COURSE OF TECHNICAL INSTRUCTION

LABORATORY PROJECTS

TECHNICIANS-IN-TRAINING
FIRST YEAR

Engineering Training Section, Headquarters, Postmaster-General's Department, Melbourne C.2.

LABORATORY PROJECTS —FIRST YEAR

ISSUED 1961

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Laboratory Projects **PROJECT NO. 1**

1st Year

ELECTRIFICATION

When ebonite is rubbed with fur, or glass is rubbed with silk one is charged positively and the other negatively.

These charges may be transferred to other bodies, and are called electrostatic charges.

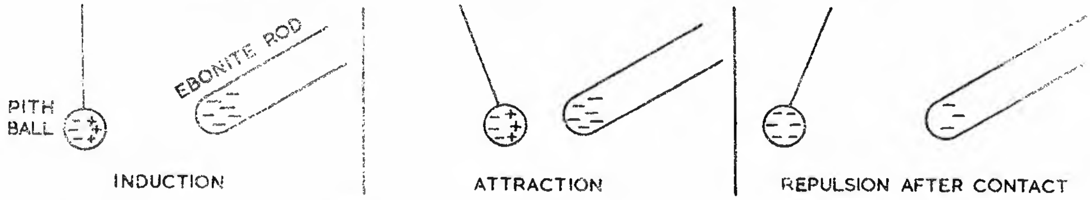
<u>AIM:</u> <u>To prove that like charges repel, and unlike charges attract.</u>

<u>APPARATUS:</u> Ebonite Rod, Fur, Glass Rod, Silk, 2 Suspended Pith Balls.

<u>METHOD:</u>

<u>STEP 1.</u> Rub the ebonite rod briskly with the fur, and place the rod near one pith ball. The results are:-

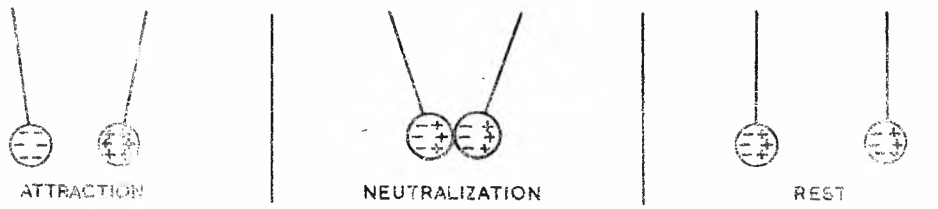
(i) Induction (ii) Attraction (iii) Repulsion after contact.



<u>STEP 2.</u> Charge the second pith ball positively by ~~rubbing lightly in the fur~~. USING GLASS ROD AND SILK

<u>STEP 3.</u> Bring the pith balls to within 1" of each other. The results are:-

(i) Attraction (ii) Neutralization (iii) Pith balls fall apart.



<u>STEP 4.</u> Neutralize the pith balls and repeat STEP 1 with both.

<u>STEP 5.</u> Bring the pith balls to within 1" of each other. Repulsion results.

<u>STEP 6.</u> ~~Repeat STEPS 1 to 5 using the glass rod and~~ silk.

<u>STEP 7.</u> ~~Compare the~~ results ~~with~~ STEPS ~~4 to 6~~.

<u>CONCLUSIONS:</u>

1. The two laws governing electrostatically charged bodies are -

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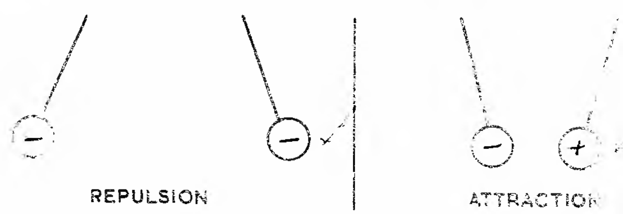
(i) ..LIKE CHARGES REPELL ✓ UNLIKE CHARGES ATTRACT ✓ ....

(ii) ...SEE OPPOSITE PAGE ....

2. Designate charges on the pith balls of the figures below.



TYPES OF CURRENT

The different types of current can be grouped under four main headings -

(i) Direct Current.
(ii) Varying Current. DC
(iii) Pulsating Current. DC
(iv) Alternating Current.

AIM: To produce and observe the listed types of current.

APPARATUS: Milliammeter 50-0-50mA, resistor 150 ohms, variable resistance, 6 volt supply, hand generator, magneto bell, connecting leads.

METHOD:

STEP 1. DIRECT CURRENT.
Connect the circuit as shown in Fig. 1.

CAUTION: ENSURE CORRECT POLARITY CONNECTIONS FOR METER AND SUPPLY.

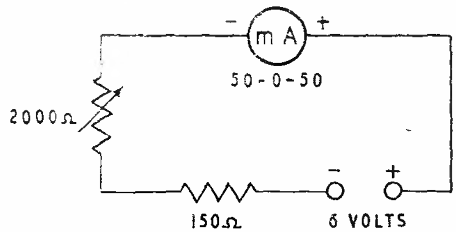


FIG. 1.

STEP 2. Observe the steady value of current.
Reverse the battery connections and note the change of meter deflection.

STEP 3. VARYING CURRENT.
Restore the circuit to Fig. 1.
Vary the rheostat's resistance.
Observe the varying values of current and direction of deflection of the meter.

STEP 4. PULSATING CURRENT.
Disconnect one battery lead and intermittently touch the lead to terminal.
Observe that the meter deflects in one direction.

STEP 5. ALTERNATING CURRENT (A.C.)
Disconnect the battery leads and tap on the battery terminals.
Observe the meter deflection.
Reverse the battery leads and tap on the battery terminals.
Observe the meter deflection.
Continue the preceding steps until the pattern of the meter deflections is understood.

STEP 6. Connect the circuit as shown in Fig. 2.

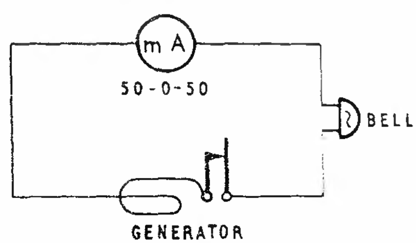
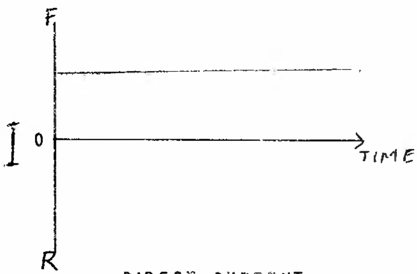


FIG. 2.

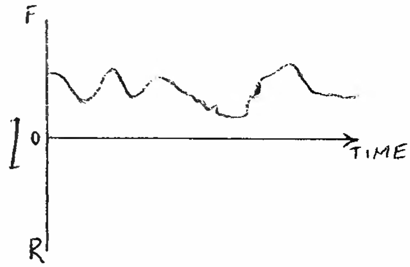
STEP 7. Turn the generator slowly.
Observe the meter deflections.
Observe that the bell operates.
Compare the results from STEP 5 and STEP 7.

CONCLUSIONS:

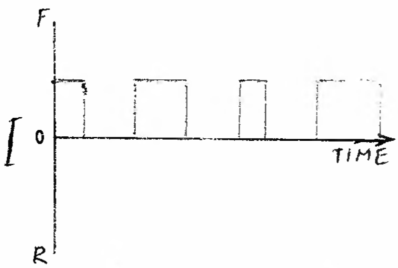
1. Represent your results graphically.



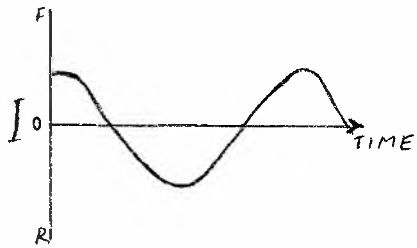
DIRECT CURRENT



VARYING DIRECT CURRENT



PULSATING DIRECT CURRENT



ALTERNATING CURRENT

2. State the difference between D.C. and A.C.

1. DC IS A FLOW OF CURRENT THROUGH A CIRCUIT IN ONE DIRECTION

2. AC IS A CURRENT WHICH REVERSES ITS DIRECTION OF FLOW REGULARY

3. What type of current flows in the circuit of -

(i) a hand torch? . . . . DC . . . .

(ii) a telegraph sounder? . . . . DC . . . .

(iii) a household light bulb? . . . AC . . . .

PROJECT NO. 3

Laboratory Projects

1st Year

CONDUCTORS AND INSULATORS

Good conductors possess "free" electrons in the outer orbits of their atomic structures, and only a small electrical force is required to dislodge these electrons in an ordered movement or current. Insulators possess few "free" electrons, and a large electrical force is required to cause a substantial current.

AIM: To prove which of the given substances are conductors with an applied e.m.f. of 6 volts.

APPARATUS: Milliammeter 0-50 mA., resistor 150 ohms, connecting leads and clips, 6 volt supply.

Samples of - Ebonite, Copper, Brass, P.V.C., Erinoid, Tin, Iron, Wood, String, Carbon, Red Fibre, Radio Resistor. Lead, Porcelain.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

CAUTION: ENSURE CORRECT POLARITY CONNECTIONS FOR METER AND SUPPLY.

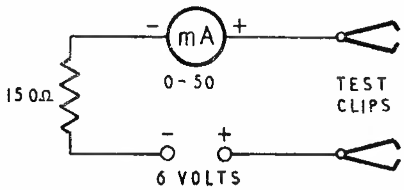


FIG. 1.

STEP 2. Connect the samples, in turn, between the test clips.
When the meter shows a deflection the substance is a conductor.
When the meter does not show a deflection, the substance is an insulator (for this value of applied e.m.f.).

NOTE: Whether an insulator insulates or conducts, depends on the magnitude of the applied e.m.f.

CONCLUSIONS:

1. Tabulate your results in the appropriate columns.

(4 [illegible])

CONDUCTORS	INSULATORS
COPPER	RED FIBRE
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
TIN	
[illegible]	
[illegible]	

2. Under [illegible] listed insulator become a conductor of electricity? [illegible]

[illegible] ✕

[illegible]

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FACTORS AFFECTING CONDUCTOR RESISTANCE

The electrical resistance of a conductor depends on --

(i) Length, (ii) Cross-sectional area, (iii) Type of Material, (iv) Temperature.

AIM: (i) To compare the resistance of various conducting materials with the same length and cross sectional area.

(ii) To compare the resistance of various conducting materials of different lengths and cross sectional area.

APPARATUS: Sample lengths of conductors, Ohm Meter.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

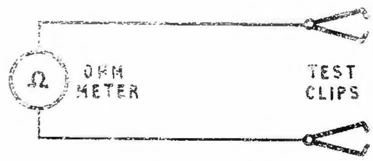


FIG. 1.

STEP 2. Insert the sample conductors in turn between the test clips.
Note the readings.
Record the readings in Table 1.

RESULTS:

SAMPLE	MATERIAL	DIAMETER	LENGTH	RESISTANCE
A	NICHROME	0·009"	36"	26Ω
B	NICHROME	0·009"	24"	18Ω
C	NICHROME	0·009"	12"	9Ω
D	NICHROME	0·006"	36"	55Ω
E	NICHROME	0·012"	36"	13Ω
F	NICHROME	0·024"	36"	3Ω
G	COPPER	0·006"	36"	·8Ω
~~H~~	~~CUPRON~~	~~0·006"~~	~~36"~~	
J	~~NICHROME~~ EUREKA	0·006"	36"	26 Ω

4

TABLE 1.

CONCLUSIONS:

1. Explain ~~the~~ how differing materials having the same length and cross-sectional area could have differing resistances. [SAME TEMP]

THE RESISTANCE COULD DIFFER IF THE MATERIALS HAD A DIFFERENT [~~COEFFICIENT OF EXPANSION~~] SPECIFIC RESISTANCE.

2

CONCLUSIONS: (Cont.)

2. When a conductor is three times the length of another conductor of similar cross-sectional area and material, its resistance will be ..THREE..TIMES.. the resistance of the other conductor.

2

3. When a conductor is twice the diameter of another conductor of similar length and material, its resistance will be ......HALF........... the resistance of the other conductor.

DEMONSTRATION

AIM: (i) To compare the resistance of an unheated conductor with a heated conductor.

APPARATUS: Filament and supporting elements of a 50V 40W. lamp.
Ohmmeter, matches.

STEP 1. Connect the circuit as shown in Fig. 2.

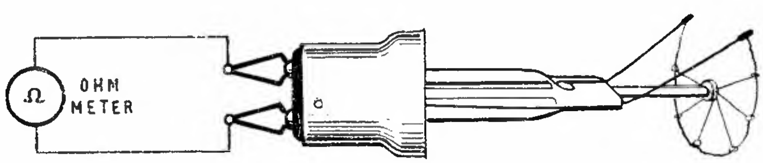


FIG. 2.

STEP 2. Measure the resistance and record Table 2.

STEP 3. Apply the match flame to the tungsten lamp filament.

STEP 4. Measure the resistance and record Table 2.

MATERIAL	RESISTANCE NORMAL TEMP.	RESISTANCE HEATED
TUNGSTEN		

TABLE 2.

CONCLUSIONS:

1. When certain materials, for example, tungsten, are heated their resistance ....

2. This is known as .... temperature coefficient of ....

EFFECT OF HEAT ON A CONDUCTOR

The resistance of a conductor varies with temperature. Most metals increase in resistance when heated, (positive temperature co-efficient of resistance), while carbon, electrolytes and insulators decrease in resistance when heated, (negative temperature co-efficient of resistance).

AIM: To prove that (i) the resistance of a metal filament lamp increases when heated,

(ii) ~~the resistance of a carbon filament lamp decreases when heated~~.

APPARATUS: Voltmeter 0-10V, Milliammeter 0-50mA, Switchboard lamps 6V Metal and Carbon filaments, lamp holder, 6V variable supply.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

CAUTION. ENSURE CORRECT POLARITY CONNECTIONS FOR METERS AND SUPPLY.

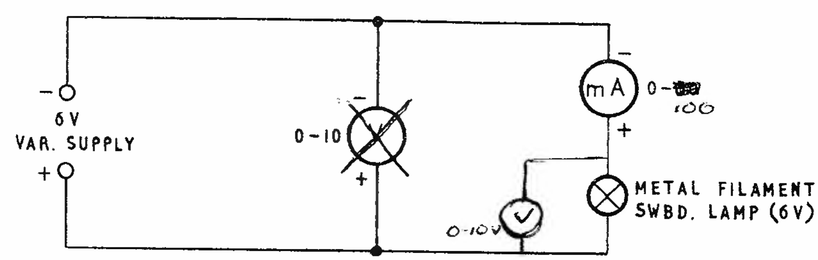


FIG. 1.

STEP 2. Adjust the supply voltage to give a current reading on the milliammeter but for no glow of lamp. Record the values of E and I in Table 1.

STEP 3. Adjust the supply voltage to allow a dull glow of the lamp. Record the values of E and I in Table 1.

STEP 4. Adjust the supply voltage to 6V to give full brilliance from the lamp. Record the values of E and I in Table 1.

STEP 5. ~~Repeat Steps 1 to 4 with carbon filament lamp~~.

STEP 6. ~~Calculate the resistance of the lamp for each step. Record in Table 1~~.

9/10 RQ.

Laboratory Projects **PROJECT NO. 5**

Ist Year

LAMP	MEASURED E		MEASURED I		CALCULATE $R = \frac{E}{I}$	
	METAL	CARBON	METAL	CARBON	METAL	CARBON
NO GLOW 1 V	1 V		14 mA		~~[illegible]~~ 71·4 Ω	
DULL GLOW 3 V	3 V		26 mA		115·4 Ω	
FULL GLOW 5 V	5 V		35 mA		142·8 Ω	

(2 marks)
(2 marks)
(2 marks)

TABLE 1.

CONCLUSIONS:

1. Compare the ~~results~~ RESISTANCE of calculations with the brilliance of the lamp.

AS THE BRILLIANCE OF THE LAMP INCREASES THE RESISTANCE OF THE FILAMENT BECAUSE THE FILAMENT MATERIAL HAS A ~~[illegible]~~ TEMP COEFFICIENT OF ① ✓

2. ~~From the results of the project, describe the characteristics of the materials used as lamp filaments.~~

A TUNGSTEN FILAMENT LAMP DRAWS THE GREATEST CURRENT AS IT IS SWITCHED ON ✓ (1 mark)

3. List two materials which have a negligible temperature co-efficient of resistance.

(i) COPPER (ii) IRON ✗

4. List ~~three~~ two types of materials commonly used in Telecom. which have a negative temperature co-efficient of resistance.

(i) CARBON ✓ (1 mark)

(ii) ELECTROLITE

~~(iii)~~

RESISTORS

Resistance is the opposition that a material offers to current.

Resistors are used in a circuit -

To vary or control current,

To vary or control the P.D. across components.

CONSTRUCTION:

(i) Carbon Type. Consist of a glass or porcelain former coated with resistive material (carbon with synthetic binder), from which are connected tinned copper leads.

(ii) Wire Wound. Consist of a coil of wire on a hollow porcelain spool, wound either inductively or non-inductively.

AIM: To study the construction and colour code of resistors.

APPARATUS: Card Mounted Carbon and Wire Wound Resistors and Connecting Leads.

METHOD:

STEP 1. List the resistor colour code in Table 1.

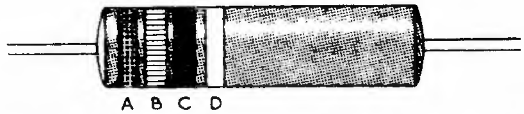
STEP 2. Indicate on Fig. 1 the meaning of each coloured band.

STEP 3. Record the value of resistors in Table 2.

STEP 4. Observe the construction of both Carbon and Wire Wound Resistors.

DIGIT	COLOUR	DIGIT	COLOUR
0	BLACK	5	GREEN
1	BROWN	6	BLUE
2	RED	7	VILOT
3	ORANGE	8	GREY
4	YELLOW	9	WHITE

TABLE 1.



A ..1st No.. C ..~~2nd~~ No. of 0's..

B ~~No. of 0's~~ 2nd No D ..TOLERENCE..

FIG. 1.

R	CARD No. 1	R	CARD No. 2
1	8.2 MΩ T=10%	1	6.8 MΩ T=10%
2	330 KΩ T=10%	2	270 KΩ T=10%
3	39 KΩ T=10%	3	22 KΩ T=10%
4	47 KΩ T=10%	4	6.8 KΩ T=10%
5	820 Ω T=10%	5	27 Ω T=10%

TABLE 2.

CONCLUSION:

Complete the following charts.

COLOUR	VALUE	%
VIOLET YELLOW BLACK	74 Ω	
RED RED ORANGE GOLD	22 KΩ	± 5%
BROWN BLACK BLACK	10 Ω	
BLUE GREEN RED SILVER	6.5 KΩ	± 10%

VALUE	COLOUR
0·3 MΩ	ORANGE, BLACK, YELLOW
47 Ω	YELLOW, VIOLET, BLACK
680 Ω	BLUE, GREY, BROWN
10 KΩ	BROWN, BLACK, ORANGE

OHMS LAW (1)

Ohms Law states that as long as the physical properties of a circuit remain unchanged, the current (I) in the circuit is directly proportional to the applied voltage (E) and inversely proportional to the resistance (R).

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

AIM: To verify Ohms Law.

APPARATUS: Voltmeter 0-10V, Milliammeter 0-100mA, Resistor 50Ω, 6V variable supply.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

CAUTION. ENSURE CORRECT POLARITY CONNECTIONS FOR METERS AND SUPPLY.

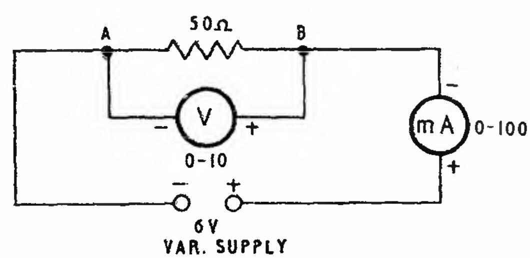


FIG. 1.

STEP 2. Adjust the supply voltage to give 1 volt P.D. across the 50Ω resistor. Record the ammeter reading in Table 1.

STEP 3. Repeat Step 2, adjusting the supply voltage to give 2, 3, 4 and 5 (2) volts P.D. in turn, across the 50Ω resistor. BR

STEP 4. Using Ohms Law calculate the current for each step (Table 1) and check against the recorded values.

STEP 5. Plot a graph of E and I on Graph 1. USING CALCULATED I

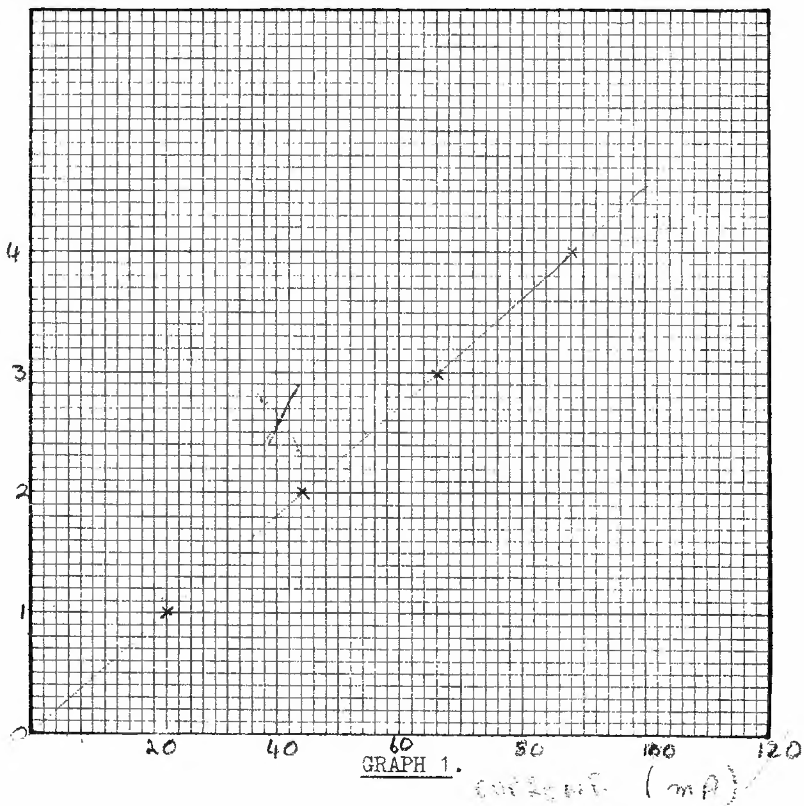
R	E	I(mA)	CALCULATION $I = \frac{E}{R}$
50Ω	1V	21	$\frac{1}{50}$ 20mA
50Ω	2V	42	$\frac{2}{50}$ 40mA
50Ω	3V	63	$\frac{3}{50}$ 60mA
50Ω	4V	84	$\frac{4}{50}$ 80mA
27.8 ~~50Ω~~	2V ~~5V~~	72	

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

$R = \frac{2}{.072}$

$R = 27.8\ \Omega$

TABLE 1.



GRAPH 1.

CONCLUSIONS:

1. If the voltages of the steps in Table 1 were trebled in value (R 50 ohms), the current values would be -

(i) ......63........ mA. (ii) ......126........ mA.

(iii) ......189........ mA. (iv) ......252........ mA.

(v) NOT REQUIRED mA.

2. From your results, a linear increase in the applied voltage results in a linear ~~non-linear~~ increase in the circuit current.

IF THE TESTING VOLTAGE FOR THE UNKNOWN RESISTANCE WAS DOUBLED THE RESISTANCE WOULD BE HALVED ✗

POINT B IN FIG 1 IS POSITIVE TO POINT E

OHMS LAW (2)

Ohms Law is the basis of all simple electrical calculations. The basic formula is often transposed to find -

(i) the voltage, when current and resistance are known - $E = I \times R$

(ii) the resistance, when the voltage and current are known - $R = \frac{E}{I}$

AIM: To verify the transposed forms of Ohms Law.

APPARATUS: Voltmeter 0-10V, Milliammeter 0-100mA, Resistors 50, 100, 150 and ~~500Ω~~, Unknown Resistor, 6V variable supply.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

CAUTION. ENSURE CORRECT POLARITY CONNECTIONS FOR METERS AND SUPPLY.

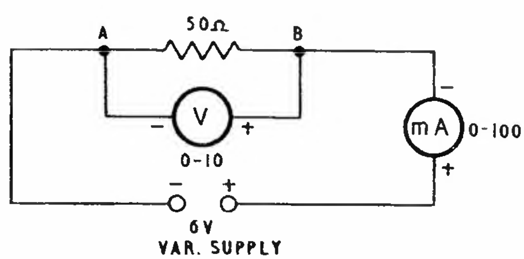


FIG. 1.

STEP 2. Adjust the supply voltage to give 2.5V P.D. across the 50Ω resistor. Record the ammeter reading in Table 1.

STEP 3. Repeat Step 2 using 100, 150 and ~~500Ω~~ resistors in turn.

STEP 4. Using Ohms Law, calculate the P.D. value for each step (Table 1), and check against the applied voltage value.

STEP 5. Disconnect the 50Ω resistor, and connect the unknown resistor between terminals A and B (Fig. 1).

STEP 6. Adjust the supply voltage to give 2, 3, 4 and 5 volts across the unknown resistor. Record the ammeter reading for each value in Table 2.

STEP 7. Using Ohms Law calculate the resistance for each set of values (Table 2).

R	E	I(mA)	CALCULATION E = IR
50Ω	2·5 V	52	·052×50 = 2·7
100Ω	2·5 V	26	·026×100 = 2·6
150Ω	2·5 V	17	·017×150 = 2·5
~~500Ω~~	~~2·5 V~~		

TABLE 1.

R	E	I(mA)	CALCULATION $R = \frac{E}{I}$
80Ω	2 V	25	$\frac{2}{.025}$ = ~~[illegible]~~ 80Ω
78Ω	3 V	38	$\frac{3}{.038}$ = 78 Ω
80Ω	4 V	50	$\frac{4}{.05}$ = 80Ω
	~~5 V~~		

TABLE 2.

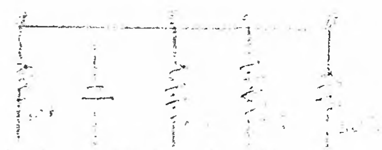
CONCLUSIONS.

1. [illegible] resistance values of Table 1 are doubled, and the same current readings are obtained, the supply voltage will [illegible] .....5..... volts.

IF ~~the~~ [illegible] Table 2 were ~~are~~ one quarter of those recorded for each voltage value, the value of the unknown resistance [illegible] would be ..... ~~ohms~~. FOUR TIMES THE ORIGINAL VALUE

3. [illegible]

[illegible] circuit (Fig. 1) is increased (supply voltage constant) the current ~~remains the same.~~ decrease. ~~increases.~~



RESISTOR C DRAWS THE GREATEST CURRENT FROM THE BATTERY

DROP OF POTENTIAL ALONG A WIRE

When a steady current flows in a conductor of uniform gauge, there is a uniform drop of potential along the conductor.

AIM: To prove the above statement.

APPARATUS: Resistance wire board, Voltmeter 0.5V(1000 ohms/V), Variable Resistance 0-50 ohms, 6 volts supply.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

CAUTION. ENSURE CORRECT POLARITY CONNECTION FOR METER AND SUPPLY.

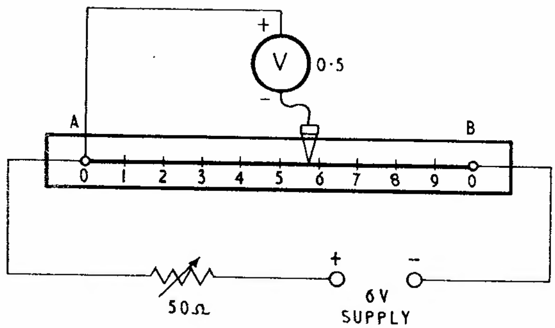


FIG. 1.

STEP 2. Adjust the P.D. across A and B to 0.5 volts.

STEP 3. Note the P.D. readings every 10 cms. along the resistance wire. Record in Table 1.

STEP 4. Represent your results graphically on Graph 1.

LENGTH IN CMS.	P.D.	LENGTH IN CMS.	P.D.
10	·05V	60	·3 v
20	·1 v	70	·35 v
30	·15 v	80	·4 v
40	·2 v	90	·45 v
50	·25v	100	·5 v

TABLE 1.

5~~6~~ BM.
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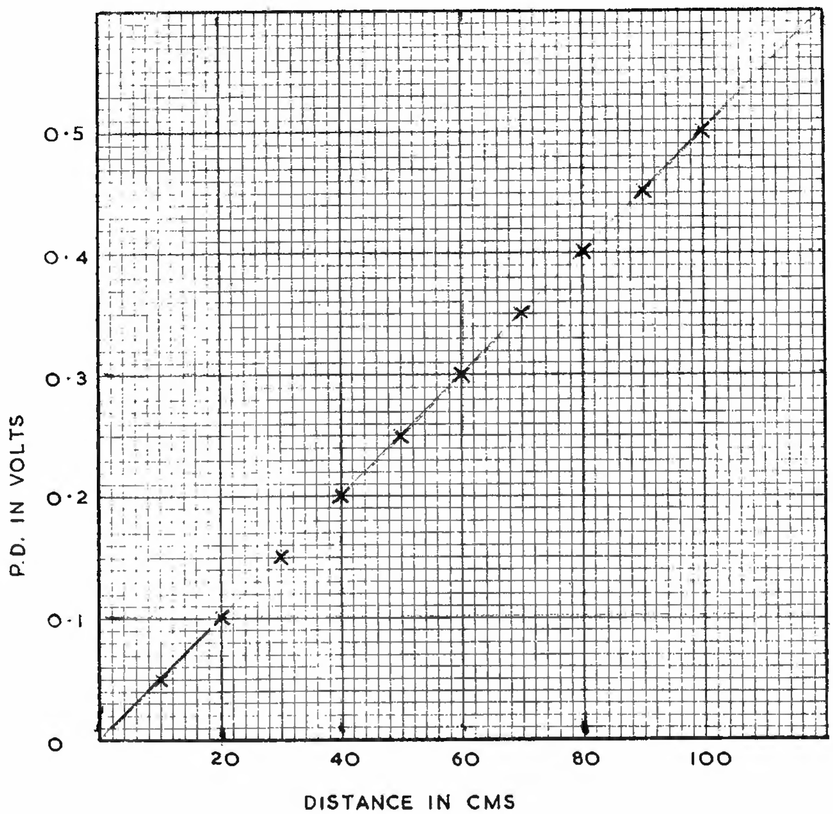
Laboratory Projects

1st Year

PROJECT NO. 9

(2)



GRAPH 1.

CONCLUSION:

Correct this statement -

(1) ① Between any two points along a conductor, the P.D. ~~due to the current~~ is proportional ~~has no relationship~~ ~~is inversely proportional~~ to the length and current

(2) ② THE POTENTIAL DROP ALONG THE WIRE IS [redacted] ·005 VOLTS PER CM

③ WHAT IS THE VOLTAGE AND POLARITY [+ VE or − VE] OF THE FOLLOWING POINTS WITH RESPECT TO A POINT 50 cms ALONG THE WIRE

(10)

(0) cms	+ ·2 VOLTS	cms	− ·025	0
0 80 cms	+ ·15 VOLTS	cms	+ · [redacted] 015	0
0 60 cms	+ ·05 VOLTS	cms	− ·175	0

OHMS LAW, SERIES CIRCUITS (1)

In a circuit containing two or more resistances in series -

(i) The sum of the voltage drops across each resistor is equal to the applied voltage.

(ii) The current through each resistor is the same as that from the source of supply.

AIM: To study voltage and current distribution in a series circuit.

APPARATUS: Resistors, 30, 40 and 50 ohms, Milliammeter 0-50 mA, Voltmeter 0-10V (1000 ohms/V), 6V variable supply.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

CAUTION. ENSURE CORRECT POLARITY CONNECTION FOR METERS AND SUPPLY.

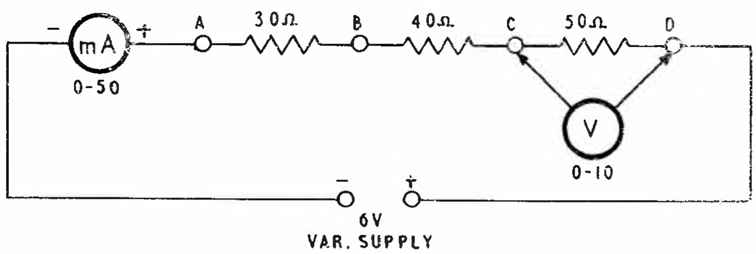


FIG. 1.

STEP 2. Adjust the circuit current to 40mA. Record in Table 1.

STEP 3. Measure the total P.D. (from points A to D). Record in Table 1.

STEP 4. Measure the P.D. across each resistor. Record in Table 2.
CC 50 Ω & REPEAT

STEP 5. Measure the current through each resistor by inserting the milliammeter at points B, C and D. Record in Table 2.

STEP 6. Add the individual P.Ds. (Table 2) and compare with the total P.D. (Table 1).

STEP 7. Compare the circuit current (Table 1) with the individual resistor currents (Table 2).

CIRCUIT I	CIRCUIT E
40 mA ✓	4·8 VOLTS ✓

1

TABLE 1.

RESISTANCE	MEASURED E	MEASURED I	CALCULATE $R=\frac{E}{I}$
30 Ω	1·2 V ✓	40 mA	$\frac{1·2}{·04}$ = 30 Ω ✓
40 Ω	1·6 V ✓	40 mA	$\frac{1·6}{·04}$ = 40 Ω ✓
[illegible]	2 V ✓	40 mA	$\frac{2}{·04}$ = 50 Ω ✓

3

TABLE 2.

CONCLUSIONS:

1. How does the sum of the voltage drop across the three series resistors compare with the applied voltage ....
0 ...THE VOLTAGE DROP IS ~~LESS~~ THAN THE APPLIED EMF ✗

2. Compare the circuit current with the individual resistor current ......THE INDIVIDUAL RESISTOR....
1 CURRENT IS THE SAME AS THE CIRCUIT CURRENT ✓

3. ~~Sketch the ammeter connections for measuring the current through each resistor.~~

③ WITH TO 50Ω RESISTER OC THERE IS NO FLOW OF CURRENT ✓
0 UNDER THESE CONDITIONS THERE IS NO DROP OF VOLTAGE ✓ ACROSS THE 30Ω AND 60Ω RESISTORS AND THE VOLTAGE BETWEEN POINTS "C" AND "D" IS [illegible] ✗

4. ~~Describe how the voltmeter is connected to measure the resistor P.Ds.~~ ..... IF ~~THE~~ POINT C IS TAKEN
2 AS A REFERENCE POINT B IS NEGATIVE ✓ POINT A IS NEGATIVE ✓ AND POINT D IS POSITIVE ✓

OHMS LAW, SERIES CIRCUITS (2)

When resistors are connected in series the total resistance is equal to the sum of the individual resistors.

AIM: To study the effect of connecting resistors in series.

APPARATUS: Voltmeter 0-10V (1000 ohms/V), Milliammeter 0-100mA, Resistors 50, 100 and 150 ohms, 6V variable supply.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

CAUTION. ENSURE CORRECT POLARITY CONNECTION FOR METERS AND SUPPLY.

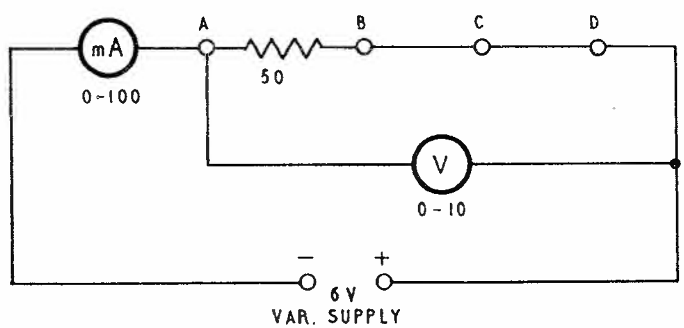


FIG. 1.

STEP 2. Adjust the P.D. across the resistor to 5 volts. Record the circuit current in Table 1.

STEP 3. Connect the 100 ohm resistor between points B and C. Repeat Step 2.

STEP 4. Connect the 150 ohm resistor between points C and D. Repeat Step 2.

STEP 5. From the recorded readings of E and I, calculate the resistance of the circuit for each step.

Laboratory Projects **PROJECT NO.11**

1st Year

STEP	E	I	CALCULATION $R = \frac{E}{I}$
2	8V	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]
4	[illegible]	12A	[illegible]

TABLE 1.

CONCLUSIONS:

1. When resistors are connected in series the total resistance decreases / ~~remains the same~~ / increases and the circuit current decreases. / remains the same. / increases.

2. Using the formula for finding the total resistance of a number of resistors in series, calculate the total resistance in Steps 3 and 4. (Compare with Table 1.)

STEP 3. [illegible]

STEP 4. [illegible]

WHEN A [illegible] [illegible]

6/10

PROJECT NO.12

Laboratory Projects

1st Year

OHMS LAW, PARALLEL CIRCUITS (1)

When resistors are connected in parallel the total resistance of the circuit decreases.

The joint resistance is less than the lowest valued resistor in the parallel group.

AIM: To study the effect of connecting resistors in parallel.

APPARATUS: Voltmeter 0-10V (1000 ohms/V), Milliammeter 0-500mA, Resistors 50, 100 and 150 ohms, 6V variable supply.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

CAUTION. ENSURE CORRECT POLARITY CONNECTION FOR METERS AND SUPPLY.

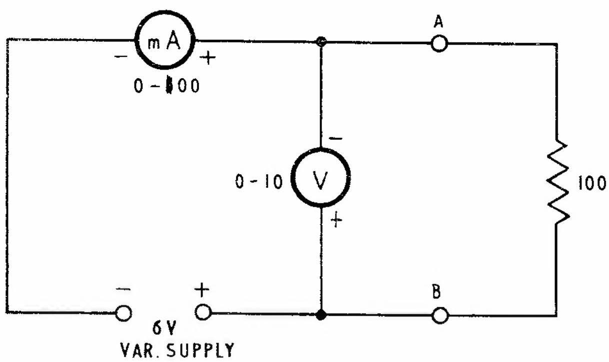


FIG. 1.

STEP 2. Adjust the supply to 3 volts. Record the current reading in Table 1.

STEP 3. Connect a 150 ohms resistor between points A and B (Fig. 1).

NOTE:- 150 ohms in parallel with 100 ohms.

Record the current reading in Table 1. ADJUST TO 3 VOLTS

STEP 4. Replace the 150 ohms resistor with a 50 ohms resistor. Record the current reading in Table 1. ADJUST TO 3 VOLTS

STEP 5. From the recorded readings of E and I calculate the resistance of the circuit for each step.

STEP	E	I	CALCULATION $R = \frac{E}{I}$
2	3 V	30 mA	$R = \frac{3}{.03}$ $R = 100\Omega$
3	3 V	50 mA	$R = \frac{3}{.05}$ $R = 60\Omega$
4	3 V	80 mA	$R = \frac{3}{.08}$ R = [illegible]

TABLE 1.

2

CONCLUSIONS:

1. When resistors are connected in parallel the joint resistance ~~increases~~ ~~remains the same~~ decreases and the current in the circuit increases. ~~remains the same.~~ ~~decreases.~~ 1

2. Using the formula for finding the joint resistance of a parallel group, calculate the value of the joint resistance in Steps 3 and 4. (Compare with Table 1.)

STEP 3.
$\frac{1}{R_J} = \frac{1}{R_1} + \frac{1}{R_2}$
$\frac{1}{R_J} = \frac{1}{150} + \frac{1}{100}$
$\frac{1}{R_J} = \frac{2}{300} + \frac{3}{300}$
$\frac{1}{R_J} = \frac{5}{300}$
$R_J = 60\Omega$

STEP 4.
$\frac{1}{R_J} = \frac{1}{R_1} + \frac{1}{R_2}$
$\frac{1}{R_J} = \frac{1}{150} + \frac{1}{50}$
$\frac{1}{R_J} = \frac{1}{150} + \frac{3}{150}$
$\frac{1}{R_J} = \frac{4}{150}$
$R_J = 37.5\Omega$

1

3. State the formula for calculating the joint resistance of a parallel group when all resistors are the same value.

$R_J = \frac{\text{R of ONE RESISTOR}}{\text{No. of RESISTORS}}$ 2 1

(4) IT IS NECESSARY TO ADJUST THE SUPPLY VOLTAGE IN STEP 3 BECAUSE THE INCREASED CIRCUIT RESISTANCE CAUSES A [illegible] CIRCUIT CURRENT WHICH PRODUCES A [illegible] VOLTAGE DROP OVER THE [illegible] 0

OHMS LAW, PARALLEL CIRCUITS (2)

In a circuit containing two or more resistors in parallel -

(i) The sum of the currents through each resistor is equal to the total current from the source of supply.

(ii) The potential difference across each resistor is equal to the applied voltage.

AIM: To study voltage and current distribution in a parallel circuit.

APPARATUS: Resistors 200, 150 [redacted] and 100 ohms, Milliammeter 0-100mA, Voltmeter 0-10V (1000 ohms/V), 6V variable supply.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

CAUTION. ENSURE CORRECT POLARITY CONNECTIONS FOR METERS AND SUPPLY.

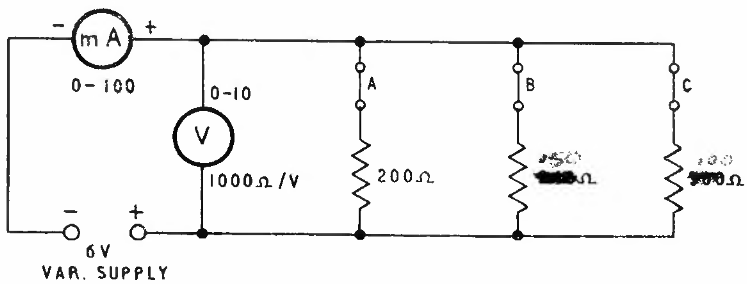


FIG. 1.

STEP 2. Adjust the circuit current to 60mA. Record in Table 1.

STEP 3. Measure the circuit P.D. Record in Table 1.

STEP 4. Measure the P.D. across each resistor. Record in Table 2.

STEP 5. Measure the current through each resistor by inserting the milliammeter at points A, B and C. Record in Table 2.

STEP 6. Add the individual currents (Table 2) and compare with the circuit current (Table 1).

STEP 7. Compare the circuit P.D. (Table 1) with the individual resistor P.Ds. (Table 2).

CIRCUIT I	CIRCUIT E	$R_T = \frac{E}{I}$
60 mA	= 3 V	$R_T = \frac{3}{.06}$ $R_T = 50\Omega$

TABLE 1.

RESISTANCE	MEASURED E	MEASURED I	CALCULATE $R = \frac{E}{I}$
200 Ω	3 V	14 mA	$R = \frac{3}{.14}$ = ~~170~~ 176 Ω
~~240~~ 150 Ω	3 V	20 mA	$R = \frac{3}{.20}$ = 150 Ω
100 Ω	3 V	26 mA	$R = \frac{3}{.26}$ = ~~[illegible]~~ 91 Ω

TABLE 2.

CONCLUSIONS:

1. With reference to the results - explain the relationship existing between the sum of the branch currents, and the total supply current.

   THE SUM OF THE CURRENTS THROUGH EACH RESISTOR IS EQUAL TO THE TOTAL CURRENT THROUGH THE SOURCE OF SUPPLY

2. With reference to the results - explain the relationship existing between the voltage drop across each resistor, and the applied voltage.

   THE POTENTIAL DIFFERENCE ACROSS EACH RESISTOR IS EQUAL TO THE APPLIED VOLTAGE

OHMS LAW, SERIES PARALLEL CIRCUITS

A Series Parallel circuit is a combination of both Series and Parallel circuits.

AIM: To study the voltage and current distribution in a series parallel circuit.

APPARATUS: Resistors 30, 100 and 150 ohms, Milliammeter 0-100 mA, Voltmeter 0-10V (1000 ohms/V). 6V variable supply.

METHOD:

STEP 1. Connect circuit as shown in Fig. 1.

CAUTION: ENSURE CORRECT POLARITY CONNECTION FOR METERS AND SUPPLY.

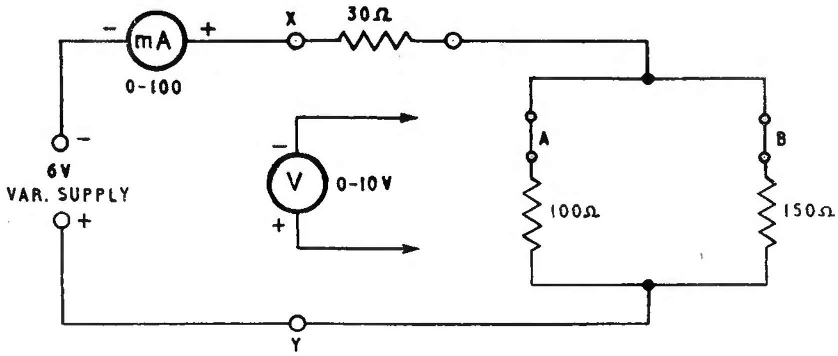


FIG. 1.

STEP 2. Adjust supply for 50 mA circuit current. Record in Table 1.

STEP 3. Measure current through each resistor. Record in Table 1.

STEP 4. Measure P.D. across each resistor. Record in Table 1.

STEP 5. Measure circuit P.D. at points x and y. Record in Table 1.

STEP 6. Calculate resistor values from E and I values. Record in Table 1.

STEP 7. Calculate circuit R from known resistor values. Record in Table 1.

Laboratory Projects

1st Year

PROJECT NO.14

RESISTANCE	MEASURED E	MEASURED I	CALCULATE $R = \frac{E}{I}$
30 Ω	1·5 V	50 mA	$R = \frac{1.5}{.05} = 30\,\Omega$
100 Ω	3 V	30 mA	$R = \frac{3}{.03} = 100\,\Omega$
150 Ω	3 V	20 mA	$R = \frac{3}{.02} = 150\,\Omega$
TOTAL RESISTANCE	**MEASURED CCT. E**	**MEASURED CCT. I**	**CALCULATE CCT. $R = \frac{E}{I}$**
90 Ω	4·5 V	50 mA	$R = \frac{4.5}{.05} = 90\,\Omega$

TABLE 1.

CONCLUSIONS:

1. What relationship has the current through each of the resistors, to the circuit current.

   (i) 30 ohms ...no current...... (ii) 100 ohms ...increase......

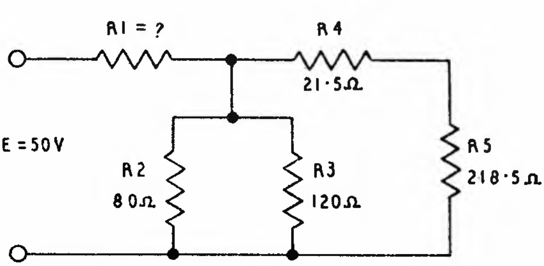
   (iii) 150 ohms ...increase......

2. What relationship has the voltage across each of the resistors, to the circuit voltage.

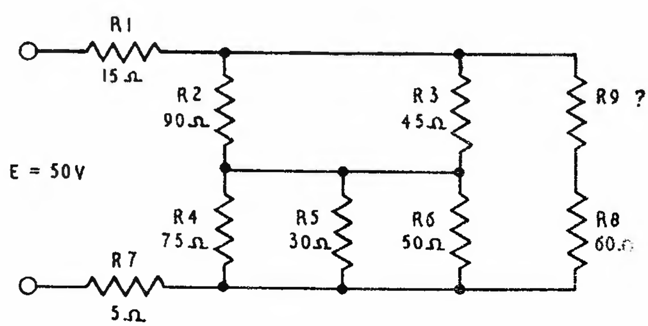
   (i) 30 ohms ...increase...... (ii) 100 ohms ...remain the same......

   (iii) 150 ohms ...remain the same......

3. If P.D. across R_2 (80 ohms) = 40 volts, solve for Total Current and R_1.



4. When the total current is 1 Amp solve for R_9.



POWER IN THE D.C. CIRCUIT

In an electrical circuit, Power is the RATE at which work is done, or the RATE at which energy is supplied or consumed.

The unit is the Watt.

AIM: To show that the power in Watts in a D.C. circuit can be calculated by either

$$E \times I, \qquad I^2R, \qquad \text{or} \qquad \frac{E^2}{R}$$

APPARATUS: Switchboard Lamp 6V and holder, Resistor 100 ohms, Voltmeter 0-10V (1000 ohms/V) Milliammeter 0-100 mA, 6V variable supply.

METHOD:

STEP 1. Connect circuit as shown in Fig. 1.

CAUTION: ENSURE CORRECT POLARITY CONNECTIONS FOR METERS AND SUPPLY.

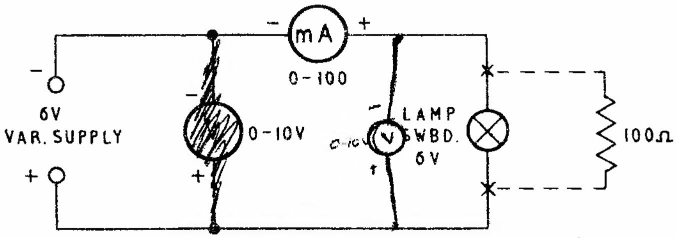


FIG. 1.

STEP 2. Adjust the supply voltage to give 2, 4 and 5 volts P.D. respectively across the lamp. Record I readings and degree of brilliance in Table 1.

STEP 3. Repeat Step 2 substituting the 100 ohms resistor for the lamp. Record I readings in Table 2.

STEP 4. Calculate the power of the lamp from the E and I readings of Table 1.

STEP 5. Calculate the power of the resistor from the I and R, and E and R readings of Table 2.

E	I	CALCULATE P = E X I	BRILLIANCE OF LAMP
2 V	·02	·04 WATTS	LOW
4 V	·03	·12 WATTS	MEDIUM
5 V	·04	·2 WATTS	HIGH

TABLE 1.

R	E	I	CALCULATE P = E x I	CALCULATE $P = I^2 R$	CALCULATE $P = \frac{E^2}{R}$
100Ω	2 V	·02	·04 WATTS	·0004 x 100 = ·04 W	4/100 = ·04 W
100Ω	4 V	·04	·16 WATTS	·0016 x 100 = ·16 W	16/100 = ·16 W
100Ω	5 V	·05	·25 WATTS	·0025 x 100 ·25 = [illegible] W	25/100 = ·25 W

TABLE 2.

CONCLUSIONS:

1. From the figures of Table 1, what conclusion can be drawn from the degree of brilliance of the lamp, in relationship to the power.

THE BRILLIANCE OF THE LAMP IS [illegible] PROPORTIONAL TO THE POWER

2. ~~What energy does the lamp consume in 24 hours continuous operation with an applied voltage of 5 volts?~~

IF THE APPLIED VOLTAGE IS DOUBLED, THE POWER CONSUMED BY A CIRCUIT IS [illegible] THE ORIGINAL VALUE

3. A 50 volt electric soldering iron is rated at 100 watts. What is the current through the iron during operation?

I OR CURRENT = 2 AMPS

SIMPLE CELL

When two dissimilar conducting materials are placed in an electrolyte, an e.m.f. is produced.

The value of e.m.f. depends on the nature of the dissimilar materials and the type of electrolyte.

AIM: To study the Simple Cell.

APPARATUS: Glass Jar, Sal Ammoniac solution, Carbon, Copper and Zinc electrodes, Carbon rod with depolariser sac, Voltmeter 0-5V.

METHOD:

STEP 1. Pour the sal ammoniac solution into the glass jar.

STEP 2. Place the two copper electrodes in the electrolyte. Measure the voltage between the plates. Record in Table 1.

STEP 3. Place the copper and carbon electrodes in the electrolyte. Measure the voltage between the electrodes and determine the polarity of each. Record in Table 1. Vary the distance between, and the area of the plates in the electrolyte.

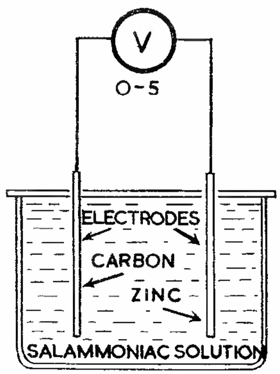


FIG. 1.

STEP 4. Repeat STEP 3, using copper and zinc electrodes.

STEP 5.A Repeat STEP 3, using carbon and zinc electrodes (Fig.1). CONNECT LAMP.

STEP 6. Repeat STEP 5, substituting the carbon electrode with depolariser sac for the carbon electrode. CONNECT LAMP

6/10 4M

Laboratory Projects **PROJECT NO.16**

1st Year

ELECTRODE MATERIALS	POLARITIES	VOLTAGE
COPPER COPPER	—	—
COPPER CARBON	− +	·25V
COPPER ZINC	+ −	·75V
CARBON ZINC	+ −	1·2 V
CARBON (PLUS DEPOLARISER) ZINC	+ −	1·5 V

TABLE 1.

3

CONCLUSIONS:

1. Explain why the terminal voltage of the cell of STEP 5 is less than the terminal voltage of the cell of STEP 6.

THE TERMINAL VOLTAGE IS LESS IN STEP 5 DUE TO THE HIGHER RESISTANCE. THIS CONDITION IS CAUSED BY HYDROGEN BUBBLES FORMING ON THE POSITIVE ELECTRODE.

IN STEP 6 THE TERMINAL VOLTAGE IS HIGHER BECAUSE THE ~~[illegible]~~ HYDR. COMBINES WITH THE ~~[illegible]~~ MG. DIOX TO FORM ~~CURRENT~~ WATER

2. (a) Correct this statement -

When the distance between, and the area of the plates in the electrolyte is varied,

the E.M.F. is - ~~increased~~? ~~decreased~~? not changed?

1

(b) ~~Explain why this is so.~~

CRUSHED CARBON IS USED IN THE DE-POLARISER TO IMPROVE CONDUCTIVITY

2

3. ~~What is the significance of the results obtained from STEP 2~~ ?

ELECTROLYSIS (1)

When a current is passed through a cell containing two electrodes and an electrolyte, the resulting electrolytic action causes chemical changes in the cell components.

The chemical effect of a current is called Electrolysis.

AIM: To study the electrolysis of lead foil.

APPARATUS: Glass Beaker, Lead foil Electrode, Solid lead electrode, Sodium Acetate Solution, Milliammeter 0-500 mA, 6V variable supply.

CAUTION: CERTAIN CHEMICALS RESULTING FROM THIS PROJECT, SUCH AS LEAD ACETATE ARE POISONOUS.

THE FOLLOWING PRECAUTIONS MUST BE TAKEN.

(i) AVOID CONTACT WITH THE SOLUTION.

(ii) THOROUGHLY CLEANSE APPARATUS AND HANDS AT THE CONCLUSION OF THE PROJECT.

METHOD:

STEP 1. Mix one teaspoon of sodium acetate in a pint of water.

STEP 2. Suspend the lead electrodes in the solution.

CAUTION: MAKE SURE THE ELECTRODES DO NOT TOUCH.

STEP 3. Connect the circuit as shown in Fig. 1 with the lead foil connected to the POSITIVE connection.

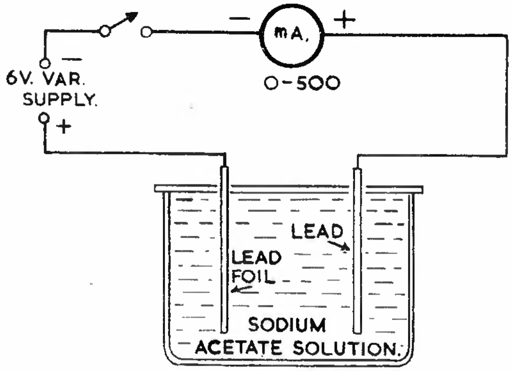


FIG. 1.

STEP 4. Adjust the variable supply for a current of approximately 300 mA.

STEP 5. Periodically observe the condition of the lead foil.

4

Laboratory Projects PROJECT NO.17

1st Year

CONCLUSIONS:

1. Over a period of time the lead foil was decomposed due to .... ACTION BETWEEN THE IONIZED .... ELECTROLYTE AND THE ~~POSITIVE~~ POSITIVE ELECTRODE ....

....

2. Mark on Fig. 2 the area where electrolysis of the lead covered cable could occur.

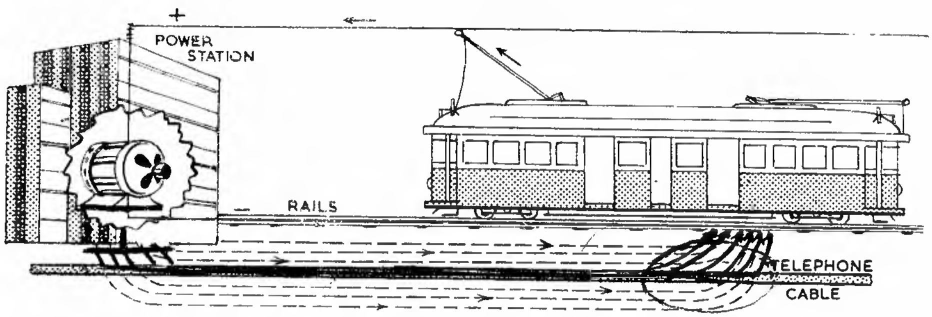


FIG. 2.

3. ~~Give reasons for your answer.~~ ... CHEMICALS PRESENT IN THE SOIL ARE TAKEN INTO SOLUTION BY MOISTURE TO FORM AN ELECTROLYTE WHEN CURRENT FLOWS THE CABLE SHEATH WILL BE DAMAGED IN THE AREA SHOWN BECAUSE ELECTROLYSIS OCCURS AT THE [illegible] ELECTRODE ... THE AFFECTED AREA IS [illegible] ... TO THE NEGATIVE TERMINAL OF THE POWER STATION DUE TO THE VOLTAGE DROP THROUGH ....

3

Na

ANODE CATHODE

Cl

ELECTROLYSIS (2)

When a current is passed through a cell containing two electrodes and an electrolyte the resulting electroytic action causes chemical changes in the cell components. The chemical effect of a current is called Electrolysis.

AIM: To study the effect of electrolysis.

APPARATUS: Glass beaker, Copper and Carbon Electrodes (alternatively copper and tin plate), Copper Sulphate Solution (approx. 1 teaspoon $CuSO_4$ to ½ pint H_2O), milliammeter 0-500 mA, 6 volts variable supply.

CAUTION: COPPER SULPHATE IS POISONOUS AND THE FOLLOWING PRECAUTIONS MUST BE TAKEN.

(i) AVOID CONTACT WITH THE SOLUTION.

(ii) THOROUGHLY CLEANSE APPARATUS AND HANDS AT THE CONCLUSION OF THE PROJECT.

METHOD:

STEP 1. Suspend the electrodes in the solution.

STEP 2. Connect the circuit as shown in Fig. 1 with the copper electrode connected to the positive polarity of the 6 volts supply.

CAUTION: MAKE SURE THE ELECTRODES DO NOT TOUCH.

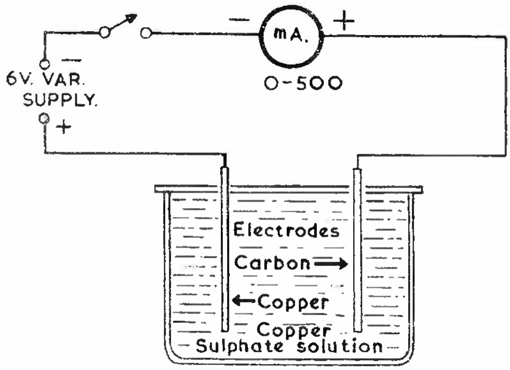


FIG. 1.

STEP 3. Adjust the variable supply for a current of about 100 mA.

STEP 4. Leave for approximately 10 minutes. Periodically observe the changes taking place within the cell.

STEP 5. Switch off the supply, remove and dry the electrodes. Observe the condition of the electrodes.

CONCLUSIONS:

1. State what has happened to -

(i) positive electrode ....

(ii) negative electrode ....

2. What part does the electrolyte play.

....

....

....

....

....

....

SECONDARY CELL

When a secondary cell is charged, electrical energy is converted into chemical energy.

When a secondary cell is discharged, chemical energy is converted into electrical energy.

AIM: To form a secondary cell, and observe the chemical action on charge and discharge.

APPARATUS: Glass Jar, Sulphuric Acid (S.G. approx. 1210), Electrodes - Lead foil plates (approx. 2" x 5/16" immersed in electrolyte), Ammeter 0-10A, Voltmeter 0-5V, Resistor 750 ohms, Audible 5 second pulse signal, 6 volt variable supply.

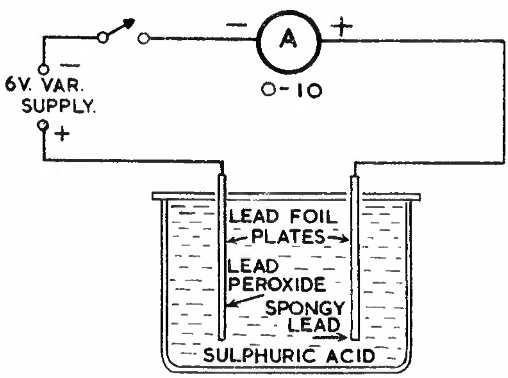
METHOD:

STEP 1. Pour the electrolyte into the Glass Jar.

CAUTION: SULPHURIC ACID IS CORROSIVE. AVOID CONTACT WITH BODY, PARTICULARLY THE EYES.

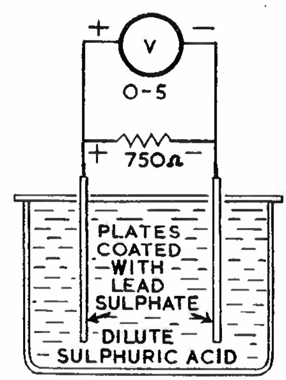
STEP 2. Place the plates in the electrolyte. Measure the voltage between the plates.

STEP 3. Connect the plates to the 6V supply for 10 minutes, as shown in Fig. 1. Note which plate is connected to the positive terminal of the supply.



CHARGING THE CELL.

FIG. 1.



DISCHARGING THE CELL.

FIG. 2.

STEP 4. Disconnect the supply and note the cell voltage.

STEP 5. Connect the circuit as shown in Fig. 2. Discharge the cell and note voltage reading every 5 seconds until discharged

STEP 6. Disconnect the circuit and reconnect to the supply for 1 minute.

STEP 7. Disconnect the supply and note the cell voltage.

STEP 8. Note the colour of the plates and compare the colour with the polarity of the plates.

STEP 9. From your results of STEP 5 plot a graph of time against voltage on discharge (Table 1).

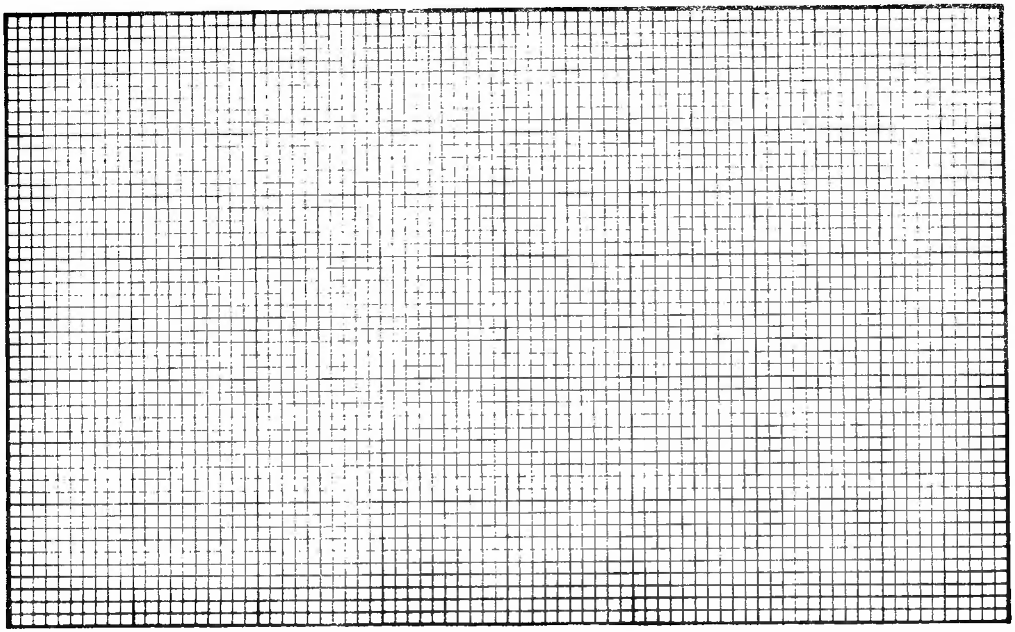


TABLE 1.

CONCLUSIONS:

1. In STEPS 2 and 4 there is a difference between voltage readings. Explain why this is so.

. . . .

. . . .

. . . .

2. The colours of the charged plates are -

Positive . . . .

Negative . . . .

3. The chemical changes taking place during discharge produce a coating of . . . . on each plate.

MAGNETISM

Magnetism is that property which causes attraction or repulsion between magnetic substances.

Unlike Poles Attract. Like Poles Repel.

Magnets may be of a permanent or temporary nature.

A position of neutrality, where equal attraction occurs, exists between the poles of a magnetic circuit.

AIM: To identify permanent magnets from given magnetic materials.

APPARATUS: Two permanent magnets, two pieces of soft iron.

METHOD:

STEP 1. Using the information at the top of the sheet, identify the permanent magnet from the two given samples.

STEP 2. Identify the soft iron pieces from the four given samples.

STEP 3. Using the magnets from STEP 2 prove the first law of magnetism.

STEP 4. Complete the labelling of Figs. 1a-1b using the terms - "Attraction", "Repulsion", and "Neutral", in the appropriate places.

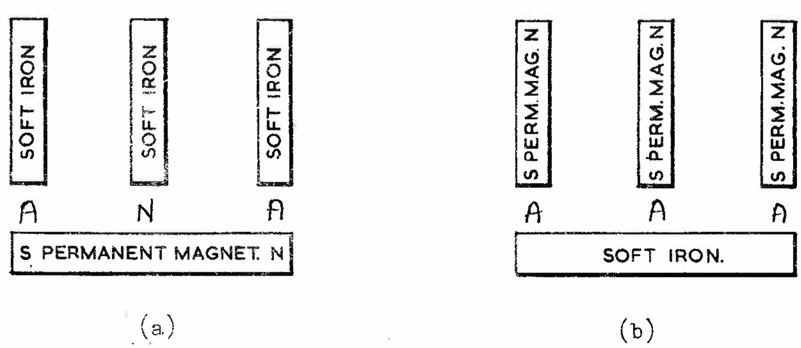


FIG. 1.

CONCLUSIONS:

1. State your method of identifying the permanent magnet of STEP 1.

ONE OF THE SAMPLES IS PLACED ON THE BENCH. THE OTHER SAMPLE IS HELD AT RIGHT ANGLES AND ALLOWED TO COME INTO CONTACT WITH THE BENCH SAMPLE AT ONE END, THE MIDDLE, THEN THE OTHER END

2. ~~What other methods could be used~~?

IF ATTRACTION IS FELT AT ALL THREE POINTS THE SAMPLE ON THE BENCH IS [illegible]

IF ATTRACTION IS FELT AT THE ENDS ONLY THE SAMPLE ON THE BENCH IS [illegible]

3. State the first law of magnetism.

LIKE POLES REPELL

UNLIKE POLES ATTRACT

MAGNETIC FIELDS

A magnetic field is that space in the vicinity of a magnet in which the forces of attraction and repulsion can be detected.

AIM: To plot and study various magnetic fields.

APPARATUS: 2 Bar Magnets, Horseshoe Magnet, Iron Filings, Frame, Compass, Piece of Soft Iron.

METHOD:

STEP 1. Take one bar magnet and move the compass around the magnet. Note and record the behavious of the compass on Fig. 1.

STEP 2. Place one bar magnet under the frame and cover with paper. Sprinkle iron filings over the paper, and tap lightly. Record the magnetic field pattern on Fig. 2a.

STEP 3. Repeat STEP 2 using -

(i) Side and end views of the magnet. Record the pattern on Figs. 2b and 2c.

(ii) Two bar magnets with unlike poles 1" apart. Record the pattern on Fig. 3a.

(iii) Two bar magnets with like poles 1" apart. Record the pattern on Fig. 3b.

(iv) Horseshoe magnet. Record the pattern on Fig. 4.

(v) Bar magnet with a piece of soft iron $\frac{1}{4}$" from one pole. Record the pattern on Fig. 5.

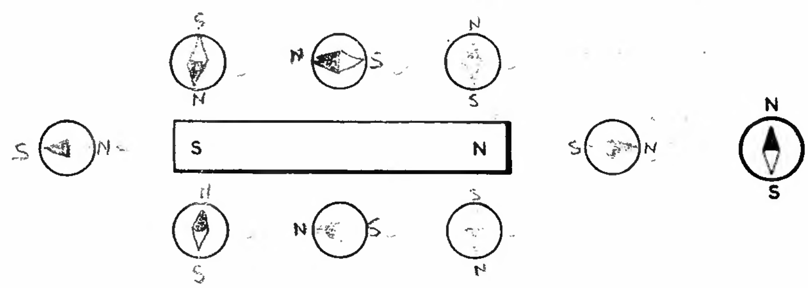
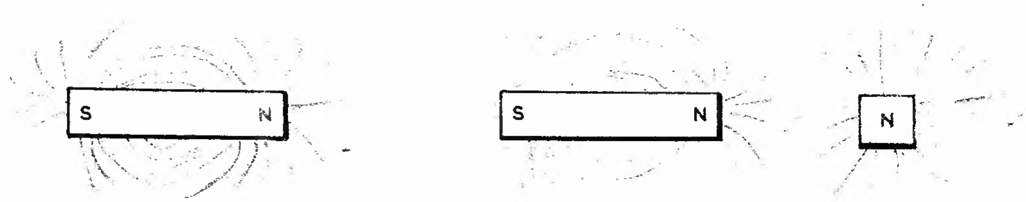


FIG. 1.



(a) (b) (c)

FIG. 2.

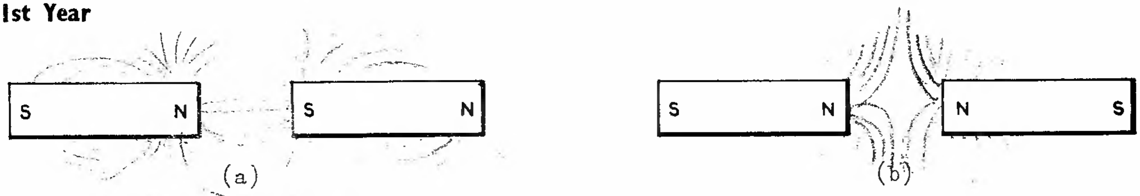


FIG. 3.

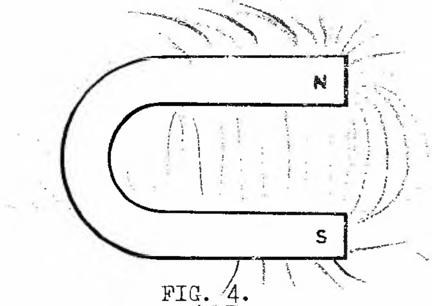


FIG. 4.

FIG. 5.

CONCLUSIONS:

1. What is a magnetic field?

2. Why does the field pattern between Figs. 3a and 3b vary?

3. Why does the soft iron in Fig. 5 show a pattern?

MAGNETIC EFFECT
PRODUCED BY CURRENT IN A CONDUCTOR

A magnetic field surrounds a conductor carrying current.

The direction of the field depends on the direction of the current.

AIM: To prove that a conductor, carrying current, produces a magnetic field, and to study the resultant field patterns.

APPARATUS: Model, Compass, Iron Filings, Ammeter 0-5A, 6 volt supply.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.
With the conductor horizontal, close the switch and move the compass along the length but slightly under the conductor, on both sides.
Record the compass deflection on Fig. 1.

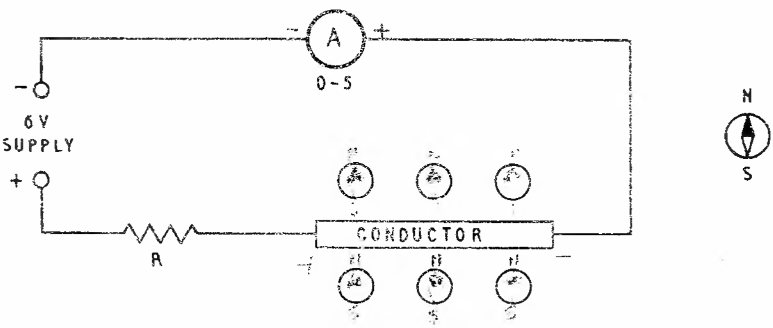


FIG. 1.

STEP 2. With the conductor vertical, move the compass around the conductor. Record the compass deflections on Fig. 2.

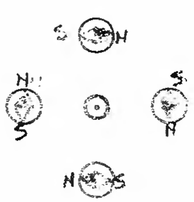


FIG. 2.

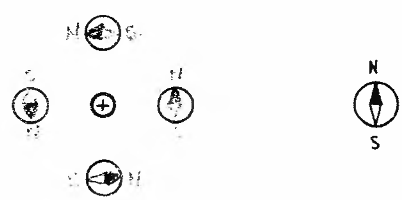


FIG. 3.

STEP 3. Reverse the current through the conductor. Record the compass deflections on Fig. 3.

STEP 4. Sprinkle iron filings on the perspex around the conductor, close the switch, and lightly tap the surface. Record the field pattern on Fig. 4.

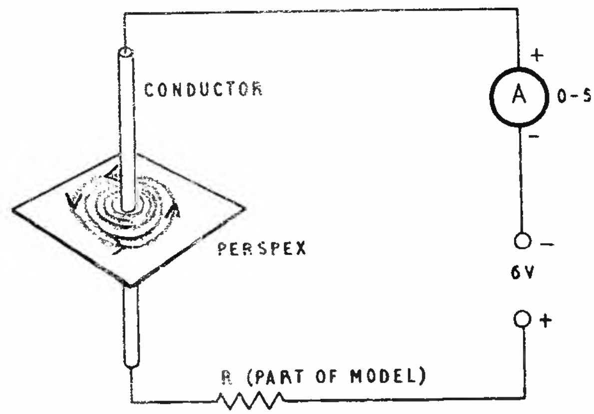


FIG. 4.

CONCLUSIONS.

1. Explain two methods of determining the direction of a magnetic field around a conductor.

(i) WHEN THE FINGERS OF THE LEFT HAND ARE WRAPPED AROUND A CONDUCTOR WITH THE THUM POINTING IN THE DIRECTION OF CURRENT FLOW THE FINGERS WILL POINT IN THE DIRECTION OF THE MAGNETIC FIELD

(ii) A COMPASS IS PLACED AT 90° TO THE VERTICAL CONDUCTOR. THE DIRECTION TO WHICH THE NORTH NEEDLE POINTS IS THE DIRECTION OF THE MAGNETIC FIELD.

2. ~~In what way does the~~ field about a permanent magnet ~~vary from that about a single conductor~~ ?

WHEN CURRENT FLOWS THROUGH A CONDUCTOR A MAGNETIC FIELD IS SET UP. THE STRENGTH OF THE FIELD DEPEDDS ON [illegible] AND [illegible] OF THE MATERIAL SURROUNDING THE CONDUCTAR. THE PERMEABILITY OF AIR IS [illegible] THAN SOFT IRON

MAGNETIC EFFECT OF SOLENOIDS

9/10

When a conductor is wound in the form of a coil, the magnetic fields of adjacent turns combine to form a large field.

The strength of the magnetic field of a solenoid is directly proportional to the value of current and number of turns. (Ampere Turns.)

The field strength can be varied by placing magnetic material within the field.

AIM: To plot and study the factors affecting the magnetic field of a solenoid.

APPARATUS: Solenoid, Resistor 10 ohms, Soft Iron Rod, Compass, Iron filings, Paper, 6 Volt Supply and Switch.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

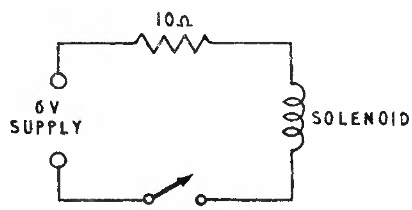


FIG. 1.

STEP 2. Close the Switch. Use the compass to determine the solenoid's polarities. Confirm with the Left Hand (Electron) Rule for solenoids.

STEP 3. Use the paper with iron filings to trace the magnetic field.

STEP 4. Place the soft iron rod in the solenoid and repeat STEP 3.

STEP 5. Increase the current through the solenoid by removing the series resistor. Using the compass, plot and record the field pattern on Fig. 2. Observe the change in field strength from STEP 4.

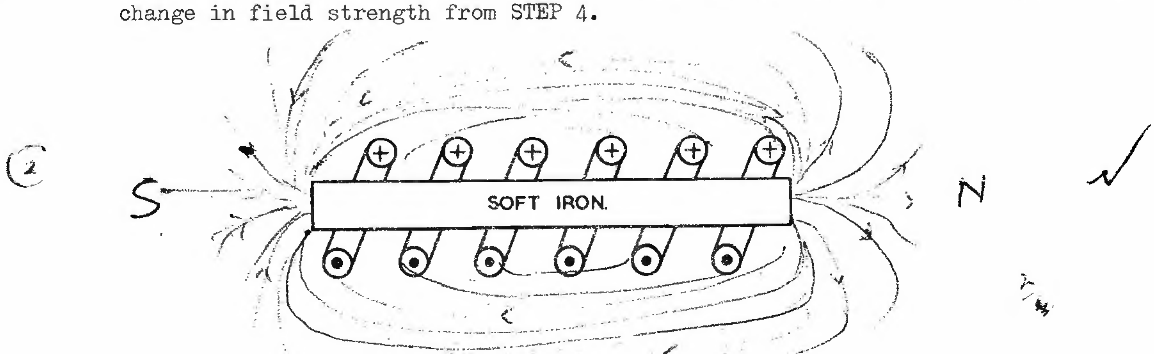
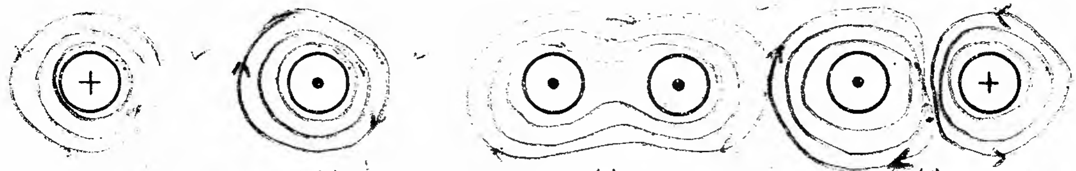


FIG. 2.

CONCLUSIONS:

1. Complete the field patterns and direction of fields in Figs. 3a-3d.



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

FIG. 3.

2. With reference to Fig. 3 explain how a solenoid establishes a magnetic field.

WHEN TWO PARALLEL CONDUCTORS ARE CARRYING CURRENT IN THE SAME DIRECTION THE [illegible] MAGNETIC FIELD [illegible] TO PRODUCE A RESULTANT FIELD STRENGTH WHICH IS [redacted] GREATER THAN THE FIELD OF ONE CONDUCTOR. THEREFORE A SOLENOID MAY BE FORMED WITH [illegible] IN THE SAME DIRECTION TO PRODUCE A RESULTANT MAGNETIC FIELD

3. Explain why the strength of the magnetic field varied between STEPS 3 and 4.

THE SOFT IRON ROD [illegible] THE [illegible] OF THE MAGNETIC CIRCUIT AND [illegible] FOR THE SAME NUMBER OF AMPERE TURNS SOFT IRON HAS HIGH [illegible]

4. Explain why the strength of the magnetic field varied between STEPS 4 and 5.

THE INCREASED CURRENT CAUSED AN INCREASE IN [illegible] WHICH DEPENDS ON AMPERE TURNS. THE INCREASE RESULTS IN INCREASED FIELD STRENGTH

PROJECT NO. 24

Laboratory Projects

Ist Year

MAGNETIC SHIELDING

When a magnetic path [redacted] with low reluctance, such as soft iron, is placed about a magnetic circuit, the field is confined within the path of low reluctance

When a non magnetic material, such as brass, is placed about the same magnetic circuit, the field is not affected.

AIM: To study the effect of various materials on a magnetic field.

APPARATUS: Solenoid with iron core, 6 volt supply, Bands of soft iron and brass, Iron Filings, Paper.

METHOD:

STEP 1. Connect solenoid to 6 volt supply (Fig. 1).

STEP 2. Using iron filings, plot the field of the solenoid. Note the field pattern and direction on Fig. 2.

STEP 3. Place the soft iron band around the solenoid.
Using iron filings - note the field pattern and direction on Fig. 3.

STEP 4. Place the band of brass around the solenoid. Using iron filings plot the field pattern.
Note the field pattern and direction on Fig. 4.

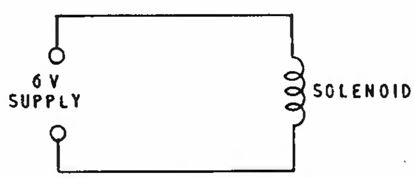


FIG. 1.

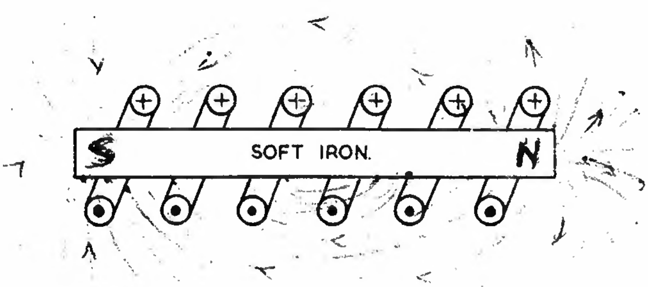


FIG. 2.

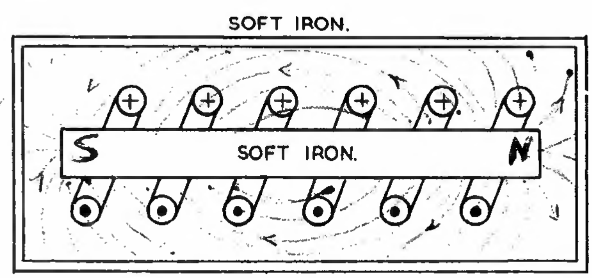


FIG. 3.

Laboratory Projects

PROJECT NO. 24

Ist Year

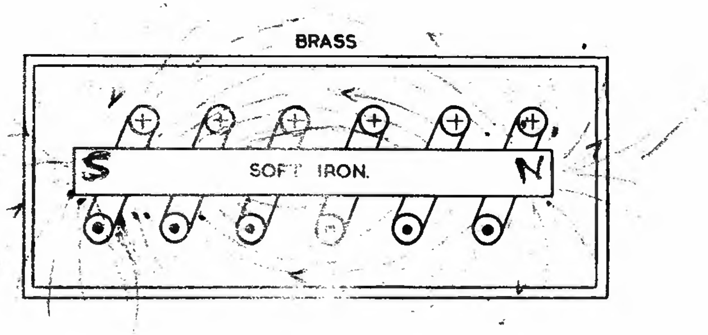


FIG. 4.

(1)

CONCLUSIONS:

1. State and define properties of soft iron which make it suitable for a magnetic shield.

SOFT IRON IS SUITABLE BECAUSE IT HAS HIGH PERMEABILITY. USED AS A SHIELD, IT PROVIDES A LOW RELUCTANCE PATH AROUND THE EQUIP., WHICH RESTRICTS THE FIELD PATTERN. ✓ (2)

2. How would the thickness of the soft iron ring affect the screening effect.

INCREASING THE THICKNESS OF THE IRON WOULD DECREASE THE RELUCTANCE OF THE [illegible] AND PROVIDE MORE EFFICIENT SHIELDING. ✓ (2)

3. When the soft iron shield is placed about the solenoid.

(i) how is the Magnetomotive Force affected?

THE MMF IS INCREASED BECAUSE IT IS DEPENDENT [illegible] THE ~~RELUCTANCE~~ FLUX DENSITY AND THE [illegible] INCREASE THE FLUX DENSITY. ✗ (0)

(ii) how is the Magnetic flux affected?

THE [illegible] [illegible] CONCENTRATED INSIDE THE [illegible] [illegible] [illegible] BEND SHARPLY [illegible] LOW [illegible] PATH. ✓ (1)

MAGNETISATION CURVES

When a magnetising force (H) is applied to a magnetic material, the degree of magnetisation (Flux density B) increases as the magnetising force increases until magnetic saturation is reached.

A Graph showing the variation of Flux density or magnetisation with magnetising force is termed a BH Curve.

The curve is dependent upon the type of material used.

AIM: To plot a B.H. Curve for a piece of magnetic material.

APPARATUS: Magnetometer, Coils (Project 20), Soft iron core, Ammeter 0-1A, 6V variable supply.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

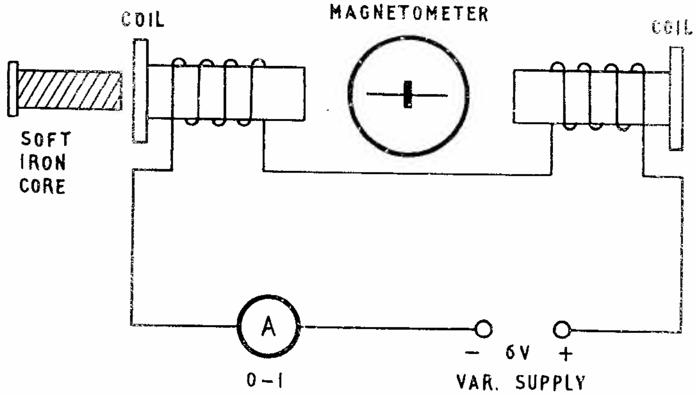


FIG. 1.

STEP 2. Vary the current. Note that magnetometer needle does not vary.

STEP 3. Decrease circuit current to Zero. Insert iron core into coil.

STEP 4. Increase the current to 10mA. Record magnetometer reading in Table 1.

STEP 5. Increase the current as per Table 1 to 700 mA. Record the magnetometer reading for each step in Table 1.

STEP 6. From your results in Table 1 plot a graph of magnetometer readings against current.

CURRENT	MAGNETOMETER DEFLECTION
10 mA	
100 mA	
200 mA	
400 mA	
600 mA	
700 mA	

TABLE 1.

GRAPH 1.

CONCLUSION:

1. With reference to your graph explain briefly the three stages of magnetisation.

....

....

....

ELECTROMAGNETIC INDUCTION (1)

Flux density is the number of lines of force per unit area in a magnetic field. The flux density in the magnetic circuit of an electromagnet can be varied by a change in the value of current, the number of turns, or the reluctance.

A change in flux density about a conductor is relative motion between a field and a conductor, and an induced e.m.f. will result.

AIM: To study electromagnetic induction.

APPARATUS: Two solenoids, Variable reluctance model, volt ~~milli~~ammeter ~~10-0-10 mA~~ .5-0-.5 V, Resistor 10 ohms, Variable resistance 0-50 ohms, Switch, 6 volt supply.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1, setting the variable resistance to a midway position.

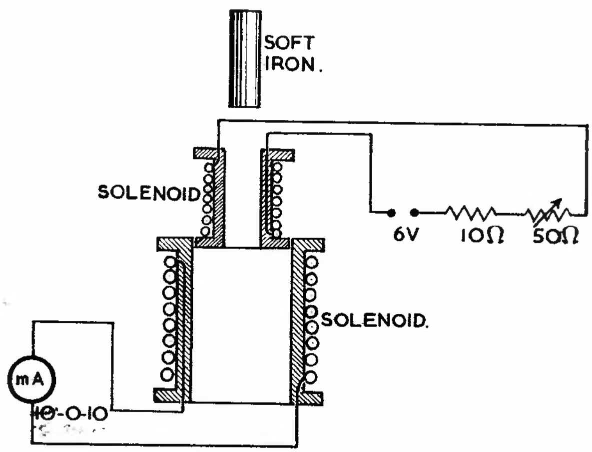


FIG. 1.

STEP 2. Move the small solenoid in and out of the larger solenoid. Observe the induced effects.

STEP 3. Move the iron core in and out of the small solenoid. Observe the induced effects.

STEP 4. With the iron core in position, intermittently stop and start the current in the small solenoid. Observe the induced effects in relation to stopping and starting the current.

STEP 5. Vary the current in the small solenoid with the variable resistance. Observe the induced effects in relation to the rise and fall in current value.

STEP 6. Disconnect the apparatus. Connect the variable reluctance generator model to the centre scale milliammeter (Fig. 2).

STEP 7. Operate the variable reluctance model and observe the induced effects.

STEP 8. Vary the reluctance by moving the armature nearer to, and further from the magnet. Observe the variations in the induced effects in relationship to the varied reluctance.

(6) C.B.

Laboratory Projects

1st Year

PROJECT NO. 26

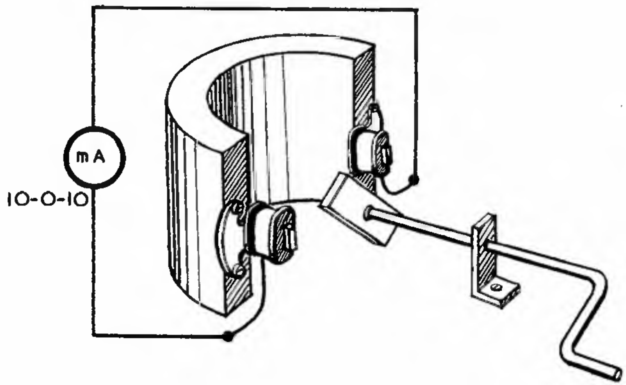


FIG. 2.

CONCLUSIONS:

1. The value of induced e.m.f. depends on ...... RATE OF CHANGE OF FLUX ✓ [illegible] RESISTANCE X

(0)

2. Referring to STEP 3, explain why the movement of the iron core produced an induced e.m.f. in the larger solenoid.

THE MAGNETIC FLUX IS ✓ DEPENDENT ON THE NUMBER OF TURNS ON THE COIL ✓ THE CURRENT FLOW ✓ AND THE RELUCTANCE ✓ MOVING THE SOFT IRON CHANGES THE MAGNETIC FLUX ✓ AND INDUCES AN EMF IN THE ABOVE COIL

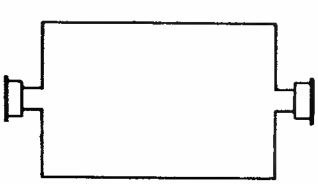
(3)

3. In STEP 7, briefly explain how an induced e.m.f. is produced.

MOVEMENT OF THE SOFT IRON ROTOR CHANGES THE RELUCTANCE ✓ OF THE MAGNETIC CIRCUIT ✓ THIS CAUSES A CHANGE OF FLUX RESULTING ✓ WHICH GENERATES AN ALTERNATING ✓ VOLTAGE IN THE WINDING ✓

(3)

4. Briefly explain how speech can take place between the two receivers.



SPEECH CAUSES ✓ DIAPHRAGM A TO MOVE VARYING THE RELUCTANCE ✓ THE FLUX [illegible] ✓ CHANGES AND INDUCES A VARYING DC X VOLTAGE IN THE WINDINGS WHICH IS APPLIED TO B. B APPEARS AS A NORMAL RECEIVER.

(0)

ELECTROMAGNETIC INDUCTION (2)

When there is relative motion between a conductor and a magnetic field, an e.m.f. is induced in the conductor, and when the circuit is closed a current will flow.

The value of the induced e.m.f. (and resultant current) depends on the field strength of the magnet, the rate of relative motion, and the number of conductors.

AIM: To study electromagnetic induction, and to prove the Left Hand (Electron) Rule for generators.

APPARATUS: Two solenoids, bar magnet, horseshoe magnet, ~~milli~~ammeter 10-0-10mA, single conductor model.

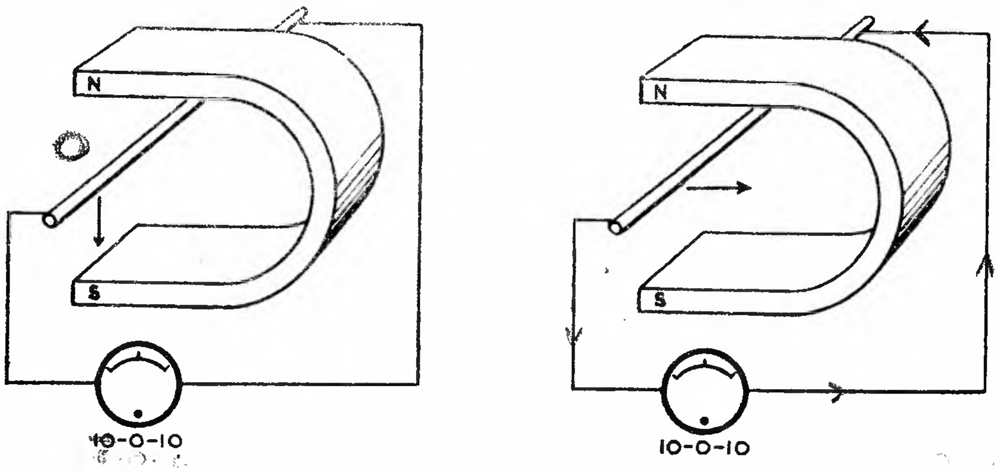
METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

STEP 2. Move the conductor along the lines of force.

STEP 3. Move the conductor across the lines of force.

STEP 4. Note on Figs. 1a and 1b the ~~deflection and~~ direction of current, ~~as indicated by the meter.~~



(a) (b)

FIG. 1.

STEP 5. Connect the circuit as shown in Fig. 2 with the milliammeter connected to the smaller coil.

STEP 6. Move the bar magnet up and down inside the coil. Observe the meter deflections.

STEP 7. Move the bar magnet up and down outside the coil. Observe the meter deflections.

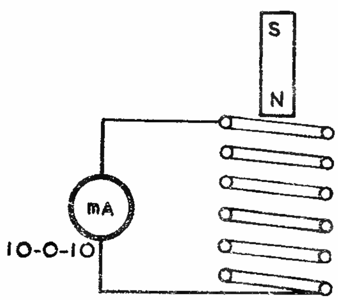


FIG. 2.

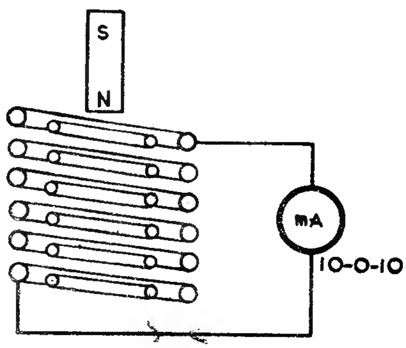


FIG. 3.

STEP 8. Connect the circuit as shown in Fig. 3 with the inner coil open circuited and the milliammeter connected to the outer solenoid.

STEP 9. Move the bar magnet up and down inside the centre coil. Observe the meter deflections.

CONCLUSIONS:

1. Explain why there is no meter deflection in STEP 2.

TO GENERATE AN EMF THE LINES OF FORCE MUST CUT THE CONDUCTOR WHEN MOVEMENT TAKES PLACE. TO ACHIEVE THIS, THE FIELD MUST BE AT RIGHT ANGLES TO THE CONDUCTOR. 2 ✓

2. Why were the meter deflections greater in STEP 6 than in STEP 3 ?

BECAUSE OF THE LARGE NUMBER OF CONDUCTORS

2 ✓

3. On Figs. 4[redacted] complete the details of (i) direction of current, (ii) direction of field, in relationship to the indicated direction of magnet movement.

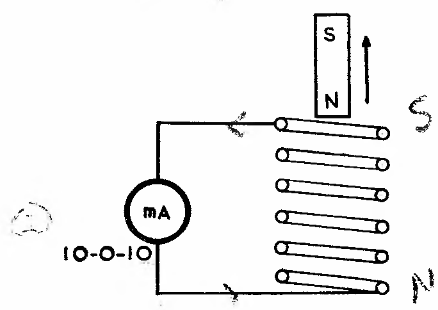
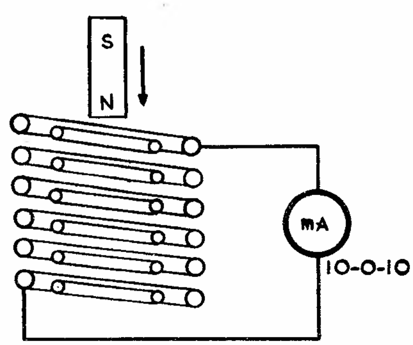


FIG. 4.



[redacted]

A.C. AND D.C. GENERATORS

When a conductor "cuts" a magnetic field an e.m.f. is induced across the conductor.

When the conductor moves in a 360° path within the field the resultant output is an alternating voltage, which in the practical generator, is delivered to the external circuit by means of slip rings and brushes.

When a commutator is fitted in place of slip rings, the resultant output is D.C.

AIM: To study (i) a simple A.C. generator.

(ii) a simple D.C. generator.

APPARATUS: Permanent magnet generator model, Centre zero milliammeter.

METHOD:

STEP 1. Connect the meter to the A.C. terminals of the model.

STEP 2. Starting with the armature in a vertical position, rotate slowly through 180°. Note and verify the direction of current with the Left Hand (Electron) Rule for generators.

STEP 3. Rotate the armature slowly from 180° to 360°. Note and verify the direction of current with the Left Hand (Electron) Rule for generators.

STEP 4. Increase the speed of rotation and observe the increase in the value of current.

STEP 5. Connect the meter to the D.C. terminals of the model. Repeat STEPS 2, 3 and 4.

STEP 6. Complete the graphs of the output voltages, and show the direction of the induced e.m.f. on the conductors in Fig. 1.

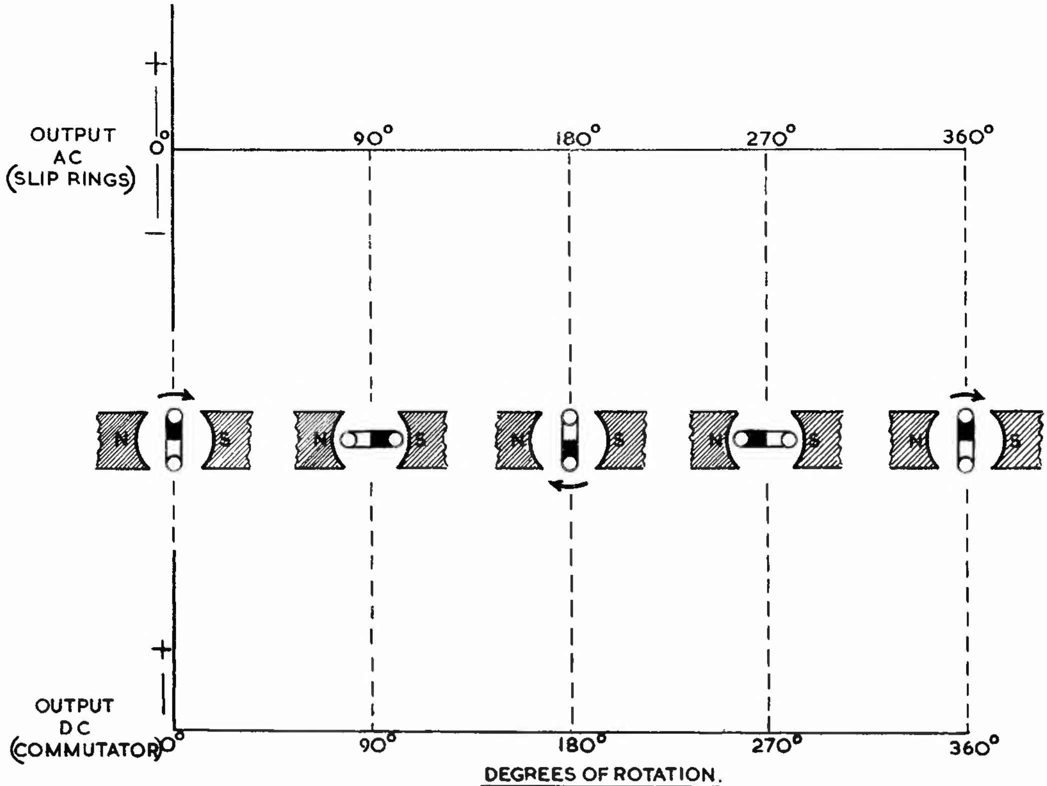


FIG. 1.

CONCLUSIONS:

1. Why is the current opposite in direction in STEPS 2 and 3 ?

. . . .

. . . .

. . . .

. . . .

2. List how the induced e.m.f. of the generator model can be increased.

(i) . . . .

. . . .

(ii) . . . .

. . . .

10 DB

PROJECT NO. 29

Laboratory Projects

Ist Year

MOTORS

When a current-carrying conductor is placed in a magnetic field, a force is exerted on the conductor, tending to move it.

This is called the Motor Principle, and the direction of movement can be determined by the Right Hand (Electron) Rule for motors.

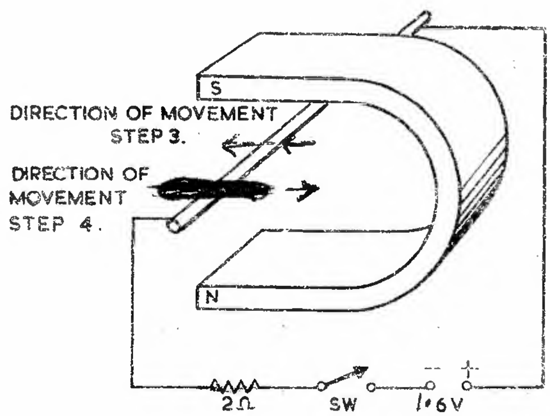
AIM: To study the motor principle.
To prove the Right Hand (Electron) Rule for motors.

APPARATUS: Motor-principle model, ~~Resistor 2 ohms~~, Ammeter 0-5A, Permanent magnet motor model, 6 volt supply.

METHOD:

STEP 1. Connect the motor-principle model in circuit, as shown in Fig. 1.

STEP 2. Place the magnet about the conductor with the South pole uppermost.



(2)

FIG. 1.

STEP 3. Close the switch and observe the direction of conductor movement. Record the direction of conductor movement on Fig. 1.

STEP 4. Reverse the current, and observe the direction of conductor movement. Record the direction of movement on Fig. 1.

STEP 5. Reverse the magnet and observe the direction of conductor movement.

STEP 6. Verify the Right Hand (Electron) Rule in all the preceding steps.

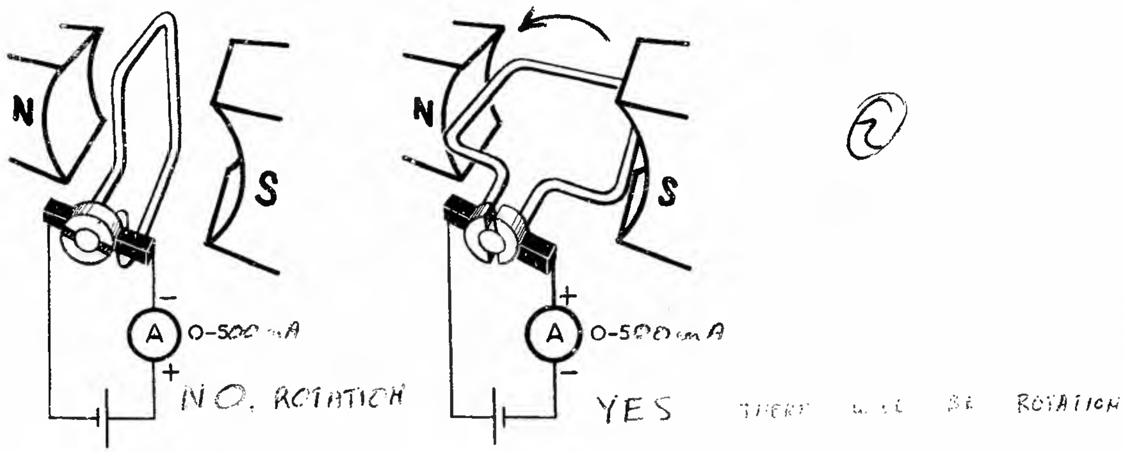
STEP 7. Connect the Motor Model to the battery supply as in Fig. 2.

STEP 8. Hold the armature stationary. Close switch and observe the value of current.

STEP 9. Allow the armature to rotate and observe the value of current.

STEP 10. Compare the values of current in STEPS 8 and 9.

STEP 11. Indicate on Figs. 2a and 2b (i) if rotation will occur.
(ii) the direction of rotation.



(a) (b)

FIG. 2.

②

CONCLUSIONS.

1. Explain the reason for the different values of current in STEPS 8 and 9.

IN STEP 8 WITH THE ARMATURE STATIONARY THERE IS NO BACK EMF, & THE [illegible] CURRENT FLOWS. IN STEP 9 THE ARMATURE CURRENT IS LESS BECAUSE THE BACK EMF [illegible] THE APPLIED EMF.

④

2. Explain briefly, two methods by which the mechanical power output of the motor model could be increased.

① BY INCREASING THE MAGNETIC FIELD STRENGTH [FLUX]

② BY INCREASING THE APPLIED EMF

②

SELF INDUCTION

Inductance is the property of a circuit by which a voltage is induced in the circuit when the current is started, stopped, or changed in value.

A circuit possesses the property of Self Inductance, when a current changing in the circuit, induces an e.m.f. in the same circuit. This process is termed Self Induction.

In a circuit possessing self inductance, the current takes a definite time to rise to its Ohm's Law value, as the induced e.m.f. is in such a direction as to oppose its rise.

When an inductive circuit is broken, the resultant induced e.m.f. is of such a polarity that it tends to maintain the original direction of current, (that is, there is an opposition to change).

AIM: To study the effects of Self Induction.

DEMONSTRATION

APPARATUS: Inductor 0.5H, ammeter 0-10A, milliammeter 50-0-50mA with shunt, Two 250V-15W incandescent lamps, or one Fluorescent Tube 230V - 40W, 6 volt supply and switch.

METHOD:

STEP 1. Connect the circuit as in Fig. 1, using either the lamps or fluorescent tube.

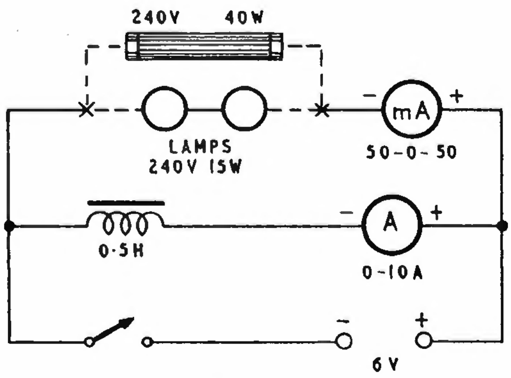


FIG. 1.

STEP 2. Open and close the Switch several times and observe the following -

(i) The behaviour of the current in the Inductor branch compared to current in the lamp branch.

(ii) The reversal of current through the lamp(s) after the switch is opened.

(iii) The brilliance of the lamp(s) as an indication of the value of the induced e.m.f.

Laboratory Projects **PROJECT NO. 30**

1st Year

PROJECT

APPARATUS: Solenoid, Iron Core, Switchboard Lamp 6V, resistor 150 ohms, 6 volt supply and switch.

METHOD:

STEP 1. Connect the circuit as in Fig. 2.

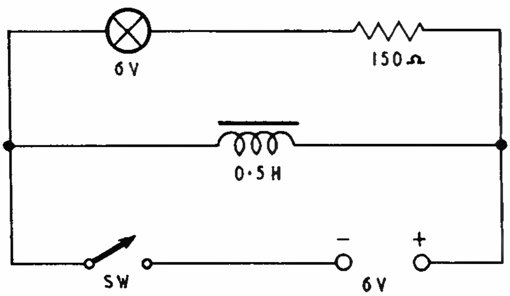


FIG. 2.

STEP 2. Open and close the circuit several times with and without the soft iron core. Observe the behaviour of the lamp when the circuit is opened.

CONCLUSIONS.

1. List the factors determining the value of induced e.m.f. due to self induction.

B C

2. With reference to Fig. 1, explain why the current reverses through the lamp when the supply is switched off.

THE CURRENT THROUGH THE COIL TENDS TO [illegible] THIS PRODUCES AN EMF OF SELF INDUCTION WHICH CAUSES THE VOLTAGE ACROSS THE COIL TO [illegible] THIS EMF THEN PRODUCES CURRENT FLOW THROUGH THE COIL IN THE [illegible] DIRECTION AND THROUGH THE LAMP IN THE [illegible] DIRECTION.

3. With reference to Fig. 2, explain the behaviour of the lamp when the circuit is opened.

WITH THE SWITCH CLOSED [illegible] FLOWS THROUGH THE LAMP FROM THE [illegible] WHEN THE SWITCH IS OPENED THE LAMP FLASHES DUE TO HIGH [illegible] PRODUCED BY COLLAPSING [illegible]

10/10

TRANSFORMERS

When two electrically separate coils are so situated that the magnetic flux produced by current in one coil links the turns of the other coil, an e.m.f. will be induced across the second coil when the magnetic flux changes.

The value of induced e.m.f. depends on the rate of change of flux, and the turns ratio (T).

$$T = \frac{Ns}{Np} \quad \text{and} \quad E_s = E_p \times T.$$

AIM: To study Mutual Induction, Turns Ratio, and Voltage Ratio as applied to a transformer.

APPARATUS: Transformer 4012A, Voltmeter A.C. 0-50V 1000 ohms/V., A.C. Supply (approximately 15V).

METHOD:

STEP 1. Measure and record the supply voltage.

STEP 2. Connect the supply voltage across transformer terminals 5 and 6.

STEP 3. Measure the induced voltage across coils 1-2, 7-8 and 3-4. Record all voltages in Fig. 1, and E_p & E_s in Table 1.

STEP 4. Increase the secondary turns by joining terminals 3 and 8.

STEP 5. Measure the induced voltage across terminals 7 and 4. Record the values of E_p & E_s in Fig. 2 and Table 2.

STEP 6. With terminals 3 and 8 joined connect A.C. supply to terminals 7 and 4.

STEP 7. Measure the induced voltage across terminals 5 and 6. Record the values of E_p & E_s in Fig. 3 and Table 3.

STEP 8. Calculate in Tables 1, 2 and 3 the turns ratio for each step.

Laboratory Projects **PROJECT NO. 31**

1st Year

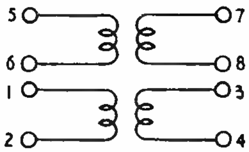


FIG. 1.

PRIMARY E	SECONDARY E	TURNS RATIO
6v	6v ✓	1 : 1 ✓

Table 1.

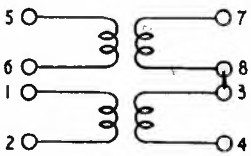


FIG. 2.

PRIMARY E	SECONDARY E	TURNS RATIO
6v	12 ✓	2 : 1 ✓

Table 2.

(3)

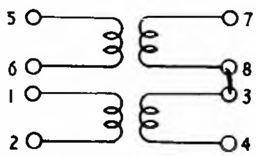


FIG. 3.

PRIMARY E	SECONDARY E	TURNS RATIO
3v ✓	6v ✓	1 : 2 ✓

Table 3.

CONCLUSIONS.

1A If the coil 5-6 has 300 turns, what are the number of turns on the other windings. ~~Give reasons for your answer.~~

1:A ... 300 TURNS ... 300 TURNS ... 300 [illegible] (2)

1B. WHAT ARE THE IMPEDIENCE RATIOS IN TABLE 2 & 3

TABLE 2 ... RATIO ... 4 : 1 ✓

TABLE 3 ... RATIO ... 1 : 4 ✓ (2)

= [illegible] = [illegible] = .5

= [illegible] = [illegible] = .5

2. From ~~conclusion 1 explain why the induced voltage recorded from STEP 7 differs from the supply voltage.~~

WHAT IS THE MAXIUM POSSIBLE Z RATIO THAT CAN BE OBTAINED FROM THIS TRANSFORMER

9 : 1 ✓ (3)

PROJECT NO. 32 **Laboratory Projects**

1st Year

IMPEDANCE MATCHING

Maximum power is transferred from a source of supply to a load, when the load resistance (or impedance) equals the internal resistance (or impedance) of the supply.

AIM: To study the conditions necessary to transfer maximum power from a supply to a load.

APPARATUS: Decade box, Voltmeter 0-50V, Milliammeter 0-50mA, 24V supply (I.R. approximately 600 ohms). Switch.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

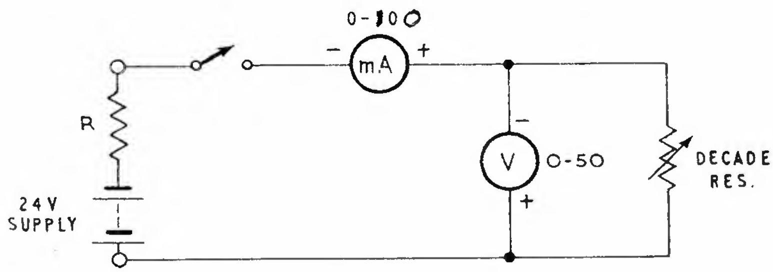


FIG. 1.

STEP 2. Adjust the Decade box to 200 ohms. Close the switch, note and record values of E & I in Table 1.

STEP 3. Repeat STEP 2, using 400, 600, 800, 1000, 1200 and 1400 ohms load resistances.

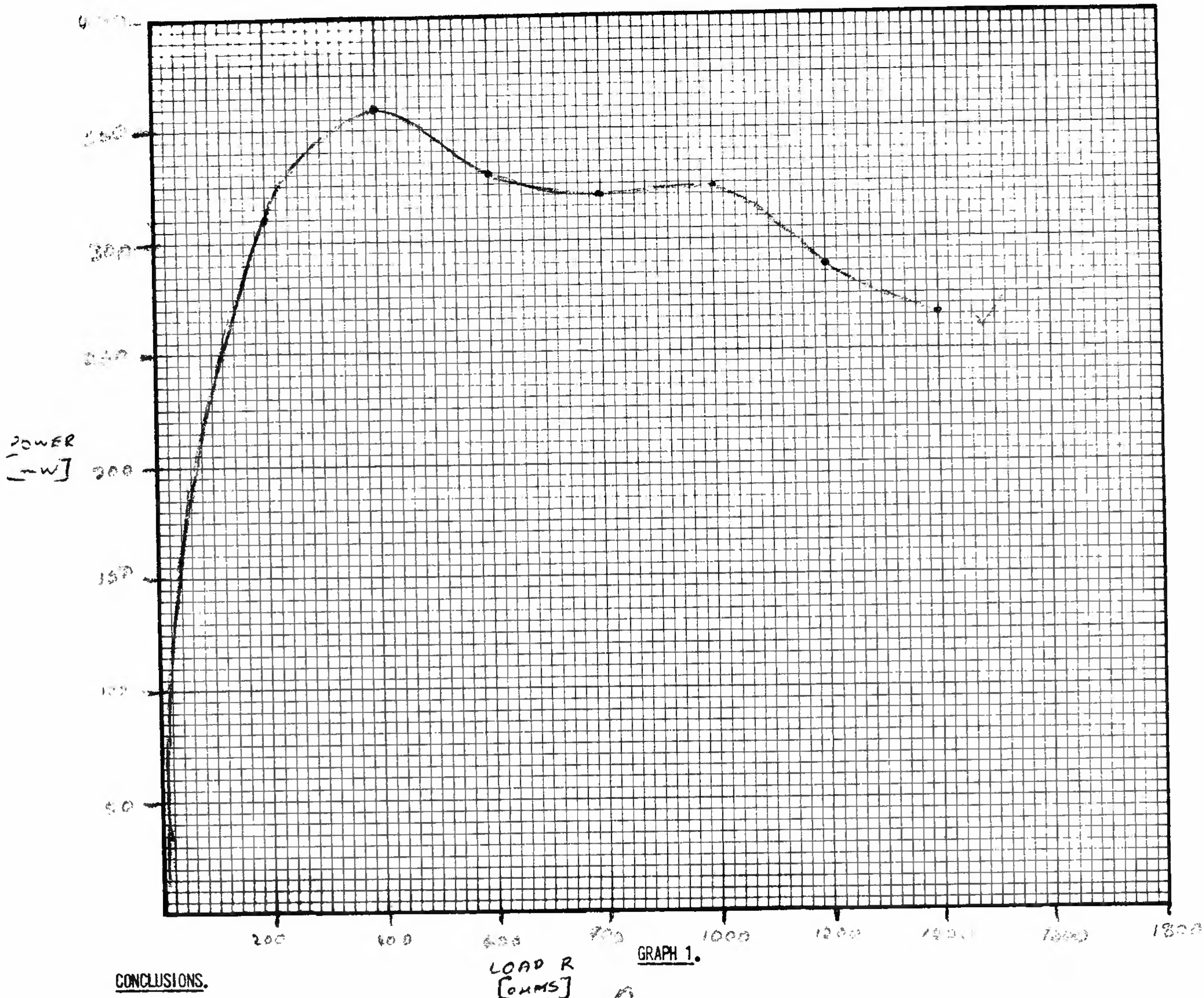
STEP 4. Calculate the power in each load resistance (Table 1).

STEP 5. Plot a graph of Power against Load Resistance on Graph 1.

STEP 6. Read and record the open circuit voltage ....

LOAD R	E	I	POWER = EXI (IN mW)
200Ω	[illegible]	[illegible]	[illegible]
400Ω	12V	[illegible]	·03 × 12 = 360 mW
600Ω	[illegible]	22 mA	[illegible]
800Ω	[illegible]	20 mA	[illegible]
1000Ω	18V	[illegible]	[illegible]
1200Ω	[illegible]	16 mA	·016 × [illegible]
1400Ω	14V	[illegible]	[illegible] 266 mW

TABLE 1.



GRAPH 1.

CONCLUSIONS.

1. From the plotted graph state -

(i) The value of load resistance giving maximum power transference from the source of supply.

400 Ω ✓

(ii) ~~The value of maximum power transferred~~. INT RESISTANCE OF THE SUPPLY

400 Ω ✓

2. Calculate the internal resistance of ~~the~~ A source of supply. (~~Use O/C voltage.~~)

$R = \frac{E}{I} = \frac{14}{28} = \frac{14000}{28} =$

500 Ω

R = 500 Ω ✓

PROJECT NO. 33 **Laboratory Projects**

Ist Year

INSTRUMENT MULTIPLIERS

All measuring instruments using the magnetic principle are designed and calibrated to give maximum deflection for a definite value of current.

For example, 10 mA Full Scale Deflection (F.S.D.).

The voltage range of this type of instrument can be extended by the use of a "Multiplier" which is a resistor connected in series, to limit the current through the meter to the F.S.D. value.

CAUTION: MEASURING INSTRUMENTS MUST NOT BE CONNECTED TO CIRCUITS WHERE THE VALUES TO BE MEASURED ARE LIKELY TO BE GREATER THAN THE VALUE OF F.S.D., AS DAMAGE TO THE INSTRUMENT CAN RESULT.

AIM: To convert a 10 mA. F.S.D. instrument (internal resistance 88 ohms) to read -

(i) 3 volts.
(ii) 10 volts.

APPARATUS: Milliammeter 0-10mA (~~100~~ 88 ohms), Decade box, V~~oltmeter 0-10V~~, 6V ~~variable supply~~.

METHOD:

STEP 1. Calculate the value of multiplier required for each voltage range.

P.D. across instrument with F.S.D. of 10 mA -

$$E = I \times R$$

$$E = .001 \times 88$$

$$E = .088 V$$

(3 volts).

E (mult'r) = E (total) - E (inst.)

= 3 - .088

= 2.912 V

R (mult'r) = $\frac{E}{I}$

= $\frac{2.912}{.001}$

= 2912 Ω

2

ANSWER:- Multiplier = ________

(10 volts).

E (mult'r) = E (total) - E (inst.)

= 10 - .088

= 9.912 V

R (mult'r) = $\frac{E}{I}$

= $\frac{9.912}{.001}$

= 9912 Ω

2

ANSWER:- Multiplier = ________

STEP 2. Adjust the decade resistance box to the calculated value of multiplier resistance required for conversion of the instrument to 3 volts F.S.D.

STEP 3. Connect the circuit as shown in Fig. 1.

CAUTION: THE CIRCUIT MUST BE CHECKED BY THE INSTRUCTOR BEFORE THE BATTERY IS APPLIED.

STEP 4. Adjust the decade resistance box for accuracy of instrument reading, and compare with the calculated value.

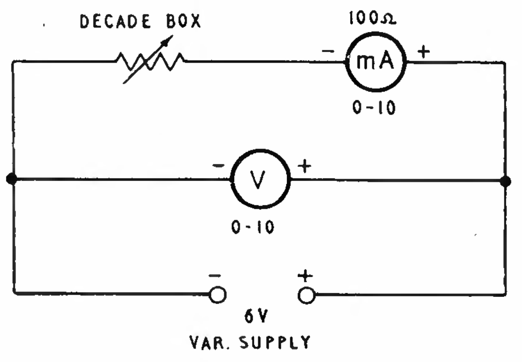


FIG. 1.

STEP 5. Adjust the decade resistance box to the calculated value of multiplier resistance required for conversion of the instrument to 10 volts F.S.D.

CAUTION: THE CIRCUIT MUST BE CHECKED BY THE INSTRUCTOR BEFORE THE BATTERY IS APPLIED.

STEP 6. Adjust the decade resistance box for accuracy of instrument reading, and compare with the calculated value.

CONCLUSIONS.

2

1. The range of a voltmeter can be extended by USING A [illegible] VALUE OF MULTIPLIER IN [illegible] WITH THE METER FOR FULL SCALE DEFLECTION. E METER

2. What is the value of multiplier to convert a 1 mA, 100 ohms instrument to read 1000 volts F.S.D. ?

E = I × R = 100 × ·001 = 1 A

4

E [m] = 1000 − ·1 = 999·9

R [m] = 999·9 / ·001 = 999,900 Ω

PROJECT NO. 34 | **Laboratory Projects**

1st Year

INSTRUMENT SHUNTS

All measuring instruments using the magnetic principle are designed and calibrated to give maximum deflection for a definite value of current.

For example, 10 mA Full Scale Deflection (F.S.D.).

CAUTION: MEASURING INSTRUMENTS MUST NOT BE CONNECTED TO CIRCUITS WHERE THE VALUES TO BE MEASURED ARE LIKELY TO BE GREATER THAN THE VALUE OF F.S.D., AS DAMAGE TO THE INSTRUMENT CAN RESULT.

The current range of this type of instrument can be extended by the use of a Shunt Resistance which is designed to divert (or shunt) all current in excess of the F.S.D. value. [POOR]

AIM: To convert a 1~~0~~ mA F.S.D. instrument (Internal resistance ~~100~~ 88 ohms) to read -

(i) 20 mA
(ii) 100 mA

APPARATUS: Milliammeter 0-1~~0~~ mA (~~100~~ 88 ohms), ~~Decade box~~, Milliammeter 0-100mA, 6V variable supply.

METHOD:

STEP 1. Calculate the value of shunt resistance required for each current range. 2 DECIMAL PLACES.

P.D. across instrument with F.S.D. of 1~~0~~ mA -

$E = IR$

$E = .001 \times 88$

$E = .088\ V$

(20 mA)

I (shunt) = I (total) - I (inst.)

= 20 mA - 1 mA

= 19 mA

R (shunt) = $\frac{E}{I}$

= [illegible]

= 4.63

ANSWER:- Shunt Resistance = 4.63

LENGTH OF SHUNT = 9.26 in

(100 mA)

I (shunt) = I (total) - I (inst.)

= 100 mA - 1 mA

= 99 mA

R (shunt) = $\frac{E}{I}$

= $\frac{88}{99}$

= 0.89

ANSWER:- Shunt Resistance = 0.89 ✓

LENGTH OF SHUNT = 1.78 in

SHUNT RESISTANCE .5Ω PER INCH.

STEP 2. Adjust the ~~decade resistance box~~ SHUNT LENGTH to the calculated value of shunt resistance required for conversion of the instrument to 20 mA F.S.D. 4 DECIMAL PLACES

STEP 3. Connect the circuit as shown in Fig. 1. CHECK AGAINST OTHER METER.

CAUTION: THE CIRCUIT MUST BE CHECKED BY THE INSTRUCTOR BEFORE THE BATTERY IS APPLIED.

STEP 4. ~~Adjust the decade box for accuracy of instrument reading and compare with the calculated value~~.

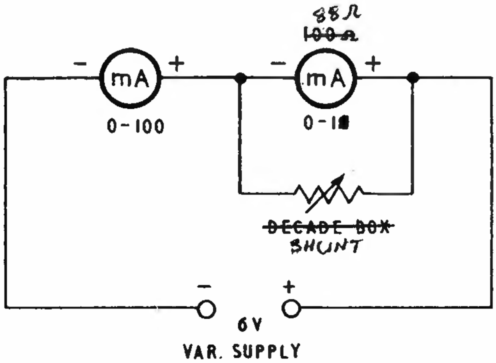


FIG. 1.

STEP 5. Adjust the ~~decade resistance box~~ SHUNT LENGTH to the calculated value of shunt resistance required for meter conversion to 100 mA F.S.D. CHECK AGAINST OTHER METER

CAUTION: THE CIRCUIT MUST BE CHECKED BY THE INSTRUCTOR BEFORE THE BATTERY IS APPLIED.

STEP 6. ~~Adjust the decade resistance box for accuracy of instrument reading and compare with the calculated value~~.

CONCLUSIONS.

1. The range of an ammeter can be extended by . . USING . . A LOWER . . RESISTANCE . . SHUNT . . . .

2. What is the value of shunt resistance required to convert a 1 mA, 100 ohms instrument to read 1 ampere F.S.D. ?

. . . E = I×R = .001×100 = .1 V . . . .

. . . . Inst = E/R = .1/100 = 1mA = .999 . . . .

. . . . R = E/I = .1/.999 = .1001 Ω . . . .

. . . .

PROJECT NO.35

MEASURING RESISTANCE

SLIDE WIRE OR METRE BRIDGE METHOD

Laboratory Projects

1st Year

In any electrical circuit there is no current between points of equal potential.

The ratio of P.D's across any series resistances equals the ratio of the respective resistances.

The P.D. across any part of a series circuit bears the same ratio to the P.D. across the whole of the circuit, as the resistance of that part has to the total resistance.

This not only applies to a circuit possessing only series components, but also to the series section of a complex circuit.

AIM: To find the value of unknown resistances, with a slide wire bridge, using the principles stated above.

APPARATUS: Slide wire bridge, 6 volt supply, resistors 100 and 30 ohms, voltmeters 10-0-10V and 0.5-0-0.5V, three unknown resistances.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

CAUTION: CONNECT THE BATTERY SUPPLY TO THE BRIDGE BEFORE CONNECTING THE VOLTMETER IN CIRCUIT ON ITS 10-0-10V SCALE.

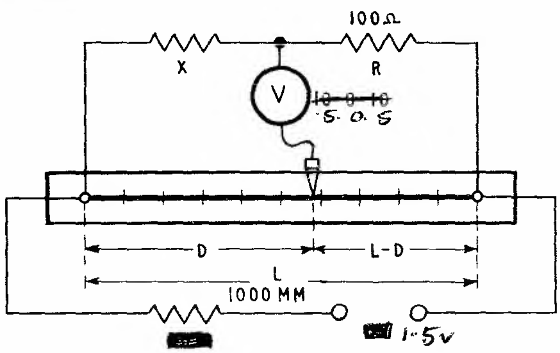


FIG. 1.

STEP 2. Adjust the moveable contact along the bridge wire until the voltmeter shows zero deflection ~~on the 10-0-10V Scale~~.

STEP 3. Switch the voltmeter to the 0.5-0-0.5V scale and adjust the moveable contact for zero deflection.

CAUTION: DO NOT MOVE THE SLIDING CONTACT WHILST SWITCHING THE METER TO THE NEW SCALE.

STEP 4. Accurately note the length of wire on the bridge scale, from the end to the sliding contact, and record this as "D" in Table 1.

The remaining length of wire equals "L - D", where L = total length in millimetres.

Then from Fig. 1 -

$$\frac{X}{D} = \frac{R}{L - D}$$

$$\therefore \quad X = \frac{D\,R}{L - D}$$

where X = unknown resistance, R = known resistance

STEP 5. Solve for "X" (Table 1).

Laboratory Projects

Ist Year

PROJECT NO. 35

STEP 6. Repeat steps 1-5 using the other unknown resistances.

X	R Ω	L	D mm	L - D mm	$X = \frac{DR}{L-D}$
A	100	1000	500	500	$X = \frac{500 \times 100}{500} = 100\ \Omega$
B	100	1000	230	770	$X = \frac{230 \times 100}{770} = 30\ \Omega$
C	100	1000	450	550	$X = \frac{450 \times 100}{550} = 82\ \Omega$

TABLE 1.

CONCLUSIONS.

1. Why is it necessary to adjust the sliding contact of the bridge, to achieve a zero reading on the voltmeter.

THE TOTAL POTENTIAL DROP ALONG THE SLIDE WIRE IS THE SAME AS THE DROP OVER X & R IN SERIES. TO OBTAIN A BALANCE THE SLIDE MUST BE MOVED TO A POINT WHICH IS AT THE SAME POTENTIAL AS THE JUNCTION OF X & R

2. Explain the principle of electrical theory which enables us to use units of length and resistance together in the formula of STEP 4.

PROVIDING THE WIRE HAS UNIFORM CROSS SECTIONAL AREA THE RESISTANCE IS PROPORTIONAL TO THE LENGTH.

3, IF THE BATTERY VOLTAGE WAS DOUBLED THE RESULT WOULD BE THE SAME

PROJECT NO. 36

Laboratory Projects

1st Year

WHEATSTONE BRIDGE

In an electrical circuit there is no current between points of equal potential.

The ratio of P.D.'s across any series resistances equals the ratio of the respective resistances.

The P.D. across any part of a series circuit bears the same ratio to the P.D. across the whole of the circuit, as the resistance of that part has to the total resistance.

The Wheatstone Bridge uses these principles and provides a very accurate method of measuring resistance.

AIM: To study and use the principle of the Wheatstone Bridge.

APPARATUS: Voltmeter 0.5-0-0.5V, Resistors 30, 40, 150 ohms, Decade resistance box, 6V supply, Bell receiver, Tone supply. Transformer 4012A.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

DECADE BOX
G = 52Ω
H = 66Ω
D = 264Ω
J = 960Ω

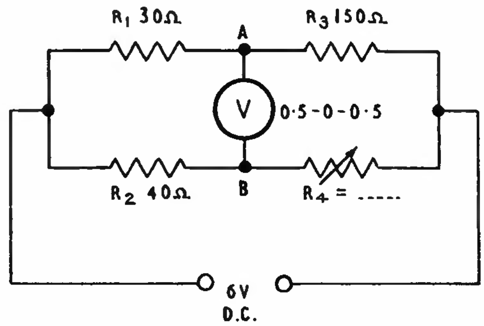


FIG. 1.

CALCULATIONS
G = 39Ω ✓
H = 49.5Ω ✓
D = 198Ω ✓
J = 720Ω ✓

STEP 2. Adjust the decade box until the P.D. between points A & B is zero. Record the resistance value on Fig. 1.

When the P.D. between A and B = 0

$$\text{Then } \frac{R_1}{R_2} = \frac{R_3}{R_4}$$

STEP 3. Connect the circuit as shown in Fig. 2.

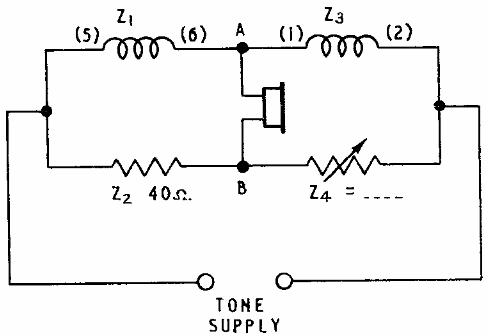


FIG. 2.

STEP 4. Adjust the decade box until minimum tone is heard. Record the resistance value in Fig. 2.

When there is minimum P.D. between A and B.

$$\text{Then } \frac{Z_1}{Z_2} = \frac{Z_3}{Z_4}$$

CONCLUSION: ~~Using simulated voltage readings, explain why in STEP 2, the voltmeter read zero under balanced conditions.~~

WITH THE BRIDGE BALANCED (FIG 2) THE VALUE OF R4 WOULD BE 200 Ω ✓ THE VOLTAGE ACROSS R1 WOULD BE 12 VOLTS AND THE VOLTAGE ACROSS R2 WOULD BE 12 VOLTS

IF A 12 V SUPPLY WAS USED THE RESULTS OBTAINED FOR THE UNKNOWN RESISTORS WOULD BE THE SAME

PROJECT NO.37

Laboratory Projects

1st Year

MEASURING RESISTANCE
SERIES VOLTMETER METHOD

In a series circuit the sum of the voltage drops around the circuit is equal to the applied voltage, and the current through each component is the same as that from the source of supply. This principle is used in Telecom to determine the value of an unknown resistance (for example, a subscriber's line).

AIM: To measure the values of unknown resistances by the Series Voltmeter Method.

APPARATUS: Voltmeter ~~0-50V~~ 0-100V (1000 ohms/V), ~~25~~ 50 volts supply, 3 unknown resistances.

METHOD:

STEP 1. Using the ~~0-50~~ 0-100 Voltmeter measure the supply voltage. Record the voltmeter reading as V_1 in Table 1.

STEP 2. Connect the resistor RX_1 in series with the voltmeter across the battery, as shown in Fig. 1.

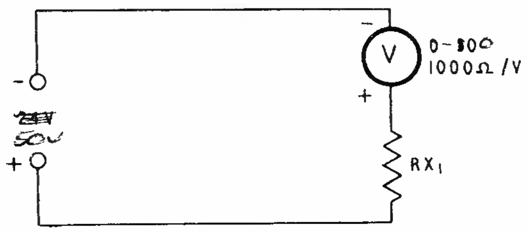


FIG. 1.

STEP 3. Record the voltmeter reading as V_2 in Table 1.

STEP 4. Calculate the P.D. across RX_1 $(V_1 - V_2)$.

The current through the voltmeter (and RX_1) is found from –

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

$$\therefore \quad I = \frac{V_2}{R_m}$$

where V_2 = voltmeter reading.

R_m = voltmeter resistance.

Since $$RX_1 = \frac{E}{I}$$

$(E = V_1 - V_2$ and, $I = \frac{V_2}{R_m})$

Then $$RX_1 = \frac{V_1 - V_2}{\frac{V_2}{R_m}}$$

$$\therefore \quad RX_1 = \frac{(V_1 - V_2)\,R_m}{V_2}$$

10/10   6 B

Laboratory Projects   **PROJECT NO.37**

Ist Year

RESISTANCE	V_1	V_2	RES. V'MR	$RX = \left(\frac{V_1 - V_2}{V_2}\right) Rm$
RX_1 BLACK	41	40	[illegible]	22·5 KΩ ✓ 2
RX_2 WHITE	49	24 V	[illegible]	104 KΩ ✓ 2
RX_3 RED	49	22 V	[illegible]	48·5 KΩ ✓ 2

6

TABLE 1.

CONCLUSION.

1. Using the Series Voltmeter method, as shown in Fig. 2, calculate the insulation resistance of a subscriber's line when the testing voltage is 80V, the voltmeter resistance is 200,000 ohms, and the voltmeter reading when connected in circuit, is 20V.

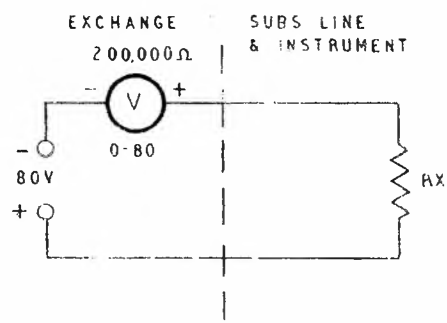


FIG. 2.

$$Rx = \left(\frac{V_1 - V_2}{V_2}\right) Rm$$

$$= \left(\frac{80 - 20}{20}\right) \times 200000$$

$$= \frac{60}{20} \times 200000$$

$$= 3 \times 200000$$

$$= 600{,}000\ \Omega$$

4

PROJECT NO. 38 | **Laboratory Projects**
1st Year

CAPACITOR CHARGE AND DISCHARGE CHARACTERISTICS

A capacitor is a device which is capable of storing electrical energy in the form of a static charge.

When the capacitor is connected to a source of e.m.f., the incoming charge raises the P.D. across its plates until it is equal and opposite to the source.

When the capacitor is discharged the P.D. between the plates decreases until both plates are at the same potential.

AIM: To study the charge and discharge characteristics of a capacitor.

APPARATUS: Capacitor ~~6,000~~ 2000 µF, resistor ~~750~~ 1000 ohms, milliammeter 50-0-50mA, Voltmeter 0-50V, c/o switch, ~~24~~ 50 volt supply.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

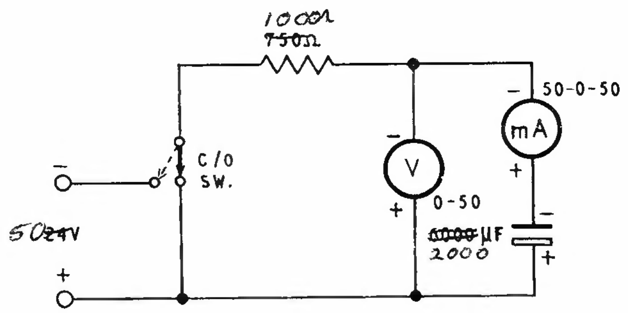


FIG. 1.

STEP 2. Charge the capacitor, and note the behaviour and direction of the current as indicated by the milliammeter. → Vm

STEP 3. Discharge the capacitor, and note the behaviour and direction of the current as indicated by the milliammeter.

STEP 4. ~~Repeat STEPS 2 and 3 recording the current readings every 5 seconds for 40 seconds~~.

STEP 5. ~~Repeat STEPS 2 and 3 recording the voltage readings every 5 seconds for 40 seconds~~.

STEP 6. ~~From the recorded readings of current and voltage~~, plot a graph of the charge and discharge of the capacitor against time (Graph 1).

CONCLUSIONS:

1. ~~Why is the discharge current opposite in direction to the charge current~~?

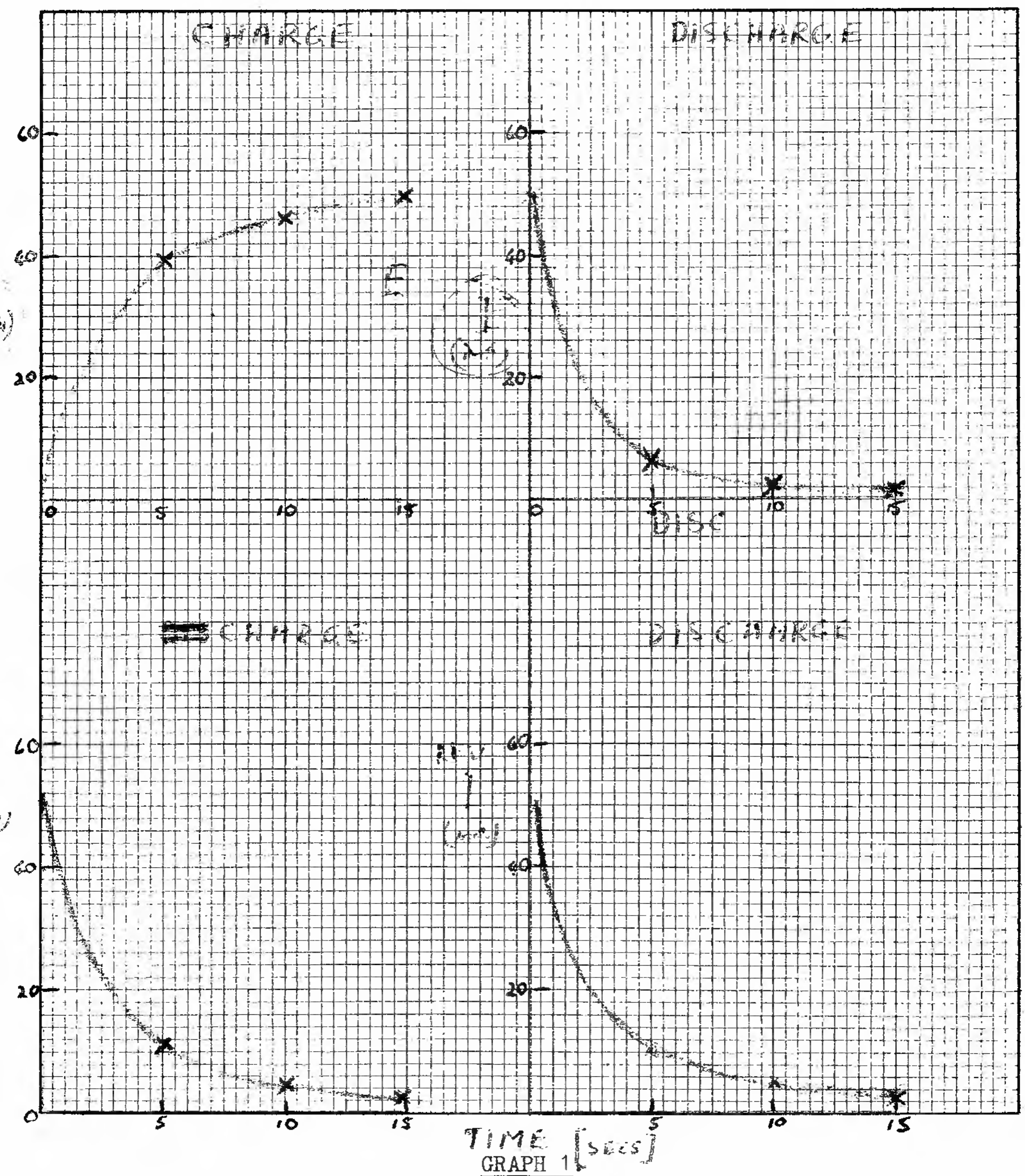
Q = CE = 2000 × 50 = 10,000 COULOMBS

2. ~~Why does the current cease when a capacitor is fully charged~~?

IF A 2000 Ω RESISTOR WAS USED THE CHARGING TIME WOULD ~~DECREASE~~ INCREASED

THE DISCHARGE TIME WOULD BE ~~DE~~INCREASED

3/4



GRAPH 1

INDUCTANCE, CAPACITANCE AND RESISTANCE IN D.C. & A.C. CIRCUITS

The total opposition offered by a circuit to D.C. is called Resistance and is measured in ohms.

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

The current in this circuit is found from $I = \frac{E}{R}$

The total opposition to A.C. offered by a circuit containing Inductance (L) and/or Capacitance (C) is called Reactance (X) and is measured in ohms.

$$X_L = 2\pi fL \quad \text{and} \quad X_C = \frac{1}{2\pi fc}$$

The current in this circuit is found from $I = \frac{E}{X}$

The total opposition to A.C. offered by a circuit containing Resistance (R) and Reactance (X) is called Impedance (Z), and is measured in ohms.

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

The current in this circuit is found from $I = \frac{E}{Z}$

AIM: To compare the effects produced when Inductance, Capacitance and Resistance are connected in D.C., and A.C. circuits.

APPARATUS: Resistor 750 ohms, Inductor 30 H, Capacitor 2 μF, Milliammeter 0-10mA (D.C.), Milliammeter 0-10mA (A.C.), 6 volts D.C. Supply, 6V A.C. Supply.

METHOD:

STEP 1. Connect the resistor in series with the D.C. milliammeter across the 6V D.C. supply. Note and record the current in Fig. 1.

STEP 2. Repeat Step 1 using (i) the inductor, (ii) the capacitor.

STEP 3. Repeat Steps 1 and 2 using the A.C. milliammeter and the 6V A.C. supply.

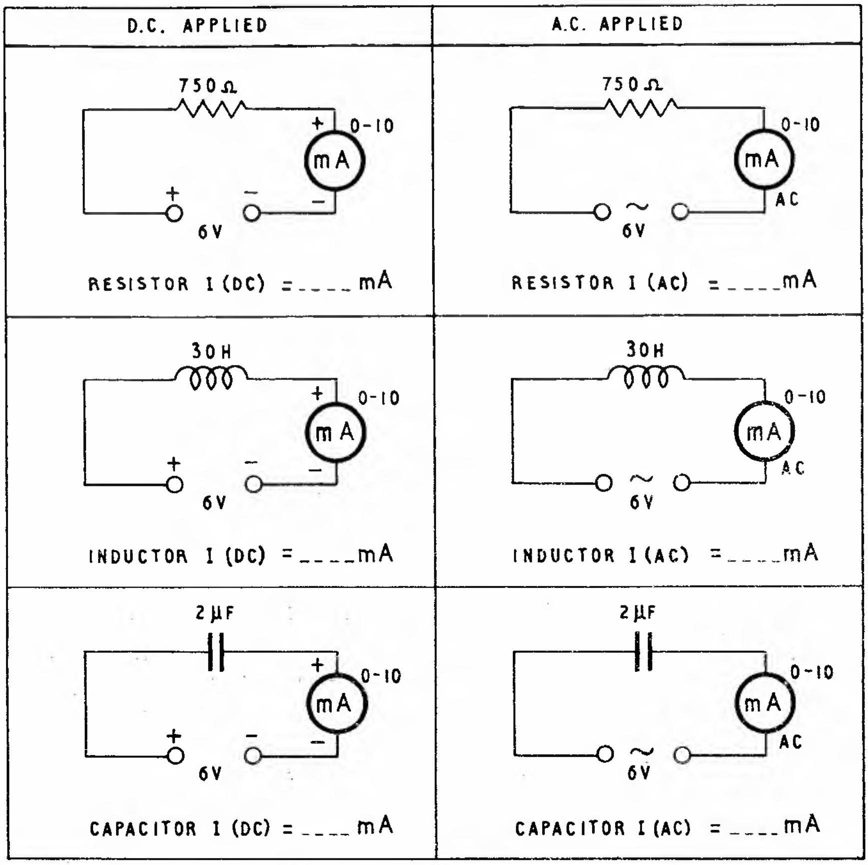


FIG. 1.

CONCLUSIONS:

1. Compare the results obtained when A.C. and D.C. are applied to the resistor.

....

....

2. (i) When A.C. is applied to the inductor, the current value, in comparison with the D.C. value rises? / falls? / shows no change?

(ii) Briefly explain the principle causing this effect.

....

....

3. Compare the results obtained when A.C. and D.C. are applied to the capacitor.

....

....

PROJECT NO.40 **Laboratory Projects**

Ist Year

ELECTRONICS.
DIODE

A thermionic valve having two elements is called a Diode. The element which emits electrons when heated is called the Cathode.

The element which collects electrons when it is positively charged is called the Anode.

The magnitude of the anode current (or electron stream between cathode and anode) depends on the temperature of the cathode, and potential of the anode.

AIM: To prove that the anode current in the diode varies with anode voltage.

APPARATUS: Valve test board, voltmeter 0-10V, milliammeter 0-10mA, Diode 6H6, 6.3 volts filament supply, 50 volts anode supply. Potentiometer 5,000 ohms 50W.

METHOD:

STEP 1. Connect the battery supplies, the voltmeter and the ammeter to the valve test board (Fig. 1).

CAUTION: MAKE SURE THAT THE BATTERY SUPPLIES ARE CONNECTED TO THE CORRECT TERMINALS, AND ARE IN CORRECT POLARITY.

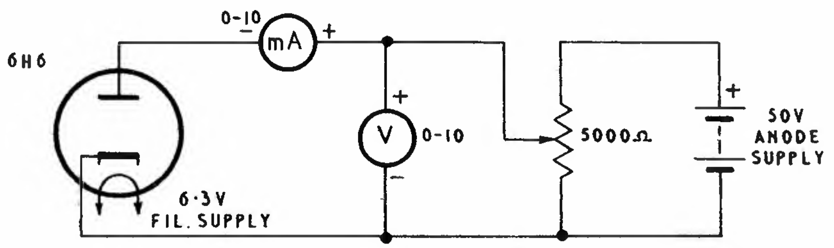


FIG. 1.

STEP 2. ~~Adjust the potentiometer until the voltmeter reads approximately 8 vol~~ts.

STEP 3. ~~Plug the diode tube into its socket, and wait until the milliammeter reads approximately 5mA~~.

STEP 4. Adjust the potentiometer until the anode voltage is zero.

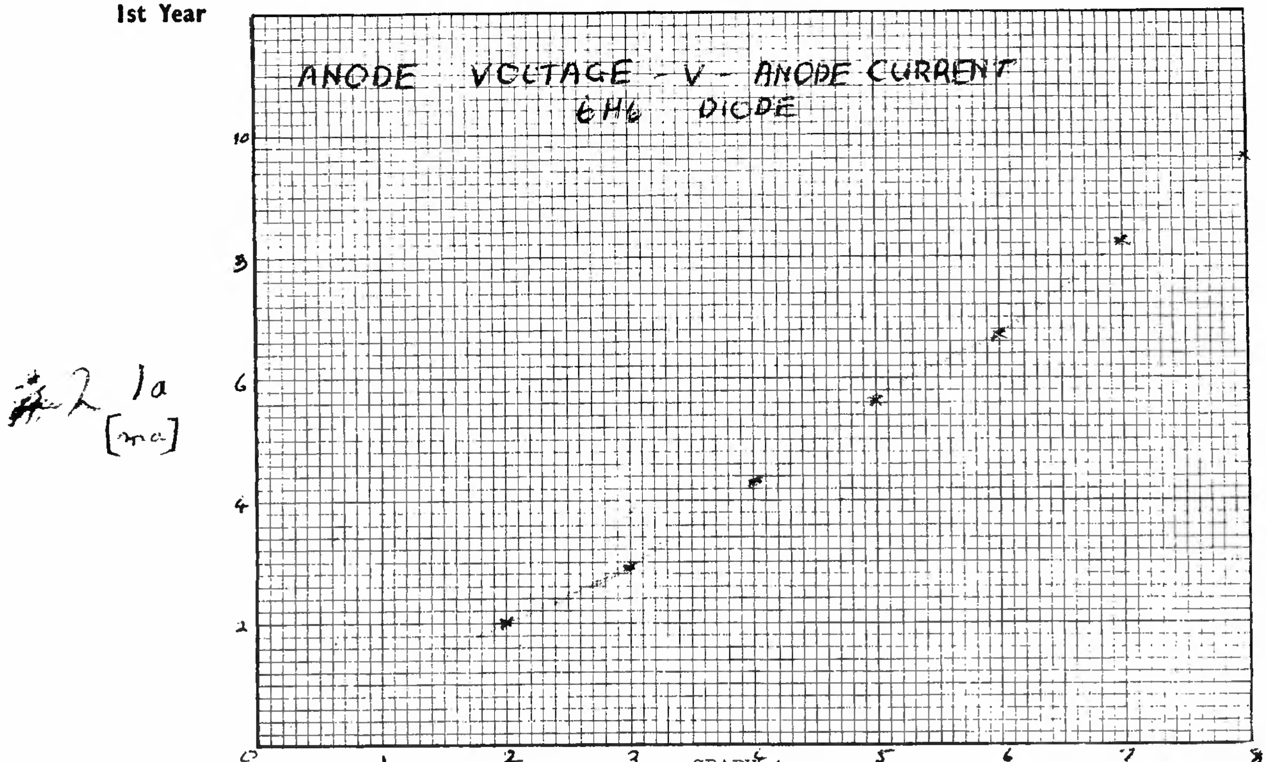
STEP 5. Adjust the potentiometer until the anode voltage is 1 volt. Note and record the current reading in Table 1.

STEP 6. Repeat STEP 5 with anode voltage readings of 2, 3, 4, 5 and 6 volts respectively. 7 + 8 volts

STEP 7. Plot a graph of Anode Current (I_a) versus Anode Voltage (E_a) on Graph 1.

ANODE VOLTS	ANODE CURRENT
2	2
3	2·9
4	4·3
5	5·6
6	6·7
7	8·2
8	9·6

TABLE 1.



GRAPH 1.

CONCLUSIONS:

1. Explain what is meant by "space charge".

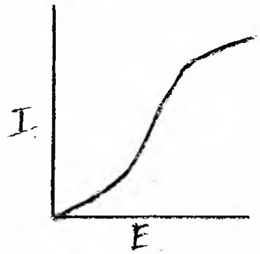
...THE ELECTRON CLOUD AROUND THE CATHODE...............

....

2. Why does anode potential affect anode current?

...BECAUSE MORE ELECTRONS ARE ATTRACTED FROM THE SPACE CHARGE

3. Draw a graph to indicate [redacted] Saturation.



4. [redacted] saturation occurs when? ..WHEN...THERE..IS..INSUFFICIENT...ANODE....

..POTENTIAL TO ATTRACT MORE ELECTRONS...........

....

ELECTRONICS.
DIODE AS A RECTIFIER

For the operation of most electronic equipment it is necessary to convert or rectify the alternating current from the commercial mains to a direct current.

The diode is used for rectification in two ways:-

(i) half wave rectification
(ii) full wave rectification.

AIM: To study the operation of a Diode used for half and full wave rectification.

APPARATUS: Diode Model Board, Duo-Diode 6X5, Transformer 4012A, Voltmeter 0-10V (D.C.). Voltmeter 0-10V (A.C.), 6V A.C. Supply, Cathode Ray Oscilloscope.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1

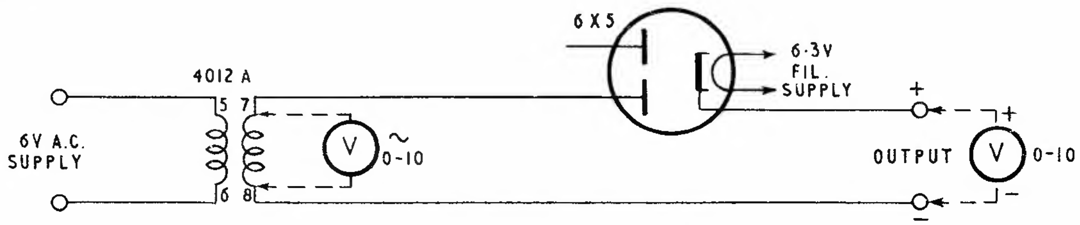


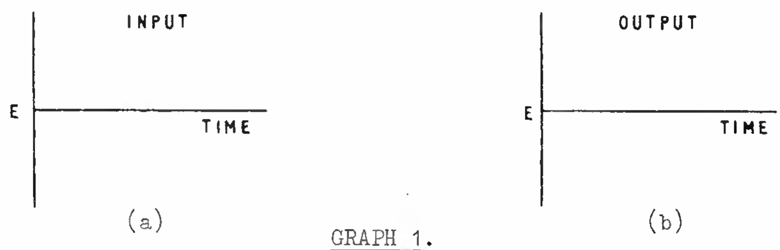
FIG. 1.

STEP 2. Measure and record the alternating input voltage, and the direct output voltage.

Alternating Input Voltage . . . . Direct Output Voltage . . . . . .

STEP 3. DEMONSTRATION

Connect the C.R.O. to the input and output of the Diode. Record waveforms of two cycles on Graphs 1a and 1b.



GRAPH 1.

STEP 4. Connect the circuit as shown in Fig. 2.

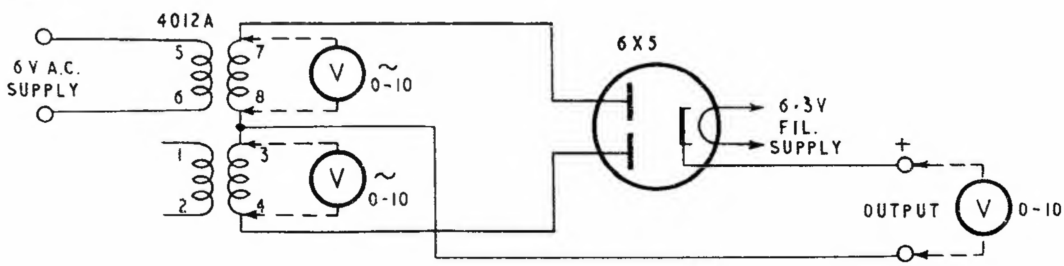


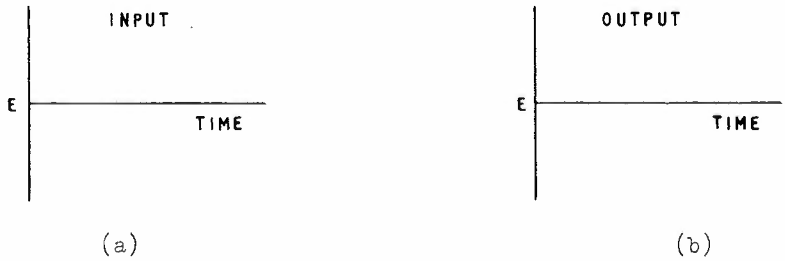
FIG. 2.

STEP 5. Measure and record the alternating input voltage and the direct output voltage.

Alternating input voltage . . . . Direct output voltage . . . .

STEP 6. DEMONSTRATION

Connect the C.R.O. across each of the secondary windings of the transformer, and across the output of the Diode. Record the waveforms of two cycles on Graphs 2a and 2b.



GRAPH 2.

CONCLUSIONS:

1. Sketch the standard symbols, and label the elements of (i) an indirectly heated diode.
(ii) a directly heated diode.

INDIRECTLY HEATED. DIRECTLY HEATED.

2. Briefly explain why the recorded output voltage from full wave rectification is greater than that from half wave rectification.

. . . .

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. . . .

ELECTRONICS.

TRIODE

The diode is limited in its application as it can only be used for rectification.

With the introduction of a third element, in the form of a grid, between the anode and cathode, the valve can be used as an amplifier, oscillator, or as a means of current control.

The extra element is called the Control Grid, and the three element valve is called a Triode.

In the construction, the grid is placed close to the cathode, and small variations of potential (Eg) on the grid cause large variations in Anode Current (Ia).

AIM: To study the Anode Current versus Grid Voltage characteristic curve of a triode.

APPARATUS: Triode test board, Voltmeter 0-100V, Milliammeter 0-10mA, Voltmeter 10-0-10V Triode 6C5, Anode supply 50V, Filament Supply 6.3V Grid Bias 9V, Potentiometer 5,000 and 10,000 ohms 50W.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

CAUTION: MAKE SURE OF CORRECT POLARITIES AND TERMINATIONS OF POWER SUPPLIES.

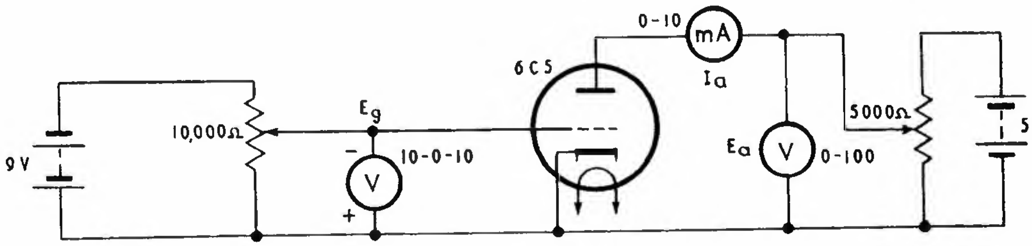


FIG. 1.

STEP 2. Adjust anode voltage (Ea) to 20V.

STEP 3. Plug in the 6C5. Observe that the cathode glows.

STEP 4. With grid potential zero note and record the anode current reading in Table 1.

STEP 5. Adjust grid voltage to 1 volt negative. Note and record the anode current reading in Table 1.

STEP 6. Repeat STEP 5 using negative 2, 3, 4 and 5 volts grid potential.

STEP 7. Adjust grid voltage to zero and reverse the polarity of the Grid supply.

STEP 8. Repeat STEP 5 with 1 volt positive grid bias.

STEP 9. Repeat STEP 8 with 2 volts positive grid bias.

STEP 10. From Table 1 plot a graph of Anode Current (Ia) versus Grid Voltage (Eg) on Graph 1.

GRID BIAS	ANODE CURRENT
−5 V	
−4 V	
−3 V	
−2 V	
−1 V	
0 V	
+1 V	
+2 V	

TABLE 1.

CONCLUSIONS:

1. The function of the control grid in a Triode valve is ....

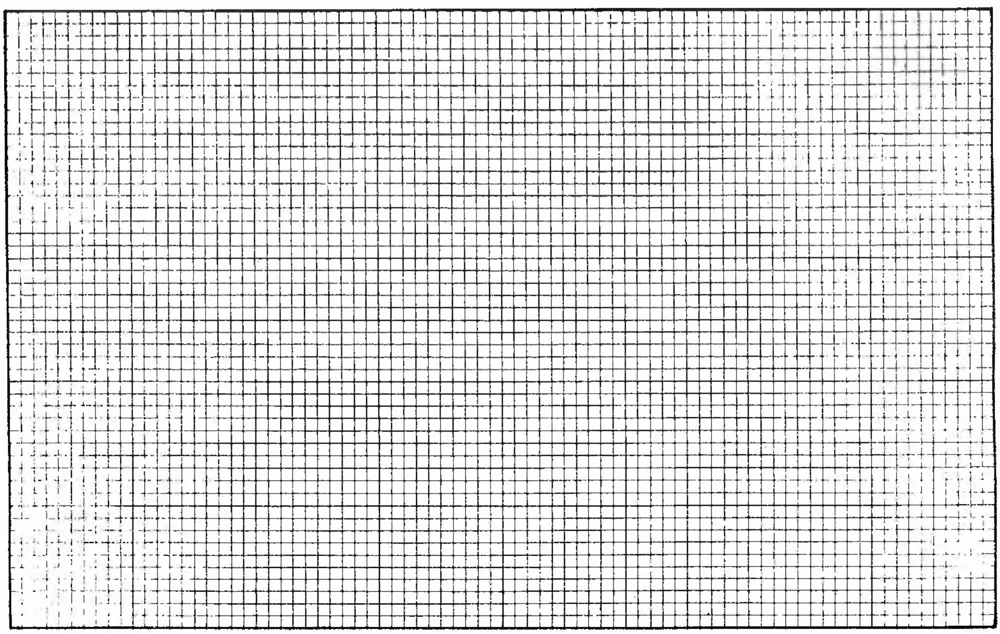
....

....

....

2. With reference to Graph 1, state the values of grid bias at which the following occur.

(i) Cut off point .... (ii) Negative linear section ....



GRAPH 1.

SOUND

Sound is a stimulus which produces the sensation of hearing.

Sound usually originates from some form of mechanical vibration which sets up corresponding vibrations in the transmitting medium, which can be either a solid, liquid, or a gas.

DEMONSTRATION

AIM: To prove that a transmitting medium is necessary for the transmission of sound.

APPARATUS: Vacuum jar, vacuum pump, magneto bell (rubber mounted), A.C. Supply.

METHOD:

STEP 1. Set up the apparatus as shown in Fig. 1.

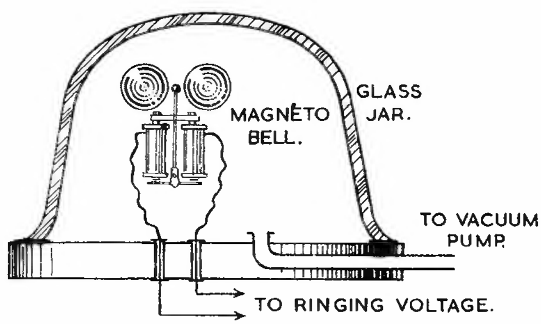


FIG. 1.

STEP 2. Evacuate the air from the vacuum jar.

STEP 3. Note the decreasing volume of sound as the air is evacuated.

STEP 4. Gradually allow the air back into the jar and note the effect.

CONCLUSIONS:

1. Why is the sound from the bell audible before the air is evacuated from the jar?

....

....

....

2. Why is the sound inaudible when the air is evacuated from the jar?

....

....

TELEPHONE TRANSMITTERS

For the transmission of speech, telephones use a carbon transmitter which uses the characteristic of carbon to vary its electrical resistance with varying mechanical pressure, in coverting sound energy into the control of electrical energy.

AIM: To show that the electrical resistance of carbon varies with mechanical pressure.

APPARATUS: Model, milliammeter 0–100mA, voltmeter 0–10V, set of weights.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

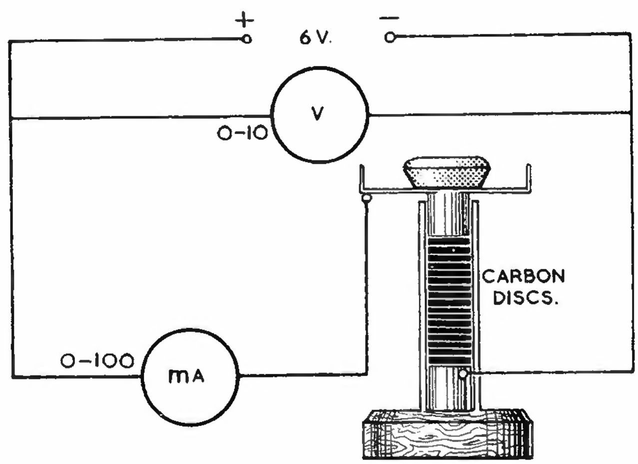


FIG. 1.

STEP 2. Place ¼ oz. weight on the platform. Note and Record E and I in Table 1.

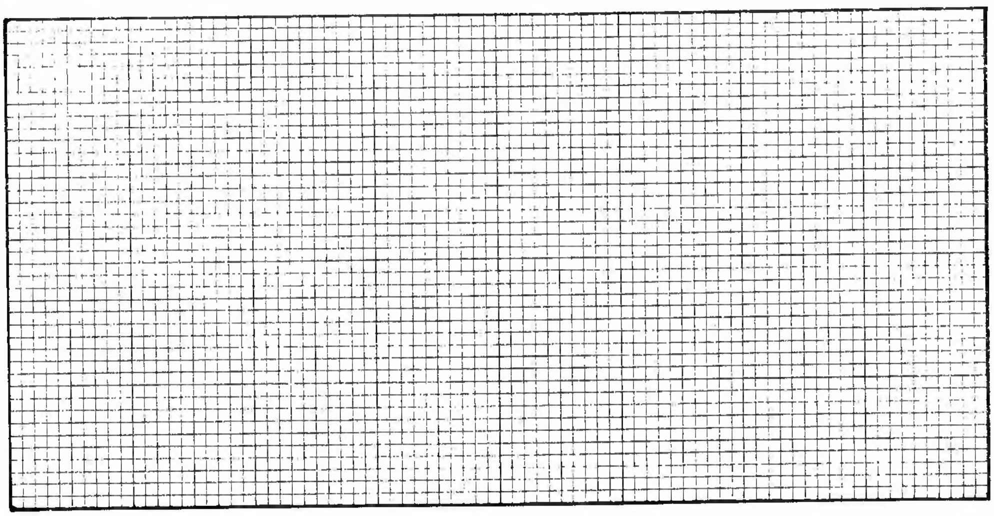
STEP 3. Repeat STEP 2 increasing the weight in ¼ oz. steps up to 2 oz.

STEP 4. Calculate the resistance for each step (Table 1.)

STEP 5. Plot a graph of resistance versus weight in Graph 1.

INCREASED WEIGHT IN OZS.	E	I	R
$\frac{1}{4}$			
$\frac{1}{2}$			
$\frac{3}{4}$			
1			
$1\frac{1}{4}$			
$1\frac{1}{2}$			
$1\frac{3}{4}$			
2			

TABLE 1.



GRAPH 1.

CONCLUSION:

1. In relation to the results obtained describe what happens when a sound wave strikes the diaphragm of a telephone transmitter.

....

....

....

....

....

TELEPHONE RECEIVERS

A permanent magnet is necessary in a receiver, to ensure that the sound produced by the receiver is the same frequency as the signal energising the coils and actuating the diaphragm of the transmitter.

For a given varying current input, the amplitude of vibration of the receiver diaphragm, and the sound wave produced, is dependent on the field strength of the magnet.

DEMONSTRATION

AIM: (i) To prove the above statements.

(ii) To study the characteristics of different types of receivers.

APPARATUS: Bell type receiver, 2P receiver, 2-1L receivers, (one fitted with swedish soft iron instead of perm. magnet).

Tone supply (approximately 200 c/s), C.R.O., variable oscillator, Microphone, Amplifier and speaker, level meter.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

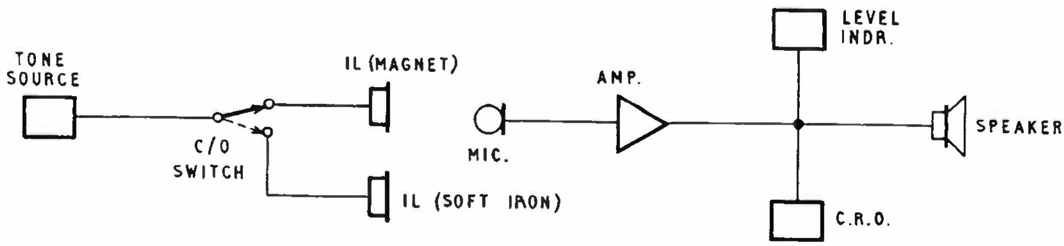


FIG. 1.

STEP 2. With tone supplied to the 1L receiver (with magnet), observe the frequency of output tone on the C.R.O., the volume on the level indicator, and from the speaker. Record the relative frequency and volume on Graph 1.

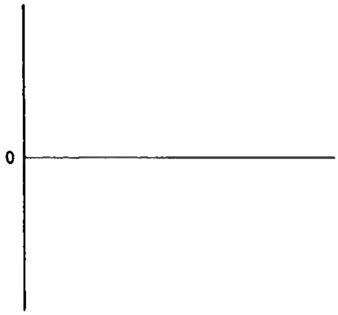
STEP 3. Repeat STEP 2 using the 1L receiver without magnet. Record the relative frequency and volume on Graph 2.

STEP 4. Connect the bell receiver across the tone supply and compare the results with STEPS 2 and 3. Record the relative frequency and volume on Graph 3.

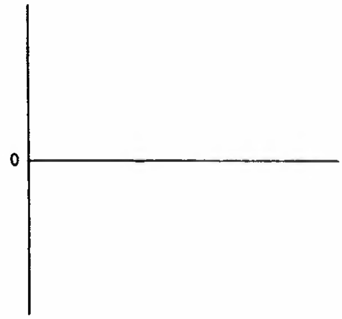
STEP 5. Connect the variable oscillator (constant level output) across the 1L and 2P receivers in turn.

STEP 6. Note the mechanical resonant peaks of the diaphragms. Compare the frequency versus volume characteristics with Graph 4.

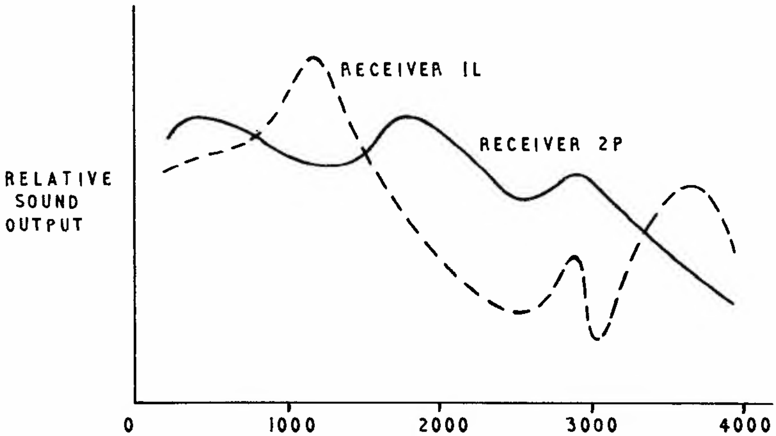
GRAPH 1.



GRAPH 2.



GRAPH 3.



GRAPH 4.

CONCLUSIONS:

1. In STEP 2, the frequency of the sound output compared to the frequency of the input current, is ....

2. In STEP 3, the frequency of the sound output compared to the frequency of the input current, is ....

3. Explain your answers to Questions 1 and 2.

....

....

....

4. What conclusions can be drawn regarding relative volumes in STEPS 2, 3, and 4.

....

....

....

PROJECT NO. 46

Laboratory Projects

1st Year

INDICATORS.

In magneto switchboards a clearing indicator is connected across each switched conversation.

The indicators must therefore be high impedance, to prevent shunting of speech currents, and as they are mounted together, they must be magnetically shielded to prevent crosstalk by mutual induction between neighbouring indicators.

AIM: (i) To compare the shunting effect of an old type line indicator (low impedance) as compared to a modern clearing indicator (high impedance).

(ii) To show the necessity of magnetically shielding neighbouring clearing indicators.

APPARATUS: Tone supply, approximately 1,000 c/s (27,000 ohms), Bell type receiver, Indicators - Line (old type), and Clearing (modern type), Resistor 27,000 ohms.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1, using a modern type clearing indicator. Note the volume of tone in the receiver.

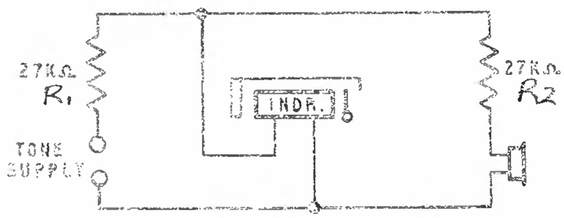


FIG. 1.

STEP 2. Repeat STEP 1 using an old type line indicator.

STEP 3. Compare the volume of tone obtained in STEPS 1 and 2.

STEP 4. Using unshielded indicators, connect the circuit as shown in Fig. 2.

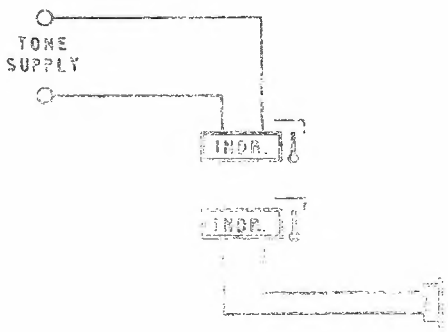


FIG. 2.

STEP 5. Note the volume of crosstalk produced.

STEP 6. Repeat STEPS 4 and 5 using shielded indicators.

STEP 7. Compare the results from STEPS 5 and 6.

Laboratory Projects **PROJECT NO. 46**

1st Year

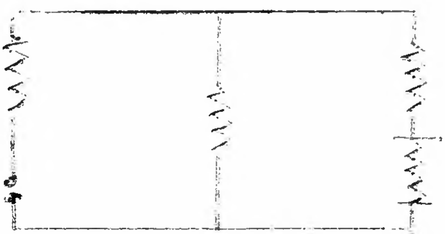
CONCLUSIONS:

1. The level of tone received in STEP 1 is HIGHER than that received in STEP 2, because THE CROSS AACROSS R1 IS LESS DUE TO THE [illegible] IMPEDIENCE OF THE INDICATOR

2. Compare the results from STEPS 4, 5 and 6, giving reasons for your answer.

A HIGH LEVEL OF CROSS-TALK IS OBTAINED WHEN USING UNSHIELDED INDICATORS THIS IS CAUSED BY MUTUAL INDUCTION BETWEEN THE INDICATORS

~~IF THE TONE SUPPLY ([illegible]) ([illegible]) IS 6V~~



TELEPHONE RELAYS (1)

A telephone relay is an electromagnetic - mechanical device, the spring contacts of which are used to open and close electrical circuits.

The value of current required to operate a relay depends on -

(i) spring tension

(ii) reluctance of the magnetic circuit (including the armature air gap)

(iii) number of turns.

AIM: To study factors which affect the operation of a telephone relay.

APPARATUS: Two double wound relays, 50/50 ohms with one extra armature, Gramme gauge, Milliammeter 0-100mA, 6V variable supply.

(Relays No.1 and No.2 previously adjusted to approximately 15 and 30 grammes pressure on the armature, respectively.)

METHOD:

STEP 1. Using the gramme gauge measure the pressure on the armature of Relay 1. Record in Table 1.

STEP 2. Connect the circuit as shown in Fig. 1.

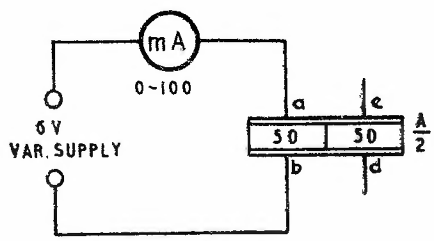


FIG. 1.

STEP 3. Slowly adjust the variable battery supply until the armature just operates. Record the value of operate current in Table 1.

STEP 4. Repeat Steps 1, 2 and 3 using Relay No.2.

STEP 5. Note the distance between the armature and core face of relay No.1, and remove the armature.

STEP 6. Fit the spare armature to Relay No.1, and note that the armature adjustment allows approximately twice the gap between armature and core face, than that previously used.

STEP 7. Repeat Steps 2 and 3.

RELAY	SPRING TENSION	OPERATE CURRENT	
		ARMATURE AIR GAP NORMAL	ARMATURE AIR GAP TWICE NORMAL
No. 1			
No. 2			

TABLE 1.

CONCLUSIONS:

1. The reason for the difference in value of operate current in STEPS 3 and 4 is . . . .

. . . .

. . . .

. . . .

. . . .

. . . .

2. The reason for the difference in value of operate current in STEPS 7 and 3 is . . . .

. . . .

. . . .

. . . .

. . . .

. . . .

PROJECT NO.48

TELEPHONE RELAYS (2)

AIM: To further study factors which affect the operation of a telephone relay.

APPARATUS: Listed in Project No. 41.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1. (This doubles the number of turns on Relay 1, in comparison to Project No. 41)

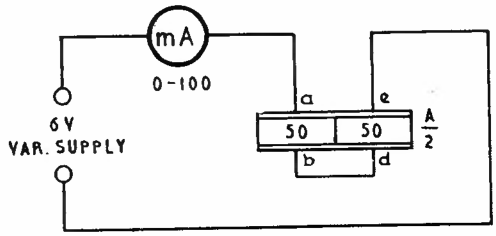


FIG. 1.

STEP 2. Slowly adjust the variable battery supply until the armature just operates. Record the value of operate current in Table 1.

STEP 3. Repeat STEP 2 using Relay No. 2.

STEP 4. Note the distance between the armature and core face of Relay No. 1 and remove the armature.

STEP 5. Fit the spare armature to Relay No. 1 and note that the armature adjustment allows approximately twice the gap between armature and core face, than that previously used.

STEP 6. Repeat STEPS 1 and 2.

RELAY		SPRING TENSION	OPERATE CURRENT	
			ARMATURE AIR GAP NORMAL	ARMATURE AIR GAP TWICE NORMAL
No.1	2200 TURNS a - b			
	4400 TURNS a - e			
No.2	2200 TURNS a - b			
	4400 TURNS a - e			

TABLE 1.

CONCLUSIONS:

1. Explain the reason for the difference in value of operate current between STEP 6 of this project and STEP 7 of project 41.

2. List the component parts of a telephone relay

TELEPHONE RELAYS. (3)

When the circuit to a telephone relay is broken, the collapsing field cuts the coil and the surrounding component parts.

The resulting induced e.m.f. across the coil is applied across the opening switch contacts, and the electrical energy present is dissipated in the form of a spark.

When a circuit is provided for current to flow as a result of this self induction of the coil, the operate direction of flux is maintained, and the relay's release is delayed.

AIM: To examine the above factors as applied to the release of a telephone relay.

APPARATUS: Relay 100 ohms, resistor 50 ohms, switch, 50 volts supply.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

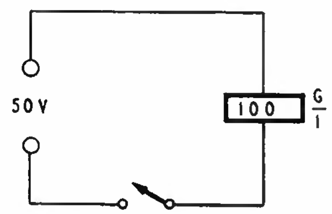


FIG. 1.

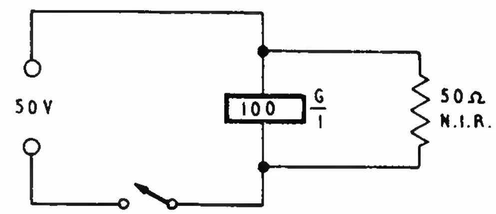


FIG. 2.

STEP 2. Close and open the switch several times.

NOTE: (i) The time taken for the armature to restore to normal.
(ii) The spark across the switch contacts when the switch is opened.

STEP 3. Connect the circuit as shown in Fig. 2.

STEP 4. Repeat STEP 2.

CONCLUSIONS.

1. The reason for the spark across the switch contacts at the instant of opening is ....

....

....

....

2. Why is the relay's release delayed when the resistor is fitted across it.

....

....

....

....

....

SIDETONE SUPPRESSION

Sounds picked up by a transmitter of a telephone and reproduced in the local receiver are termed Sidetone.

Excessive sidetone reduces the sending and receiving efficiencies of a telephone, and modern telephones incorporate an Antisidetone Induction Coil (A.S.T.I.C.) which uses the principle of the Wheatstone Bridge to reduce sidetone effects.

AIM: To show that the A.S.T.I.C. No. 21A -

(i) Balances at approximately 600 ohms.

(ii) Reduces sidetone compared with an induction coil No. 12.

APPARATUS: A.S.T.I.C. No. 21A, I.C. No. 12, Bell type receiver, Decade box, Tone supply approximately 1,000 c/s.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

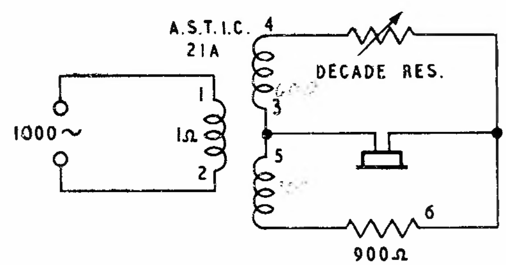


FIG. 1.

STEP 2. Adjust the decade resistance for the balanced condition, when minimum tone is heard in the receiver.

STEP 3. Note the volume of the tone, and the value of resistance in the decade box.

STEP 4. Connect the circuit as shown in Fig. 2. Use the same value of resistance in the decade box as obtained in STEP 3.

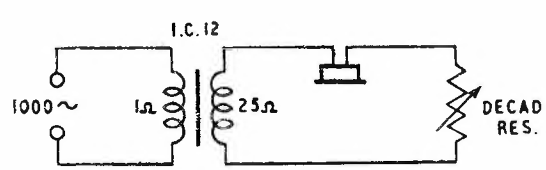


FIG. 2.

STEP 5. Note volume of tone from receiver and compare with the volume obtained in STEP 3.

CONCLUSIONS:

1. List the advantages obtained by reducing sidetone.

(1) SUBSCRIBER TENDS TO SPEAK LOUDER WHEN SIDE TONE IS REDUCED.

(2) ROOM NOISES PICKED UP BY THE TRANSMITTER ARE HEARD AT LOWER LEVEL IN THE RECEIVER.

2. Explain why the adjustment of the decade resistance box results in a reduction of tone in STEP 2.

WHEN THE RATIO B/H THE DECADE RESISTANCE & THE 900Ω BALANCE NETWORK EQUALS THE RATIO B/H WINDING 3-4 AND THE OTHER WINDING THE VOLTAGE ACROSS THE RECEIVER WILL BE AT A MINIMUM.

3, GOOD

DIALLING CONDITIONS

Signalling from automatic telephones is by means of a dial, which interrupts the D.C. in the loop circuit to operate the pulsing relay in the exchange selectors.

When dialling is in progress, "off normal" springs in the dial, arrange the telephone circuit to give the best pulsing conditions, and prevent the pulses from being heard as annoying clicks in the receiver.

AIM: To study the basic circuit operation during dialling.

APPARATUS: Automatic telephone, double wound relay, 50/50 ohms, milliammeter 0-100 mA, resistors 400 ohms, 50 volt supply.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

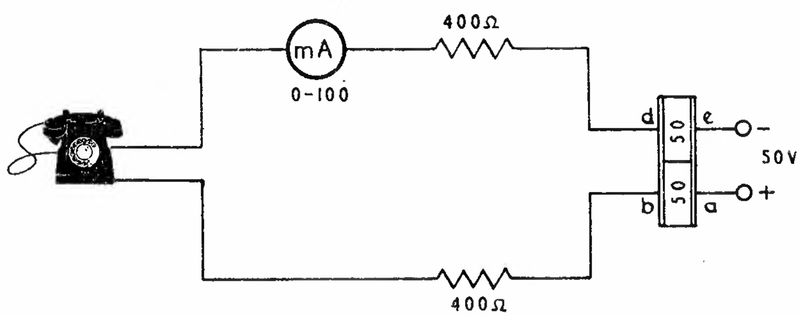


FIG. 1.

STEP 2. With the telephone handset normal, note the current and condition of relay. Record in Table 1.

STEP 3. Lift handset and note current and relay action. Record in Table 1.

STEP 4. Pull dial off normal. Note and record current and relay condition.

STEP 5. Dial 0. Using the finger as a brake, allow dial to restore slowly. From the meter behaviour, note -

(i) lost motion period.

(i) pulse ratio.

(iii) number of pulses.

(iv) current variation during pulsing. (Table 1.)

STEP 6. Dial 0. Allow the dial to restore at normal speed. Note -

(i) pulsing action of relay.

(ii) absense of clicks in receiver.

B

Laboratory Projects

1st Year

PROJECT NO. 5

TELEPHONE CONDITION	CURRENT	RELAY CONDITION
HANDSET NORMAL	O	Not Opp
HANDSET LIFTED DIAL NORMAL	50mA	Opp
HANDSET LIFTED DIAL OFF NORMAL	53mA	Opp
HANDSET LIFTED DIAL PULSING	0-53 mA	PULSING

Opp - Operated

TABLE 1.

CONCLUSIONS:

1. Explain why different values of current were recorded in STEPS 2, 3 and 4.

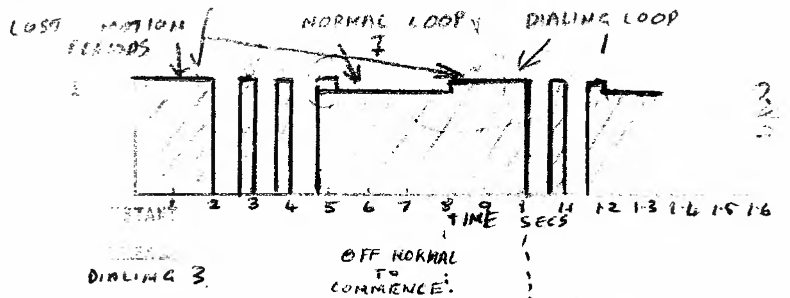
..IN.... STEP..2....NO. CURRENT... FLOWS... BECAUSE. THE LOOP IS O/C

..IN... STEP...3. NORMAL LOOP .CURRENT. IS. FLOWING...... ✓ ...

..IN... STEP..4. CURRENT IS MAX BECAUSE. THE.. O/N. SPRINGS. REDUCE THE RESISTANCE OF THE TELEPHONE ✓

3

2. From STEP 5, indicate on the graph the ~~approximate~~ occurrence of pulses when 32 is dialled.



GRAPH 1.

3. Explain why no clicks were heard in STEP 5.

.... BECAUSE ...THE...OFF. NORMAL ..SPRINGS..SHORTED .OUT

...THE... TRANSMITTER ..+.. RECEIVER ..O/CT............. ✓

2

....

TRANSMISSION FEEDS

Transmission feeds are used in C.B. systems to supply D.C. from the exchange battery for the operation of the telephones connected to the exchange.

AIM: To study the principle of operation of a transmission feed.

APPARATUS: Two C.B. telephones, double wound high impedance relays 50/50 ohms, resistors 50 and 400 ohms, milliammeter 0-100 mA; 50 volt supply.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

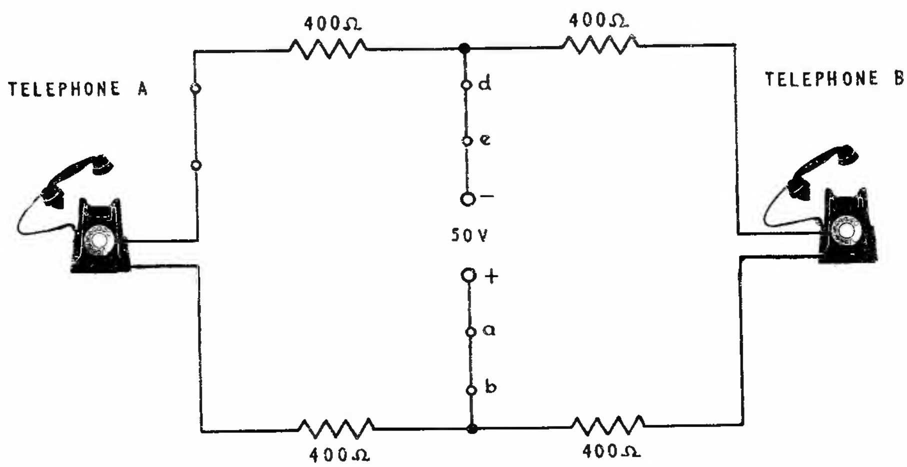


FIG. 1.

STEP 2. Lift the receiver and note side tone in each telephone.

STEP 3. Speak into the telephones and note the level of transmission.

STEP 4. Remove straps A-B, D-E, and replace with 50 ohm resistors, and repeat STEPS 2 and 3.

STEP 5. Remove the 50 ohm resistors and replace with the 50 ohm windings of the relay. Connect the coil tags to the correspondingly labelled terminals of Fig. 1. Repeat STEPS 2 and 3.

STEP 6. Connect the milliammeter in series with telephone A and note the reading. Reduce the loop resistance of telephone B by short circuiting one 400 ohm resistor. Note the effect on current in telephone A.

CONCLUSIONS:

1. The level of transmission in STEP 4 is . . . . than that of STEP 3, because . . . .

. . . .

. . . .

2. In STEP 5, the level of transmission is . . . . than in STEP 4, because . . . .

. . . .

. . . .

3. From STEP 6, the effect of connecting a low resistance line to a high resistance line with this type of transmission feed is. . . .

. . . .

. . . .

PROJECT NO.53

Laboratory Projects

1st Year

STONE TRANSMISSION FEED

The Stone transmission feed uses separate retards for each subscriber to prevent a low resistance line shunting D.C. away from a line of comparatively high resistance when the two are connected together.

Speech currents pass from one telephone to the other via capacitors in the transmission feed circuit.

AIM: To study the Stone system of transmission feed.

APPARATUS: Two C.B. telephones, two double wound, high impedance relays 50/50 ohms, resistors 400 ohms, milliammeter 0-100 mA, capacitors 2 μF, 50 volt supply.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

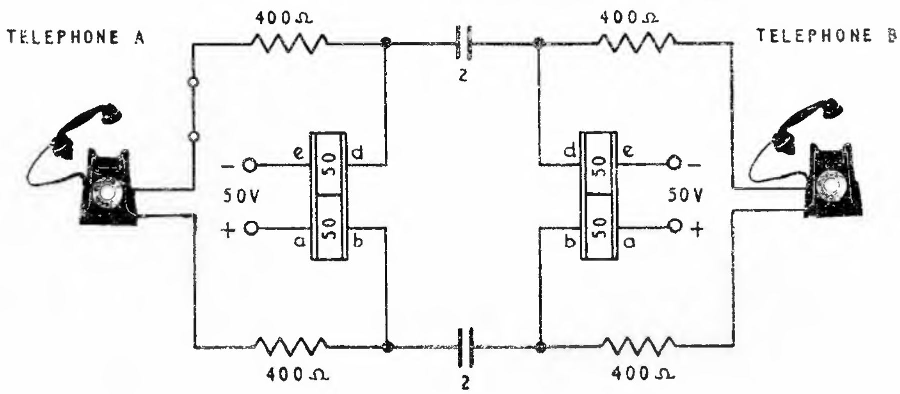


FIG. 1.

STEP 2. Lift the receiver of each telephone and note the side tone.

STEP 3. Speak into the telephones and note the level of transmission.

STEP 4. Disconnect the 2 μF capacitors and repeat STEPS 2 and 3.

STEP 5. Connect the milliammeter in the circuit of telephone A and note the current. Reduce the loop resistance of telephone B by short circuiting one 400 ohm resistor. Note the effect on current in telephone A.

STEP 6 S/C THE CAPACITORS & REPEAT STEP 5

CONCLUSIONS.

1. Redraw Fig. 1 and on it indicate -

   (i) the path for speech currents in STEP 3.

   (ii) the path for speech currents in STEP 4.

CIRCUIT CONDITION	A	B	TEL A	[illegible]	[illegible]	[illegible]	[illegible]
BOTH CRADLED	45V	5V	0mA	45V	5V	0mA	
A LIFTS OFF	45V	5V	50mA	45V	5V	0mA	
B LIFTS OFF	45V	5V	50mA	45V	5V	50mA	
A HANGS UP	45V	5V	0mA	45V	5V	50mA.	

2. Referring to STEPS 3 and 4, explain the reason for any difference in the transmission level.

THE LEVEL OF RECEIVED SPEECH IN STEP 4 IS [illegible] BECAUSE THE VARIATIONS OF VOLTAGE FOR ONE LOOP CIRCUIT ARE [illegible] TO THE OTHER LOOP C/CT.

3. What is the advantage of a battery feed of this type compared with the type used in Project No. 45 STEP 5.

WITH STONE TRANSMISSION FEED THE CURRENT FLOW IN ONE LOOP IS NOT AFFECTED BY THE CURRENT FLOW IN THE OTHER LOOP.