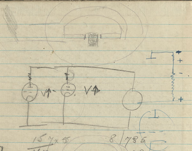


157 x 55 / 160

8 | 785

98.125

15 - 15 - 100%
25 - 25 - 100%
20 - 20 - 100%
38 - 40 - 98%
59 - 60 - 98.125%
59 - 60 98.18

98
157
216
220

108
216/220 x 100
11 | 1080
98.1818
90
2
90

6/10 x 98.5
59.10

98.6

59.1
59.1 67.1

50000
.0001
.05
5

Conductors & Insulators.

Conductors are substances which readily permit the flow of electrons to take place under the influence of Electrical Forces & insulators are substances which under the same circumstances do not allow a flow of electrons.

Effects of Electric Currents.

1. Heating Effect. A wire carrying a current becomes heated. (Electric radiators & lamps)
2. Magnetic Effect. A wire carrying a current is surrounded by a magnetic field (motors & dynamos)
3. Chemical Effect. An electric current flowing through a liquid will decompose it (in most cases) (Electro-plating)

Electrical Units.

The unit of current (I) is the Ampere (A)

The chemical effect gives the practical standard for measuring current.

The International Ampere is the unvarying current which will deposite 0.001118 gms. of $Ag.\ sec^{-1}$ from a solution of its salts.

The Coulomb Q. is the quantity of electricity passing per second when a current of 1A is the rate of flow

ie. $Q = It$

E.M.F. & P.D.

The E.M.F. required to cause a current to flow is measured in Volts (V)

The difference in Potential between diffent parts of a circuit is P.D. (V) & is measured in Volts also.

Resistance (R) is the opposition which the material forming the circuit offers the current & is measured in Ohms (Ω)

Ohm's Law

The current in a circuit depends upon the applied pressure & also upon the resistance.

Ohm's Law states that

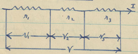
$$I \propto E/R$$

ie. $I = k\ E/R$

By choosing suitable units $k = 1$

$$\therefore I(\text{in amps}) = \frac{E(\text{in volts})}{R(\text{in ohms})}$$

Resistances in Series



$I = V_1/R_1 = V_2/R_2 = V_3/R_3 = V/R$

But $V = V_1 + V_2 + V_3 = I_1 R_1 + IR_2 + IR_3$

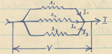
$\therefore V/R = I$

$\therefore V = IR = I(R_1 + R_2 + R_3)$

$\therefore R = R_1 + R_2 + R_3$

The equivalent Resistance of a number in series is the sum of the seperate resistances.

Resistances in Parallel.



$I = V/R$

$I_1 = V/R_1$

$I_2 = V/R_2$

$I_3 = V/R_3$

& $I = I_1 + I_2 + I_3$

$= V/R_1 + V/R_2 + V/R_3$

$\therefore I/V = 1/R_1 + 1/R_2 + 1/R_3$

$= 1/R.$

$\therefore R = 1/(1/R_1 + 1/R_2 + 1/R_3)$

The reciprocal of the equivalent resistance is equal to the sum of the reciprocal of each seperate resistance when in parallel.

Measure	C. G. S.	F. P. S	Conversion
Length	Centimetre	Foot	1 ft = 30·48 cm
Mass	Gram	Pound	1 cm = 0·3937 in.
Time	Second	Second.	1 lb. = 453·6 gm.
Velocity	$cm.sec.^{-1}$	$ft.sec.^{-1}$	
Acceleration due to gravity (g)	$981\ cm.sec.^{-2}$	$32\ ft.sec.^{-2}$	
Force	dyne	lb. wt.	1 lb wt = 445,000 dynes
Work	Erg	Foot lb.	1 H.P. = 746 wts
Energy	Joule = 10^7 ergs.		= 550 ft lb. sec^{-1}
Power	Watt = 1 Joule sec^{-1}	HP. = 550 ft/sec	

$1\ H.P. = 550\ ft.lbs.sec^{-1} = 550 \times 30\cdot48 \times 453\cdot6\ cm.gm.sec^{-1}$

$= 550 \times 30\cdot48 \times 453\cdot6 \times 981\ cm.dynes.sec^{-1}$

$= 550 \times 30\cdot48 \times 453\cdot6 \times 981 / 10^7$ watts.

$= 746$ watts.

Work, Energy & Power.

Work is measured in Joules.

1 Joule = 10^7 ergs.

Work done = E.M.F. × Q.

1 Joule = 1 volt × 1 Coulomb.

1 Watt = 1 Joule sec^{-1}

$= 1V \times 1\ coulomb.sec^{-1}$

$= 1V \times 1A.$

or $W = E \times I.$

$W = I \times IR$

$= I^2R$

or $W = E \times \frac{E}{R}$

$= E^2/R.$

Specific Resistance.

$R \propto l$ (l = length)

Also $R \propto 1/a$ (a = area of crosssection)

$\therefore R \propto l/a$

or $R = \rho\, l/a$ where ρ is constant for the particular material of the circuit is called the Specific Resistance.

ρ is the measure of resistance between opposite faces of either a 1 cm.³ sided cube or 1 in sided cube of the material.

Material	ρ cm. cube	ρ in cube.
Copper	1·61 μΩ.	0·633 μΩ.
Iron	9·69	3·82
German Silver	30·0	11·8
Eureka	49·0	19·3

Effect of heat on resistance.

All metals (pure) increase in resistance with a rise in temperature
Alloys, esp. "Resistance Materials" have a practically constant resistance.
Carbon + Insulators. decrease in resistance.

Within the normal temp. range (0 - 100°C) the resistance of most conductors is given by

$$R_t = R_0(1 + \alpha t)$$

Material	Per °C.
Copper	0.0043
Iron	0.0063
German Silver	0.0004
Eureka	0.0000
Carbon	− 0.05

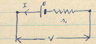
Commercial Units.

1 Joule = 1 watt. for 1 sec.
1 Commercial unit of Electricity
or Board of Trade Unit = 1 kilo watt. hour. (K.W. hr.)
or B.O.T.U. = 1,000 watt hours.
= 3,600,000 Joules.

Power	Energy
Watt.	1 Joule = 1 watt sec.
Kilo watt	Kilo Watt-hour
H.P.	H.P. hour = 746 watt hours.
	erg.
	foot. lb.

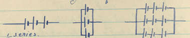
Internal Resistance of Cells.

Consider the internal resistance (r) as an external resistance to an ideal cell.



$V = E - Ir_1$

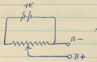
Arrangement of Cells.



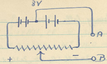
1 series. 2 parallel 3 series parallel.

1. Total emf's & r is the sum of seperate emf's & r's.
Current is the same as for one
2. E.m.f. is as for one cell, cells should be identical; $r = 1/\frac{1}{r_1}+\frac{1}{r_2}+\frac{1}{r_3}+\cdots$
I is the sum of each cell's working I.
3. Is a combination of the first two.

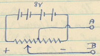
Potentiometer or Potential divider.

1 

Potential drop between AB = 4 volts → 0.

2 

P.D. between AB = ± 4 volts.

3 

P.D. between AB = ± 4 Volts.

The Current-carrying Capacity of cables etc.

The conductance (G) of a conductor is the reciprocal of its resistance & is measured in mhos.

$\therefore G = \frac{a}{\rho l}$ or $G \propto a$.

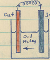
A safe rule for copper is to allow 1000A. in^{-2}

The size of a cable is governed by:—
i. I^2R loss (heat.)
ii IR voltage drop.

The current carrying capacity is the maximum current allowable under the specified condition without causing undue temp. rise or voltage drop.

Primary Cells.

Voltaic Cell



$Zn + H_2SO_4 \rightarrow ZnSO_4 + 2H^+$

This cell is soon polarised by H_2 on the copper rod.

e.m.f. = 1.08 volts.

Local action is prevented by amalgamating the zinc.

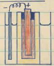
Daniell Cell. is the above with a porous pot containing $CuSO_4$ as depolarizer.

$Zn + H_2SO_4 \rightarrow ZnSO_4 + 2H^+$

$2H^+ + CuSO_4 \rightarrow H_2SO_4 + Cu^{++}$

The copper after losing its charge is plated onto the copper rod.

Leclanché Cell.



- ○ Electrolyte, NH_4Cl aq.
- +ve Carbon rod.
- -ve zinc rod.
- pitch seal with gas vent.
- Depolarizer, MnO_2 + C. damp.
- Porous pot.

e.m.f. ≃ 1.46V. $r = 1.0 \rightarrow 5.0\ \Omega$.

$Zn + 2NH_4Cl \rightarrow ZnCl_2 + 2NH_3 + H_2^+$

$2MnO_2 + 2NH_3 + 2H^+ + H_2O \rightarrow Mn_2O_3 + 2NH_4OH$ + electrical energy.

The carbon in the depolarizer serves as a conductor.

Dry Cell

e.m.f. 1.5V. $r = 0.15 \rightarrow 0.4\ \Omega$.

Inert Cell

Same as Leclanché on addition of H_2O.

N.B. With solid depolarizers cells should only be used intermittently.

Secondary Cells.

Lead-Acid, Accumulator of Storage cell

Both plates are covered initially with a mixture of red lead & dil H_2SO_4 & then are "formed" in charging.

Charging

$H_2SO_4 \rightarrow 2H^+ + SO_4''$

Anode $PbO + H_2SO_4 + H_2O + SO_4'' \rightarrow PbO_2 + 2H_2SO_4 + 2\ominus$

Cathode. $PbO + H_2SO_4 + 2H^+ \rightarrow Pb + H_2SO_4 + H_2O + 2\oplus$

Discharging.

$$PbO_2 + 2H^+ + H_2SO_4 \rightarrow PbSO_4 + 2H_2O + 2\oplus$$

$$Pb + SO_4'' \rightarrow PbSO_4 + 2\ominus$$

Their capacity is increased by increasing the active surface area of the plates.

Initial charge. Observe maker's instructions.

Tests for completion of charge

i. Appearance of plates. +ve chocolate brown: -ve: slate grey.

ii. Voltage - 2.5 - 2.7.

iii. Plates gassing freely.

iv. Sp.G. test with hydrometer.

Care & Maintenance.

i. Do not over or undercharge or alter stated rate.

ii. Do not run nearly discharged batteries.

iii. Do not stand them undischarged.

iv. Keep plates covered, make up evaporation.

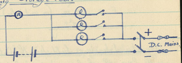
v. Keep terminals & top of cell, clean, dry & greased with vaseline.

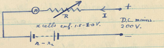
Alkaline Cell or Nickel-Iron or Nife cell.

is robust, light & can stand discharged & can be overcharged or undercharged.

e.m.f. = 1.3V.

Charging Storage Cells





Since r & e.m.f. are varying a variable resistor or lamps must be used to keep the charging rate steady.

Example.

Initial Resistance R. $= \frac{200 - 1.5x}{I} - xr_1 \ \Omega$.

Final R. $= \frac{200 - 2x}{I} - xr_2 \ \Omega$

Magnetism

1 Unit of pole strength is that, when placed 1 cm. from a similar pole in vacuo is repelled with a force of 1 dyne.

Inverse Square Law.

$$F \propto \frac{m_1 m_2}{r^2}$$

$$F = \frac{m_1 m_2}{r^2} \text{ (in unit poles)}$$

Magnetic Intensity or Field strength (H) at a point is the force with which a unit +ve pole ~~is repelled~~ experiences, provided the field is unaltered by its presence.

$$H = \lim_{\Delta m \to 0} \frac{\Delta F}{\Delta m} \text{ gauss or dynes pole}^{-1}$$

$$\therefore H = \frac{m.1}{r^2}$$

Intensity of Magnetisation (I)

$$I = \frac{M}{V} = \frac{2ml}{2la} = \frac{m}{a}.$$

Magnetic Induction.

Let there be 4π lines of induction per unit pole (convention) in vacuo

∴ at a distance r. from m poles. in vacuo.

Total flux (Φ) = ~~$4\pi r$~~ $4\pi m$

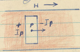
$$\therefore B = 4\pi m / 4\pi r^2.$$

$$= \frac{m}{r^2}$$

$$= H.$$

In vacuo the Intensity is equal to the Induction.

In a magnetisable medium.



Since the faces of the cavity are magnetised by induction. Then the force on P due to these faces $= 2I\beta P/r^2$ where r is radius of disc & if the disc is very thin

Let I be intensity of magnetisation. ∴ m = Iβ where β = area

the force $= 2I\beta/r^2$ if per unit pole

$= 2I\,2\pi r^2/r^2$ dynes pole^{-1}.

$= 4\pi I$ gauss

∴ the total force = $H + 4\pi I$ gauss.

This is equal to the induction though

$\therefore D = H + 4\pi I.$

The Magnetic Susceptibility of a medium, χ is given by $I = \chi H$

The Permeability μ of a medium is given by $B = \mu H$.

Since $B = H + 4\pi I$

$\mu = B/H = 1 + 4\pi I/H$

$= 1 + 4\pi\chi$

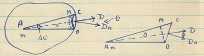
In a medium of permeability μ

$B = m/r^2$

$= \mu H.$

$\therefore H = m/\mu r^2.$

Gauss's Theorem.



Let us imagine a closed surface drawn in a magnetic field.

Consider the flux across a small element of area, BC (ΔS)

then $D n\Delta S$ is the normal induction across ΔS

$= D\cos\theta\ \Delta S.$

$= \frac{m}{r^2} \times \text{area } BM.$

but BM/r^2 = the solid angle $\Delta\omega$

$\therefore Dn\Delta s = m.\Delta\omega$

$\therefore$ the total normal induction

$= \int m.\, d\omega$

$= m\int_0^{4\pi} d\omega$

$= m \times 4\pi$

$= 4\pi m$

Gauss's theorem states that the total normal induction of a closed surface is 4π times the magnetic pole strength in the surface.

Total normal induction = flux.

The number of lines of induction from a unit Magnetic pole.

Let a closed sphere of radius r have a single pole of strength m unit poles at its centre

By Gauss's theorem.

the normal flux = $4\pi m$.

Since all the flux is normal the total flux from unit pole = $4\pi m / m$ lines.

= 4π lines.

where the numerical value of the induction is equal the number of lines drawn through the considered area.

Magnetic Potential is the work done on one unit positive pole in bringing it from infinity to the point in question.

Let a +ve pole of m units be moved from a point r to $(r+\Delta r)$ where $\Delta r \to 0$ so that the intensity is constant.

Then the work done = force × distance.

$= -\frac{m}{r^2} \times \Delta r$.

∴ V (the potential at the point)

$= -\int_{\infty}^{r} \frac{m}{r^2} \Delta r$.

$$V = \frac{m}{r}.$$

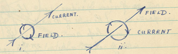
In a medium of permeability μ

$$V = \frac{m}{\mu r}$$

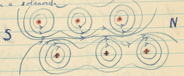
$H = -\frac{dV}{dx}$ where x is the distance from the origin of the force.

Electro Magnetism.

A magnetic field surround a current flowing in a conductor.



The effect as in ii is increased by the no. of loops as in a solenoid.



Electro Magnets.

This is a coil of wire with a soft iron core usually.

$F \propto IN$ where I is the current & N the no. of turns.

The E.M.U. of Current. is that current when flowing in ~~area~~ arc of 1 cm, radius 1 cm the field it produces at the centre of its curve is 1 gauss.

ie. in a loop r cm in radius. the magnetic intensity at the centre $= 2\pi r i/r$ gauss $= 2\pi i$ gauss

when a current of i E.M.U. is flowing.

1 E.M.U. of current = 10 ampères.

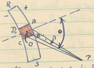
Equivalent Magnetic Shells.

These are extremely thin shells (virtual) magnetized in a direction perpendicular to the surface of the shell. They are magnetised to an equivalent value as that produced by a certain current flowing through the periphery of the shell.

The strength, ϕ is the magnetic moment per unit area.

$\phi = I \times V / a$

$= It$ where t is the thickness of the shell.



Let Δs be area of each face of element ABCD.

$\therefore$ the magnetism $= I.\Delta s$

$= \Delta m$ say.

The magnetic potential at P due to AB

$= \Delta m / (r - l\cos\theta)$

& that due to CD

$= -\Delta m / (r + l\cos\theta)$

where $2l = t$.

$$\therefore \Delta V_P = \Delta m \left[\frac{1}{r - l\cos\theta} - \frac{1}{r + l\cos\theta} \right]$$

Let $l/r \to 0$ where t & thus l is very small.

$$\Delta V_P = \frac{\Delta m . 2l\cos\theta}{r^2 + l^2\cos^2\theta}$$

$$= \Delta m . 2l \cos\theta / r^2$$

$$= I.\Delta s . t \cos\theta / r^2$$

$$= \phi \Delta s \cos\theta / r^2$$

but $\Delta s \cdot \cos\theta / r^2 = \Delta\omega$ where $\Delta\omega$ is the solid angle subtended by ABCD at P.

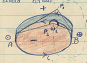
Hence $\Delta V_p = \phi . \Delta\omega$.

$\therefore \; V_p = \phi\,\omega$ where ω is the angle subtended by the shell at P.

Similarly on the other side of the shell

$$V_p = -\phi\,\omega.$$

The work done in carrying a unit +ve pole round a closed circuit.



Replace the circuit by an equivalent magnetic shell.

Consider P_1 & P_2 close to opposite faces of the shell.

$\therefore V_{p_1} = \varphi\,\omega_1$

" $V_{p_2} = -\varphi\,\omega_2$ where φ is the strength of the shell.

Hence the work done in taking the pole from P_2 to P_1 $= \varphi\omega_1 - (-\varphi\omega_2)$

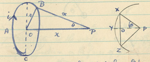
$= \varphi(\omega_1 + \omega_2)$

where the shell is so thin that P_1 & P_2 coinside.

$$\omega_1 + \omega_2 = 4\pi r^2 / r^2$$
$$= 4\pi.$$

$\therefore$ the work done $= 4\pi\,\varphi$.

The magnetic field due to a circular current at a point on it's axis.



$V_p = i\omega$ where ω is the solid angle subtended by AB at P.

$\omega = \Delta XYZ / XP^2.$

$= \Delta ABC\,(\text{spherical}) / x^2$

$= 2\pi x^2 (1 - \cos\theta)/x^2$

$= 2\pi(1 - \cos\theta)$

$= 2\pi\left(1 - x/(x^2+r^2)^{\frac{1}{2}}\right)$

The magnetic intensity at P

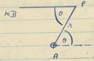
$= -dV/dx = 2\pi i\, r^2 / (r^2+x^2)^{\frac{3}{2}}$

The intensity at O is found by putting $x = 0$

$\therefore H = 2\pi i/a^2$.

The Magnetic field due to a linear current.

Let P be a point, r distant from an infinite wire carrying current i. Let the return wire be at infinity.



Θ
B

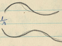
If $APC = \theta$.

$\omega = 2\theta$.

$\therefore V = 2i\theta$.

$\therefore H_p = -dV/d\theta \times \frac{1}{r}$

$= -2i/r$



Magnetic Field inside a long, straight solenoid.

Consider a solenoid having t turns per unit length & i be the current.

Then the circuit can be replaced by a magnetic shell.

$\varphi = i$ = Intensity of magnetisation per unit area.

$\therefore$ the magnetic moment I.

$= i \times \pi a^2$.

but the thickness of the shell $= 1/n$

$\therefore$ the pole strength $= \frac{M}{V} \times a$

$= m/\frac{1}{n}$

$= n\pi a^2 i$.

Let σ be the surface density of distribution of magnetism on the faces of the shells.

then $\sigma = ni$.

Consider P at the centre of the solenoid.

$H_p = 4\pi\sigma$ (Gauss's theorem)

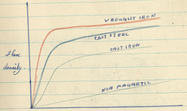
$= 4\pi ni$.

P is between two shells to apply this theorem.

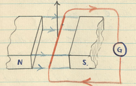
If P is in a shell, this shell must be split.

$\therefore H_p = \frac{4\pi i T}{l}$

where T is the total number of turns & l the length of the solenoid.



Action of a moving conductor in a magnetic field.

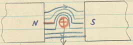


Changing of flux linkages causes an e.m.f. to be produced in the conductor. The direction of which is given by Fleming Right-Hand Rule

$E \propto \phi N$

This is the dynamo effect.

Action of a current in a magnetic field.



By interaction of the magnetic field of the conductor & the initial field, the conductor moves, the direction being given by Fleming left hand rule.
This is the motor effect.

Equations of the Magnetic Circuit.

Consider a Toroid with a core of permeability μ, mean radius r cms. & T turns & i e.m.u. of current flowing through it. & a the crossectional area.

$H = 4\pi i T / 2\pi r$

but $B = \mu H$.

$\therefore B = 4\pi \times iT\mu / 2\pi r$

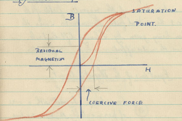
but. $\Phi = Ba$

$= 4\pi \times iT\mu a / 2\pi r$.

$= \dfrac{4\pi i T}{2\pi r / \mu a}$

Flux = Magneto-motive Force / Reluctance.

Hysteresis loop.



The demagnetisation of iron consists of applying a slowly decreasing magnetic field by AC. with a variable resistance in series.

Energy in a Magnetic Field.

Consider a toroid of cr. sec. area A. & n turns.

In δt secs $A\delta B$ lines of induction are set up

& there are $nA\delta B$ flux linkage changes.

$\therefore$ the back e.m.f. $= nA\,\delta B/\delta t$ e.m.u. of potential.

& the current against this is i

$\therefore$ the magnetic energy $= i\delta t \times nA\delta B/\delta t$ ergs.

now $H = 4\pi ni/l$

or $ni = lH/4\pi$

$\therefore$ the energy $= i\delta t\, nA\delta B/\delta t$

$= lH/4\pi \cdot A\delta B$ ergs.

lA is the volume of the field (or toroid)

$\therefore$ the energy $= 1/4\pi \int H\,dB$ ergs/unit c.c. vol.

$= \frac{1}{4\pi} \int \frac{B}{\mu}\,dB$

$= \frac{1}{4\pi\mu} \int B\,dB$.

$= \frac{1}{4\pi\mu} \times \frac{B^2}{2}$

$= B^2/8\pi\mu$ ergs per c.c.

or $\mu H^2 / 8\pi$ ergs cc^{-1}

grid or anode leads. In receiving gear the grid circuit is usually tuned & in transmitting, the ano circuit.

Magnetic Field in a Toroid.

Consider a unit +ve pole carried once round the magnetic circuit

The work done by the current in restoring the field = $2\pi r H$ ergs.

Each line of force cuts each turn once. * This is not true but the final effect is the same. (vide diagram)

∴ the no. of flux linkage changes

$= 4\pi n$

∴ the Back emf. $= 4\pi n/t$ where t is the time

∴ the work done $= \frac{4\pi n}{t} \times it.$

$= 4\pi n i$ ergs

or $= 2\pi r H$

hence $H = 4\pi n i / 2\pi r$

but $l = 2\pi r$

∴ $H = 4\pi n i / l$ gauss.

A solenoid is part of an infinite toroid so that this result applies to the centre of a solenoid but not the ends.

slowly decreasing magnetic field by AC. with a variable resistance in series.

+ve to the original bias.

cathode & Ia which was rising is reduced.

The fall of Ia allows the field of R.C. to partly collapse or change its direction of movement. The reverses the direction of induced current in L.C. & the grid becomes +ve. The +ve grid makes Ia rise again, the field, around R.C. grows & the initial action which made the grid negative repeats etc.

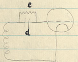
Each reversal of the feed back adds a little to the oscillatory current in L.C. until I^2R & other losses prevent further growth. When the oscillatory current has reached its max. value. it will continue to flow so long as the valve is in operation. The frequency of the current is governed by L&C. & if these are adjustable f may be controlled as desired.

An amount of power, almost but not quite equal to the amount of power available as feed back may be drawn from the circuit. for external use.

It matters not, from the production of oscillation point of view, whether the tuned circuit is connected in the grid or anode leads. In receiving gear the grid circuit is usually tuned & in transmitters, the anode circuit.

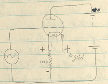
If grid current is permitted to flow (ie. if grid is operated at zero mean potential) it will damp the circuit L.C. To prevent Ig bias is applied to triodes by means of a battery or by means of the self biasing action of a "leaky grid condenser"

Self biasing by "leaky condenser"
When an oscillatory voltage is applied between grid & cathode of a triode Ig flows during each +ve cycle. The Ig may be utilised to provide self biasing.



The +ve potential attracts electrons from the cathode to the grid, these rush into & charge d in their efforts to return to the cathode. The charge in d sets up a P.D. between its plates so that the plate connected to the grid is -ve. This, of course, makes the grid -ve i.e. biases it. In the absence of leak e further applications of +ve potential (ie. more +ve half cycles) will result in a "piling up" the charge in d & increasing the bias until it equals the peak value of the input (ie. signal) ~~(the valve then)~~
The leak e allows the charge to leak slowly away, the rate of leakage is adjusted to maintain the mean value of bias slightly less than the peak value of the +ve half cycles so that each +ve "tip" maintains charge in d.
The bias is automatically adjusted to suit the conditions under which the valve is operating (ie if the amplitude of the oscillation in L.C changes the bias also changes)

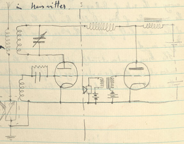
Cathode biasing.



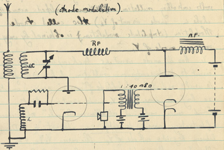
for A.F usually.

Oscillator in transmitter.

series Modulation



2 valve choke controlled transmitter.
(choke modulation).



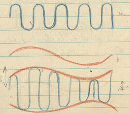


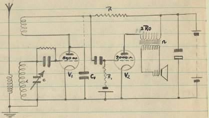
Fig 2

The circuit is of a practical transmitter using choke control (A.f. volts controlling oscillation amplitude are developed across Af. choke in anode circuit of V_2) Also called Anode Modulation (Amplitude modulation) is obtained by varying volts on anode of V_1

V_1 has its anode circuit L.C. back coupled to its grid circuit to produce continuous oscillation. which is transferred to aerial & radiated. Amplitude of "carrier" remains constant so long as current in V_2 anode circuit is constant.
Sound causes mechanical vibrations on the "mike" which causes a fluctuating current to supply an alternating P.D. between the grid & cathode of V_2. This varies $V_2 I_a$ & an alternating voltage appears across the A.F. choke.

When the alternating P.D. across Af. choke is +ve at anode end it adds to the H.T. volts. & amplitude of oscillation in LC is increased. Conversely when alternating P.D. is -ve at anode end. of A.f. choke it subtracts from supply volts & the L.C amplitude is decreased.
The wave in fig. 2. is a "carrier wave" or fundamental of f determined by L.C. constants & amplitude by H.T. volts on anode VI
The second wave fig 2 is the anode output of V_2 - this wave

is called the modulation & it may be of complex waveforms due to speech or music.
The third wave is a combination of carrier & modulation. This is the wave which is radiated. If the carrier amplitude is a & the A.f. amplitude is b the amplitude of the modulated wave varies between a-b & a+b
The wave may be resolved into 3 major components (Fourier's theorem). They are a+b, a, & a-b ie. the carrier; the carrier plus the upper side band & the carrier plus the lower sideband
a station radiating on a 1000 Kc/s with 5,000 c/s modulation. varies its f between 995 Kc/s & 1005 Kc/s. ie. a 10 Kc/s spread
The depth of modulation is b : a & percentage modulation is 100 b : a. The third curve shows 50% modulation. More than 100% modulation on speech is impossible as the transmitter output will be chopped.



$n = \sqrt{2R_o / S_p\ Coil\ Z}$

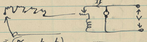
2 Valve receiver (0 - V - 1)

Signal on aerial induces circulatory current in LC. which varies in amplitude as does the modulation. The signal amplified by Q of L.C. (Subject to leaky grid damping) is applied between grid & cathode of 1st. valve. The bias developed by the leaky grid condenser will vary in sympathy with modulation (ie. the mean value of I_a will follow modulation) Both R.f. & A.f. are present in anode circuit of V_1 & after a portion of the R.f. has been used to provide feedback the R.f. is disposed of thro' C_1. The A.f. current develops A.f. volts across R. R is in parallel with R_1 ie the load of V_1 is between grid & cathode of V_2. V_2 amplifies volts developed across R & provides comparatively large current which is, of course, power for the operation of m/c. speaker.

Voltage control of generators.

Manual Control.

a Wire wound rheostat, usually stud type.

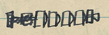


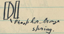
$E \propto \Phi$ (N constant).

$\therefore I_f \propto E$.

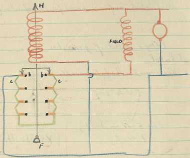
$V = R_f . I_f.$

b. Carbon Rheostat or Pile.





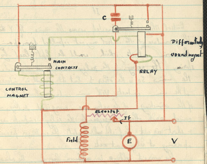
Automatic Voltage Control



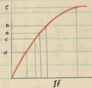
Carbon Pile Automatic Voltage regulator.

This type is simple & requires no attention. Field current can be controlled thru' a wide range. The control solenoid H connected across the generator actuates the lever F, which rocks two vertical stacks of carbon plates. The Carbon plates which rock about their centre have silver inserts b.b at the front & high resistance spacers at the back c.c.

Downward movement of the control lever rocks the stacks forward bringing the silver inserts progressively into contact. Until the resistance of the stack is practically reduced to zero & reverse movement rocks the plates backwards progressively seperating the inserts & increasing the resistance. The two stacks of plates connected in series or parallel are in series with the field circuit to be controlled. They will keep the generator voltage constant with in ±2%.



Tirrel Vibrating Relay Regulator.

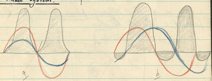


Control Magnet is connected across the mains. If V ~~rises~~ increases the armature of the control magnet is pulled down opening the main contacts, which would be kept closed by the spring. ~~The relay~~ ½ the relay winding is connected across the mains. So is the other ½ but its circuit is interrupted at the main contacts. With main contacts closed both halves of the winding of the relay are energised & they, magnetically cancel each other. Consequently the relay contacts are closed & short circuit the field rheostat. The condenser prevents sparking at relay contacts.

The correct voltage is as shown by a. The rheostat is set to 20° below normal at d. If V falls to c the main contacts close, the relay is demagnetised & relay contacts close, shorting the rheostat. ~~If~~ If rises quickly & V would rise to e. However when b is reached the main contacts open & the shunt is removed & V tends to e. The whole process repeats etc. so that V vibrates between b & c. This vibration is extremely quick & V is constant to ± 0·5 %.

Polyphase A.C. Systems.

3. Phase System.

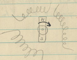


In a single phase system, the power absorbed varies as in a. If current & voltage are out of phase we have some negative power b.

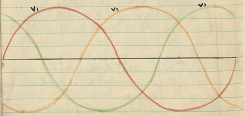
By using polyphase systems the periods of negative power can be eliminated & a greater ratio of power obtained

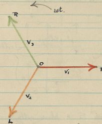
* Also 3 phase rectifiers have the advantage that the requisite smoothing circuits are simpler than in single phase circuits

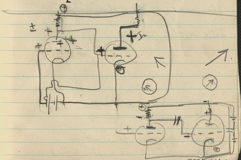
Three phase Alternator.



This type has three distinct windings on its stator, & the rotor produces equal alternating voltage in each of the windings. The winding are so arranged that the e.m.f. produced in any one of them differs in phase by 120° from the e.m.f.s produced in either of the others

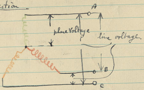






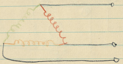
The three phases are connected in 2 ways.

1 Star Connection.



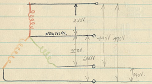
Line voltage = $\sqrt{3}$ × phase voltage.
Line current = [illegible] × phase current.

Delta or Mesh Connection.

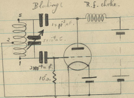


Line voltage = phase voltage
line current = $\sqrt{3}$ × phase current.

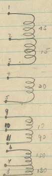
Three Phase 4-wire system



If voltage between line wires is 440 V. suitable for ~~line wires~~ motors then V between any line & neutral is 440/1.732V = 250V.



Hartley Oscillator



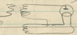
Join 3 & 4. Join short to H.T. –ve. 6,7,8, 9,10, 11

EXPT 21 to construct a Hartley oscillator using an HL2 (or equivalent valve) note change in Ia when s/c i the grid leak ii the RF choke. iii tuning condenser.

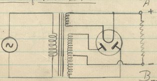
Note change of Ia as tuning C is varied. Draw Graph of Ia against C.

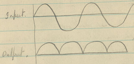
Mark "Onset of Squegging"

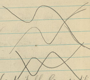
Feedback from anode to grid is via the common L.C. circuit – the blocking condenser is to prevent ~~H.T.~~ Ea shorting to cathode. the R.f. choke prevents the low internal R of the H.T. battery from shorting the valve as oscillator
the L is centre-tapped (i.e. Voltage node) so that it may be joined between grid & cathode without shorting either volt antinodes.
the grid condenser & leak provide auto-bias. note:– leak is rather high in value to deliberately cause "squegging."



Conversion of AC to D.C.

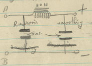




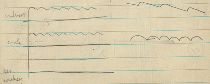


Full wave rectification

Smoothing. by Filter Circuit * (not suitable for a rectifier using gas filled valves)



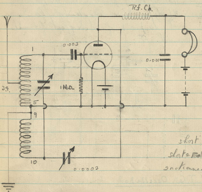
for gas filled valves use choke input — ie. omit smoothing Condenser



Comparison of Full & Half Wave Rectification

1A Full wave ≡ 2A half wave.

∴ I^2R losses (as in transformer) are less in full wave than in half wave rectifier.



short 10 & 11
short to Earth 6, 7, 8
2 not connected.

Expt 21. a. The Hartley as a transmitter with a simple series modulation.

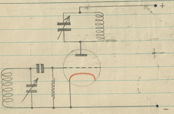
Receive on commercial set. $f = 1$ Mc/s $\lambda = 300$ m.

Expt 22. Reconstruct 21 as detector with reaction using modified Hartley circuit – using HL2 valve – note Ia as reaction C passes oscillation ~~valve~~ point.

22a Note effect of gridleak to LT +ve.

22b R.f. bypass to anode instead of phones.

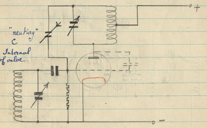
22c ariel to pin 1 of coil & effect of small C in series with AE.



T.P.T.G. Oscillator.

This functions by virtue of the internal capacitance of the valve (ie. Ca.g.) providing feed back.

It is essential that the anode voltage changes in a negative direction (sense) at the same instant as the grid changes in a positive sense. (E_a 180° out of phase with E_g) so that feed back will take place in the correct "sense". The anode circuit must be tuned to the same f. as the grid circuit.

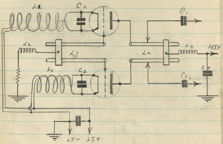


Tuned Anode circuit showing neutralising. (neuting.)

Extract Philips Tech Journal Vol. 2 No. 6.

"The Yagi aerial consists of a no. of parallel rods set up in one plane, which are coupled by the electromagnetic field with each other & with the dipole which is connected to the transmitter or receiver. The length of the rods & their mutual distances are determined experimentally so that max. amplification is obtained in the direction in which the rods are situated one behind the other. The sketch gives an example for $\lambda = 136$ cms.

The action consists briefly of this, that the I's from the correct direction induce such tensions in the various rods that the components caused thereby in the rods connected to the receiver are added. If a reflector rod is also introduced such as is indicated in the figure one obtains as a result that the ~~result~~ signal which now reaches the receiver has an amplitude greater than by a factor of 3.5 than if a single di-pole were used.



Circuit of 120 Mc/s Oscillator

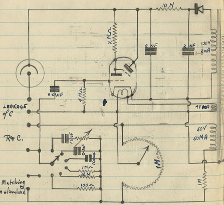
Lg & La are Lecher Tuning lines

L_1 is double wound $\lambda/4$ chokes

L_2 is $\lambda/4$ chokes

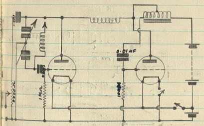
$C_2, _3, _4$ are Rf. By pass C's

C_1 is output Coupling C's.



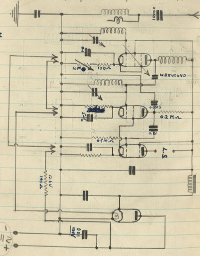
Circuit of R & C Bridge.

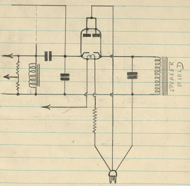
Signal Generator.



Circuit of Typical T.R.F. Universal Set.

35 M





Let r be ~~(the internal R of the)~~ apparent Res of R.

$$r = V^2 / I_a$$

$$= V_2 / V_g . g_m$$

$$= \frac{1}{g_m} . V_2 / V_g$$

$$= \frac{1}{g_m} . \frac{\mu R_c}{R_a + R_c}$$

$$= \frac{1}{g_m} . \frac{\mu R_c}{R_a g_m + R_c g_m}$$

$$= \frac{1}{g_m} . \frac{1}{\frac{R_a}{R_c} + \frac{R_c}{\mu}}$$

$$= \frac{1}{g_m} . \times \frac{g_m}{g_c + g_a}$$

$$= \frac{1}{g_c + \frac{\mu}{g_m}}$$

$$= \frac{g_m}{g_c . g_m + \mu}$$

$$= \frac{1}{g_c} + \frac{g_m}{\mu}$$

=

$\frac{g_m}{\mu} =$

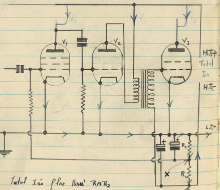
$\frac{\mu}{g_m} = R_0$

$R_a = \frac{E_a}{I_0}$

$g_m = \frac{I_g}{V_g}$

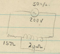
$\frac{E_g}{V_g} =$

Automatic biasing in Battery Sets.



Total I_a's flow thro' R_1 & R_2
Y is negative to L.T. – line.
Tapping for biasing are decoupled by large electro's
(12 V. 25 µF.)

I

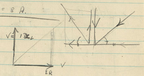


a =

b) $I = 200 / \sqrt{(R^2 + X^2)} = \frac{200}{\sqrt{625}} = \frac{200}{25}$

$= 8\ A.$

a)



a) $\tan\theta = X/R = 1.3\dot{3}$

$\theta = 53°.8'$

b) $I = 8\ A.$

c) $I_C = I_L$

i.e. $X_C = 25\ \Omega.$

i.e. $C = \frac{1}{400\pi\, 25}$

$\frac{10^4}{35\pi} =$

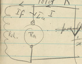
4.000
1.9971
1.5491
2.0412
1.9588

2   100 Ω   1 mA.   250 V   100 mA

Total R = $\frac{250}{1}$

= 250000

series R = 249,999 Ω.



total R = $\frac{0.1}{100} \times 1000$

= 1 ohm.

~~parallel R =~~

$\frac{1}{x} + \frac{1}{100} = 1$

$\frac{1}{x} = \frac{99}{100}$

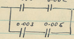
$x = 1.\frac{1}{99}$

$V = I_a R_a = I_f R_{sh}$

$I = I_a + I_{sh}$

$V =$

1



8   297 × 20

~~30.5~~

1000 V. 61

61) 5940.993

549

450

427

230

183

53

2   $\frac{300,000,000}{12,5000}$;   2.4 m.   ii.

i. $\lambda = 3 \times 10^8 / 125000 = 2400$ m

ii $\lambda = 20$ m.

---

a. = 1 MΩ   b. 500 μF.   c. 500 micro amps.

d. 200 millivolts   e. 5 henries.   f. 2 kilovolts.

15.	15
25	25
20	20
38	10
59	60
59	60
22	25
59	60

$\frac{216}{220} = 98.2\%$

216   19.6

$\frac{3}{10} \times \frac{54}{60} \times \frac{4}{10}$ $\frac{2}{5}$ 29.5

18   39.2

22 × ~~102~~ × $\frac{3}{\cancel{20}}$

practical. lab.

$\frac{108}{\cancel{216}} \times \frac{\cancel{102} \times 3}{\cancel{220}\ \ \cancel{10}}$ $\frac{66}{5}$

11   98.5 − 39   13.5

5) 29.5
11) 329

10.1
15.1
30.1
15.
30

39.
48
29.5
77.5
7.3
85.5
98.5
110.0

~~51.5~~
59.5
29.5
89.0

$(gc' - gc)(gm + ga + gc')$

$gc'gm + gc'ga + gc'^2$
$-gc\,gm - gc\,ga - gc'gc$

$$\frac{gm + ga + gc}{gc'gm + gc'ga + g} - \frac{1}{}$$

$$\frac{1}{gc' - gc}\left(\frac{gm + ga + gc'}{gm + ga + gc} - 1\right)$$

$$= \frac{1}{gc' - gc}\left(\frac{gm + ga + gc' - gm - ga - gc'}{gm + ga + gc}\right)$$

$$= \frac{1}{gm + ga + gc}$$

Q.E.D.

Let r be the apparent resistance of the cathode load

$V_k = Iar.$

$V.A.F. = V_k/V_1 = gm/gm + ga + gc.$

$= \frac{Iar}{V_g + V_k} = gm/gm + ga + gc.$

$= \frac{Iar}{V_g} = \frac{gm}{gm + ga + g_c} - 1$

$= \frac{gm - gm + ga + gc}{gm + ga + gc}$

$\therefore r = \frac{1}{gm + ga + g_c} - \frac{1}{gm}$

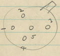
$= \frac{gm - (gm + g_a + g)}{gm(gm + g_a + g_c)}$

$= \frac{-ga + gc}{(gm^2 + ga + g_c)gm.}$

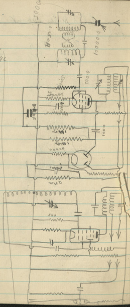
$=$

$$\left(\frac{gm+ga+gc}{gm+ga+gc'} - 1\right)\frac{1}{gc'-gc}$$

$$\frac{gm+ga+gc}{gmgc'+gagc'} - \frac{1}{gc'-gc}$$



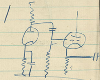
244 Leaks.
1 ~~grid~~ sidecontrol.
5 cathode,
1 or 5.
Top. anode
3 screen

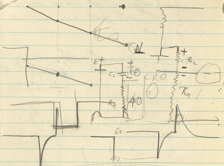


Oct. ~~M12~~ ~~T13~~ ~~W14~~ ~~Th15~~ ~~F16~~ ~~S17~~ ~~S18~~ ~~M19~~ ~~T20~~
~~W21~~ ~~Th22~~ ~~F23~~ ~~S24~~ ~~S25~~ ~~M26~~ ~~T27~~ W28
~~Th29~~ ~~F30~~ ~~S.31~~ no. interelectrode shorts.

Nov. ~~S.1~~ ~~M.2~~ ~~T3~~ ~~W4~~ ~~Th5~~ ~~F6~~
~~Sa7~~ ~~Su8~~ ~~M9~~ ~~T10~~ ~~W11~~ ~~Th12~~ ~~F13~~
~~S14~~ Su15 M16 T17 W18 THE DAY

B.O. C9 R. cut-off.
SY M'V. ASM/V. pentode line base.
~~-ve~~ feed back.



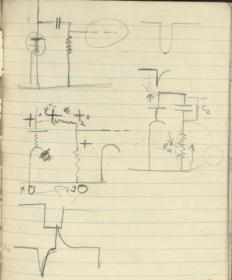


HT = 150

1) $E_a = 150V$ $C_2 = 90$ $R_4 = 60$

2) $E_a = 100$ $C_2 = 60$ $R_4 = 40$

3) $E_a = 150V$ $C_2 = 90$ $R_4 = 60$.



6 20 26 27
21