giving the H.T. supply. L.F. transformers generally have a step-up ratio of from 1 to 1 to 1 to 8; the most usual ratio is 1 to 5.

The iron core should be built up of narrow strips or laminations of stalloy iron. The magnetic circuit is closed by similar strips on either side of the windings, parallel to the core. These two strips are yoked together by shorter strips at right angles. Each strip should be enamelled. Fifteen strips will be required for the core, eight strips each for the two sides, and 16 yoke strips, $\frac{6}{16}$ in. wide.

Mains Transformer Data. By means of a constant obtained from the table below,

[illegible] Voltage	*Frequency cycles per second*								
	20	30	40	50	60	70	80	90	100
50	525	485	444	400	362	325	287	250	206
100	1050	975	888	800	725	650	575	500	412
110	1155	1073	976	880	797	715	632	550	453
150	1575	1455	1332	1200	1086	975	861	750	618
200	2100	1950	1775	1600	1450	1300	1150	1000	825
210	2205	2048	1864	1680	1533	1365	1207	1050	866
220	2310	2146	1952	1760	1594	1430	1264	1100	906
230	2415	2243	2041	1840	1666	1495	1321	1150	947
240	2520	2341	2130	1920	1739	1560	1378	1200	988
250	2625	2425	2220	2000	1810	1625	1435	1250	1030

the turns of wire for a primary of a transformer may easily be ascertained. For example, the constant of a transformer for a supply of 220 volts 50 cycles is 1,760. Therefore, with a core of 1 sq. in. cross sectional area you use 1,760 turns of wire for primary. For a core of 2 sq. in. you use $\frac{1{,}760}{2} = 880$ turns and so on. The secondary is directly proportional to the voltage ratio.

TRANSFORMER COUPLING. (See *Low-frequency Couplings*.)

TRANSFORMER RATIOS. The usual ratio of primary turns to secondary turns is spoken of as the transformation ratio; thus a transformer with 100 primary turns and 1,000 secondary turns would have a transformation ratio of 100 to 1,000 or 1 to 10.

$$\frac{\text{Primary turns}}{\text{Secondary turns}} = \frac{\text{Primary E.M.F.}}{\text{Secondary E.M.F.}} = \text{Transformation Ratio}$$

(See also *Low-frequency Couplings*.)

TRANSFORMER WINDINGS. It is when two low-frequency stages are employed that it is necessary to limit the gain in individual stages to avoid overloading the next valve. The type of output valve employed is another important factor. If the output valve is a small-power valve, or a small pentode, both of which are intended to give the greatest output reasonably possible from comparatively small grid inputs, the previous stage or stages of amplification must be kept within bounds. Generally speaking, a modern detector stage followed by a $3\frac{1}{2}$ to 1 transformer is quite adequate to load fully the average small power or pentode valve. If the detector is preceded by one or more high-frequency stages, it will probably also be able to load a super-power valve, if coupled by a $3\frac{1}{2}$ to 1 transformer. If no high-frequency stage is employed, the detector can be coupled to a super-power valve through a high-ratio transformer, or a further low-frequency stage may be interposed between the detector and the super-power valve, the coupling in each case being a low-ratio transformer.

In the case of an output valve, it is not merely a voltage drop in the anode circuit which is required, but an appreciable amount of power which can be used to operate the loudspeaker. This amount of power can be measured by multiplying the *alternating* voltage drop across the load by the *alternating* component of the anode current. The load in this case is, of course, the speaker winding, or the primary winding of the output transformer, if one is used, or by the combined circuit provided by the output choke and the speaker winding in a choke output circuit.

DETAILS OF STALLOY CORE STAMPINGS

Size No.	Dimensions A	Dimensions B	Dimensions C	Number of Stampings	Approx. Watts	Turns per Volt (50 cycles)	Approx. Winding Area
	in.	*in.*	*in.*	*doz. prs.*			*sq. in.*
4	$\frac{15}{16}$	$2\frac{5}{16}$	$\frac{7}{8}$	6	50	8	$1\frac{1}{2}$
5	$\frac{5}{8}$	$1\frac{1}{2}$	$\frac{3}{4}$	6	30	12	$\frac{3}{4}$
28	$1\frac{1}{4}$	3	$1\frac{1}{4}$	6	250	6	3
29	2	$4\frac{1}{2}$	$1\frac{3}{8}$	6	300	4	$5\frac{1}{4}$
30	$\frac{5}{16}$	$1\frac{1}{8}$	$\frac{7}{8}$	6	45	8	$\frac{2}{3}$
31	1	$3\frac{1}{2}$	1	6	100	8	$2\frac{7}{8}$
32	1	$2\frac{1}{4}$	1	6	75	8	$1\frac{3}{4}$
33	$1\frac{1}{4}$	$2\frac{3}{4}$	1	6	125	6	$2\frac{1}{4}$
35	$1\frac{1}{2}$	$3\frac{3}{4}$	$1\frac{5}{8}$	6	200	5	$5\frac{1}{4}$

This table covers most of the commoner sizes of stampings, but some makers give different numbers to stampings of similar size.

For most three-electrode output valves, the optimum (or best) value of the load impedance is of the order of twice the valve resistance. The value is not very critical, and the usual range of speaker impedances covers most requirements excepting pentode output valves.

TRANSFORMERS, LOW-FREQUENCY. The ratio of the transformer should be chosen according to the position it occupies in the receiver. If only one stage of L.F. is employed this may conveniently be one of the high-ratio transformers, say 7 to 1. If a pentode is used do not use a higher ratio than 5 to 1.

If more than one L.F. stage is used, the first transformer should be of medium ratio, say 3 to 1, and the second of 4 or 5 to 1.

The usual markings of the terminals of L.F. transformers now are P, HT, G, and GB. These should be connected respectively to the plate, high tension, grid, and grid bias. If one of the older types of transformer is used this will be marked IP, OP, IS, and OS. These correspond respectively to plate, H.T., G.B. and grid.

Where it is thought desirable to avoid the

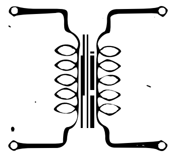


FIG. 493. *Theoretical sign for an L.F. transformer.*

direct current flowing through the primary of the transformer, it should be parallel fed. This means that the terminal marked H.T. should be joined to earth, the terminal marked P fed *via* a fixed condenser of up to 2 μF. to the plate of the valve, and the high tension applied to the plate through an anode resistance of a value about four times the impedance of the valve. (See also *Low-frequency Couplings.*)

TRANSFORMING A.C. (See *Mains Transformer.*)

TRANSFORMING SECTION. A length of *waveguide* or transmission line of modified cross-section, or with a metallic or dielectric insert used for *impedance* transformation.

TRANSIENTS. Sudden climaxes in music exemplified by cymbal clashes, final chords, etc. Other effects heard on the radio which come within the description of transients are pistol shots, slamming doors, etc. The charge and discharge characteristics of a condenser.

TRANSISTOR. A three-electrode crystal which amplifies and oscillates like a valve. The type of crystal detector used in the early days of broadcasting was unstable, and the point contact rectifier was found to be inherently more efficient than the valve as a detector of short centimetre waves used for radar.

Some of the better-known semi-conductors are galena, carborundum, silicon, and a new material called germanium, which has many unique electrical characteristics. The need of a stable and reproducible detector for radar work early in the war led to the production of a modern version called the crystal valve :

resembling a small cartridge fuse, about ¾-in. long and ¼-in. diameter; permanently adjusted and more robust than the valve. Many hundreds of thousands were made during the war, and this British design was later copied by the Americans.

Silicon, when suitably treated with small amounts of boron and tin respectively, is the best for centimetre wave detection; germanium is, no doubt, the most interesting of all semi-conductors, its high resistance to voltage breakdown making it an attractive valve substitute in many applications. Although our knowledge of semi-conductors is still incomplete, considerable progress has been made empirically, and this has led to the discovery of the crystal triode.

TRANSITRON. A valve circuit whose action depends on the negative trans-conductance of the suppressor grid of a pentode with respect to the screen grid. An oscillator, used for purposes similar to those for which the dynatron is employed. The transitron has the advantage that its operation is not impaired by continued use of the valve, whereas in the case of the dynatron the condition of the anode surface has a marked effect on behaviour. This is because the negative-resistance property of the valve used as a dynatron is dependent upon secondary emission by the anode. In the case of the transitron a cloud of electrons tends to accumulate between the screening and suppressor grids, and this cloud acts as a virtual cathode. The accumulation of electrons is due to the negatively biased suppressor which tends to repel electrons in transit to the anode, and also due to the fact that the screening grid is again at a higher potential than the anode.

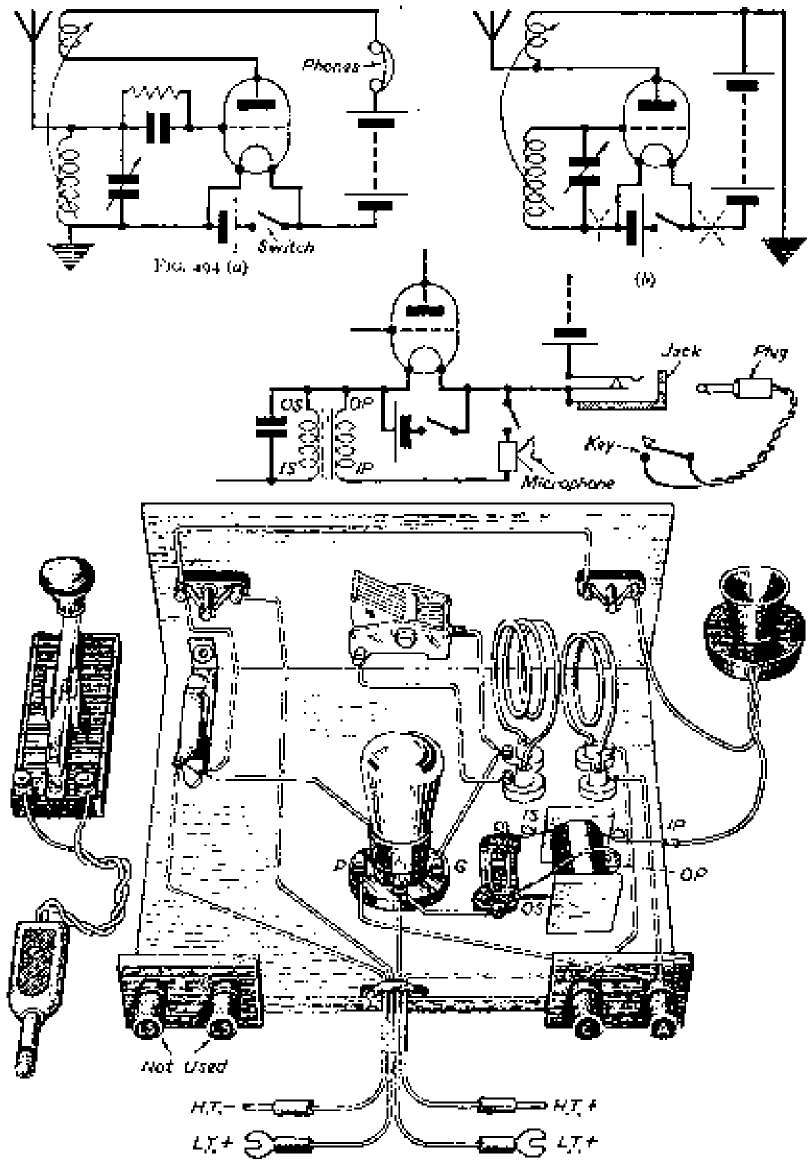
As the screening and suppressor grids are at the same radio-frequency potential, because they are connected together by a condenser, any increase in screen potential brings about a corresponding increase in suppressor potential. This counters the effect of the initial negative bias on the suppressor and allows a greater flow of electrons to the anode. At the same time it brings about a reduction in screen current. We thus have a negative resistance effect in the screen circuit connected between the screen and the high-tension positive supply point.

TRANSMISSION. The act of generating high-frequency oscillations and feeding them into an aerial circuit. Fig. 494 (*a*) illustrates a simple one-valve set employing two coils for aerial tuning and reaction. When the two coils are brought close together oscillation occurs due to the feeding back of the energy from the anode circuit to the grid circuit. To employ this energy for transmitting purposes it is necessary to ensure that it shall be passed into the aerial, and therefore the aerial and earth connections are changed round.

Fig. 494 (*b*) shows practically the same circuit arrangements, with the exception that the aerial is now joined to the anode instead of to the grid, and the earth connection is taken from the other end of the reaction coil. (The phones are naturally removed.) This method of connection ensures that the maximum current which the valve is capable of generating is fed into the aerial circuit, and if a milliammeter is inserted in series with the anode coil a reading of the anode current is obtained. If this current (expressed as a decimal fraction of an amp.) is multiplied by the voltage of the high-tension battery, the figure obtained will express the power of the transmitter in watts.

This circuit is the basic arrangement of *all* transmitters, and it is only necessary now to insert a key for the transmission of Morse signals, or a microphone for the transmission of speech or music. The most efficient way of breaking the circuit is to disconnect the wire linking the batteries, and therefore a tapping key should be inserted at the point marked X. When the key is depressed the circuit is completed and oscillations will be present in the aerial circuit. As soon as the key is released the oscillations will cease. The signals of the Morse code may therefore be easily transmitted. For speech, the oscillations must be continuous in the aerial circuit, and the speech currents superimposed upon those oscillations. A microphone and a microphone transformer are the essentials required, and the secondary of the transformer (which should have a step-up ratio) is joined in the grid circuit at the point marked Y. The microphone is joined in series with the primary of the transformer, and to complete this part of the circuit a battery is necessary.

Fig. 495 shows how this microphone circuit may be completed by using the accumulator which supplies the filament of the valve, and also the method of including the secondary in the grid circuit. The



FIGS. 494 AND 495. *A* 1*-valve transmitter, with circuit showing how it differs from a* 1*-valve receiver*

value of the condenser across the secondary must be fairly carefully chosen in conjunction with the secondary winding and the frequencies which it is desired to transmit. It is also advisable to shunt the H.T. supply with a large condenser. This method of employing a microphone is not efficient, although it is the simplest method, and in actual modern practice a separate valve is used for the microphone, and this is wired up to form what is known as the "Modulator" circuit. It is arranged so that part of the aerial energy is absorbed according to the speech currents in the grid circuit of the modulator valve. The first valve generates the oscillations (known as the "Carrier Wave"), and the second valve modulates these oscillations.

Experiments in transmission must not be carried out without the sanction of the Postmaster-General, and a transmitting licence must be obtained before transmissions are undertaken.

TRANSMISSION FACTOR. Of a gramophone record is that ratio of the needle amplitude to the cutting stylus amplitude. Somewhat high, it is not independent of frequency.

TRANSMISSION UNIT. A measure of strength of sound evolved by telephone engineers. The unit is now used in radio and talkie work to indicate the strength of loudspeaker outputs. The transmission unit is usually expressed as T.U. or Db, which is the abbreviation of decibel, another name for it. (See also *Decibel.*)

TRANSMITTER. The sending station. This may employ spark, tonic train or speech as the method of communication. Whatever method of communication is used, the principle is the same, namely, oscillating currents are introduced into the aerial circuit of the transmitter.

A simple transmitter is shown in Fig. 497. It will be noticed that "suppressor grid" modulation is employed, but if so desired other methods can, of course, be tried, though the beginner is well advised to stick to the above, as highly satisfactory results can be obtained with the minimum of trouble.

To avoid the use of several meters, jacks are fitted in the essential leads, thus allowing one meter to serve all circuits. The meter should be mounted in a convenient central position on the front panel, while the jacks should be so placed that their connecting leads are kept as short as possible.

It is advisable to note at this point, although the matter will be dealt with in detail later, that it is very important for the C.O. to be thoroughly screened from the P.A., in fact, the C.O. should be assembled in one of the screening boxes previously mentioned, or adequate screening built round the whole section.

For the biasing of the P.A., batteries are used, suitable H.F. chokes being included in the same manner as in the supplies to the screens, to prevent any trace of H.F. getting into the respective circuits.

The Speech or Microphone Amplifier.

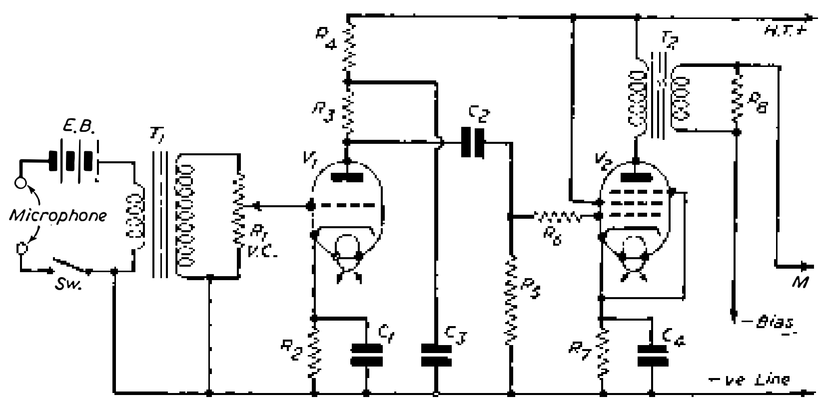


FIG. 496. *The microphone or speech amplifier circuit.*

Fig. 496 shows the theoretical circuit. It is quite straightforward, and follows normal L.F. amplifier design.

Two transformers are necessary, one (T1) for the microphone input, the ratio of which depends on the microphone requirements, and (T2), a good make of output transformer having a ratio of, say, 1 : 1, which is connected in the anode circuit of the valve (V2).

The volume control, V.C., is essential, and it is best inserted early on in the circuit, as a more satisfactory control can be maintained. A simple switch is connected in series with the primary of T1 and the energising battery, E.B., and in view of the fact that such batteries are often left switched on, it is advisable to provide some form of signal light, which can be operated off the same battery or off the heater circuit. A word of warning about the latter. See that you keep all A.C. leads away from microphone leads and T1, otherwise bad hum might be introduced.

Mention of hum brings in another very important item, namely, the screening of the amplifier against mains interference and H.F. from the transmitting section.

It is not a difficult matter to make a screening box to suit the layout of the components or, better still, well-made metal boxes can be purchased for a few shillings.

It may be that a constructor already has a good 1-, 2- or 3-valve A.C. operated amplifier, complete with its own mains equipment. In such a case, there is no reason why it should not be used, providing, of course, that it is capable of giving distortionless amplification.

The Mains Unit. The mains unit, for the transmitter, is shown in Fig. 498, where it will be seen that it differs slightly from normal practice in the arrangement of the smoothing chokes.

It will be appreciated, after the diagram has been examined, that the output should be free of any trace of ripple or hum, as it is essential for the various feeds to be pure D.C., as far as possible, otherwise objectionable snags will be introduced into the transmission.

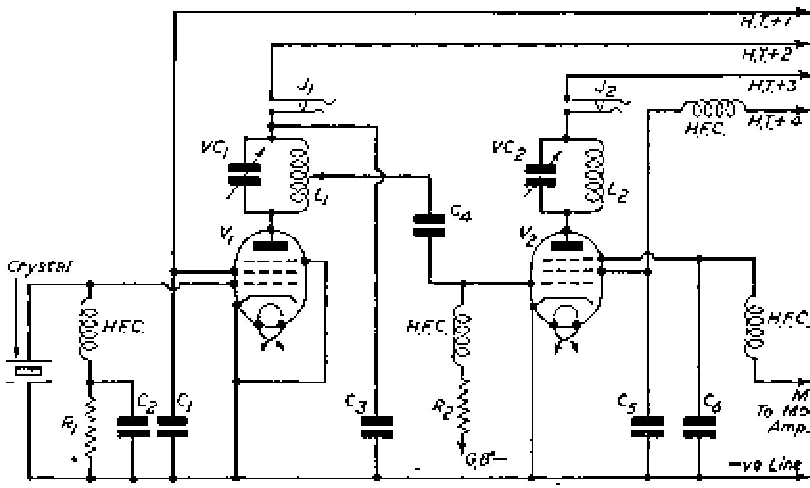


FIG. 497. *The oscillator and power amplifier circuit.*

It is not necessary for the chokes to be all of the same type or make. The vital qualifications are sufficient inductance when carrying their current load, reasonable resistance and well-constructed cores.

The various outputs are arranged for the H.T. supply points shown in the diagrams of the speech amplifier, and the C.O. and R.F. amplifier stages.

In case any constructor has a 500/0/500-volt transformer, it could be used, providing the output is reduced by shunt or series resistances to the equivalent of that indicated in Fig. 498. The rectifier required for the unit is the Cossor 442 B.U. or equivalent, which has an output of 350/0/350 volts at 120 milliamps., the filament requiring 4 volts at 2·5 amps. As this is of the directly heated type, it is always advisable to include a reliable single pole "snap" action switch in the centre tap of the H.T. secondary winding (X on the diagram), to allow the heater to reach its maximum temperature before throwing the load into circuit, thus avoiding violent voltage surges.

The various resistances are calculated for the valves suggested; therefore, it will be necessary to modify them if other combinations are used. It is assumed that the smoothing chokes have an average resistance of, say, 500 to 600 ohms.

To avoid any misunderstanding, the outputs should be connected thus: the supply from CH 3, i.e. H.T.+ is intended for the speech amplifier. H.T. + 1 is the supply for the screen of the C.O., while H.T. + 2 is for the anode circuit of the same valve. The screen of the R.F. amplifier is fed from the output H.T. + 4, and the anode from H.T. + 3, i.e. direct from the choke Ch.1.

It will be noted that a double-pole M.B. switch is included in the mains supply, and fuses (F) inserted between it and the primary of the mains transformer. For the slight extra cost, it is well worth while including suitable fuses in the anodes of the rectifier, as they cost very much less than a new rectifier. The points are marked F.

Component Values. Referring to the diagrams, Figs. 496 and 497, the following are the values for the components in the speech amplifier.

T1, a reliable make of microphone transformer to suit the microphone in use.

T2, a good 1 : 1 output transformer.

The volume control (R1) is an Erie ·5 megohm, while R3 is 50,000 ohms; R4, 20,000 ohms; and R2, the bias resistance, 750 ohms for a Cossor 41 MHL, or according to valve specification.

The grid H.F. stopper, R.6, is 50,000 ohms, while the grid-leak R5 is 0·2 megohms. The bias resistance should be chosen to suit the value, its by-pass condenser C4 being 50 μF. (12-volt rating) of the electrolytic type.

The by-pass condenser C1 (for R2) should have the same value, for preference, though a smaller capacity can be used if one is to hand.

The intervalve coupling condenser C2 is 0·05 μF., mica di-electric; the anode decoupling component C3 is 2 μF. or 4 μF., and the resistance R8 across the secondary of the output transformer T2 is 10,000 ohms.

It is advisable to use a separate battery for the energising of the microphone, and screen all leads on the primary side of the transformer.

The C.O. Stage. The condensers C1, C2 and C3 are 0·0006 μF., while R1 is, say, 40,000 ohms, the best value being determined, as previously explained, by experiment.

The tank circuit, L1, VC1, must be designed according to the waveband to be covered, but a value of 100 $\mu\mu$F. for VC1 is a satisfactory capacity for the 20- to 160-metre range.

It will be remembered that it is essential for the C.O. stage to be fully screened from the remainder of the circuit, particularly the R.F. amplifier.

The R.F. Amplifier. The coupling condenser C4 is 0·001 μF., mica di-electric and the resistance R2 in the G.B. circuit, 10,000 ohms. The decoupling condensers C5 and C6 are ·01 μF. and ·001 μF. respectively.

There is one point to note about the tank circuit L2, VC2 and that is, it is advisable to use double-spaced vanes for VC2, and a heavy-gauge copper-wire coil, air spaced, for L2, it being supported by the stand-off insulators obtainable for such purposes.

All H.F. chokes must be of good make, and it is desirable to see that they do not resonate at any frequency within the band under consideration.

The actual rating of the complete transmitter, using the valves suggested, is in the neighbourhood of 7·5 watts, thus bringing it within the scope of a 10-watt licence, that being the power permissible for a beginner. It is, of course, assumed that a full licence has been obtained before the transmitter is "put on the air."

TRANSMITTER BLOCKER. A device used to prevent received energy passing from the *aerial* to the *transmitter*.

TRANSMITTER-RECEIVER. A *transmitter* and a receiver combined in a single unit.

TRANSPONDER. An *I.F.F.* unit which receives *pulses* from a radar set or *interrogator*, and in response to the received pulses transmits a pulse or sequence of pulses to enable the craft or beacon

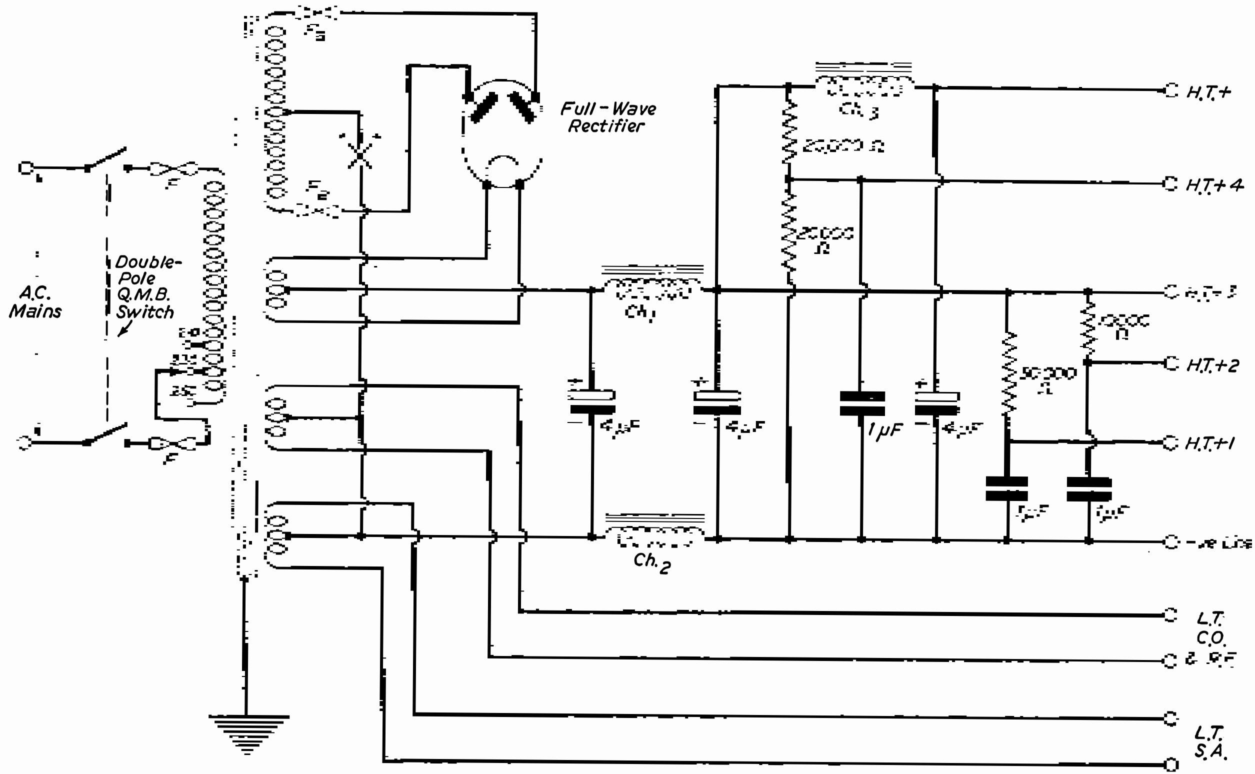


FIG. 498. *Theoretical circuit diagram of the mains power unit for a 10-watt transmitter.*

incorporating it to be recognised by the interrogating station.

TRANSPORTABLE SETS. This term is applied to receivers which are self-contained, but which are too large to be really "portable." They usually contain all batteries, or mains apparatus, in addition to the loudspeaker and aerial. They are very convenient for carrying from room to room, or, in the case of battery-operated receivers, for taking out in the country in a car.

TRAVELLING WAVE. The field configuration corresponding to the normal transmission of energy in one direction only.

TREMBLER. The vibrating reed of a sounder (*which see*).

TRICKLE CHARGER FOR D.C. MAINS. There still remain in this country many localities where electrical energy from the

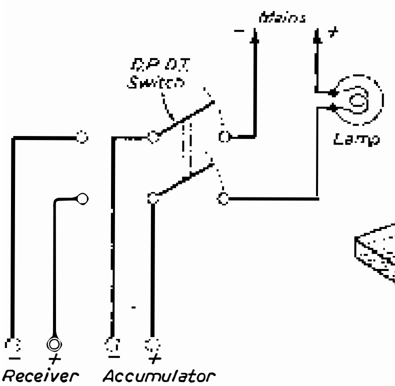


FIG. 499. *Theoretical circuit showing arrangement of charger. At the bottom of the diagram are the two pairs of terminals for connection to the receiver and the accumulator. From these terminals connections are made to the centre and one side of a double-pole double-throw switch. From the other side of the switch connection is made from the mains plug by means of a flex lead, in the positive leg of which the lamp is inserted.*

mains is available only in the form of direct current. To attain the maximum useful life an accumulator should never be fully discharged (or run "right down"), and recharging must be carried out regularly and at the correct rate. The simple D.C. trickle charger now to be described will enable these requirements to be carried out.

The theoretical diagram (Fig. 499) shows how extremely simple the device actually is. It is, moreover, absolutely foolproof in use.

A Lamp Resistance. Current is taken from the mains, a resistance being inserted in the positive lead which regulates the rate of the charge. This resistance is conveniently obtainable by the use of a suitably sized electric lamp. (The actual size of lamp required will be dealt with later.) The charging current is applied through a double-pole change-over switch to a pair of terminals marked "accumulator," and these are capable of connection via the opposite side of the switch to another pair of terminals marked "receiver." The "accumulator" terminals are for connection to the accumulator, and the "receiver" terminals are joined to the L.T. terminals on the set.

It is quite clear then that with the change-over switch in one position the accumu-

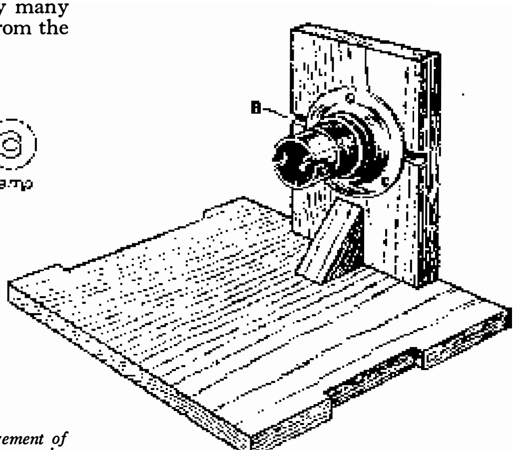


FIG. 500. *The base and lamp bracket assembled. The groove B allows the necessary clearance for the flex leads to the back of the lamp holder.*

lator is receiving the charging current, and with the switch in the reverse position the accumulator is connected to the set for ordinary service. Once these connections have been made nothing has to be disconnected again in use, all that it is necessary to do being to operate the switch before retiring at night and reversing it again in the morning, the charging of the accumulator having been properly carried out during the night.

Finding the Resistance. This is quite easily arrived at in the following way: (1) make sure of the total filament current consumed by the valves in the set; (2) decide approximately how many hours each day the set is in use; (3) decide how many hours each night the charger shall have in which to do its work. Now multiply the first figure by the second figure, and the result is the number of ampere-hours taken from the accumulator in one day. Divide this result by the third figure, and it will give the amount of current needed to replace the full charge in the accumulator in one night. This last figure is now multiplied by the voltage of the mains, and a figure representing the size of the lamp in watts is obtained.

Example:

(1) Total current consumed by valves $= \cdot 3$ amp.

(2) Number of hours set is used per day $= 6$.

$\cdot 3 \times 6 = 1 \cdot 8$ amp. hr.

(3) Number of hours charger is used in one night $= 9$.

$1 \cdot 8 \div 9 = \cdot 2$ amp.

Voltage of supply mains $= 200$.

$\cdot 2 \times 200 = 40$ watts.

If the figures applicable to a listener's own case give a result of an odd nature, such as 28 watts for example, a lamp of the next larger size available (30 watts) should be used.

List of Components

- 1 douple-pole double-throw mains switch;
- 4 terminals (2 marked —, 2 marked +);
- 1 batten-type electric lamp holder.

It is essential that the switch be a good one suitable for mains use, and as the cost of the charger is so moderate a good quality lamp holder and terminals of the standard insulated type should be used.

In addition two small pieces of ebonite, some plywood or hardwood ½ in. thick, and sufficient sheet metal to make a cover for the unit will be required. Some insulated connecting wire and a length of flex to connect with the mains plug one probably has already. Proceed with the construction by cutting the base and lamp-holder supprot from ½-in. thick wood.

Cut a groove across the lamp-holder support as at B in Fig. 500, to allow clearance for the connecting wires to go behind the holder.

The lamp holder can now be fixed, so

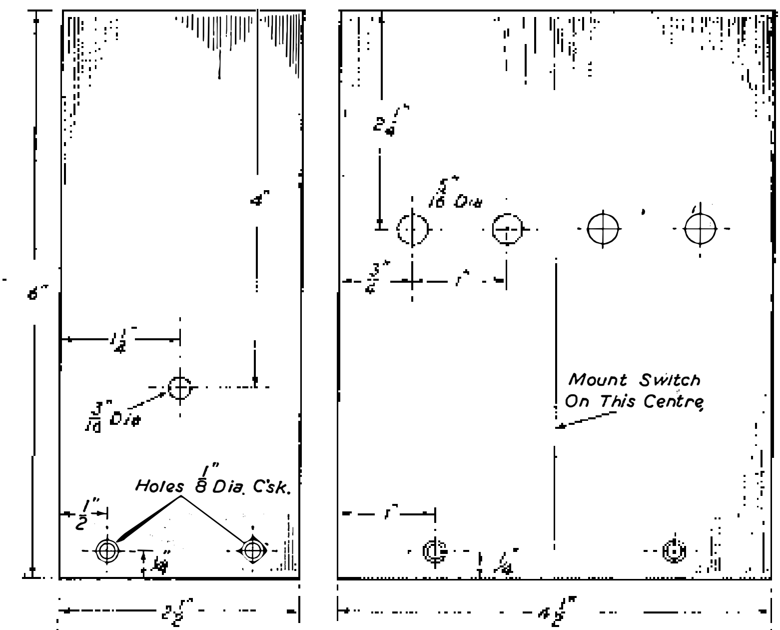


FIG. 501. *The two small ebonite panels.*

screw the support firmly to the base in the recess allowed for it. Extra rigidity is ensured by fixing in a small angle block, when the assembly will appear as in Fig. 500. Next prepare the two ebonite panels. They can be cut out of a panel 7 in. by 6 in. The necessary holes for mounting the switch will depend upon the particular make of component purchased.

Mount the switch and terminals on their panel, and screw both pieces of ebonite into their recesses in the base. Proceed with the wiring by reference to Fig. 499. Connections from the terminals to the switch are easily made with the usual kind of insulated connecting wire, soldered joints being the best provided they are efficiently made. Now make the connection from one contact of the lamp holder to the appropriate point on the switch. This is more easily done with a single piece of well-insulated flex. Now join up the long length of flex, one lead to the remaining point on the switch and the other lead to the unused contact of the lamp holder. The other end of the flex is passed through the hole in the middle of the smaller ebonite panel and connected with the mains plug or adapter.

There now remains to be made the metal cover, which is a protection and gives the unit that well-finished appearance the majority desire these days. The material used to construct the cover can be of one's own choice, tinned iron sheet being about the least expensive.

If the given dimensions have been followed up to this point, do so again for the cover as shown in Fig. 503. Mark out on the metal sheet very carefully as shown and drill all the holes. The large holes are for the purpose of cooling and are therefore essential.

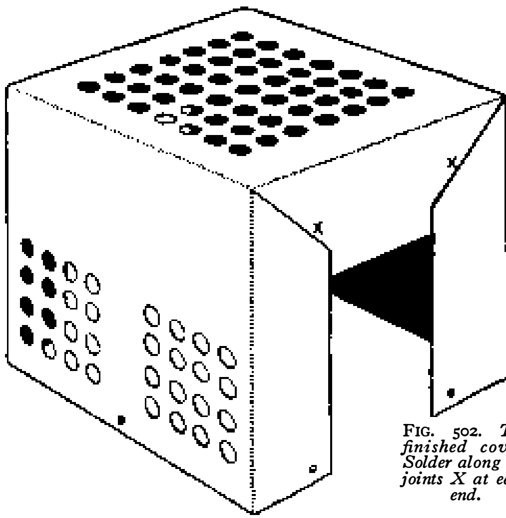


FIG. 502. *The finished cover. Solder along the joints X at each end.*

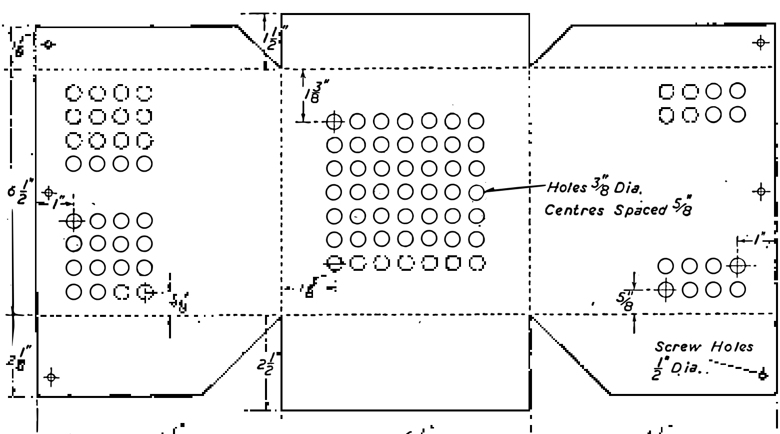


FIG. 503. *The sheet-metal cover.*

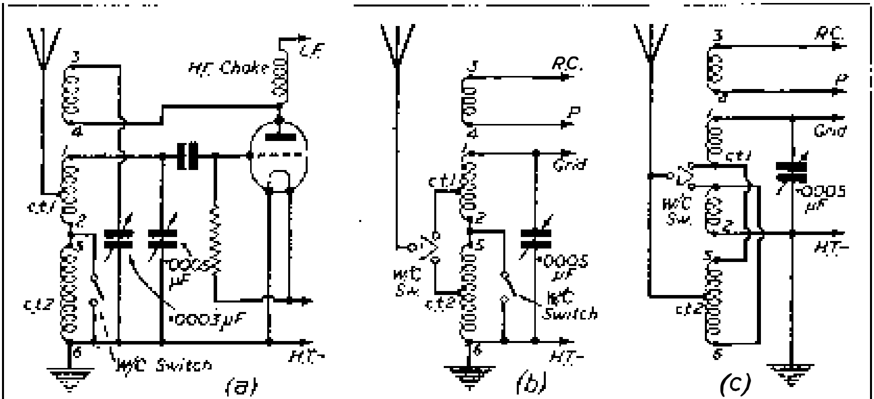


FIG. 504. *Three methods of connecting the tuner, shown in* FIG. 505, *into a detector circuit.*

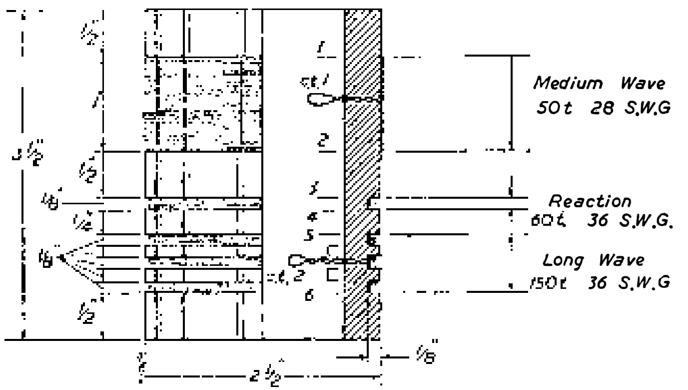


FIG. 505. *Constructional details of a tuner made on an eight-ribbed 2½ in. diameter ebonite former. All turns are wound in the same direction.*

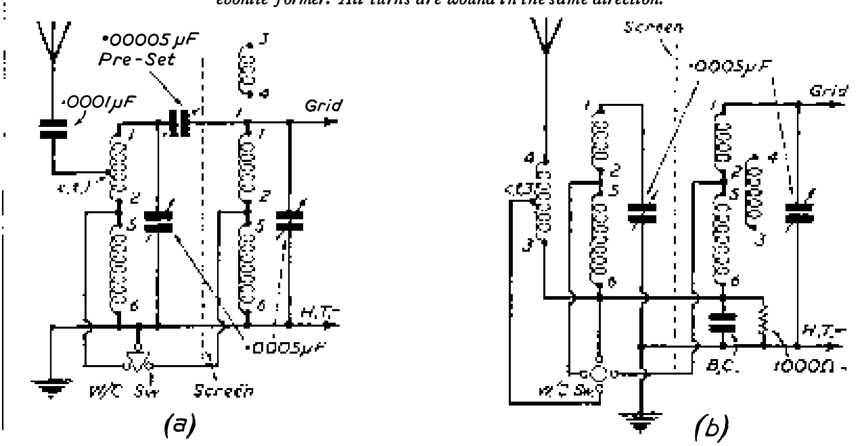


FIG. 506. *Band-pass-tuned circuit, including a pair of small tuners.*

After cutting out with shears and trimming up as neatly as possible, the bends, indicated by dotted lines in Fig. 503, are made, and the joints of the three flaps forming the opposite sides of the cover soldered. These joints are marked "X" in Fig. 502, which shows the finished cover. Do not connect up the accumulator yet, as the charger is not ready for use until the polarity of the mains has been arranged to correspond with that given in Fig. 499.

To do this put the charger switch in the "charge" position and plug into the mains and switch the current on. The pair of terminals marked "accumulator" must now be tested with pole-finding paper.

Having discovered the polarity of these terminals, if it happens to correspond with the markings on them all is well and good. If the polarity differs, however, the matter must be put right by reversing the mains plug.

This done, switch off and connect the accumulator and receiver.

TRIGAIRON. A *triggered spark-gap* in a gastight envelope.

TRIGGER. To cause a circuit to operate by applying an impulse to it.

TRIGGERED SPARK-GAP. A spark gap in which the main discharge is initiated by a low-power discharge produced by one or more subsidiary electrodes.

TRIGGERING CIRCUIT. (See *Firing Circuit.*)

TRIMMING CONDENSER. A small adjustable capacitor connected in parallel with another capacitor to enable the combined capacitance to be adjusted (B.S.I.). Small pre-set condensers fitted to ganged variable condensers and wired in parallel with each section. They are used to balance out the uneven capacities formed between the connecting wires.

TRIODE. The 3-electrode valve.

TRIODE-PENTODE. This is a frequency changer consisting of a triode and a pentode the pentode section operating as a first detector and the triode as an oscillator. External mixing arrangements must be provided when this valve is used, as in the case of two separate valves.

TRITET. Term used to describe a popular transmitting circuit employing a pentode valve, so connected to provide a triode-tetrode combination.

TROMBONE. A U-shaped length of guide of transmission line of adjustable length.

TROPOSPHERE. (See *Ionophere.*)

T.S.F. The French abbreviation for wireless. The three words are "Telegraphie sans Fils" (telegraphy without wires).

TUNED-ANODE COUPLING. A method of coupling high-frequency valves characterised by including in the anode circuit of the valve a coil with a tuning condenser joined in parallel. This method gives the greatest amplification, but unfortunately usually results in instability. To overcome this, the coil is usually tapped at the electrical centre, and this tapping is joined to the H.T. source, whilst the low potential end of the coil is connected back to the grid of the valve via a small condenser. This is known as a Neutralised, or Centre-tapped, Tuned Anode arrangement. (See also *Neutrodyne.*)

TUNED-GRID COUPLING. A method of H.F. coupling characterised by including an H.F. choke in the anode of the valve, and feeding the anode via a small fixed condenser to one side of a tuned circuit. This side of the circuit is also joined, through the appropriate condenser, to the grid of the following valve. The other end of the tuned circuit is joined to earth. This is sometimes also called "Parallel Tuned Anode."

TUNED-PLATE CIRCUIT. The same as tuned anode circuit, anode and plate being the same thing.

TUNER. The term applied to a closed oscillatory circuit. The coil with its parallel condenser which is included in a receiver for tuning.

TUNGARRECTIFIER. (See *Accumulator.*)

TUNING COIL. An inductance coil used in conjunction with a variable condenser for bringing a circuit in resonance with a frequency which it is desired to receive.

The First Essentials of Coil Design. The fundamental purpose of the tuning circuit is to separate one wavelength from another without affecting quality or permitting jamming from a station working on a nearby wavelength.

In the earliest days of broadcasting selectivity was not an urgent problem, as stations were few and low in power; in addition, nobody expected really good quality and consequently no one was disappointed. In any case, it is doubtful if the loss of quality caused by the tuning would be apparent above the general distortion of the 1922 loudspeakers and transformers. The old plug-in coil is still in use to some extent today, and whatever may be said against it, it possesses the advantage of extreme flexibility and gives the user a possible range of, say, 20 to 25,000 m., should he for any reason require it.

The successor to the plug-in coil was the 6-pin type, which for many years was considered to be the last word in design, but these coils still had the disadvantage that they had to be changed for long and short wavelengths and the multiplicity of pins often resulted in a momentary wrong connection, with occasional disastrous results. The neutrodyne circuit became very popular and necessitated a special type of coil. The reason for the introduction of this circuit was that valves had reached the stage of efficiency where the condenser effect between grid and anode caused terrific instability and oscillation unless some means were introduced to stop it. This could take the form of an inefficient coil, or a potentiometer to apply a small positive bias to the valve grid, but both those methods were unsatisfactory, as they either ruined selectivity or range, or both. The function of the neutrodyne was to balance out the troublesome grid anode capacity by means of a small condenser adjusted so that an equal amount of energy was fed from anode to grid in reverse to that fed through the capacity of the valve itself (see Fig. 514).

Screening. Following immediately on the problem of efficient coil design came the question of adequate screening one from the other. A common form was the 6-pin coil in a copper can, but such an arrangement was unsatisfactory, as the proximity of the metal to the coil greatly reduced the efficiency of the latter, and to overcome this difficulty, two special forms of coil were introduced. One was the binocular coil, which consisted of two coils, usually small, placed side by side so that the field was limited, and the other was the toroidal coil, which was wound on a small mandrel like a spring and then curved round until it resembled an unduly bulky curtain ring. Both these arrangements had the great disadvantage that far more wire was necessary to reach the tuning range, which resulted in an increase of H.F. resistance and impaired selectivity.

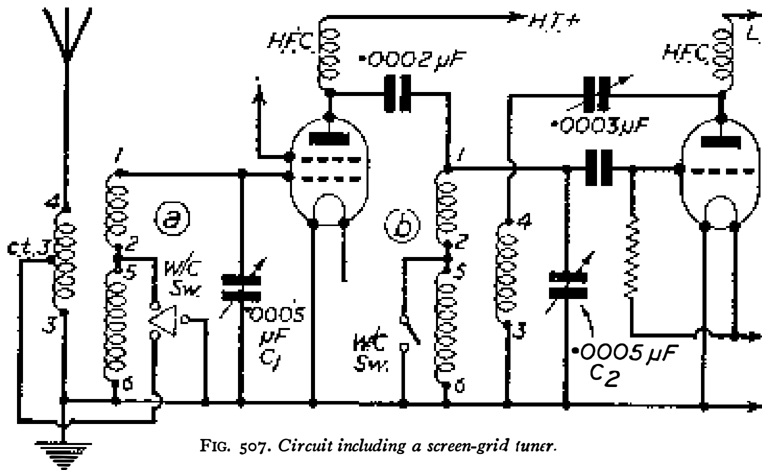


FIG. 507. *Circuit including a screen-grid tuner.*

Just before the advent of the screen-grid valve, super-high efficiency low-loss coils appeared. Whatever may have been the merits of this type of coil when used in some form of neutrodyne circuit, there is much to be said against it when used in conjunction with a screen-grid valve.

Today valves are of very high efficiency indeed, and when associated with a really efficient coil, it becomes almost impossible to make the set stable. In fact, with a modern type of mains H.F. valve and a 4-in. low-loss coil, nothing less than $\frac{1}{8}$-in. sheet copper with soldered joints is adequate for screening. Therefore, for practical purposes, two combinations suggest themselves. A high-efficiency valve with a medium efficiency coil, or *vice versa*; as the efficiency of the coil will be impaired by the presence of the necessary screening, anyway, it is obvious that the first arrangement is preferable.

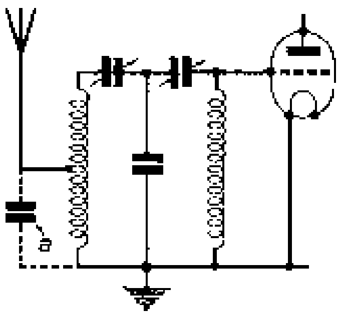


FIG. 508. *The circuit arrangement of the band-pass scheme.*

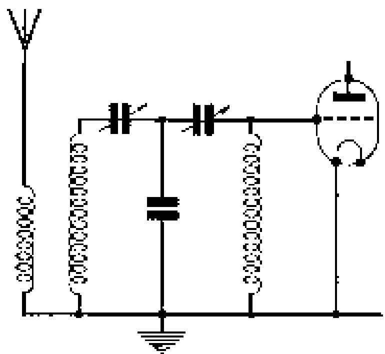


FIG. 509. *Simple band-pass circuit arrangement.*

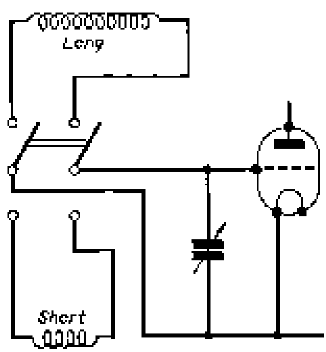


FIG. 510. *A simple method of fitting a switch for wave-changing.*

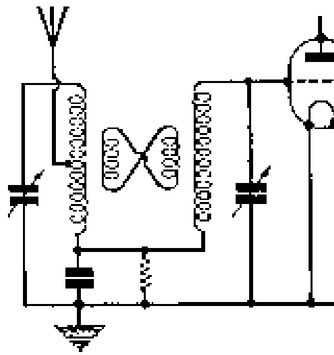


FIG. 511. *The circuit of the "Link" coupled band-pass tuner.*

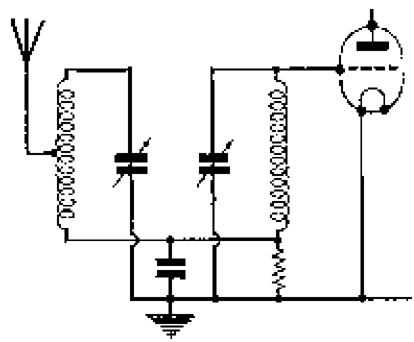


FIG. 512. *A band-pass tuner using capacity coupling.*

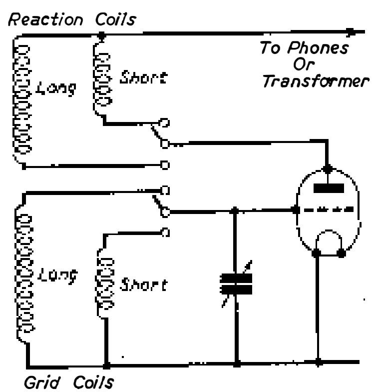


FIG. 513. *A simplified method of switching without loss of efficiency.*

These may be the ordinary screened band-pass coils. The principal feature of the superhet is the high degree of selectivity obtainable, and this is

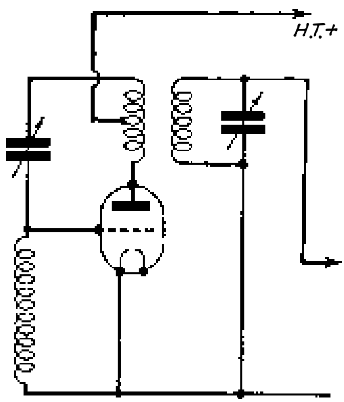


FIG. 514. *The Neutrodyne circuit.*

carried out by changing the frequency of the received station into some predetermined frequency and then carrying out the amplification of the signal at this new frequency. These "intermediate frequency amplifier" coils, as they are called,

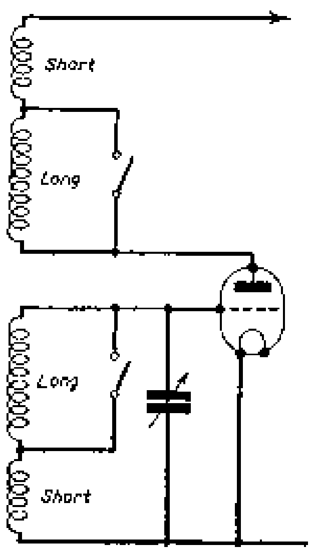


FIG. 515. *A single-pole single-throw switch for wave-changing.*

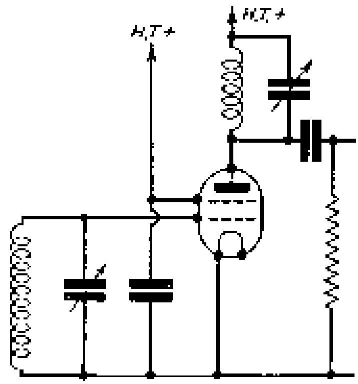


FIG. 516. *Tuned anode coupling with S.G. valve.*

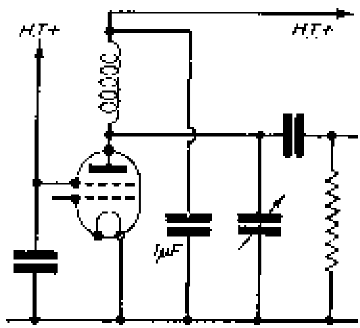


FIG. 517. *Another form of tuned anode coupling.*

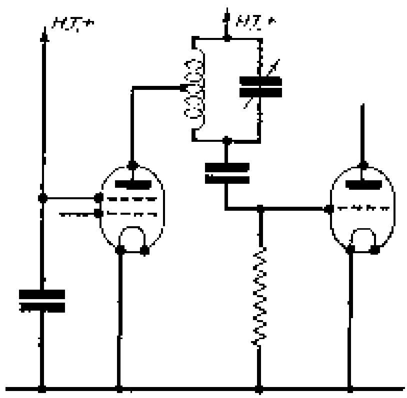


FIG. 518. *The centre-tapped tuned anode.*

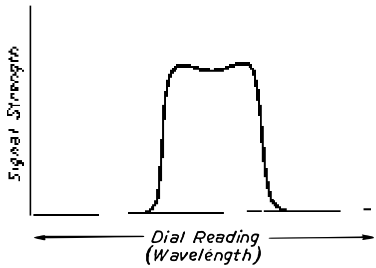


FIG. 519. *Band-pass wave form.*

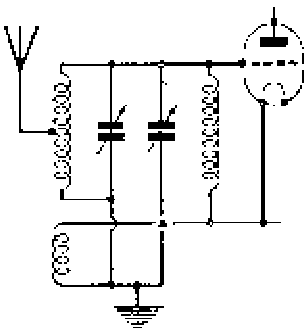


FIG. 520. *Inductive band-pass coupling.*

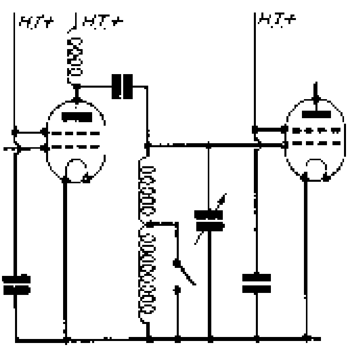


FIG. 521. *The tuned grid system.*

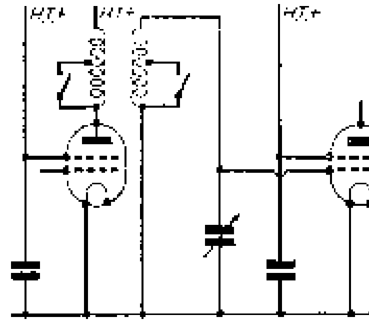


FIG. 522. *A H.F. transformer with wave-switching.*

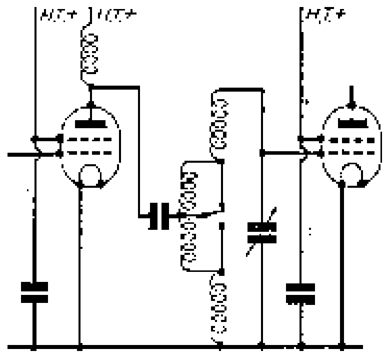


FIG. 523. *Wave-change switching of parallel-fed tuned grid circuit.*

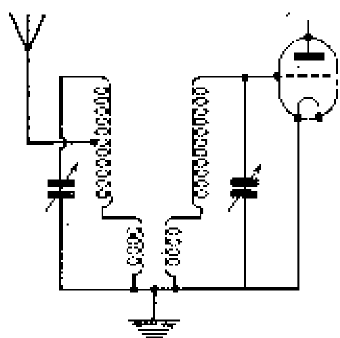


FIG. 524. *A band-pass tuner with common coupling coil.*

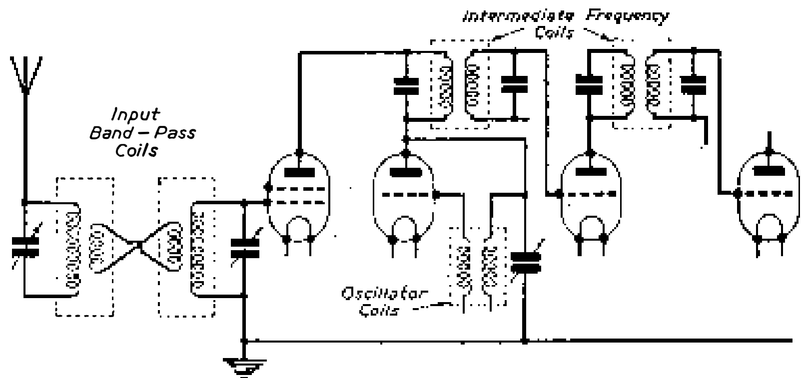


FIG. 525. *The superhet coils and their disposition.*

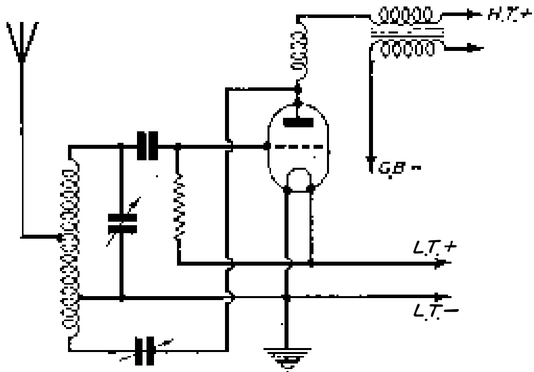


FIG. 526. *A capacity-controlled reaction circuit.*

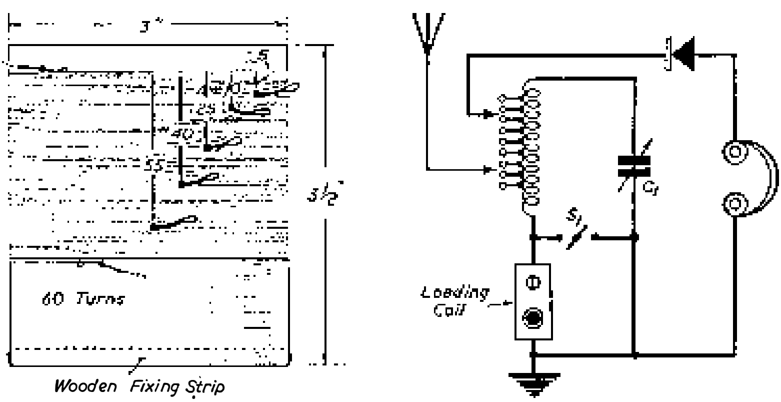


FIG. 527. *A tapped coil crystal set showing* (*left*) *details of the coil winding with* 26 *gauge D.C.C. wire.*

must be very accurately made, as no tuning condensers are fitted in these stages, and they must be designed and adjusted to cover the smallest possible band of frequencies, in order to give the selectivity. It is possible to design these coils to cover such a narrow band that definite side-band cut-off results, and tone compensators have to be inserted on the L.F. side to get a loudspeaker signal of good quality.

A further important coil in the superhet, is the oscillator coil—an arrangement which is employed after the first valve to change the frequency of the received signal. This particular coil works in conjunction with the tuned circuit of the first detector, and in order to enable one-knob control to be carried out (that is a ganged condenser to tune input coils and first detector coils), the oscillator coil requires to be wound to a certain value, and disposed in a certain position relative to the first detector coil, so that to whatever frequency this latter coil is tuned, the oscillator coil will have the same effect from the shortest to the highest wavelength.

A glance at a modern superhet receiver will reveal the fact that all coils are "canned," and in order to use a "ganged" condenser, specially shaped vanes have to be used for the section included for the oscillator coil. (See also *Coil*, *Band-pass Tuning Circuit*, *Condenser*, and *Variable Condenser*.) For various circuits see Figs. 507 to 527.

TUNING SCREW. A variable *reactance* in the form of a rod passing through the wall of a *waveguide* or resonator and having a depth of penetration adjustable by screwing.

TURNSTILE AERIAL. An *aerial* consisting of crossed linear elements which are so excited as to radiate equally in all directions in the plane of the aerial.

TWEETER. A loudspeaker unit designed to reproduce only the high frequencies (usually above 3,000 cycles per second). (See *Woofer*.)

TWIN WIRE. A wire which consists of two wires twisted together, but not electrically connected. A good example is the flex used for house wiring. This is known as twin flex, and consists of two lengths of flexible wire, each enclosed in a cotton covering, the two wires being twisted for the whole of their length.

TWIST. A progressive rotation of the cross section of the guide about the longitudinal axis.

TWO-ELECTRODE VALVE. A valve consisting of a cathode and an anode only. This valve is also known as a diode, and is used for high-quality rectification purposes, or for half-wave rectification in mains receivers. An ordinary three-electrode valve may be used as a diode by ignoring the grid.

TWO-STAGE AMPLIFIER. An amplifier having two distinct circuits. It does not, therefore, necessarily consist of two valves. For instance, one valve may be used with transformer coupling to two valves in parallel, or two valves in push-pull.

TYNDALL'S PHENOMENON. If a light beam penetrates a dark room containing particles of dust, the light is in evidence from the *scatterings* of it on the particles, the light being fairly polarised.

TYPE A DISPLAY. A *range-amplitude display* in which the *time base* is sensibly a straight time.

TYPE B DISPLAY. A radar *display* in which an *echo* appears as a bright *spot* whose rectangular co-ordinates on the screen indicate the bearing and range of the target.

U

ULTRA-SHORT WAVES. The term given to those wavelengths between 1 and 10 m.

UMBRELLA AERIAL. An aerial having a mast with the wires for the aerial attached to the top of the mast, and then brought down to the ground in radial fashion. The name is given to the aerial on account of the fact that the arrangement is very similar to an umbrella stick and its ribs. This type of aerial is only employed in confined spaces.

UNDAMPED. Remaining constant. A train of oscillations of constant amplitude.

UNDISTORTED OUTPUT. A term applied to signal impulses at the anode of the output valve which are a true replica of the signals received at the aerial. This term is also used to denote the strength of signals which may be given by a specific valve, bearing in mind its working potentials, and the amount of second harmonic distortion which is permissible. This strength, which is measured in watts, may be ascertained from the dynamic curves of the valve, and is rather difficult to work out. A very rough formula, which, although not correct, gives a proportionate result (that is if applied to any number of valves will give the relation between the respective outputs), is as follows: grid bias squared, multiplied by amplification factor squared, divided by eight times the normal impedance. The answer is in watts.

UNIDIRECTIONAL. In one direction. Direct current.

UNILATERAL. In single layers, or in one direction.

UNILATERAL CONDUCTIVITY. Conducting in one direction only. A crystal detector is a good example of unilateral conductivity.

UNIT B.O.T. The Board of Trade Unit is 1,000 watt-hours.

UNIT ELECTROSTATIC CHARGE. That electrostatic charge causing a mechanical repelling force of one *dyne* on an equal charge of *similar sign* at a point 1 cm. from it in a vacuum, both charges to be concentrated.

UNIT ELECTROSTATIC FLUX. The electrostratic flux existent in a unit electrostatic tube of force.

UNIT MAGNETIC FLUX. The magnetic flux existent in a unit magnetic tube of force. Unit is the Maxwell.

UNIT MAGNETIC POLE. That pole which located in a vacuum at a distance of 1 cm. from a like pole, produces a mechanical force of repulsion of 1 dyne. (See *Weber*, *Maxwell*, and *Gilbert*.)

UNIT OF CAPACITY. The unit of capacity is the farad. A conductor has a capacity of 1 farad when a charge of 1 coulomb raises the potential 1 volt. In wireless practice the practical unit is the microfarad. (See *Microfarad*, etc.)

UNIT OF CONDUCTANCE. The unit of conductance is the mho, which is the reciprocal of the ohm.

UNIT OF CURRENT. The unit of current is the ampere. It is a flow of 1 coulomb per second. A pressure of 1 volt will pass a current of 1 amp. through a resistance of 1 ohm.

UNIT OF INDUCTANCE. The unit of inductance is the henry. It is the amount of inductance in a circuit which will produce a difference in potential of 1 volt when the amperage is changing at the rate of 1 amp. per second.

UNIT OF POTENTIAL. The unit of potential is the volt. It is the pressure required to pass a current of 1 amp. through a resistance of 1 ohm.

UNIT OF POWER. The unit of power is the power required to perform 1 foot-pound of work per second. It is referred to as F.P.S.

UNIT OF RESISTANCE. The unit of resistance is the ohm (*which see*).

V

VACUUM. A space which is theoretically devoid of all matter. When a glass bulb as used in a valve is evacuated, it is said to be a vacuum. In practice it is impossible to completely evacuate a bulb.

VACUUM TUBE. The tube used in X-ray work. It consists of a glass vessel which is evacuated, and has two electrodes.

VALVE. The name given to the glass or metal vessels containing electrodes used in wireless receivers. (See *Valves*.)

VALVE AMPLIFIER. A valve acts as an amplifier owing to the fact that the anode current produced by the application of a potential to the cathode and anode is much greater than that which is passed to the grid. The signal oscillations on the grid vary the anode current, and as this is of greater magnitude than the signal oscillations amplification takes place. The term is also applied to a valve and its associated couplings in high- or low-frequency stages.

VALVE DETECTOR. The valve may be made to rectify the received signal oscillations by applying a negative potential to the grid so that a unidirectional current is produced in the anode circuit. Rectification may also be carried out by including in the grid circuit a fixed condenser, with a high resistance joined to the cathode. The inclusion of this condenser and resistance has the same effect, namely the production of a unidirectional current in the anode circuit. (See also *Grid Leak*, *Power Grid Detection*, *Anode Bend Rectification*.)

VALVES EXPLAINED. In a modern triode valve there are three distinct parts; these are the filament at the centre, surrounded by the grid, which in its turn is surrounded by the anode; these three parts are known as electrodes. In addition, two or more additional grids are found in some types of valve.

The functioning of the valve is commenced by passing a low-tension current from an accumulator through the filament; this has the effect of heating it. When the filament has reached the correct temperature it throws off minute electrical negative charges which are known as electrons. The electrons pass through the grid, and are attracted to the anode; they flow thence back to the high-tension battery. To attract these negative electrons to the anode from the filament, the anode is kept positively charged, for it is a well-known fact that in electricity a positive charge attracts a negative charge. To charge the anode positively, it is connected to the positive side of a high-tension battery, the negative side of the battery being connected to low-tension negative. In this way the voltage to the filament is unaltered, but the voltage of the anode with respect to the filament is greatly increased and with it the electron flow.

The grid is a spirally wound length of special wire, and as before stated, is between the filament and the anode. To this the incoming wireless signals are applied. These signals are alternately negative and positive; this changing of polarity tends to control the electron flow from the filament to the anode, for when the grid is positive, it acts like a small anode, and because it is nearer to the filament its attraction for the electrons is much greater, but this also means an increase in anode current. The grid, however, is just as often negative, and has the effect of repelling electrons leaving the filament, for like repels like. A negative grid will therefore mean a decrease in anode current. It may be seen then, that if the grid is biased negatively with a grid-bias battery as much as possible, it will tend to stop any positive signal voltages from making the grid positive; grid current is thus prevented, although the controlling action of the grid is maintained. If over- or underbiased, however, the grid will not be able to deal properly with the applied signal voltages.

Valves in which a trace of gas is allowed to remain are classified as "gassy" or "soft," and are apt to become unstable, besides having a very short life. In the process of manufacture the valve is connected to pumps and as nearly as possible evacuated and hermetically sealed. It is then brought into close proximity to a high-frequency coil, the high-frequency currents of which tend to heat the electrodes; this has the effect of releasing any gases remaining in the metal of the electrodes, and when the temperature becomes sufficiently high a small piece of magnesium, previously fixed inside the valve, is ignited and burnt. The combustion of the magnesium absorbs the remaining traces of gas in the valve. The process of combustion causes a portion of the metal to be deposited upon the inside of the glass bulb in the form of oxide of magnesium, which gives that silvered effect which may be seen in the upper parts of many valves. The operation of final exhaustion by magnesium is called "gettering," and the magnesium is known as the "getter."

A development in modern valves of the screened-grid and detector types is the coating of the outer surface of the glass bulbs with a finely divided metal powder. This appears to be applied in a dry state to the tacky surface of a coat of varnish. Its effect is to eliminate the usual aluminium shield, and must be earthed in the

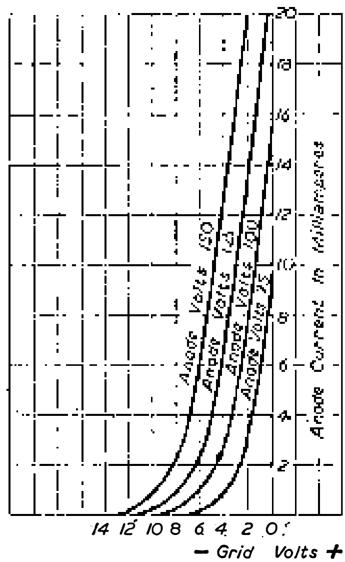


FIG. 528. *A steep slope valve curve.*

same way as such shield. This earthing is already arranged in the valve by the manufacturers. The effect of the metal coating is to isolate the valve electrically and prevent stray currents from interfering with other surrounding components. The screening provided by this metallic coating is quite as efficient as is obtained by enclosing the valve in a metal box, so long as the valve holder is correctly wired up. If one of these metallised valves is examined, attached to the coating just above the base of the valve will

VALVE BASE CONNECTIONS FOR STANDARD (B.V.A.) VALVES.

(See p. 342 for definitions of abbreviations used.)

Valve Type		Base	Pin Connections 1	2	3	4	5	6	7	8	9	Top Cap
Triode	D.H.	4	A	G	F	F	—	—	—	—	—	—
Triode	I.H.	5	A	G	H	H	C	—	—	—	—	—
Triode	I.H.	7	M	—	—	H	H	C	A	—	—	G
Tetrode	D.H.	4	G2	G1	F	F	—	—	—	—	—	A
Tetrode	I.H.	5	G2	G1	H	H	C	—	—	—	—	A
H.F. Pentode or Tetrode	D.H.	7	M	G1	G3	F	F	—	G2	—	—	A
H.F. Pentode or Tetrode	I.H.	5	G2	G1	H	H	C, G3	—	—	—	—	A
H.F. Pentode or Tetrode	I.H.	7	M	G1	G3	H	H	C	G2	—	—	A
H.F. Pentode or Tetrode	I.H.	7	M	A	G3	H	H	C	G2	—	—	G
H.F. Hexode	D.H.	7	M	A	G3	F	F	G4	G2	—	—	G1
Output Pentode	D.H.	4	A	G1	F	F	—	—	—	—	—	G2
Output Pentode	D.H.	5	A	G1	F	F	G2	—	—	—	—	—
Output Pentode	I.H.	5	A	G1	H	H	C	—	—	—	—	G2
Output Pentode	I.H.	7	—	G1	G2	H	H	C	A	—	—	—
Heptode	D.H.	7	Ao	Go	G2	F	F	—	A	—	—	G1
Heptode	I.H.	7	Ao	Go	G2	H	H	C	A	—	—	G1
Octode	D.H.	7	G2	G1	G3, G5	F	F	M, G6	A	—	—	G4
Octode	I.H.	7	G2	G1	G3, G5	H	H	C, M G6	A	—	—	G4
Class B Output	D.H.	7	G2	G1	A1	F	F	—	A2	—	—	—
Double-diode	D.H.	4	D1	D2	F	F	—	—	—	—	—	—
Double-diode	I.H.	5	D1	D2	H	H	C	—	—	—	—	—
Double-diode-triode	D.H.	5	A	D2	F, M	F	D1	—	—	—	—	G
Double-diode-triode	I.H.	7	D1	M	D2	H	H	C	A	—	—	G
Triple-diode-triode	I.H.	9	D2	D3	—	H	H	C	A	D1	M	G
Single-diode-triode	I.H.	7	—	G1	G2	H	H	C, M	D	—	—	A
Triode-pentode	D.H.	9	G2	A1	G3	F	F	—	Ao	Go	M	G1
Triode-pentode	I.H.	9	G2	A1	G3	H	H	C	Ao	Go	M	G1
Triode-hexode	D.H.	7	Ao	Go	G2	F	F	M	A	—	—	G1
Triode-hexode	I.H.	7	Ao	Go	G2	H	H	C	A	—	—	G1
Double-pentode	D.H.	7	G1^{2}	G1^{1}	A1	F	F	G2^{1}, G2^{2}	G2	—	—	—
Double-pentode	D.H.	9	G1^{2}	A1	G2^{1}	F	F	—	G2^{2}	A2	G1^{2}	—
Double-diode-H.F. Pentode	I.H.	9	G2	A	—	H	H	C, G3	D1	D2	M	G1
Double-diode Output Pentode	I.H.	7	D1	A	D2	H	H	C	G2	—	—	G1
Double-diode Output Pentode	I.H.	7	D1	C	D2	H	H	A	G2	—	—	G1
Rectifier, Half-wave	D.H.	4	A	—	F	F	—	—	—	—	—	—
Rectifier, Half-wave (high voltage)	D.H.	4	—	—	F	F	—	—	—	—	—	A
Rectifier, Half-wave	I.H.	5	A	—	H	H	C	—	—	—	—	—
Rectifier, Half-wave (high voltage)	I.H.	4	—	—	H.C.	H	—	—	—	—	—	A
Rectifier, Full-wave	D.H.	4	A	A	F	F	—	—	—	—	—	—
Rectifier, Full-wave	I.H.	4	A	A	H.C.	H	—	—	—	—	—	—
Rectifier, Full-wave	I.H.	5	A	A	H	H	C	—	—	—	—	—
Rectifier, Full-wave	I.H.	7	H.C.T.	A1	C1	H	H	C2	A2	—	—	—
Barretter		4	—	—	F	F	—	—	—	—	—	—
C.R. Tuning Indicator	I.H.	7	—	G	Targ.	H	H	C	A	—	—	—

FIG. 529. (*Right*) *Valve-leg spacing for 7-pin valves.*

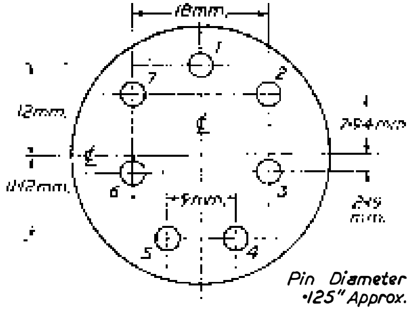


FIG. 530. (*Below*) *Valve-leg spacing for 4- and 5-pin valves. The diameter of the valve pins is 3·2 mm.*

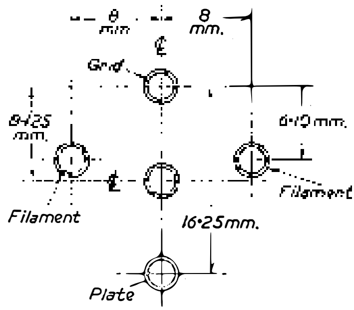


FIG. 531. (*Below*) *Valve-leg spacing for 9-pin valves.*

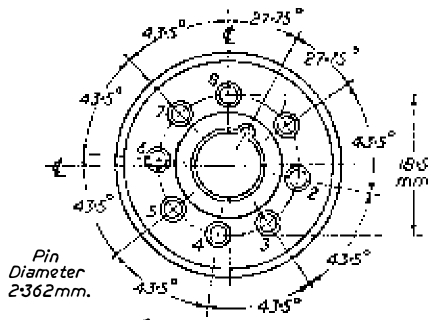
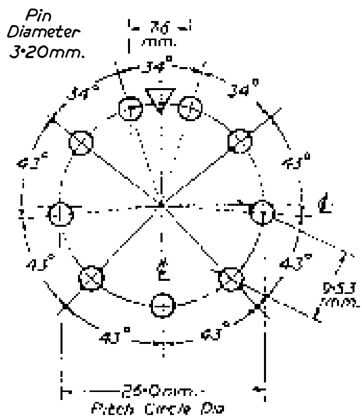


FIG. 532. *Mazda Octal base.*



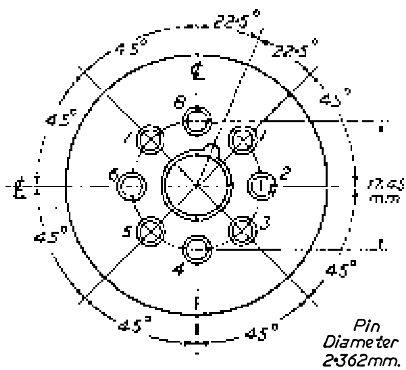


FIG. 533. *International Octal base.*

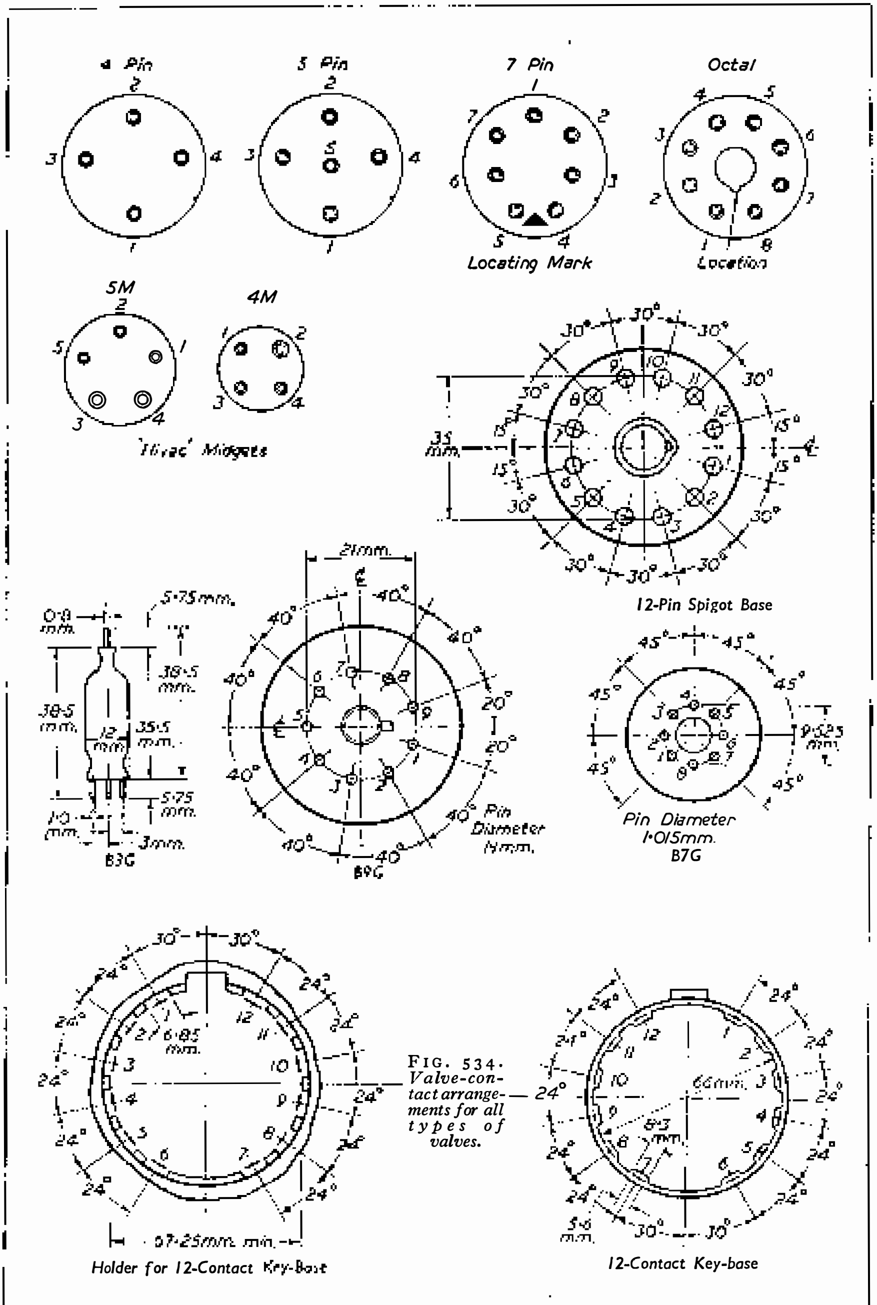


FIG. 534. *Valve-contact arrangements for all types of valves.*

ABBREVIATIONS (relative to Table on page 339)

I.H.—Indirectly heated; D.H.—Directly heated.
M.—Metallising.
F—Filament.
H—Heater.
C, C1, etc.—Cathodes.
A A1, etc.—Anodes (Ao—Oscillator anode).
G or G1—Control grid (Go—Oscillator control grid)
G2—Screening grid.
G3—Suppressor grid.
D, D1, etc.—Diodes (anodes).

VALVE BASE CONNECTIONS FOR OCTAL VALVES. (See Fig. 534.)

Valve Type		*Pin Connections* 1	2	3	4	5	6	7	8	*Top Cap*
Triode	I.H.	M	H	A	—	G	—	H	C	—
Triode	I.H.	M	H	—	A	—	—	H	C	G
H.F. Pentode	I.H.	M	H	A	G2	G3	—	H	C	G1
Output Pentode	I.H.	M	H	A	G2	G1	—	H	C	—
Heptode	I.H.	M	H	A	G3, G5	Go (G1)	Ao (G2)	H	C	G4
Double-diode	I.H.	M	H	D2	C2	D1	—	H	C1	—
Double-diode-triode	I.H.	M	H	A	D1	D2	—	H	C	G
Rectifier, Full-wave	I.H.	M	H	—	A	—	A	—	H, C	—
Rectifier, Full-wave	I.H.	—	H	H	A2	C2	A1	—	H, C1	—
Rectifier, Full-wave	IH.	M	H	A	—	A	—	H	C	—
Rectifier, Full-wave	Gaseous	M	—	A	—	A	—	—	C	—

HIVAC MIDGET VALVES

			Filament Volts	*Filament Current (mA)*	*Anode Volts*	*Screen Volts*	*Grid Volts*	*Anode Current (mA)*	*Screen Current (mA)*	*Impedance (Ohms)*	*Slope (mA/v)*	*Magnification factor*	*Number of Pins*
XSG	1·5V.	Screen Grid	1·5	80	50	30	0	0·55	0·25	666,000	0·30	200	4
XW	1·5V.	H.F. Pentode	1·5	80	50	45	0	0·75	0·2	1,000,000	0·52	520	5
XH	1·5V.	Detector and Amplifying Triode	1·5	80	50	—	0	0·45	—	50,000	0·50	25	4
XD	1·5V.	Detector and Amplifying Triode	1·5	80	50	—	0	0·45	—	50,000	0·40	20	4
XL	1·5V.	Amplifying and Output Triode	1·5	80	50	—	—1·0	0·7	—	20,000	0·60	12	4
XLO	1·5V.	Oscillator, Amplifying and Output Triode	1·5	80	50	—	—1·0	0·9	—	20,000	0·65	13	4
XP	1·5V.	Output Triode	1·5	80	50	—	—4·5	1·75	—	7,250	0·72	5·2	4
XY	1·5V.	Output Pentode	1·5	160	45	45	—1·5	1·75	0·35	66,000	1·00	66	5
XSG	2·0V.	Screen Grid	2·0	80	50	30	0	0·6	0·3	500,000	0·40	200	4
XVS	2·0V.	Variable-Mu Screen Grid	2·0	80	50	30	0	0·4	0·15	1,500,000	0·33	500	4
XW	2·0V.	H.F. Pentode	2·0	80	50	45	0	0·95	0·3	1,000,000	0·60	600	5
XH	2·0V.	Detector and Amplifying Triode	2·0	80	50	—	0	0·45	—	50,000	0·56	28	4
XD	2·0V.	Detector and Amplifying Triode	2·0	80	50	—	0	0·65	—	38,000	0·56	21	4
XL	2·0V.	Amplifying and Output Triode	2·0	80	50	—	—1·0	1·0	—	12,500	0·84	10·5	4
XLO	2·0V.	Oscillator, Amplifying and Output Triode	2·0	80	50	—	—1·0	1·1	—	12,500	0·92	11·5	4
XP	2·0V.	Output Triode	2·0	80	50	—	—3·0	2·0	—	6,000	1·00	6	4
XY	2·0V.	Output Pentode	2·0	160	50	50	—2·0	1·75	0·4	60,000	1·40	84	5

HIVAC HEARING AID VALVES

10-mm. MIDGET TYPE

Type No.	*Fil. Volts*	*Fil. Current*	*Anode Volts*	*Screen Volts*	*Mutual Cond.*	*Ampl. Factor*	*Impedance*	*Length*	*Weight*	*Dia.*
XW 0·75A. (H.F. Pen.)	0·75	27m/A	60 max.	45 max.	0·2m/AV (at 30 volts)	300	1·5 megohms	27 mm.	3 gr.	10·5 mm.
XY 1·4A (L.5 Pen)	1·4	32	60 max.	45 max.	0·55m/AV (at 30 volts)	33	60,000 ohms	36 mm.	4 gr.	10·5 mm.

A new series of 10-mm. Hearing Aid Valves is being produced. For details, apply to the makers.

be found a small disc or ring. This sometimes bears the letter E. From this disc or ring a thin wire can be seen passing into the holder, and the metallic coating covers both disc and wire. The filament leg beneath this disc *must* be joined to the earth terminal of the set to enable the screening to be effective.

Impedance. Impedance indicates the capability of a valve to handle large or small volume: the lower the figure of impedance the more undistorted output—i.e. the volume of pure signals that the valve will give. Impedance is arrived at by measuring the corresponding change of high-tension *current* that will result from changing the high-tension voltage; for example, suppose that a valve has the anode, or plate, connected to 110 volts and that the current drawn from the battery is 11 mA, also if the anode voltage is reduced to 90 there is a reduction in the amount of H.T. current used to the extent of 4 mA. From this it will be seen that a change of 20 volts on the anode has reduced the amount of current drawn through the valve by 4 mA. Such results would be obtained from a valve having an impedance of 5,000 ohms. If the same experiment was tried with a high-impedance valve, the change resulting would be very much smaller; in the case of a screened-grid valve, only a fraction of a milliamp.

Low-impedance Valves. The job that a valve is required to do is to change its high-tension current when a signal is applied to its grid, but it must not alter the nature of the signal so applied by becoming overloaded, which would cause distortion. Fig. 535 shows a valve of low impedance. A glance at the "150" curve will show that it is practically straight from 8 mA to just over 26 mA, or in other words, the incoming signal can swing up and down over a nominally straight line that is 18 mA long without touching the curve portion which causes the valve to distort very badly. This long, straight portion indicates that it is a low-impedance valve capable of handling large signals. Reference to Fig. 537 shows that this valve is entirely different, and that the "150" line is only straight between $\frac{3}{4}$ and $2\frac{1}{4}$ mA. From this it will be seen that the total swing is only $1\frac{1}{2}$ mA, and that therefore the valve will handle very little volume before distortion sets in. A low-impedance valve has a small amplification factor and a high-impedance valve a large amplification factor. The amplification factor (sometimes called "magnification factor") of a valve is the influence that a signal applied to the grid has over the H.T. current. Take the original case of the 5,000-ohm valve referred to above. It will be remembered that it took a variation of 20 volts high tension to vary the high-tension current 4 mA. If the anode voltage is left alone and 2 volts grid bias applied to the grid,

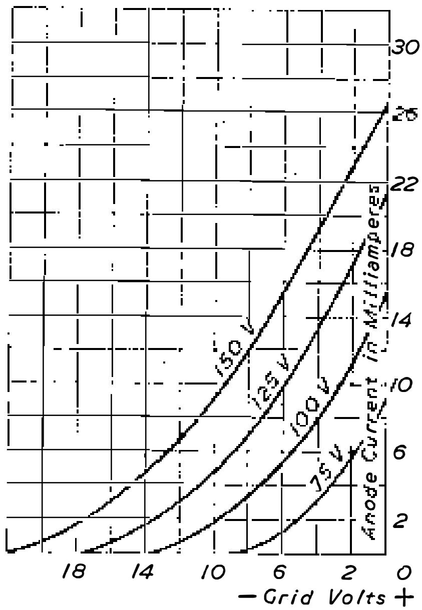


FIG. 535. *Characteristic curve of a low-impedance medium-slope valve.*

it will be found that the same charge of 4 mA takes place. Therefore, 2 volts applied to the grid has as much influence as 20 volts applied to the anode; if 20 is divided by 2 the answer is 10, which is the amplification factor of the valve, or the amount of influence that the grid has over the anode. The valve shown in Fig. 537 has an amplification factor of 40, and will therefore amplify a signal four times as much as the valve shown in Fig. 535 with amplification factor of 10; but with the high amplification factor there is a corresponding rise in impedance, and consequently the valve will not handle as much volume as the valve with the lower factor.

To summarise briefly, a high-impedance valve may be used to amplify weak signals, but a low-impedance valve must be used to prevent distortion when handling loud signals. Take for example a 2-valve set employing detector and output valves.

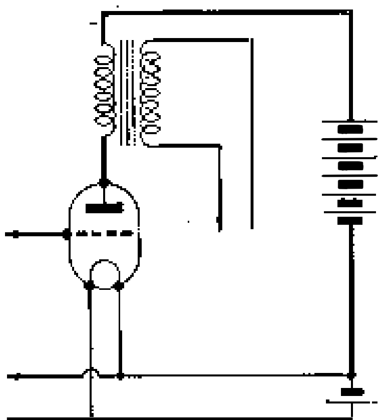


FIG. 536. *Matching is making the impedance of the anode roughly equal to the valve impedance. The anode circuit is shown by the heavy black line.*

The first valve will be called upon to handle a very small input, thus a valve of high impedance can be used, and its amplifying properties employed to advantage. The signals, now strengthened by the first valve, are passed on to the second valve, which must be capable of handling the larger input, and therefore a valve of low impedance must be used. This rule of valve graduation holds good if resistance capacity coupling is used, but if a transformer is employed it is equally essential that the valve and transformer must suit each other. It is the valve and transformer that *follows* it that are the pair, and definitely not the transformer which goes in front of the valve. Matching is making the impedance of the anode circuit roughly equal to the valve impedance (see Fig. 536). A transformer is like a valve in some respects, as it possesses primary impedance and amplification factor in the form of the ratio; the transformer with a high primary impedance has a low ratio, and one with a low primary impedance has a high ratio. If a high-impedance valve is used, a transformer with high primary impedance must also be used which has a small ratio, and *vice versa*. As a rough guide, the ratio of a transformer less 1, multiplied by the impedance of a valve should not exceed 60,000. For example, a transformer having a ratio of 3 : 1 : take 1 away, which gives 2; multiply by the impedance of the valve to be used—say 30,000—the answer is 60,000, which is quite in order. On the other hand, if a 3 : 1 transformer is to be used with a valve having an impedance of 50,000 ohms, this simple sum will come out at 100,000, which is too high.

Mutual Conductance. The characteristic which has not been dealt with is mutual conductance, or slope as it is sometimes called. This is a combination of impedance and amplification factor, and may be described as indicating the goodness of the valve. It has not many influences on the valve's performance, but a marked influence on the value of the grid bias necessary. Reference to Figs. 535 and 528 will show that there is a marked resemblance between these curves, inasmuch as the straight portion of their

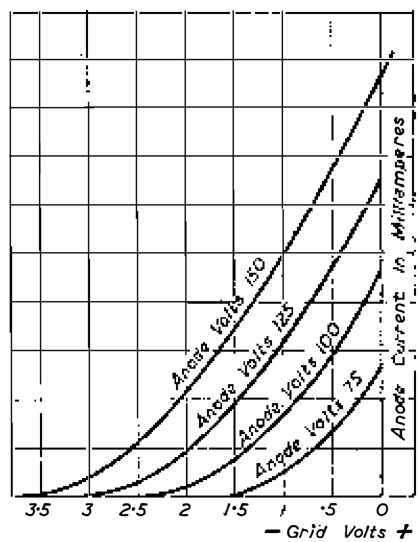


FIG. 537. *Characteristic curve of a very high-impedance valve.*

curves measured in mA is almost the same, but on the other hand, they differ greatly in the angle at which this line is set. Fig. 535 is the curve of a valve with a slope of 2. Fig. 528 is a similar curve of a valve with a slope of 4. The latter

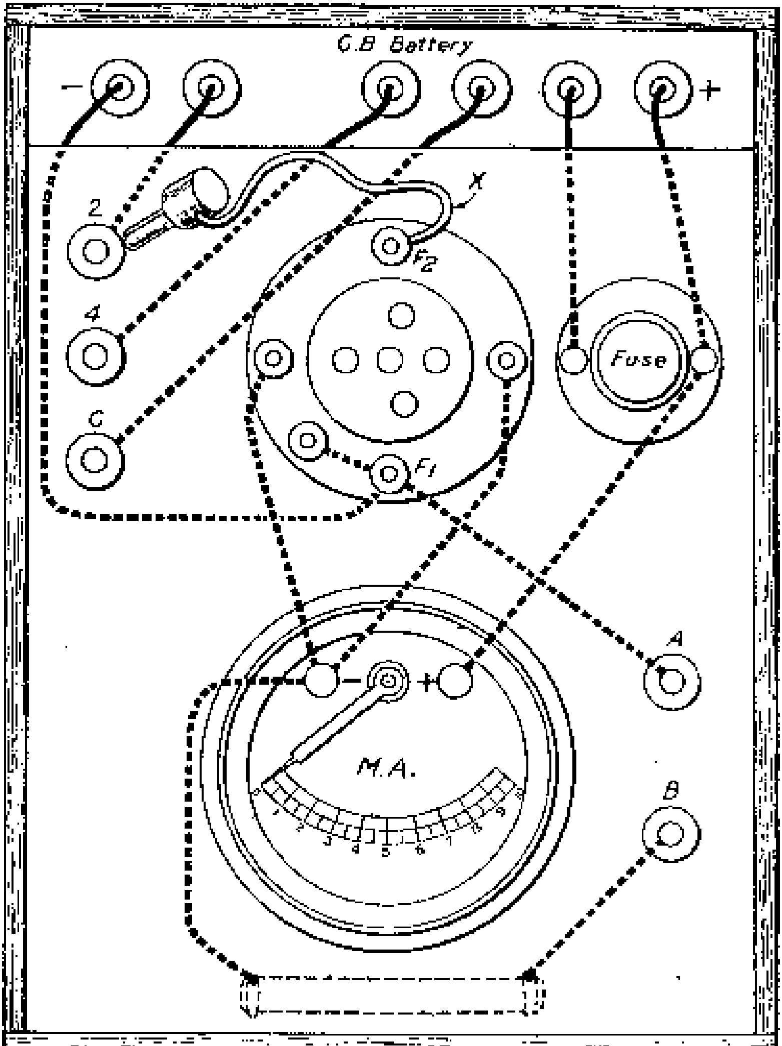


FIG. 538. *Wiring diagram of the valve tester.*

is steeper than the former and is said to be a steep-slope valve.

Grid Bias Values for Valves. Refer to Fig. 535, and look along the grid bias figures at the bottom, and follow the 6-volt line upwards until it strikes the 125-volt line, turn to the right, and it will be found that the valve takes 10 mA under these conditions—i.e. 125 volts H.T. and 6 volts grid bias. It will also be noticed that the point struck is sensibly on the straight portion. Now turn to Fig. 528 and find the 6-volt G.B. line; follow it until it hits the 125-volt line, turn to the right and denote the H.T. consumption, only 2¼ mA; also particularly note that the point is right on the bend of the curve, which will result in horrible distortion. It is therefore obvious that the same grid bias is not suitable for both valves; the valve in Fig. 528 has twice the slope of that in Fig. 535, consequently it only requires half the grid bias. (See also *Pentode*, *Tetrode*, etc.)

VALVE-LEG SPACING. The spacing of the valve legs is so arranged that it is impossible to plug a valve into its holder in the wrong way. The actual disposition of the legs is shown in Figs. 529 to 533. This illustration also gives the actual measurements between the pins of the valve.

VALVE OSCILLATOR. A valve having some form of coupling between anode and grid circuits to maintain continuous interaction. This usually takes the form of a coil in each circuit, closely coupled. The frequency of the oscillations depends upon the electrical time period of the circuits in question. The valve oscillator is used for transmission and for superheterodyne receivers.

VALVE STABILISER CIRCUIT. (See *Anti-Jitter Circuit.*)

VALVE TESTER. The components required are:

1 Small box	6 Wander plugs
1 Panel	1 Milliammeter 0-10
2 Terminals	
1 Plug	One 1,000-ohm resistance
3 Sockets	
1 Fuse holder	1 9-volt bias battery
1 5-pin valve holder	1 yd. flex

The diagram shows clearly the position of the components and the wiring (see Fig. 538).

Connect

(1) Grid bias — to filament 1, cathode, and terminal A.

(2) Second socket to 2. (Third socket is blank.)

(3) Fourth socket to 4.

(4) Fifth socket to 6.

(5) Sixth socket to fuse holder.

(6) Seventh socket (+) to fuse holder and + terminal on milliammeter.

(7) Filament 2 to wander plug with wire X.

(8) Plate and grid to — terminal on milliammeter.

(9) Spaghetti between — terminal on milliammeter and terminal B.

The valve to be tested is plugged into the valve holder, after the wander plug has been placed in the socket corresponding to its filament voltage.

S.G. valves .	read approx. 2 to 3 mA.
Det. H.F. and L.F.	read approx. 3 to 4 mA.
Power	read approx. 4 to 6 mA.
Super power	read approx. 6 to 8 mA.

The filament can be tested by simply connecting the filament pins on terminals A and B. If the milliammeter shows current, the filament is O.K. The filament of a valve often sags and touches the grid, causing the valve to cease functioning. If such a valve is placed in the tester the needle bangs over to 10.

To test fuse bulbs and pilot lamps simply screw into the fuse holder.

To test transformers, resistances, etc., a pair of test prods on flex should be connected to A and B. Connect the prods to each end of the winding or resistance to be tested, when a reading will be obtained if O.K. Resistances above 100,000 ohms will not show any appreciable reading, therefore the test is not suitable for grid leaks.

To adapt the tester for A.C. valves the plug and connection X should be taken off entirely and a twin flex connected to terminals F1 and F2 on the valve holders. The other end of the flex should be connected to the filament terminals of a valve adaptor, and this plugged into a convenient valve holder in the receiver. The valve should be inserted in tester and the set switched on. After allowing a minute for the valve to heat up a reading should be obtained if O.K.

D.C. valves can also be tested with this adaptor in a similar way to A.C. valves, with the exception that the adaptor should be inserted in the valve holder out of which the valve to be tested was taken.

VALVE VOLTMETER. Used for measuring the voltage of alternating or high-frequency currents, and consists of a valve connected on the anode-bend-detection system. A milliammeter is wired in the anode circuit of the valve and the reading of this is taken as a measure of the A.C. voltage applied between the grid and cathode. The meter must, of course, be calibrated if it is to be used for accurate work (see Fig. 538).

VANE-TYPE MAGNETRON. A *cavity magnetron* in which the walls between adjacent cavities have plane surfaces.

VAR. (See *Reactive Volt-amperes*.)

VARIABLE CONDENSER. A device consisting of a moving and fixed electrode, with a dielectric separating the electrodes. There are four separate types of variable condenser, each of which has certain definite characteristics. The first to be introduced was the straight-line capacity type, which had a metal vane shaped in a half-circle, with the spindle in the exact centre. The result of this pattern is that the actual capacity changes in proportion to the degrees of the knob. In other words, if the dial is moved from, say, 20° to 30°, it will vary the capacity exactly the same amount as turning it, say, from 70 to 80. As the wavelength of the coil is not directly proportional to the capacity of the variable condenser, the use of this type causes all the stations to be bunched at one end and widely separated at the other.

The square-law type has vanes specially shaped to give a definite result, and when associated with a coil, the dial reading gives a definite indication of the wavelength; thus, if 30 on the dial is 300 metres and 90 on the dial is 400 metres, then with a square-law condenser 60 must be 350 metres and so on. For station identification this is admittedly extremely useful, but it does not overcome entirely the tendency for stations to be more bunched at one end than the other; the reason for this is not generally appreciated. As the wavelength is increased, the station separation in terms of metres becomes less. For example, it is far easier to separate two stations at 300 and 310 metres respectively than it is to separate two stations of exactly the same power working on a wavelength of 500 metres and 510 metres respectively. It will be observed that in both cases the stations differ by 10 metres, but actually the second pair are closer together than the first pair. The reason for this is that the relative distance between the wavelengths of stations cannot be measured in metres, but must be measured in kilocycles (kcs.)

Square-law Condenser. The shape of a square-law condenser plate is shown in Fig. 539. The term "square-law" is derived from the fact that the capacity increases as the square of the angular movement of the plates. It will therefore

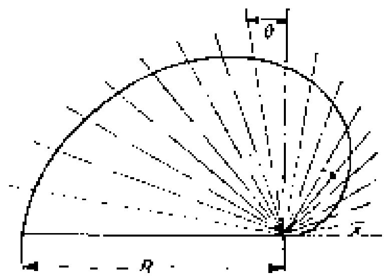


FIG. 539. *The shape of the square-law condenser plate.*

have a straight wavelength curve instead of (as in the semi-circular type) a straight capacity curve. This means briefly that the wavelength range will be equally distributed round the scale and not crowded as the capacity approaches a minimum. The wavelength will vary directly as the movement of the condenser plates.

Where, therefore, it is found with a particular set that the lowest broadcast wavelength comes in with the moving plates about one-third in, tuning will be sufficiently selective and the substitution of a square-law condenser is not likely to be of much advantage. It is only the constructor who finds the various stations congested (that is, the moving plates just entering) into about $\frac{1}{2}$-in. movement of the plates who will obtain more selective and sharper tuning by such substitution.

Setting out Square-law Plates. Fig. 539 shows how square-law plates are set out. The 180 degrees are subdivided into 10 degrees, and the points through which the curve passes are obtained from the following formula:

$$r = 2\sqrt{a\theta},$$

where r = radius,
a = constant,
θ = angle expressed in radians.

Before a can be found the basal radius R must be decided on. Taking 75 mm.

as an example (θ in this case being π radians) and substituting in the formula :

$$75 = 2\sqrt{a\pi}$$
$$5625 = 4a\pi$$
$$a = \frac{625}{4\pi} = 448 \text{ approx.}$$

The factor θ is $\frac{10}{58} = \cdot 17$. The formula therefore becomes, with a condenser having R as 75 mm. :

$$r = 2\sqrt{448 \times \cdot 17}$$

This gives the first radius X, and each succeeding one will be found by applying the same formula and increasing the value by ·17.

Thus for the second radius the formula would be :

$$r = 2\sqrt{448 \times \cdot 34}$$

The area of a square-law condenser plate can accurately be found from the following formula :

$$A = \tfrac{1}{4}\pi R^2$$

The Straight-line Frequency type is arranged so that each degree on the dial is equivalent to a definite frequency difference, and therefore a movement at one end of the dial will affect the tuning of the circuit exactly the same as a similar movement at another portion of the dial. Therefore, every station is spaced along the dial in the position that it is allotted by its true frequency, and this condenser is, consequently, the best possible type to use when convenience and ease of manipulation is desired.

It should be borne in mind that of all the types of condensers available, the straight-line frequency is the least suitable for ganging, unless the user is absolutely certain that the coils associated are accurately matched.

Special Function of the Log-law Condenser. The log-law condenser, or more correctly the logarithmic condenser, has a special function to fulfil. From a point of view of station separation, it is midway between the square-law and the straight-line frequency, but has a special advantage for ganging, as the shape of the vanes permits discrepancies of the coil matching to be overcome. It is incorrect to imagine that a trimming condenser will gang up a set if the coils are not properly matched, as an adjustment of the trimmers at one part of the dial will result in throwing out the other sections. With the logarithmic condenser, where each set of moving vanes can be moved separately, it is simply a matter of advancing one set in front of the other, so that ganging is accomplished at the top of the dial, when the special shape of the vanes will result in ganging being preserved throughout the whole length, provided, of course, the trimmers have been adjusted to equalise odd capacities.

VARIABLE FREQUENCY OSCILLATOR. In amateur transmitters the fundamental frequency is usually generated by a crystal, the output or transmitted frequency being obtained from this fundamental by means of frequency multipliers (*which see*). The drawback to the crystal is that only one fundamental frequency is available unless the crystal is changed. It is possible, however, to use a tuning circuit in such a manner that a stable oscillator may be obtained, and this may be tuned over a wide band. This type of oscillator is known as a V.F.O. or variable frequency oscillator.

VARIABLE-MU PENTODE. A valve possessing similar characteristics to the variable-mu screened-grid valve, but possessing an extra grid which increases its efficiency as an H.F. amplifier.

VARIABLE-MU S.G. VALVE. Screened-grid valve having variable impedance. (See also *Valve*.)

VARIAC. An auto transformer with a toroidal winding on which moves a sliding contact, giving a continuously-adjustable output voltage.

VARIOCOUPLER. A variometer.

VARIOMETER. Two coils, one rotatable within the other.

V-BEAM SYSTEM. A radar *aerial* arrangement in which two *fan beams*, one vertical and the other oblique, intersect at ground level. In the V-beam system of measuring elevation the aerials are continuously rotated together about a vertical axis. The time elapsing between the echoes received on the two beams from an object is a measure of its angle of elevation.

VELOCITY MODULATION. A method of modulating the output current of a television transmitter by means of which the scanning spot moves quickly over the dark portions of the picture to be televised and slowly over the bright parts of the picture. Also known as variable tube scanning.

The acceleration and retardation of electrons in an electron stream in order to cause *bunching*.

VELOCITY OF ETHER WAVES. The velocity of ether waves is 186,282 miles per second. This is equal to 300,000,000 metres per second. (See also *Sound Waves* and *Light*.)

VELOCITY OF LIGHT. The same as the speed of ether waves, 186,282 miles per second.

VERI. Abbreviation for verification of a transmission.

VERTEBRATE WAVEGUIDE. A form of flexible *waveguide* comprising a number of short sections of guide terminating in and coupled to one another by *choked flanges*, these being held in an elastic tubular support.

VERTEX PLATE. A *matching plate* placed at the vertex of a *reflector*.

VERTICAL FIELD-STRENGTH DIAGRAM. A representation of the field-strength at a constant distance from an *aerial* and in a vertical plane passing through the aerial.

VESTIGIAL SIDEBAND TRANSMISSION. Single sideband transmission for television coaxial cable projects with, in addition to the carrier, a small but highly influential portion of the other sideband. In television the video signal frequency band, extending as it does to nearly zero frequency, makes it unsuitable for direct transmission over coaxial cable except over short distances. The vestigial sideband principle may be applied to shift the video frequency band appropriately without greatly increasing the transmitted bandwidth, and at the same time obviate almost unsurmountable problems in filter design involved in single sideband television transmission. The inherent stability and freedom from interference which characterises coaxial cable transmission is thus made available for relaying programmes over long distances.

VIDEO. Television term signifying picture or vision, as distinct from sound (audio).

VIDEO FREQUENCIES. The frequencies of modulated signals which may be applied to a cathode-ray tube to produce a picture or *display*.

VISIBLE SPECTRUM. This extends from infra-red, through red, orange, yellow, green, blue, and violet to ultra-violet.

VISUAL TUNING INDICATORS. A device wired into a circuit to enable the correct resonance point to be seen. This arrangement has been rendered necessary by the employment of A.V.C. When the receiver is exactly tuned to a station the A.V.C. comes into action and controls the H.F. amplification. There are many forms of indicator, some of which take the form of a light which varies with input signal strength, and some in the form of a meter. The cathode-ray tuning indicator consists of a valve having cathode, heater, target anode, and space-charge grid. It is wired to the second detector in a superhet and the emission is directed on to a fluorescent disc which it causes to glow with a green colour. The degree of fluorescence and the shape of the glow depend upon the strength of the electron stream which in

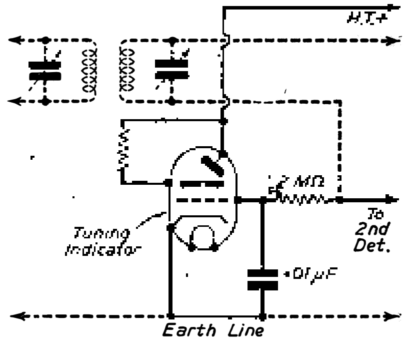


FIG. 540. *Connections for cathode-ray tuning indicator.*

turn is dependent upon the signal arriving at the second detector stage.

VOLT. The volt is the unit of electromotive force or pressure.

It is the practical unit of potential difference, being that potential difference which produces a current of one ampere when applied to a conductor the resistance of which is one ohm. It is equal to 108 C.G.S. electro-magnetic units, the symbol being V; 1 volt $= 3{\cdot}33 \times 10^{-2}$ statvolts or 10^8 abvolts; 1 statvolt $= 3 \times 10^{10}$ abvolts $= 300$ volts; 1 abvolt $= 3{\cdot}33 \times 10^{-11}$ statvolts.

The international volt is the potential difference which will produce a current of one international ampere when steadily applied to a conductor the resistance of which is one international ohm.

Other units are the *millivolt* (which equals one-thousandth of a volt), the *microvolt* (one-millionth of a volt), and the *kilovolt*, which equals 1,000 volts.

VOLT-AMPERE. The product of R.M.S. volts and R.M.S. amperes. Symbol V.A.

VOLTA EFFECT. When two dissimilar metals are in contact with one another (in air) one becomes positive and the other negative.

VOLTAGE AMPLIFICATION.

$$R_{\mu} = \frac{R_1 \times R_2}{R_1 + R_2}$$

VOLTAGE AMPLIFICATION FACTORS. When considering voltage amplifying stages, the gain per stage can be calculated from:

V.A.F. =

$$\frac{\text{Amplification Factor } (\mu) \times \text{External Load Impedance}}{\text{External Load Impedance} + \text{Valve Impedance}}$$

VOLTAGE DOUBLER. The term applied to a rectifying circuit wherein a metal oxide rectifier is employed. The rectifier is connected, together with fixed condensers, to provide a bridge circuit, and this results in a step-up in voltage.

VOLTAGE DROP. The difference of potential along a resistance.

VOLTAGE DROP AND RESISTANCE. The voltage drop in a resistance is equal to the current in amperes, multiplied by the resistance in ohms. A resistance of 4 ohms in a circuit carrying 2 amperes will cause a drop of 8 volts.

VOLTAGE DROPPING RESISTORS. The value of these can be calculated from the same formula as above and can be re-written

$$R_b = \frac{E}{I\ (mA)} \times 1{,}000$$

when E represents the voltage to be dropped and I the current flowing in the circuit. If, as in the case of mains voltage dropping resistors or line cords, the current is expressed in amperes, the multiplication by 1,000 must be ignored.

VOLTAGE STANDING-WAVE RATIO. The *standing-wave ratio* can be measured as the ratio of the field strength at a voltage minimum to that at an adjacent maximum.

VOLTAIC CELL. A cell invented by Professor Volta, and consisting of two plates, one of zinc and one of copper, immersed in a weak solution of sulphuric acid. The acid solution should consist of about 10 parts of water to 1 of acid, and the metal plates may be kept apart by a block of wood (see Fig. 541).

VOLTMETER. A measuring instrument used to indicate the pressure, or E.M.F. applied to a circuit. An instrument of this type consumes current, and therefore it is essential that the use to which it is to be put should be first decided upon before the type of meter is chosen. A cheap meter will have a low resistance—say, round about 200 ohms per volt, and will therefore consume 5 milliampt. per volt, a quite considerable value when the meter is used to test, say, a H.T. battery of 120 volts rated to deliver 3 or 4 milliamps. This type of instrument is also useless for testing the output of battery eliminators, as the voltage will drop when the current taken is greater

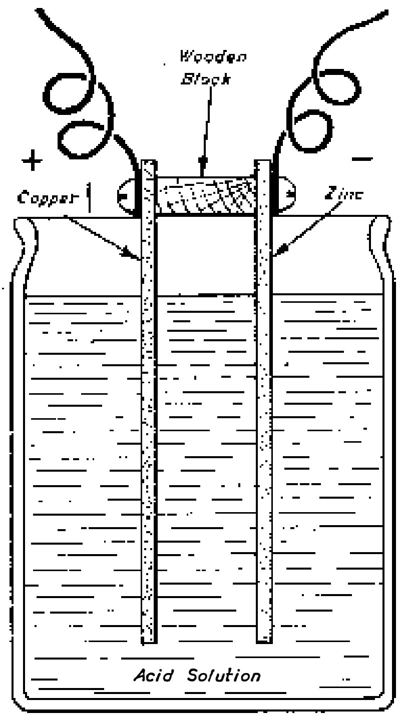


FIG. 541. *Details of the Voltaic cell.*

than the eliminator is rated to deliver. A good voltmeter of the moving-coil type will have a resistance of about 1,000 ohms per volt, and will therefore only consume ·1 of a milliamp. per volt, or 1 milliamp. for an instrument reading 100 volts. A voltmeter has to be joined in parallel (or across) the source to be measured. (See also *Meter*.)

VOLUME CONTROL. Unless the loudspeaker gives forth the same tone on either soft or loud signals, then overloading is taking place in the receiver. There are two remedies for overloading; one is to increase the handling capabilities

of the valve by applying more H.T., and the other is to cut down the signal strength.
A number of receivers have the reaction control labelled "Volume Control," but this is not strictly correct. A volume control should be able to cut down the strength of any signal, but the reaction control can only build up the strength of received signals, and cannot cut down below the original strength received by the detector. There are several different forms of volume control, but there are few which do not possess some fault.
The Transformer. In conjunction with the ordinary type of low-frequency transformer there are two possible arrangements. These are shown in Figs. 542 and 543. In Fig. 542 is shown a variable resistance shunted across the primary of the transformer, and the value of the resistance should be chosen so that when "all in" it does not have too great an effect upon the reproduction quality. Of course, when the transformer is a high-class component the presence of an external resistance across either primary or secondary will materially affect the response curve and the reproduction will be affected. In some cases, particu-

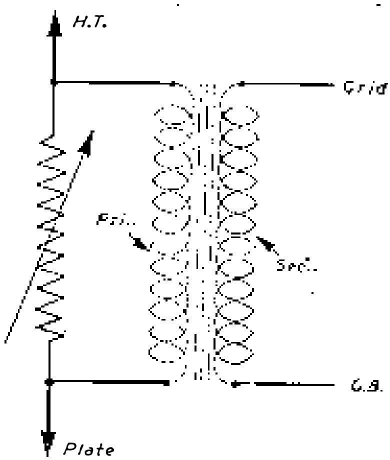


FIG. 542. *A simple form of control in conjunction with the L.F. transformer.*

larly in the cheap transformer line, the reproduction may be improved owing to the flattening of the curve. The value of the resistance in Fig. 542 should be about 100,000 ohms—not more.

In Fig. 543 a high-resistance potentiometer is connected across the secondary winding—the arm of the potentiometer being joined to the grid of the following

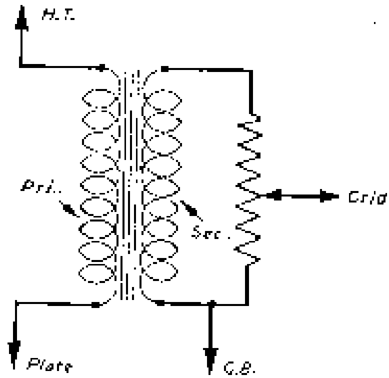


FIG. 543. *A better form of control than* FIG. 542. *A potentiometer across the secondary winding.*

valve. In this case the value of the resistance across the transformer is constant the whole time, and the adjustment of the arm simply taps off the required signal voltage. In Fig. 542 the adjustment of signal strength also varies the value of the resistance shunted across the primary, and therefore this method will affect the quality more than the Fig. 543 arrangement. The potentiometer should have a value of 1 or 2 megohms. To ensure noiseless adjustment a fairly good-class component should be employed.
Where resistance capacity coupling is employed, the grid leak can conveniently be substituted by the potentiometer method of Fig. 543, and this arrangement is shown in Fig. 545. Very little, if any, distortion is introduced by this method of volume control, and the only trouble that can arise here is noisiness due to a poor contact between the resistance element and the moving arm. This is the best method of I.F. volume control.
Overloading the Detector. It is not always in the L.F. side of the receiver that overloading troubles arise. In sets fitted with one or more H.F. stages the detector valve may be overloaded. A common form of control is a series aerial condenser, but this will affect the turning adjustment. The value should be ·0003 μF. maximum.
A much better aerial arrangement is shown in Fig. 544—this arrangement not

affecting the selectivity as does a series aerial condenser. A simple differential reaction condenser of ·0003 μF. is used for this. The moving plates are joined to the aerial lead, and one set of fixed plates is joined to earth and the other end to the aerial terminal of the set. A more elaborate version, for use in band-pass circuits and other critical tuned circuits, is shown in Fig. 546. For this a small semi-variable condenser of ·0003 μF. is joined between the earth terminal and one set of fixed plates. The semi-variable is adjusted until a value is reached where the setting of the moving plates of the differential does not have any effect on the tuning. Fig. 548 shows another form of aerial control, using this time a variable resistance. The value should be 25,000 or 50,000 ohms, and should be of the potentiometer type, having three terminals.

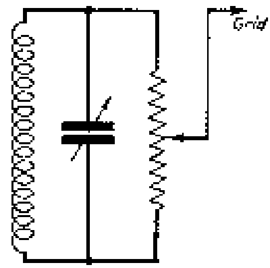


FIG. 547. *A potentiometer across the grid coil.*

One end of the resistance element is joined to earth and the other end is

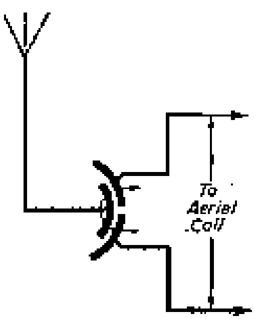


FIG. 544. *A differential condenser in the aerial circuit.*

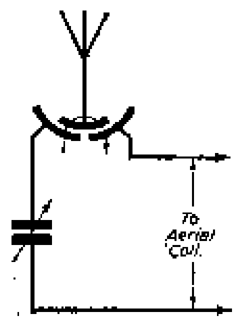


FIG. 546. *An improved arrangement of the circuit in* FIG. 544.

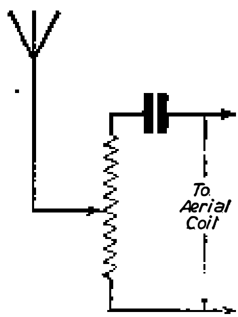


FIG. 548. *A resistance instead of a differential condenser in the aerial circuit.*

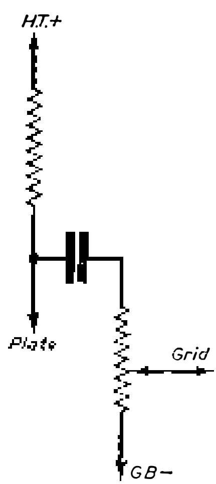


FIG. 545. *A potentiometer used instead of the grid leak in a R.C. amplifier.*

joined to the aerial terminal via a small fixed condenser, value about ·001 μF. The arm is joined to the aerial.

The final method dealt with is shown in Fig. 547, and for this a potentiometer of 50,000 ohms is required. It is joined across the aerial coil, the arm being taken to the grid of the first valve. Some coils will be badly upset, but in most cases this will be found as good an arrangement as Fig. 546. (See also *Automatic Volume Control* and *Quiet Automatic Volume Control.*)

VOLUME EXPANSION. Owing to certain factors governing the recording process, it is not feasible to secure on a gramophone record the same ratio of maximum amplitude to minimum amplitude as that existing for the original sound. During the recording, the amplitude has to be restricted or compressed; therefore, during reproduction, the loud passages do not bear a true relation to the softer passages.

This incorrect ratio can be corrected to a certain extent by incorporating in the reproducing amplifier a *volume expander* circuit which has the effect of amplifying loud signals more than soft ones, thus allowing a more faithful ratio to be obtained. A typical circuit is shown in Fig. 549.

W

WALKING STROBE PULSE. A *strobe pulse* whose timing (see *Strobe Pulse*) is automatically varied between given limits.

WANDER PLUGS. Small plugs, or brass pins fitted with springs or slotted, having ebonite ends. These are attached to flexible leads and employed for varying the voltage applied to a circuit by inserting in sockets provided on batteries of the dry-cell type.

WATT. The Electrical Unit of Power; the rate of work represented by a current of 1 ampere under a pressure of 1 volt. 746 watts = 1 h.p. It is the product of volts and amps. 1 watt = 10^7 ergs per second; 1 erg per second = 10^{-7} watt.

WATT-HOUR. A commercial unit of electrical work. It is the work done in 1 hour by a current of 1 amp. flowing between two points having a difference of potential of 1 volt.

WAVEBAND, AMATEUR. It has been internationally agreed to allot the following bands of frequencies for amateur use. These are referred to as the 5-, 10-, 20-, 40-, 80-, and 160-metre bands.

Frequency in Megacycles	*Frequency in Megacycles*
1·715 to 2·000	1215·000 to 1300·000
3·500 to 3·635	2300·000 to 2450·000
3·685 to 3·800	5650·000 to 5850·000
144·000 to 146·000	10000·000 to 10500·000
420·000 to 460·000	

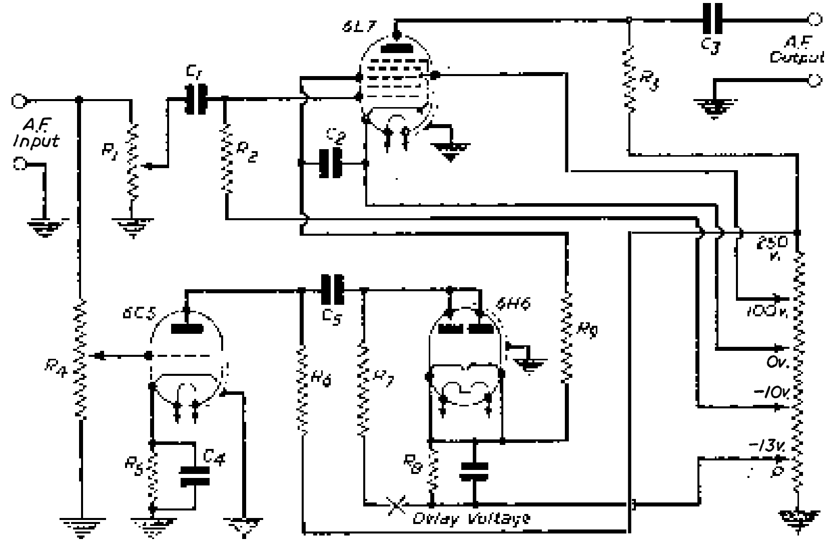


FIG. 549. Circuit incorporating volume expansion.

WAVE-CHANGE SWITCH. A switch included in a circuit to produce a change in the range of frequencies over which that circuit will tune. The present wavelengths employed by European broadcasting stations are between 173 and 882·3 metres, and there is then a gap until 1,060 metres. The gap is reserved for commercial stations, ships, etc. The long wavelengths, as they are called, extend from 1,060 to 1,973·5 metres.

WAVE CLUTTER. Interference on a radar *display* caused by *echoes* from sea waves.

WAVE FREQUENCY. (See *Frequency*.)

WAVEGUIDE GASKET. Used as a seal as in engineering, but also required to provide electrical continuity.

WAVEGUIDE LENS. A lens in which the

required phase changes result from transmission through suitable *waveguide* elements.

WAVEGUIDES. When working on extremely high frequencies—in the region of 3,000 megacycles per second, or wavelength of one centimetre—it is found that the normal wire transmission lines or feeder is extremely inefficient. It is also found that these microwaves tend to obey physical rather than electrical laws, with the result that they can be "poured down a tube," in rather the same way that water can.

The radio-frequency output from a microwave transmitter can be fed along a tube of certain cross-section (the optimum cross-section is a function of the frequency in use) and may be radiated from the other end. The end of the waveguide remote from the transmitter may be belled out in the form of a horn. The open end may also be passed through a parabolic reflector to obtain increased directional effects.

It is found that the tubular waveguide may be curved in the direction of its length without serious loss in efficiency, and also that the guide may consist of various sections of tubing arranged in line, with gaps between them; even then, the radio-frequency output is "guided" along the feeder.

The design of waveguides is somewhat complicated, and presents several mathematical problems. In consequence, it cannot be dealt with in full here.

In general, the waveguide is made of rectangular cross-section, and the chief requirement is that one side of the rectangle shall be more than one half-wavelength and less than one wavelength long, while the other shall be less than one half-wave.

WAVEGUIDE SHIM. A thin resilient metal sheet inserted between *waveguide* components to ensure electrical contact.

WAVEGUIDE SWITCH. A device for controlling the flow of power along a *waveguide.*

WAVE IMPEDANCE. The ratio of the transverse electric field to the transverse magnetic field.

WAVELENGTH. The distance from the crest of one oscillation to the crest of the next. This distance is measured in metres.

$$\text{Wavelength} = \frac{300{,}000}{\text{Frequency}}$$

(See *Aerial, Natural Wavelength of.*)

WAVELENGTH-FREQUENCY CONVERSION TABLE

Metres to Kilocycles and Megacycles

Metres	*Kilocycles*	*Mega-cycles*	*Metres*	*Kilo-cycles*
5	60,000	60	360	833·3
10	30,000	30	370	810·8
20	15,000	15	380	789·5
30	10,000	10	390	769·2
40	7,500	7·5	400	750
50	6,000	6	410	731·7
60	5,000	5	420	714·3
70	4,285	4·28	430	697·7
80	3,750	3·7	440	681·8
90	3,333	3·3	450	666·7
100	3,000	3·0	460	652·2
150	2,000	2·0	470	638·3
200	1,500	1·5	480	625
205	1,463	1·46	490	612·2
210	1,429	1·42	500	600
215	1,395	1·39	510	588·2
220	1,364	1·36	520	576·9
225	1,333	1·33	530	566
230	1,304	1·3	540	555·6
235	1,277	1·27	550	545·4
240	1,250	1·25	560	535·7
245	1,225	1·22	570	526·3
250	1,200	1·2	580	517·2
255	1,177	1·17	590	508·5
260	1,154	1·15	600	500
265	1,132	1·13	650	461·5
270	1,111	1·11	700	428·6
275	1,091	1·09	750	400
280	1,071	1·07	800	375
290	1,034	1·03	850	352·9
295	1,017	1·017	900	333·3
300	1,000	1·0	950	315·9
310	967·7		1,000	300
320	937·5		1,250	240
330	909·1		1,500	200
340	882·4		1,750	171·4
350	857·1		2,000	150

Note.—To convert kilocycles to wavelength in metres, divide 300,000 by the number of kilocycles. To convert wavelength in metres to kilocycles, divide 300,000 by the number of metres.
To convert kilocycles to megacycles, divide by 1,000.

WAVELENGTH OF TUNED CIRCUIT. Formula for the wavelength of a tuned oscillatory circuit is : $1884{\cdot}96\sqrt{LC}$, where L = inductance in microhenrys and C = capacity in microfarads.

WAVEMETER. A device for measuring the wavelength of a received signal, or setting a receiver to a predetermined wavelength in order to receive a particular station. The device consists of a coil tuned by a variable condenser, the latter having a calibrated dial. Across this tuned circuit is arranged a battery and small buzzer. If desired a switch may be included in order to avoid disconnecting the battery. When the buzzer is operated oscillatory currents are set up in the tuned circuit, and these can be picked up by a receiver over quite a considerable distance. If the dial of the wavemeter is set to a given wavelength and the buzzer put in action, upon rotating the tuning dial of your receiver you will find a spot where the oscillations from the buzzer are at a maximum. At this spot the receiver is tuned to the wavelength shown by the dial of the wavemeter. In order to enable sharp tuning to be carried out it is advisable to remove the wavemeter as far away as possible from the receiver. Furthermore, once the wavemeter has been calibrated, the coils and condenser should be enclosed in boxes so that they may not be damaged and the values altered. The diagram (Fig. 550) shows the circuit arrangement.

There are three types of wavemeter in general use. First, there is the "buzzer" meter, which is in reality a miniature "spark" transmitting station which can be tuned to known wavelengths. It consists of an oscillating circuit similar to the aerial circuit of a receiver. This is excited by a buzzer like that used in an electric bell. Secondly, there is the absorption wavemeter, which works by virtue of absorbing energy from the circuit of the set it is desired to calibrate. It consists essentially of a tuned circuit, comprising an inductance and a variable condenser. It is brought into close proximity to the circuit to be calibrated. This latter has to be oscillating, but when the wavemeter is brought near it ceases to oscillate on the particular wavelength to which the wavemeter is tuned. This kind of wavemeter is very simple and requires no batteries, but it has the one drawback, that as it has to be brought very close to the circuit undergoing calibration it is sometimes difficult to use.

The heterodyne wavemeter is similar to the other two, in that it has a tuned circuit controlled by a variable condenser. This circuit, however, is made to oscillate by means of an ordinary valve. It might be compared to a one-valve receiver, in which the reaction is "turned on full" all the time. It is placed some little way from the set to be calibrated. The latter is then made to oscillate by advancing the reaction, and on tuning-in to the wavelength which the wavemeter is radiating, the familiar squeal one gets when passing a station with the reaction too far advanced is heard in the loudspeaker or phones. When this squeal is heard the wavelength of the meter is noted and the same figure marked on the dial of the receiver opposite where the pointer is.

If a wavemeter is to be reasonably accurate, and what is most important, remain accurate, it must be carefully constructed, and must include only good-class components which will not vary their characteristics in the course of time. It will be realised that any change in the value of the components will upset the readings and necessitate the recalibration of the meter. It is for this reason that one valve must always be kept for the meter. A different valve would most likely throw the readings right out. In fact, it is best not to remove the valve at all unless you

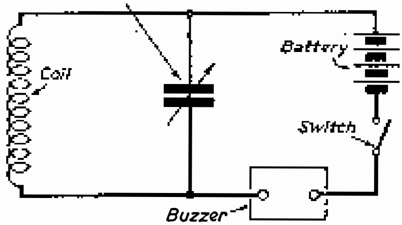


FIG. 550. *A buzzer wavemeter.*

are certain of pushing it right home in its holder each time. It is the same with the other components—once they are fixed leave them alone, and try by all means to avoid the accumulation of dust, especially when accompanied with moisture.

The only part to be "constructed" is the coil. This is wound on a 3-in. diameter paxolin former 6 in. long. Wind the wire as evenly and tightly as possible, so that it will not shift later on and alter the wavelength. Pierce two small holes about ¼ in. from one end of the tube, and leaving a short length for connection, secure the wire through the holes. Then commence winding. Put on 55 turns, which by the way should consist of 24-gauge D.S.C. wire, and then make two more holes and finish off by threading the wire through the holes as before, leaving a short length for connections. This is the medium-wave grid coil. The reaction coil follows, and consists of 25 turns in the same direction composed of the same gauge wire. Leave a space of about ½ in. before starting the long-wave coils. These consist of 170 and 50 turns for grid and reaction windings respectively. Fig. 552 will make the construction quite clear.

Mounting the Components. Fig. 551 gives a bird's-eye view of the layout with the panel represented as lying flat. Probably

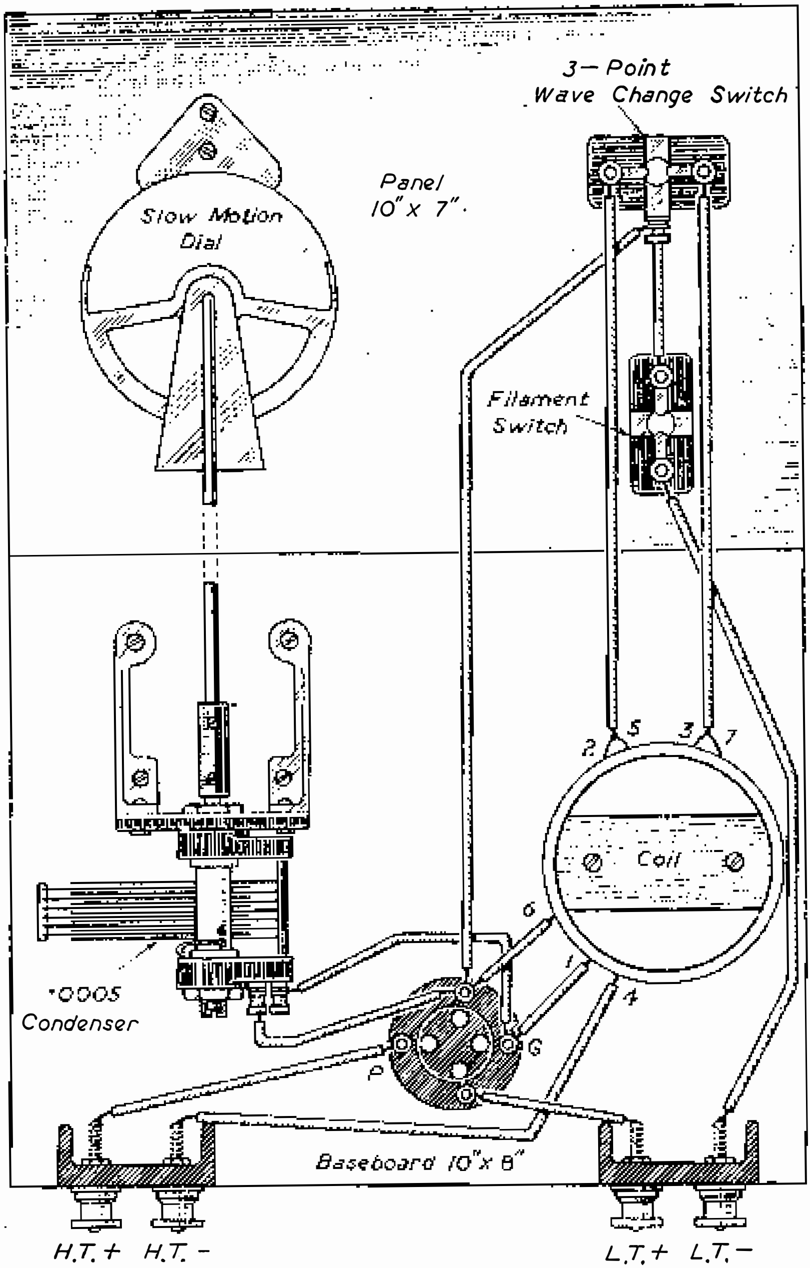


FIG. 55 I. *Wiring diagram for the heterodyne wavemeter.*

the first thing that will strike you as being somewhat unusual is the mounting of the variable condenser. It is supported on a little ebonite panel of its own some way back from the panel. This is to reduce hand-capacity effects. If you are not familiar with heterodyne wavemeters you may not at once see the reason for this, but it is because there is no aerial or earth used with the meter. In a receiving set the moving vanes of the tuning condenser are connected to earth so that bringing one's hand, which is also at earth potential, into proximity with them when tuning has no effect. The fixed vanes which are at high potential are screened by the moving vanes. Here, however, both the fixed and the moving vanes are at high potential, hence the need for placing the condenser so also is the coil mounted well back. A piece of wood is fixed across the lower end of the coil with the aid of glue or one or two small brads, and then the wood is secured to the baseboard with screws. The rest of the arrangements are quite straight-forward, and comprise the mounting of the two switches on the panel, the valve holder and the two terminal mounts with their four terminals.

Although the wiring is so simple it should not be carried out carelessly. Every wire should be as straight as possible and no fancy work indulged in, in the form of square corners or angles. Stiff wire is better than limp, as it is less likely to vary its position and so cause any slight inaccuracies in wavelength after the meter is calibrated. The same remarks apply to

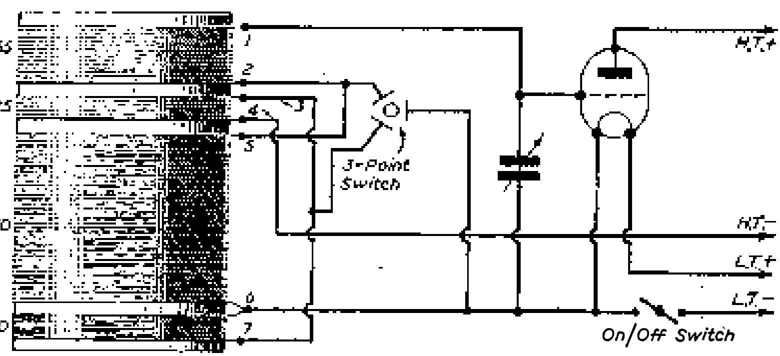


FIG. 552. *Details of the coil for the heterodyne wavemeter shown in* FIG. 551.

some way back from the front panel. This is actually done by mounting it on a separate panel of its own and controlling it by an extension handle. The panel used is simply a piece of ebonite $2\frac{1}{2}$ in. by 4 in. held upright with two small panel brackets, and having a hole near the top for the condenser spindle to pass through. The control of the condenser is by means of a really good slow-motion dial with an extension. The original component used was intended as a reaction control, and was fitted with a small reaction condenser of the solid-dielectric type. This, of course, was removed, and an air-dielectric tuning condenser used instead as shown. If on ordering you explain to the makers that the condenser is not required, they will, no doubt, supply the dial and extension without this.

For the same reason that the condenser is placed some distance from the front panel, some extent to the wires from the set to the batteries, especially the H.T. battery. The best way is to build a cabinet to house both set and batteries and so do away with any trailing leads. It is advisable to solder all connections where possible. Where two wires from the coil are connected to the same terminal on the wave-change switch, it is best to solder them together as near to the coil as practicable, and take a single stiff connecting wire from this union to the switch terminal.

Calibrating and using the Meter. Calibration is carried out in the usual way with squared paper. Draw a line and mark it in the dial readings of the wavemeter condenser and another at right angles to it and mark it in wavelengths. Tune in a known station on a selective receiver, and tune the wavemeter to the same wavelength by turning its dial until it causes a howl right on top of the transmission being received. Mark the known wavelength of the station on the graph and also the dial reading of the wavemeter. In each case draw a pencil line in the usual way, from the point marked, so that the two lines follow the square lines of the paper, and where they cross mark the spot with a point. Repeat this procedure with as many known stations as possible. The graph is completed by joining up each of the points thus plotted with a line. This will not be straight but slightly curved. This plotting must be carried out for both wavelengths. Either make two graphs, or plot both curves on the same graph using, say, red ink for the medium-wave curve and blue ink for the long-wave one.

The meter is now calibrated, and to use it adopt the procedure mentioned in the first part of this se ion. Any set to be calibrated is set oscillating. Then rotate the knobs until the heterodyne whistle or squeal of the meter is picked up. It is already known to what wavelength the meter has previously been set, this having been done by means of the graph. Assume it was 350 metres, perhaps 120° on the wavemeter dial. Since the set under test is tuned to the same wavelength as the meter it must be tuned to 350 metres. The meter is then set to another wavelength and the procedure repeated.

There are several points to be observed in calibrating and using the meter. The endeavour should be to keep the operating conditions the same. Do not, for instance, stand the meter on a wooden table one day and on another place it on an iron mantelshelf. Keep the batteries at the same voltage. Here it may be mentioned that there is no need to use a higher value of H.T. than is necessary to keep the meter oscillating.

Finally, it is essential that the meter should oscillate. If it fails to do so, then the meter will be useless for all test purposes, as it will be impossible to obtain a note from it for heterodyning.

WAVE TRAP. A device inserted in the aerial lead for preventing interference. There are two forms of wave trap, an acceptor and a rejector. The former accepts the unwanted signal, whilst the latter rejects all but the wanted signal. The device in both cases consists of an oscillatory circuit, i.e. a coil and variable condenser. The acceptor circuit is connected in series with the aerial and the receiver, whilst the rejector is connected in parallel.

WEBER. The unit of pole strength named after the German physicist Weber (1795-1878). North and south poles are called positive and negative poles respectively. A pole strength of m webers will repel a unit pole 1 cm. away in air, with a force of m dynes. 1 weber $= 10^8$ maxwells $= 10^8$ lines; 1 weber/sq. metre $= 10^4$ gauss; 1 gauss $= 10^{-4}$ webers/sq. metre; 1 maxwell $= 10^{-8}$ webers; 1 pragilbert/weber $= 10^{-9}$ gilbert/maxwells. (See *Ampere, Unit Magnetic Pole, Gilbert,* and *Maxwell.*)

WEDGE. A *termination* comprising a tapered length of dissipative material introduced into the guide, e.g. carbon, water, wood, etc.

WELL STROBE MARKER. A form of *strobe marker* in which the discontinuity is in the form of a rectangular depression in the *timebase.*

WET BATTERY. A battery in which the electrolyte is in liquid form.

WHEATSTONE BRIDGE. A device for measuring the value of a resistance by balancing it against other and known resistances.

Making a Wheatstone Bridge. This instrument is to the electrician as important as the balance to the chemist, and therefore is very useful to have.

It consists of a board 12 in. by 8 in. of very dry oak.

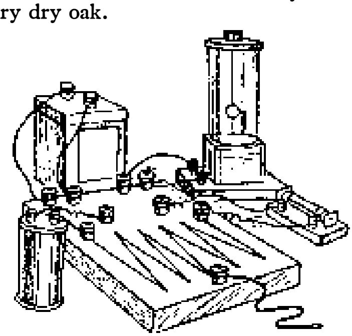


FIG. 553. *The Wheatstone Bridge and its associated apparatus.*

Mount nine brass terminals upon it in the positions shown in Fig. 554. At 20, 40, 60, 80, are brass pins driven into the base $1\frac{1}{8}$ in. apart. At a distance of 7 in. from this row of pins is a row of five more, 10, 30, 50, 70, 90, the same distance apart.

The zigzag line is a length of bare Eureka resistance wire of 22 gauge.

Fasten one end under terminal R, and stretch it tightly in a zigzag manner round the brass pins as shown, finishing off under terminal X^1.

Rule eleven horizontal lines across the board as shown, $\frac{5}{16}$ in. apart, and number the intersections of these lines with the resistance wire.

Board Connections. The dotted lines represent connections at the back of the board with thick copper wire. Be careful to join up the correct terminals—R to B, B^1 to X^1, R^1 to X, G^1 to Z, G to the middle of the R^1X wire. Solder all connections if possible, but remember that, a good screwed-up connection is better than a badly soldered one. A battery is joined up between B and B^1, and the galvanometer between G and G^1.

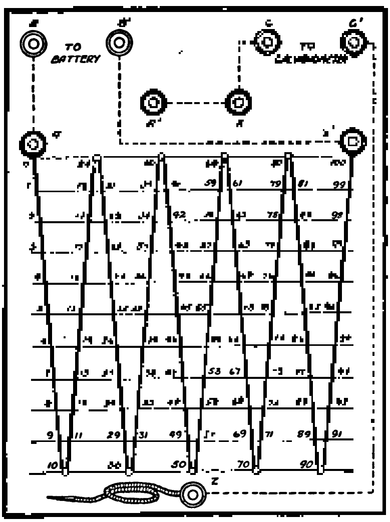


FIG. 554. *A detailed sketch of the Wheatstone bridge, showing its construction.*

The instrument is used commonly to find the resistance of a wire or given circuit.

Suppose one wants to find the resistance of a certain piece of wire. Connect it up between X and X^1. Between R and R^1 connect up a standard resistance coil, say 5 ohms.

To the terminal Z is connected a length of flexible wire, with a short tag of stiff copper wire soldered to the end of it.

When everything is connected up, touch the zigzag wire with this flexible lead. The galvo needle moves violently. Try different spots on the zigzag wire, and one will eventually find the one where the galvo needle is unaffected.

Note the number of this spot by means of the parallel lines and figures. Suppose the spot is 25.

By using the following formula find the resistance of the wire :

$$\frac{100 - N}{N} \times R = x,$$

where N = the number on the board,
R = the standard resistance,
x = the unknown resistance.

Then

$$\frac{100 - 25}{25} \times 5 = x$$

$$\frac{75}{25} \times 5 = x$$

whence the resistance of the wire is 15 ohms.

If the unknown quantity is suspected of being high resistance, a high standard resistance should be used. One can easily make the standard resistances, remembering that the Eureka 22 gauge is 1 ohm per 33 in. For 5 ohms, cut off 165 in., plus 1 in. for connections. Coil this round a small cardboard cylinder, leaving 2 in. free at either end for connections. When placed in the bridge, ½ in. of the wire should go under each terminal to give the correct resistance between the terminals.

WHIP AERIAL. A type of *aerial* consisting of a flexible rod supported at one end.

WIDE-BAND. Having a wider frequency response than the normal type of circuit at the corresponding mid-band frequency.

WIDTH CODING. Modifying the duration of the *pulses* emitted from the *transponder* in accordance with a pre-arranged code for recognition in the *display*.

WIMSHURST MACHINE. A machine for producing static charges. It consists of two glass or similar insulating discs having a number of strips of tinfoil attached to one side. These are rotated close to each other, but in opposite directions. Small tinsel brushes touch the tinfoil strips, and collecting combs are also arranged close to the brushes. Charges are produced by induction, and are conveyed to a Leyden jar.

WINDOW. A hole for coupling one cavity to another.

WIRE GAUGES. Chief is Standard Wire Gauge, abbreviated to S.W.G. (See also *Copper Wire Data*.)

WIRE, RESISTANCE. (See *Eureka Resistance Wire* table on page 11.)

WIRED WIRELESS. A process of sending wireless signals along a wire, using the wire to conduct the high-frequency currents. This method permits of a telephone line being used for its legitimate purpose of carrying telephonic communications, whilst at the same time carrying the wireless signals. They do not interact.

WOBBULATION. Variation of the oscillator frequency over a band of frequencies. Term used in connection with the oscillator and the cathode ray oscillograph. Frequency modulation at a very low (normally sub-audio) frequency.

WOLLASTON WIRE. A fine platinum wire coated with silver.

WOOD SCREWS. The following tables give proportions of wood screws and drill sizes.

TWIST DRILLS FOR WOOD SCREWS

No. (or size) of Screw	*Diameter of Neck or Shank*	*For Wood or Metal*			*With Side Lips and Centre for Wood only*	
			No., etc.	*Diameter*	*Size*	*Diameter*
1	·066	Stubb's Wire Gauge Drills	51	·067	—	—
2	·080	Stubb's Wire Gauge Drills	46	·081	—	—
3	·094	Stubb's Wire Gauge Drills	41	·096	—	—
4	·108	Stubb's Wire Gauge Drills	35	·110	—	—
5	·122	Stubb's Wire Gauge Drills	30	·128	$\frac{1}{8}$	·125
6	·136	Stubb's Wire Gauge Drills	28	·140	—	—
7	·150	Stubb's Wire Gauge Drills	23	·154	$\frac{5}{32}$	·156
8	·164	Stubb's Wire Gauge Drills	18	·169	—	—
9	·178	Stubb's Wire Gauge Drills	14	·182	$\frac{3}{16}$	·187
10	·192	Stubb's Wire Gauge Drills	9	·196	—	—
11	·206	Stubb's Wire Gauge Drills	4	·209	$\frac{7}{32}$	·218
12	·220	Stubb's Wire Gauge Drills	1	·228	—	—
13	·234	Letter Gauge Drills	B	·238	—	—
14	·248	Letter Gauge Drills	E	·250	$\frac{1}{4}$	·250
15	·262	Letter Gauge Drills	H	·266	—	—
16	·276	Letter Gauge Drills	K	·281	$\frac{9}{32}$	·281
17	·290	Letter Gauge Drills	M	·295	—	—
18	·304	Letter Gauge Drills	O	·316	$\frac{5}{16}$	·312
19	·318	Letter Gauge Drills	P	·323	—	—
20	·332	Letter Gauge Drills	R	·339	$\frac{11}{32}$	·343
21	·346	Letter Gauge Drills	S	·348	—	—
		Letter Gauge Drills	T	·358		
22	·360	Letter Gauge Drills	U	·368	$\frac{3}{8}$	·375
23	·374	Letter Gauge Drills	V	·377	$\frac{3}{8}$	·375
24	·388	Letter Gauge Drills	X	·397	—	—
25	·402	Letter Gauge Drills	Z	·413	$\frac{13}{32}$	·406
26	·416		$\frac{27}{64}$	·421	—	—
27	·430		$\frac{7}{16}$	·437	$\frac{7}{16}$	·437
28	·444		$\frac{29}{64}$	·453	—	—
29	·458		$\frac{15}{32}$	·468	$\frac{15}{32}$	·468
30	·472		$\frac{31}{64}$	·484	—	—
31	·486		$\frac{1}{2}$	·500	$\frac{1}{2}$	·500
32	·500		$\frac{33}{64}$	·515	$\frac{1}{2}$	·500

All dimensions in parts of an inch.

WOOD'S METAL. A special soft solder employed to fix crystals in the holder. It consists of 1 part of tin, 4 parts of bismuth, 1 part of cadmium, and 2 parts of lead. It melts at about 60° C. (See also *Crystals.*)

WOOFER. A speaker unit designed to reproduce the lower frequencies. (See *Tweeter.*)

WOW. Effect of change in pitch due to variation in speed in recording or reproducing machine.

WOW FACTOR. (1) The m ximum instantaneous variation from the average speed of a *recording turntable* shall not exceed plus or minus 1 per cent. of the average speed. (2) The maximum instantaneous deviation from the average speed of a *reproducing turntable* shall not exceed plus or minus 3 per cent. of the average or mean speed.

WRITE. To make a *trace* on a cathode-ray tube screen by moving the *spot* along it.

W/T (WIRELESS TELEGRAPHY). Type A1 or A2 waves.

X

XENON. A heavy inert gaseous element present in minute quantities in the atmosphere. Symbol Xe or X.

X'MITTER. Abbreviation for Transmitter.

X'MITTING. Abbreviation for Transmitting.

X-RAYS. The name given to the rays of light which are produced by passing a current through a vacuum tube. These rays possess the property of passing through opaque bodies. Another term for them is Röntgen rays.

X's. The term given to static or atmospheric disturbances. (See also *Static.*)

XTAL. Abbreviation for *Crystal.*

Y

YOUNG'S MODULUS. That force necessary to stretch a substance of unit to an elastic limit to double its length, it being constant for any one material. As a formula, $M = LF/ea$, where L = length of substance, a = area, F = force applied, e = total of elongation produced by F.

Z

ZEEMAN EFFECT. That distortion of the *spectrum lines* in the light emitted by a flame when that flame is subjected to strong magnetic fields.

ZERO BEAT. (See *Beat Frequency.*)

ZERO-SKIP FREQUENCY. The highest *critical frequency* (definition (a)).

ZINCITE. A crystal formed from oxide of zinc. Used in conjunction with bornite or copper pyrites. (See also *Crystals.*)

ZONE - POSITION INDICATOR. An auxiliary radar set for indicating the general position of an object to another radar set with a narrower field. (Sometimes called a "putter-on.")

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