SUPPLEMENT

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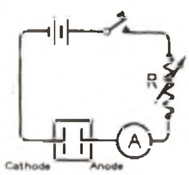
MAGNETISM AND ELECTRICITY: QUESTIONS AND ANSWERS.

Q. 1. Describe in detail an experiment to illustrate the principles of electrolysis, showing how the effect depends on the strength of the current and the time the current flows, and explain the terms " anode," " cathode," " electrode " and " electrolyte."

A. 1. " Electrolysis " is the splitting up of a substance into two components termed " ions " by means of an electric current. One ion has a positive and the other a negative charge. The substance is usually in the form of a solution termed the " electrolyte," and the current enters and leaves this electrolyte by means of two " electrodes." That by which the current enters is termed the " anode " and that by which it leaves the " cathode."

When the current flows, the positively charged ions flow to the cathode and the negatively charged ions to the anode, where they deliver their charges. Hence as a result of the passage of the current, the electrolyte is decomposed. The freed ions may then unite chemically with the electrodes or with the electrolyte.



The copper voltameter illustrates these principles, and consists of two copper electrodes immersed in a solution of copper sulphate ($CuSO_4$).

Current from a steady source is passed through the solution *via* the electrodes, and its action is to remove copper (Cu) from the solution and deposit it on the cathode. The negatively charged (SO_4) ions liberated at the anode, however, dissolve off an equal amount of copper, and the electrolyte consequently remains unchanged, the result being a transfer of copper from the anode to the cathode.

If a quantitative experiment is performed by carefully weighing the cathode and then passing a known current for a fixed time, the amount of copper deposited per ampere per second can be found. If several experiments with different current values are made, it will be seen that the amount of copper deposited is directly proportional to

(*a*) the value of the current,
(*b*) the time during which the current flows.

The quantity deposited for unit quantity of electricity is therefore constant, and is termed the " electro chemical equivalent." For copper its value is .00034gm. per coulomb.

Q. 2. Explain, by formula or otherwise, the relation between the dimensions of a conducting wire and its electrical resistance.

A copper tube, 100 metres in length, has an internal diameter of 2.5 cm. and a wall thickness of 2 mm. If the specific resistance of copper is 1.7 microhms per cm. cube, what is the resistance of the tube?

A. 2. The electrical resistance of a uniform conductor is directly proportional to its length, and inversely proportional to its cross sectional area.

The resistance of the copper tube will therefore be $\frac{\rho l}{a}$ ohms,

where l is the length in cm.

a is the cross-sectional area in sq. cm.

ρ is the " specific resistance " of copper in ohms per cm. cube.

$$\therefore \quad R = \frac{1.7 \times 10^{-6} \times 100 \times 100}{(1.27^2 - 1.25^2)\pi}$$

$$= \frac{1.7 \times 10^{-2}}{(1.27 - 1.25)(1.27 + 1.25)\pi}$$

$$= \frac{1.7 \times 10^{-2}}{0.02 \times 2.52 \times \pi}$$

$$= \frac{1.7}{2 \times 2.52 \times 3.142} = 0.108 \text{ ohms.}$$

Resistance of Tube = 0.108 ohms.

Q. 3. Explain the term " dielectric constant." What is the effect on the capacitance of placing a sheet of mica between two parallel insulated plates? What quantity of electricity will produce a difference of potential of 200 volts between the plates of a condenser of 5 microfarads? Compare the capacitances of two condensers, one having two circular plates 4 centimetres diameter and ½ millimetre apart, and the other having two square plates 5 centimetres each side and ¾ millimetre apart.

A. 3. (*a*) The dielectric constant of a substance is the ratio between the capacitances of two condensers of the same dimensions, one with the substance and the other with air as a dielectric.

(*b*) Since all solid insulators have a dielectric constant greater than unity, the capacitance will be increased when mica is substituted for air.

(*c*) The quantity of electricity is given by

$$Q = CE,$$

where Q is the charge in coulombs, C the capacitance in farads, and E the potential in volts.

In the example,

$$Q = 5 \times 10^{-6} \times 200$$
$$= 1000 \times 10^{-6}$$

Answer = 1000 micro-coulombs.

(*d*) The capacitance of a condenser is directly proportional to the area of the plates and inversely proportional to the distance between them. Therefore

$$\frac{C_1}{C_2} = \frac{A_1}{A_2} \cdot \frac{d_2}{d_1}$$

where C_1, C_2 are the respective capacitances

A_1, A_2 are the respective plate areas

d_1, d_2 are the respective distances between the plates.

$$= \frac{2^2.\pi \times 0.075}{5^2 \times 0.05}$$

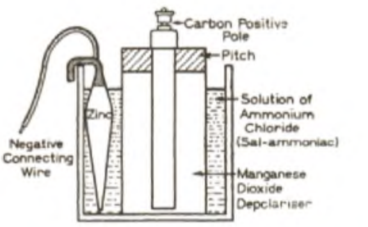
$$= \frac{4\pi \times 1.5}{25} = 0.754$$

i.e., Ratio = 3 : 4 approximately.

Q. 4. What is meant by the terms " polarization " and " internal resistance of a cell "? Describe, with a sketch, the construction and action of a simple cell using a depolarizing agent.

A. 4. " Polarization " in a primary cell is the falling off in voltage and increase in internal resistance due to hydrogen being liberated at the positive pole at such a rate that the depolarizing agent cannot act quickly enough. The film of hydrogen keeps the electrolyte from the positive pole thus increasing the internal resistance. As hydrogen is at a higher potential than the negative electrode, it also sets up a " back E.M.F." thereby reducing the voltage.

" Internal Resistance " is the resistance offered to the passage of current through a cell by virtue of the poor conductivity of the chemical constituents. It will therefore vary with the shape and size of the poles, and the quantity and quality of the electrolyte and depolarizing agent.



The Leclanché cell has positive and negative poles of carbon and zinc respectively. The electrolyte is a solution of sal-ammoniac and is contained in a glass or earthenware vessel.

The negative pole consists of a zinc rod amalgamated with mercury and immersed in the electrolyte.

The carbon positive pole is either a circular rod or a flat plate, round which is tightly packed the depolarizing agent. The latter consists of manganese dioxide, mixed with powdered carbon to improve its conductivity. The whole is enclosed in a cloth or porous earthenware container sealed with pitch, and is placed in the solution. When the circuit is closed the sal-ammoniac acts on the zinc, zinc chloride and ammonia are formed, and dissolved in the solution, and hydrogen is liberated. The hydrogen combines with the manganese dioxide, forming water and manganese sesquioxide.

Q. 5. Define " intensity of a magnetic field." A bar magnet having a pole strength of 500 units has its poles 8 cm. apart. What is the intensity of the magnetic field at a point 20 cm. away from the centre of the magnet and in line with the axis of the magnet?

A. 5. The intensity of a magnetic field at any point is the force in dynes which it would exert on a unit north pole at that point. The unit is the gauss, or one line of force per square centimetre.

The intensity of a magnetic field is directly proportional to the pole strength of the magnet and inversely proportional to the square of the distance from the pole.

In the case of a bar magnet the intensity of the field at any point is the difference between the fields due to the N and S poles respectively, *i.e.*, if AB is the magnet, C is the centre point, and P the point 20 cm. away.

$$\text{Intensity of field at P} = \frac{500}{16^2} - \frac{500}{24^2}$$

$$= 500\left[\frac{1}{16^2} - \frac{1}{24^2}\right]$$

$$= 500\left[\frac{1}{16} + \frac{1}{24}\right]\left[\frac{1}{16} - \frac{1}{24}\right]$$

$$= \frac{500.5}{48.48}$$

$$= \left(\frac{50}{48}\right)^2$$

$$= (1.04)^2$$

Answer = 1.08 gauss.

Q. 6. A battery of 100 volts and internal resistance of 1 ohm is connected across an external resistance of 10 ohms. What would be the change of voltage across this resistance if a second resistance of equal value is connected in parallel?

What power would be drawn from the supply in the second case?

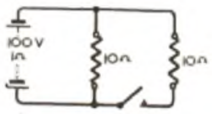
A. 6. The current in the first case will be

$$I = \frac{E}{R} = \frac{100}{10 + 1} = \frac{100}{11} \text{ amps.}$$

The P.D. across the resistance = IR

$$= \frac{100}{11} \times 10$$

$$= \frac{1000}{11} \text{ volts.}$$



When the second resistance is connected, the combined external resistance is reduced to 5 ohms, and the current is consequently increased to

$$\frac{100}{5 + 1} = \frac{100}{6} \text{ amps.}$$

$$\text{The new P.D. will be } 5 \times \frac{100}{6} = \frac{500}{6} \text{ volts.}$$

The change in voltage is, therefore,

$$\frac{1000}{11} - \frac{500}{6} = 1000\left(\frac{1}{11} - \frac{1}{12}\right)$$

$$= \frac{1000}{132}$$

$$= 7.58 \text{ volts.}$$

The power expended in the external resistance is I^2R watts,

$$\text{and is equal to } \left(\frac{100}{6}\right)^2 \times 5.$$

$$= \frac{50000}{36}$$

$$= 1390 \text{ watts, or } 1.39 \text{ kilowatts.}$$

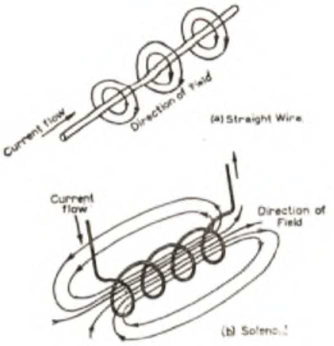
Answers = 7.58 volts and 1.39 kilowatts.

Q. 7. Sketch the magnetic field resulting from the passage of a direct current through (a) a straight wire, (b) a solenoid.

On what factors does the intensity of the field depend in the latter case?

How would the field in the solenoid be affected by the introduction of a soft iron core and, in this case, how would the intensity of the field vary with the strength of current flowing in the coil?

A. 7. The following sketches show the magnetic field of a direct current in (a) a straight wire and (b) a solenoid.



The intensity of the field in the solenoid depends directly on the magneto-motive-force and inversely on the reluctance. The former is proportional to the current and the number of turns while the latter depends directly upon the length of the magnetic circuit and inversely upon the cross-sectional area and the permeability of the magnetic circuit.

The introduction of a soft iron core into the solenoid would greatly increase the intensity of the field, due to the low reluctance of iron compared with air. The intensity would be roughly proportional to the current flow until the iron became saturated, when the rate of increase in intensity would drop and become more nearly equal to its value with an air core.

Q. 8. State what is meant by the " angle of magnetic dip." How would you proceed to measure this angle? With the aid of a sketch, describe " astatic needles " and state for what purpose they are used.

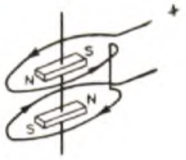
A. 8. The angle of magnetic dip is the angle made by the magnetic lines of force of the earth's field with the horizontal.

It is measured by means of an instrument called the " Dip Circle," which consists of a magnetized needle free to move on a horizontal axis. The instrument is carefully levelled and adjusted so that the plane of the needle lies in the magnetic meridian. This is best accomplished by turning the instrument until the needle is vertical, and then rotating it through a further 90°. The angle of dip is indicated by the ends of the needle on a vertical circular scale marked in degrees, and to eliminate errors due to incorrect balance, out-of-centre suspension, and the possibility of the centre of gravity lying off the magnetic axis, sets of readings are taken as follows :—

(1) both ends of the needle

(2) the same, after turning needle over on axis.

The needle is then re-magnetized in the reverse direction, (1) and (2) are repeated and the mean value of the eight readings calculated.



Astatic needles consist of a pair of small magnets similar in size, shape, and magnetic properties, mounted rigidly on a suspension with their poles in opposition, and adjusted so that the resultant effect of any external magnetic field is extremely small.

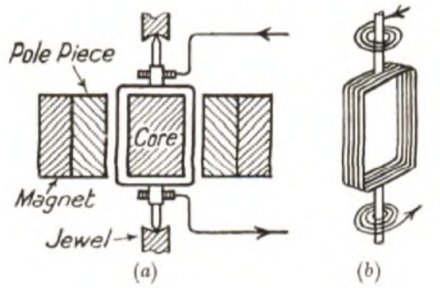
Such a combination will only be affected by a magnetic field confined to one of the pair, and this is arranged by enclosing each magnet in its own coil. The result is a very sensitive movement, as the controlling torque can be made as small as desired. Astatic pairs are used as the moving system in galvanometers for detecting extremely small currents.

Q. 9. Describe, with sketches, the construction and action of a moving coil voltmeter. How can such an instrument be adapted to measure a wide range of voltages?

A. 9. A moving coil voltmeter consists essentially of a fixed permanent magnet, in the field of which is suspended a light framework carrying the current coil. The movement of the latter is controlled by spiral springs and indicates by means of a pointer the value of the applied voltage.

The magnetic circuit is shown in sketch (a).

The pole pieces and cylindrical core are of soft iron, and are positioned so as to provide a continuous air gap, in which the coil is suspended on jewelled pivots coaxial with the soft iron cylinder. The moving coil is shown in sketch (b). The rectangular coil former is usually made of aluminium, and the spiral springs near the pivots maintain the coil in the zero position when no current is flowing. They also provide the



controlling torque for the instrument, and serve to make the electrical connexions to the coil. As the magnetic field is arranged to be constant throughout the air gap, the deflexion caused by the interaction of the fields due to the permanent magnet and the current in the coil is proportional to the latter. Currents are induced in the aluminium former when the latter moves in the magnetic field, and these serve to damp the vibration of the coil, allowing the pointer to indicate the correct voltage without over-swinging.

The moving coil is connected in series with a fixed resistance of considerable value, which will permit the correct current to flow to give a full scale deflexion when the maximum voltage it is desired to measure is applied to the terminals. Owing to the linear relation between the deflexion and the current value, the instrument will have a resistance of " x " ohms per volt of full scale deflexion. By increasing the series resistance, therefore, to the appropriate value, the instrument may be adapted to read any range of voltage.

Q. 10. A battery of 129 volts is connected across a copper wire 10 ft. long which is made up of three sections. The first section is 6 ft. long and 1/10th in. in diameter; the second section is 3 ft. long and 1/20th in. in diameter; and the third section 1 ft. long and 1/50th in. in diameter. What would be the voltage drop across each section of the wire?

A. 10. The resistance of each portion of the circuit will be equal to $\frac{\rho l}{a}$

where l = length in inches

a = cross-sectional area in square inches

ρ = specific resistance in ohms per inch cube.

As the same current passes through each portion, the voltage drop across each will be proportional to its resistance.

$$\therefore\ V_1 : V_2 : V_3 = \frac{6 \times 12\rho}{\left(\frac{1}{10}\right)^2 \pi/4} : \frac{3 \times 12\rho}{\left(\frac{1}{20}\right)^2 \pi/4} : \frac{1 \times 12\rho}{\left(\frac{1}{50}\right)^2 \pi/4}$$

$$= 6 \times 10^2 : 3 \times 20^2 : 1 \times 50^2$$

$$= 600 : 1200 : 2500$$

$$= 6 : 12 : 25$$

The sum of these is 43, or

The respective voltages are therefore

$$V_1 = \frac{6}{43} \times 129 = 18$$

$$V_2 = \frac{12}{43} \times 129 = 36$$

$$\text{and } V_3 = \frac{25}{43} \times 129 = 75.$$

Answer = 18, 36 and 75 volts.

Q. 11. *Describe briefly a simple method of producing an alternating current.*

Describe the comparative effects of passing (a) an alternating current, (b) a direct current through—

(i) *the coil of a tangent galvanometer,*

(ii) *a wire of high resistance.*

Give brief reasons for your answers.

A. 11. An alternating current may be produced by rotating a coil of wire between the poles of a magnet, and taking connexions from the ends of the wire, by means of slip rings, to an external circuit. If the coil is wound on an iron core, the effect will be more pronounced, and the conductors should move on an axis at right angles to the magnetic lines of force for maximum current to be generated.

(i) (*a*) An alternating current will cause the needle to make small or imperceptible vibrations about its normal position. The needle tries to swing alternately to the E and W, in response to the changes in direction of the current, but these are too rapid to allow the needle to move an appreciable distance in the time taken for half a cycle of current.

(i) (*b*) A direct current will cause the needle to deflect towards the E or W, depending on the direction of the current. This is due to the magnet pointing in the direction of the resultant magnetic field produced by the earth and the current in the coil.

(ii) (*a* & *b*) The wire will get hot due to the dissipation of energy at a rate of I^2R watts per second. As the effect is dependent on the square of the current, the direction of the latter is immaterial, since the square is always positive. The alternating and direct currents have, therefore, similar effects, if the R.M.S. value of the alternating current is equal to the value of the direct current.

Q. 12. *Direct currents of equal value are passed through two simple circuits of equal resistance. When the current in one circuit is suddenly interrupted, by means of a switch, heavy sparking is observed to take place at the switch contacts as these are separated. In the other circuit, practically no sparking is observed when the switch is opened. What is the difference between the two circuits which accounts for these effects, and what causes the sparking in the case of the first circuit?*

A. 12. The circuit in which sparking takes place contains inductance as well as resistance. The sparking is caused by an E.M.F. which is induced at the moment of breaking the circuit, and which momentarily overcomes the resistance of the air gap at the switch blades, causing a current to flow across them.

This induced E.M.F. always occurs during the collapse of a magnetic field in the presence of a conductor, and it is the association of an electro-magnetic flux with a conductor which gives a circuit the property of inductance.

When the current is cut off, the flux decreases to zero, and in doing so cuts the conductors of the coil, or part of the circuit, by which it was produced. An E.M.F. is thereby induced, whose strength is proportional to the flux, and to the number of conductors linked with it.

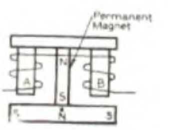
It is termed the E.M.F. of self induction, and is in the same direction as the E.M.F. which produced the original current.

TELEPHONY—PRELIMINARY. QUESTIONS AND ANSWERS.

Q. 1. *Describe, with the aid of a sketch, the effect of passing a cycle of ringing current through the coils of a magneto bell.*

Why does the bell have little shunting effect on speech currents when it is connected across a telephone circuit during conversation? (12).

A. 1. The sketch shows a skeleton diagram of the coils and magnetic circuit of a magneto bell. During one half cycle of ringing current the cores A and B are magnetized so that A has a north pole and B a south. A will therefore attract and B repel the armature, the ends of which have a south polarity due to the permanent magnet. During the next half cycle the position is reversed: A has south polarity and therefore repels the armature and B has north polarity and attracts the armature.



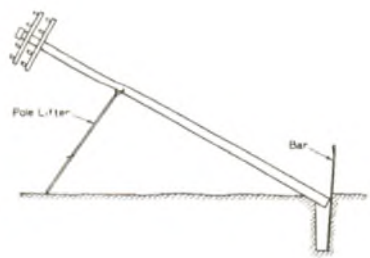
Thus the armature is alternately attracted and repelled by each core and vibrates, causing the hammer which it carries to strike the gongs.

The bell has very little shunting effect on speech currents when it is connected across the line during conversation as its impedance at speech frequencies is very high, due to the large number of turns on its windings and the low reluctance of the magnetic circuit.

Q. 2. *A light 30 ft. pole is to be erected at the side of a country road. Describe, and illustrate with sketches, the tools and methods which would be employed for the work, including the necessary excavation, in a typical case.* (12).

A. 2. If the pole is to be erected in the grass verge of a country road the hole should be excavated by the bar and spoon method. The bar is a rod of iron about six feet long with a point at one end and the other end flattened. The spoon is a cup shaped tool mounted at the end of a six foot pole. The bar is used to loosen the earth which is then lifted out by the spoon.

While the excavation is proceeding the work of cutting the notches for the arms is carried out, the arms fitted, the pole roof fixed, and the earth wire run.



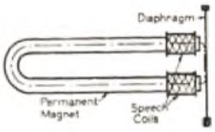
All members of the party then assist in placing the pole in position. The bar is left against the side of the hole to help to guide the butt of the pole With the butt against the bar the pole is raised by means of a ladder or pole lifter and slides into the hole. The earth round the butt of the pole is then tamped

firmly home with the flat end of the bar. The sketches illustrate the bar and spoon used and the general method of lifting the pole into position.

Q. 3. Explain how a bell receiver, when used as a transmitter, is able to generate speech currents.

Why are better results obtained with a carbon granule transmitter? (12).

A. 3. The dotted line in the sketch illustrates the magnetic circuit of a bell receiver, the reluctance of which is almost entirely contained in the two air gaps between the poles of the permanent magnet and the diaphragm. As the diaphragm vibrates due to speech currents, the magnitude of these air gaps fluctuates and consequently the magnetic flux is correspondingly varied.



The variations in flux change the linkage with the windings of the speech coils and therefore induce in them alternating currents of speech frequency. Thus the bell receiver can be used as a transmitter.

As, however, the total magnetic flux due to the permanent magnet and the movement of the diaphragm are both small, the variation in flux and consequently the induced E.M.F. in the coils are also small. The receiver does not therefore make a very effective transmitter.

The carbon transmitter is used to overcome this difficulty for its principle of controlling the variations in a current already flowing through it, instead of generating the current, enables the transmitted energy to be independent of and much greater than the directing sound energy.

Q. 4. A battery giving a constant terminal P.D. of 80 volts and a voltmeter of 200,000 ohms resistance are used in making a "wire to earth" insulation test on one wire of a telephone line 5 miles in length. If a reading of 25 volts is obtained, what is the insulation resistance of the wire in megohms per mile?

Give a sketch of the connexions, and show how any formula that you have employed is derived from Ohm's Law.

How would a stray current on the line affect the result and what correction would you make for it? (12).

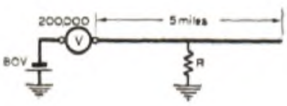
A. 4. Current required for full scale deflexion of voltmeter

$$= \frac{E}{R} = \frac{80}{200{,}000}$$

$$= 0.4 \text{ milliamps}$$

$\therefore$ Current required for 25 v. deflexion $= \frac{25}{80} \times 0.4$ m.a.

$$= .125 \text{ m.a.}$$



Then

$$I = \frac{E}{R}$$

$$\text{i.e.,} \quad .125 \times 10^{-3} = \frac{80}{R + 200{,}000}$$

$$R \times .125 \times 10^{-3} = 80 - 200{,}000 \times .125 \times 10^{-3}$$

$$= 80 - 25$$

$$R = \frac{55}{.125} \times 10^{3}$$

$$= \underline{440{,}000 \text{ ohms}}$$

Then insulation resistance per mile $= 5 \times 440{,}000$

$$= \underline{2.2 \text{ megohms}}$$

If there were a stray current on the line it would render the result valueless unless its value were added to or subtracted from that calculated from the voltmeter deflexion, according to whether the current were opposing or assisting the current from the testing battery. This is ascertained by connecting an earthed voltmeter to the line and noting the magnitude and direction of the deflexion obtained. This reading must then be added to or subtracted from the reading obtained when the earth connexion of the voltmeter is replaced by the 80 volt battery.

Q. 5. Describe the procedure adopted in preparing for and making a straight-through joint between two lengths of paper core cable of the star quad type, each cable containing about 100 pairs of 10 lb. conductors. (12).

A. 5. A tent is first erected over the joint box (or if the cable is in a manhole a guard is placed round the entrance) and the box dried out. The cables are then cut and the lead sheath removed to leave approximately 18 ins. overlap. A lead sheath is passed over one of the cables and pushed up the pipe so as not to impede operations. In each cable the wires are separated, tied up in half layers and bent back. The jointing is then commenced, starting with the lower wires in the outside layer and working up. Each wire of each quad is connected to the corresponding wire of the corresponding quad in the next section of cable. Each two wires to be joined are first given three or four twists in a length of ½ in. with the paper insulation intact. The paper is then removed as far as this twist and the conductors cleaned and twisted together by the crank handle method. The surplus wire is cut away leaving 1⅛ ins. of twisted conductor. Paper sleeves which have previously been dried are then slipped over the joint and the joint bent back parallel with the cable.

Joints between the different pairs are staggered so that the whole joint is of uniform thickness. The wires are dried either by a charcoal brazier, or, when there is any risk of explosion, by means of Silica Gel and the joint wrapped with paper, over which the lead sleeve is slid back. The joint is completed by wiping the sleeve to the cable on either side with plumber's joints. During this process a small hole is left in the sleeve so that any remaining traces of moisture which may be left in the joint will be expelled. This hole is finally covered by a patch wipe.

The joint is then tested under pressure. Air is pumped into the cable through the open end, or through a nozzle fitted in the sleeve, and the joints tested by smearing soap-suds over the wipes. Should any flaw be discovered the wiped joint is entirely re-made.

Q. 6. What are the factors which determine the direction and the magnitude of the induced electromotive force at any instant in each of the windings of the induction coil in a local battery telephone when the resistance of the transmitter is varying?

State the reasons for using an induction coil in a local battery telephone. (12).

A. 6. The induced E.M.F. in either winding is proportional to the flux cut per second, and the rate of change of flux is proportional to the number of turns on the primary winding times the rate of change of primary current. The induced E.M.F. in the primary of the induction coil is therefore proportional to the square of the number of turns on the primary winding and to the rate of change of primary current.

As the same flux links with the secondary winding the E.M.F. induced in this circuit is proportional to the product of the number of turns on the secondary winding and the rate of change of this flux.

In both cases the direction of the induced E.M.F. is such that it tends to oppose any change in the current flowing, *i.e.*, if the current is rising the induced E.M.F. is in the reverse direction to the applied E.M.F. and *vice versa*.

The use of the induction coil in a local battery instrument is best illustrated by the following example.

If a transmitter of 60 ohms resistance were connected in series with a circuit having a total resistance of 600 ohms, a 10% variation in transmitter resistance due to the speech waves, would produce only a 1% variation in the total resistance and therefore in the current flowing. If, however, an induction coil be used with a 1 ohm resistance primary winding in series with a battery and the transmitter, then the variation in current is approximately the 10% maximum obtainable. Furthermore, as the number of turns on the secondary winding is three times that of the primary, the line voltage is correspondingly increased resulting in a lower I^2R loss in the line.

Q. 7. Four primary cells arranged in series, each having an electro-motive force of 1.5 volts, and an internal resistance of 0.5 ohm, are connected to an external resistance of 28 ohms. If one of the cells were reversed, what would be the reading on a voltmeter connected across this cell? (12).

A.7. E.M.F. $= (3 - 1) \times 1.5$

$= 3$ volts

Total Resistance $= 28 + 4 \times 0.5$

$= 30$ ohms

Current $= \frac{3}{30} = 0.1$ amp

$\therefore$ P.D. across 0.5 ohm $= 0.1 \times 0.5$

$= 0.05$ volt

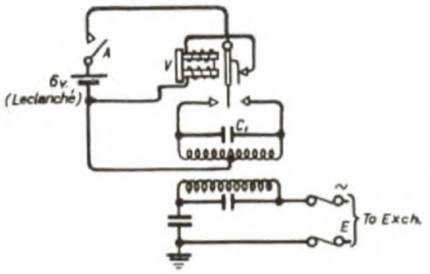
i.e. Total P.D. across reversed cell

$= 1.5 + 0.05$

$= 1.55$ volts

Q. 8. Explain, with the aid of a diagram, how an alternating current is produced by means of a "ringing vibrator." (12).

A. 8. When any circuit requiring ringing current is taken into use, a relay is operated which closes the contact A in the diagram. Current from the 6 v. battery then flows through



the windings of the vibrator and causes the reed to be attracted to the core, breaking the circuit of the vibrator coils. The reed is therefore released, the coil circuit remade and the cycle of operations repeated. This trembler bell action continues as long as the relay contact A is made.

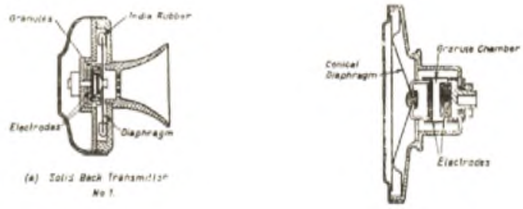
Each time the reed is attracted and released it also causes a current to flow alternately in the two halves of the primary winding of the transformer. As the direction of the current is thus changed at every half cycle of the reed vibration, an alternating E.M.F. is induced in the secondary winding.

The effect of the condenser C1 is to improve the wave form of the induced current. Each time the reed leaves one contact for the other the condenser discharges and tends to maintain the previous current. The change from one direction of flow to the other is thus less sudden and, by the selection of suitable values of inductance and capacitance, the induced E.M.F. can be made fairly smooth. The condensers in the secondary circuit are also inserted for smoothing purposes.

Q. 9. What are the advantages of the type of transmitter used in modern hand microtelephones as compared with the solid back type, and how are they obtained? Give explanatory sketches. (12).

A. 9. The advantages of the Inset Transmitter No. 10 used in modern hand microtelephones over the old solid back type are that it responds to a far greater range of frequencies, has a more uniform output over the frequency range and can be used in any position.

The solid back transmitter, due to its design with a bell shaped mouthpiece and a flat, circular diaphragm supported at the edge and loaded at the centre, has a very uneven frequency-response curve with marked peaks at 1,000 and 1,500 cycles per second. Furthermore, the shape of the granule chamber is such that the granules are liable to pack unless the transmitter is kept at the correct angle.



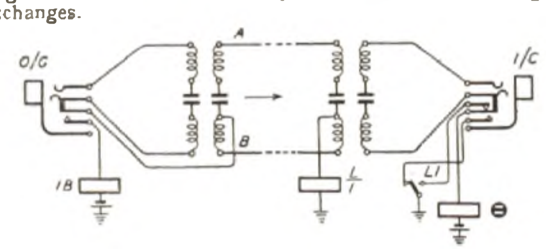
(a) Solid Back Transmitter No 1.

(b) Inset Transmitter No 10

In the design of the Inset No. 10 the shape of the mouthpiece has been redesigned and the flat diaphragm replaced by a conical one. The granule chamber is also different, the moving carbon electrode being in effect a piston moving in a cylinder filled with the granules. These changes in design have flattened and increased the range of the frequency response curve, and the almost complete immersion of the electrodes in the granules allows the transmitter to function satisfactorily in any position.

Q. 10. Give a diagram and an explanation of circuit arrangements which afford battery signalling facilities over a one-way junction between two magneto exchanges. (12).

A. 10. The sketch illustrates the principle of battery signalling used on a unidirectional junction between two magneto exchanges.



At the outgoing end the insertion of a plug causes battery *via* the coil IB to be applied to the B wire of the junction. This operates relay L at the incoming end and L1 actuates the calling indicator. When the operator answers, the insertion of the plug in the answering jack releases the calling indicator.

At the completion of conversation the A operator receives the clearing signal from the local subscriber and clears the junction, releasing relay L. Contact L1 releasing completes the circuit of the indicator *via* the contacts of the answering jack. The clear is thus passed forward to the B operator who clears her connexion.

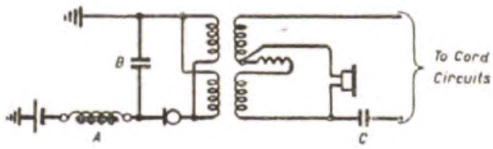
Q. 11. State the reasons for providing each of the following in the operator's telephone circuit at a central battery exchange:—

(a) an impedance coil in series with the transmitter,

(b) a condenser bridged across the transmitter and the primary windings of the induction coil,

(c) a condenser in series with the secondary circuit. (14).

A. 11. The sketch shows the operator's telephone circuit at a C.B. exchange.



(*a*) The impedance coil (A) in series with the transmitter is provided as a choke in the battery feed in order to eliminate battery noises and to prevent interference with other circuits.

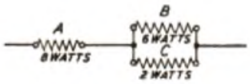
It also serves to reduce the voltage applied to the transmitter to the requisite value.

(*b*) The condenser (B) bridged across the primary of the induction coil and the transmitter provides a low impedance path for the speech current fluctuations in the primary circuit and also assists the inductance (A) in smoothing out battery variations of potential.

(*c*) The condenser (C) in series with the leads to the speaking keys is provided to prevent current from the cord circuits flowing through the operator's receiver and it also provides an important function in connexion with the engaged test as follows:—When a speaking key is thrown earth and battery from the cord circuit tip and ring wires charge the condenser C, if now the tip of the calling plug is tapped on the sleeve of an engaged jack the battery potential thus encountered will partially short circuit the condenser and the resulting discharge will cause a click in the operator's receiver, denoting to her that the circuit is engaged.

Q. 12. *A resistance A is connected in series with parallel resistances B and C, and the combination is joined to the terminals of a 40-volt battery. If the watts dissipated in A, B and C are 8, 6 and 2, respectively, what are the individual values of the resistances?* (14).

A. 12. As the watts dissipated in A are equal to the combined wattage dissipated by the parallel resistances B and C, the resistance of B and C in parallel is the same as that of A, therefore the P.D. across A equals the P.D. across B and C, *i.e.*, both equal 20 volts.



$$\text{Then Watts} = \frac{E^2}{R}$$

$$\textit{i.e.}\quad \text{Watts in A} = \frac{20^2}{R_A} = 8$$

$$R_A = \frac{20^2}{8}$$

$$= \underline{50 \text{ ohms}}$$

Similarly

$$\text{Watts in B} = \frac{20^2}{R_B} = 6$$

$$R_B = \frac{20^2}{6}$$

$$= \underline{66\tfrac{2}{3} \text{ ohms}}$$

$$\text{And Watts in C} = \frac{20^2}{R_C} = 2$$

$$R_C = \frac{20^2}{2}$$

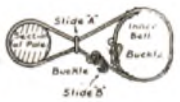
$$= \underline{200 \text{ ohms}}$$

Answer—50 ohms, $66\frac{2}{3}$ ohms, 200 ohms

TELEGRAPHY, GRADE I.: QUESTIONS AND ANSWERS.

Q. 1. (*a*) *Make a neat sketch of a lineman's safety belt.*
(*b*) *Draw a sectional view of a leading-in insulator.* (12).

A. 1.

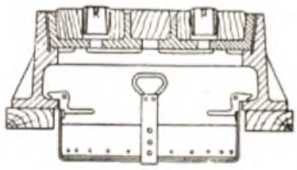


(*a*) Lineman's Safety Belt.

(*b*) Leading-in Insulator.

Q. 2. *Sketch and describe the construction of a roadway manhole frame and cover.*
How are manholes ventilated, and what is the object of providing ventilation? (12).

A. 2. A typical ventilated carriageway manhole frame and cover is illustrated in the sectional sketch below.



The *frame* consists of a hollow cylindrical iron casting, with a large bottom flange which serves to distribute the weight of passing road traffic on to wooden blocks supported on the roof of the manhole. In addition, an internal lipped flange, at approximately half the depth of the frame is provided to form a support for the manhole cover. External webs are provided as indicated in the sketch for strengthening purposes.

The *cover* consists of a circular iron frame with radial ⊥ shaped webs, durable wooden blocks being inset between these webs and holes are provided for ventilating purposes.

The construction of both frame and cover is such, that a good factor of safety is given under the heaviest load, road traffic.

The method of ventilating manholes is determined by the type of manhole and its location. In the case of carriageway manholes, ventilation is obtained by the use of a grid type of cover.

A number of holes are provided in the manhole cover through which air can circulate freely. The total ventilation area provided by the grid is approximately 22 sq. inches.

For footway manholes, ventilation is provided by means of a removable circular grid, located in the centre of the cover and having perforations which provide a gross ventilation area of approximately 6 sq. inches.

In some cases, direct ventilation through the manhole cover is not possible due to conditions such as the liability of flooding. In these circumstances ventilation can be provided by a steel or C.I. pipe leading from the highest point of the manhole and exhausting into the free air at a conveniently adjacent point, through a guard post or other pipe.

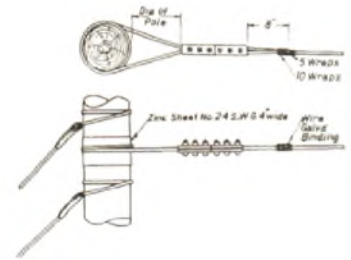
Ventilation becomes necessary, as a result of the liability of the accumulation of foul air and, as explosive gases in manholes and ducts, and the consequent danger to personnel and damage to plant, due to explosions and corrosive actions.

Q. 3. *Sketch and describe the method of terminating an aerial cable stranded suspension wire on a pole.*
What are "false terminations" and under what circumstances are they made? (13).

A. 3. The method of making a "true termination" on a pole of an aerial cable stranded suspension wire, is illustrated in the attached figure.

The point on the pole at which a "true termination" is to be made, is first lapped with a zinc strip 4″ wide and 24 S.W.G., nailed to the pole with zinc nails. This affords a mechanical protection for the pole by preventing the wire cutting into the pole and thus forming a potential source of weakness.

The stranded suspension wire is now passed twice round the zinc strip, centrally, the second turn passing over the first and the free end clamped to the main suspension wire by two stay clamps, at least 8″ spare being left to prevent unravelling of the strands. After cutting, the free end of the suspension wire is bound to the main wire by means of 60 lbs. G.I. binding wire, the method of binding and the number of the turns being clearly indicated in the sketch.



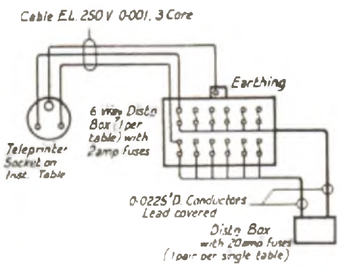
A " False Termination " is such, that the main suspension wire is clamped to the pole by means of a bracket, and in addition, a short length of auxiliary strand is lapped to the pole, the ends of the strand being clamped to the main suspension wire. The main suspension wire is not cut in this case.

False terminations are used in the following cases :—

(i) At road crossings.
(ii) At railway crossings.
(iii) In both directions at every pole provided with line stays.
(iv) In both directions at angle poles where the cable is on the inside of the angle and the " Pull on Pole " is less than 50 ft. but greater than 15 ft. (with 7/14 strand), 10 ft. (with 7/12 strand) and 5 ft. (with 7/10 strand).

Q. 4. Describe the distribution arrangements in a large telegraph office for supplying power to teleprinter motors, giving details of fuses. State the supply voltage and current allowed for each teleprinter motor in the system described. (13).

A. 4. The mains are brought to distribution boxes fitted with 20 amp. fuses. From here cables are taken to 6-way boxes fixed at the end of the different teleprinter tables. The leads to the teleprinter power sockets pass from the 6-way box *via* 2 amp. fuses. The earth pin of the power socket is earthed at the 6-way box. The sketch below shows the wiring and types and sizes of the cables.

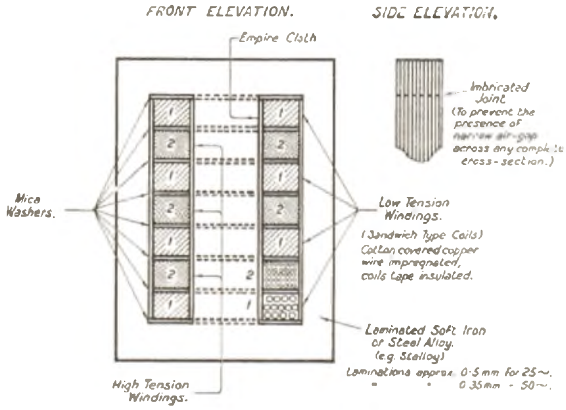


The teleprinter motor supply voltage for the system described is 110 volts D.C. and the normal load current is approximately 0.5 amp. per motor. On starting, there is a momentary surge of current of approximately 3.0-4.0 amps.

Q. 5. Draw a sectional view of a small power transformer, showing the coils and windings. Explain its action. Why is the core laminated? What determines the ratio of transformation? (12).

A. 5. A transformer consists of a low reluctance magnetic circuit linking two distinct windings, namely, a primary winding and a secondary winding. The application of an alternating voltage to the primary winding produces an alternating flux in the magnetic circuit. This flux links both the primary and secondary windings and will therefore induce an E.M.F. in the secondary winding in accordance with Lenz's Law.

The alternating magnetic flux induces E.M.Fs in the magnetic circuit in planes at right angles to the lines of magnetic force. These E.M.Fs give rise to circulating currents in the magnetic circuit and dissipate energy in the form of heating in the core. The magnitude of these circulating currents depends upon (i) the frequency of voltage supply, (ii) magnetic flux density and (iii) the resistance of the circulating paths. By laminating the iron core, the lengths of the circulating current paths are increased, and the sectional areas for individual paths decreased ; the resistance of the circulating current paths is therefore increased and the circulating currents, *i.e.*, the eddy currents, are correspondingly decreased. It can be shown that the eddy current loss is proportional to t^2, where t is the thickness of the core laminations. Hence the importance of laminating.



Neglecting the effect of leakage flux, *i.e.*, assuming that the same flux, links both the primary and secondary windings, the transformation ratio, *i.e.*, $\frac{\text{Secondary Volts}}{\text{Primary Volts}}$ is proportional to $\frac{\text{Secondary Winding Flux Linkage}}{\text{Primary Winding Flux Linkage}}$, which equals

$$\frac{\phi \cdot N_2}{\phi \cdot N_1} = \frac{N_2}{N_1}$$

Where ϕ is the magnetic flux.

N_2 is the No. of secondary turns.
N_1 is the No. of primary turns.

Q. 6. Explain what is meant by the terms " electrolyte," " specific gravity " and " electromotive force " as applied to a secondary cell.

A. 6. The term " *electrolyte* " as applied to a secondary cell, refers to the ionized medium in which the positive electrode (*i.e.*, the anode) and the negative electrode (*i.e.*, the cathode) are immersed. This ionized medium, in the most common form of secondary cell, namely, the wet, lead—lead peroxide type, consists of a dilute solution of sulphuric acid in water. The process of solution produces ionization of the sulphuric acid, by which, each molecule of H_2SO_4, (which consists of 2 atoms of hydrogen, 1 atom of sulphur and 4 atoms of oxygen), splits into 3 parts, namely :—2 atoms of hydrogen, which have each lost an electron and 1 complex ion, containing 1 atom of sulphur and 4 atoms of oxygen plus 2 electrons from the hydrogen atoms. The hydrogen ion is therefore electro-positive and the SO_4 ion is electro negative, hence the electrical conductivity of the electrolyte.

" *Specific Gravity* " refers to the S.G. of the electrolyte and is expressed as the ratio of the mass of a given volume of the electrolyte to the mass of an equal volume of pure water, both at normal temperature and pressure.

In the case of a lead type secondary cell, fully charged, the S.G. should be approximately 1.215.

The *Electromotive Force* (E.M.F.) of a secondary cell, is the electrical pressure generated in the cell as a result of chemical action. It is equal to the voltage between the +ve and −ve plates when the cell is on open circuit, and can also be calculated in the case of a cell delivering a current I amps. from :—

$$E = E.M.F. = V + I.R.$$

where V is the terminal voltage and R is the internal resistance of the cell in ohms.

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