ELECTRICAL LABORATORY PRACTICE

Name of the Course:	Diploma in MECHANICAL ENGINEERING		
Course code:	EEP 421	Semester	4th
Total Period:	90	Examination	4 hrs
Lab. periods:	6 P/W	Term Work	25
Maximum marks:	75	End Semester Examination	50

Course Objectives

Students will develop an ability towards

- Observe and identify electrical components
- Measuring earth resistance
- Operation and performance measurement of electrical machines

Sr No	Content
1	Study of different parts and identification of terminals and testing of insulation resistance of a DC machine
2	Study of 3 point and 4 point starter
3	Speed variation of DC motor by field control and armature voltage control method
4	Identification of terminals and determination of transformation ratio of a single phase transformer.
5	Determination of regulation of transformer by direct loadings
6	Measurement of earth resistance of an earthing installation
7	Study of PMMC & MI type instrument
8.	Start and run of a 3-phase induction rotor by Star-Delta
9.	Connect and run an alternator and starter, measure the terminal voltage on different load condition
10.	Start and run a synchronous motor and measure its speed at no load

DIFFERENT PARTS OF D.C. MACHINE

AIM OF THE EXPERIMENT: To study the different parts of D.C. machine (Motor or Generator).

APPARATUS REQUIRED: A model of D.C. Machine.

MACHINE SPECIFICATION:

Type:________ Volt:__________ Amp:_________ Wound:_________

O/P:__________ Speed:_______ Number:_____ Rating:__________

THEORY :- A D.C. machine that converts mechanical power to electrical power is called a D.C. generator. Its principle is given by Faraday's law of electromagnetic induction and direction of motion is given by Fleming's right hand rule.

A D.C. machine that converts electrical power into mechanical power is known as D.C. motor. It works on the principle that when a conductor carrying current is placed in a magnetic field, mechanical force acts on the current carrying conductor and as a result the conductors starts rotating. Its direction of rotation is given by Fleming's left hand rule.

DIFFERENT PARTS OF D.C. MACHINE

A D.C. machine consists of the following essential parts for its operation and satisfactory performance.

(i) Armature
(ii) Main field poles
(iii) Commutating poles or interpoles
(iv) Yoke
(v) Commutator
(vi) Brushes
(vii) Brush holders
(viii) Brush lead
(ix) Bearing
(x) Cooling fan
(xi) Shaft
(xii) Eye bolt
(xiii) Bed plate
(xiv) Terminal box
(xv) Coupling
(xvi) Name plate
(xvii) Enclosure

i. ***Armature:*** It is of cylindrical shape rotating between the stationary magnetic poles and consists of slots, teeth, core and winding in the slots. The rotating armature is subjected to alternating flux, which gives rise to eddy current and hysteresis loss in the armature core and teeth. Hence to reduce eddy current losses it is built up of 0.4 to 0.5 mm dynamo sheet steel laminations, insulated from each other by a thin layer of varnish. Armature windings of D.C. machine is responsible for generation of induced e.m.f. Simple lap and wave winding are commonly used for the armature of D.C. machine. Armature coils are properly hold in slots against the centrifugal force by wooden or fibre wedge inserted in the upper portion of the slot. Slots used in d.c. machine are of rectangular shape.

ii. ***Main poles:*** It is the stationary part of the machine, consisting of pole body, pole shoe and field windings (Series or shunt). These are made up of sheet steel laminations of 1.0 to 1.2 mm thickness. The pole body and pole shoe are normally parts of the same lamination. The pole shoes support the field coils placed on the pole body and also spread the total flux over a greater area, there by reducing the air gap reluctance and giving the desired flux distribution to limit saturation in the teeth of the armature. Flux produced by the main pole is of constant nature and as such there are no iron losses in the pole body. The main poles are secured to the yoke by means of bolts.

iii. ***Commutating poles or Inter poles:*** There are arranged mid way between the main poles with inter pole winding on them, in order to improve commutation under loaded condition of the machine. Thus these poles ensure spark-less operation of the brushes at the commutator. These are made up of wrought iron or mild steel and are bolted to the yoke.

iv. *Yoke:-* The outer fame of the machine is known as yoke. It is made up of cast steel or forged steel. It serves as mechanical support for the entire assembly of the machine. It gives the magnetic path for flux and hence known as magnetic frame.

v. *Commutator:* The function of commutator is to collect the current from armature, It is built up of a number of wedge shaped segments of high conductivity, hard drawn copper, assembled over a steel cylinder and insulated from each other by mica or micanite of about 0.8mm thickness. The ends of the armature coils are connected to the commutator, which together with the brushes rectifies alternating e.m.f. induced in the armature coils and helps in the collection of current.

vi. *Brushes:* These are needed to collect the current from the rotating commutator or to lead the current to it. Normally these are made up of carbon and graphite, so that while in contact with the commutator, the commutator surface is not spoiled.

vii. *Brush holders:* These are used to accommodate the brushes. Where a spring presses the brushes against the commutator with pressure of 1.5 to 2.0 N/cm^2 (0.1 to 0.25 Kg/cm2).

viii. *Brush lead:* The brush lead is also sometimes known as the pig-tail. It is a piece of wire connected to the carbon. It is made of a copper conductor and its purpose is to make a connection between the brush and a point outside the circuit.

ix. *(ix)Bearing:* It is the important part of all types of rotating machines. Their main function is to support the rotating part and to allow its smooth motion with minimum friction. It is of two types ball bearing and roller bearing. In small machines ball bearings are used at both the ends. For medium size machine roller bearing used at driving end and ball bearing at the non-driving (commutator end) end.

x. *Cooling fan:* A cooling fan made of cast iron is also fitted on the opposite side of the commutator shaft. As the armature starts rotating, it also rotates and gives fresh air for cooling the armature.

xi. *Shaft:* It is made of mild steel and rests on the two bearings provided in the side covers. The armature and commutator are also fitted on the shaft.

xii. *Eye bolt:* The eye-bolt is provided with the body generally on the top for lifting the machine.

xiii. *Bed plate:* The bed plate is also known as the base of the machine. The machine is fitted on the foundation and is bolted at the bed plate.

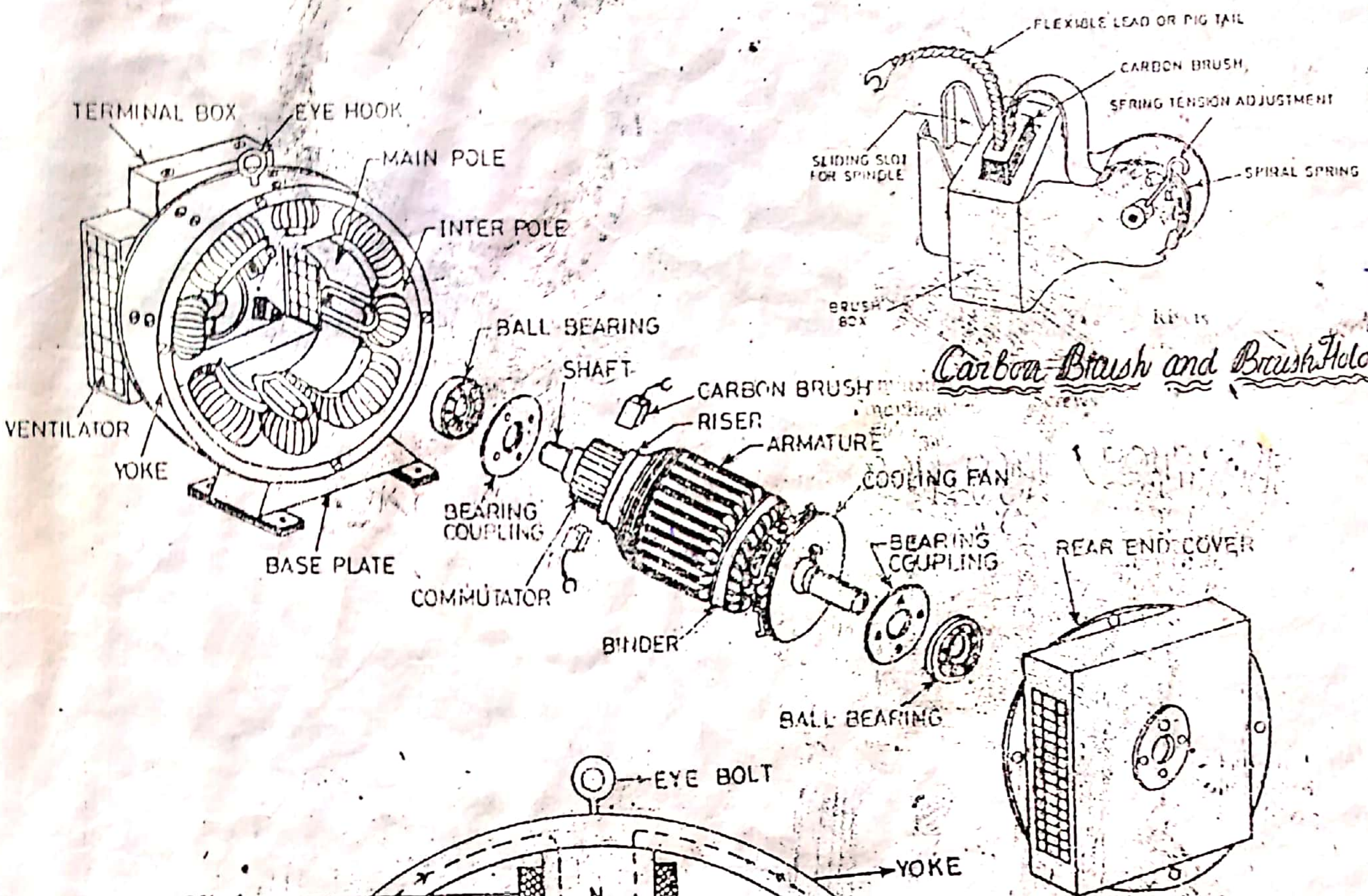
xiv. *Terminal box:* This is an insulated box which carries the brass nuts and bolts to which wired from the brushes and field poles are brought out for connection with the external circuit.

xv. *Coupling :-* It is the mechanical connection between the shaft of the generator and that of the prime mover which drives the generator.

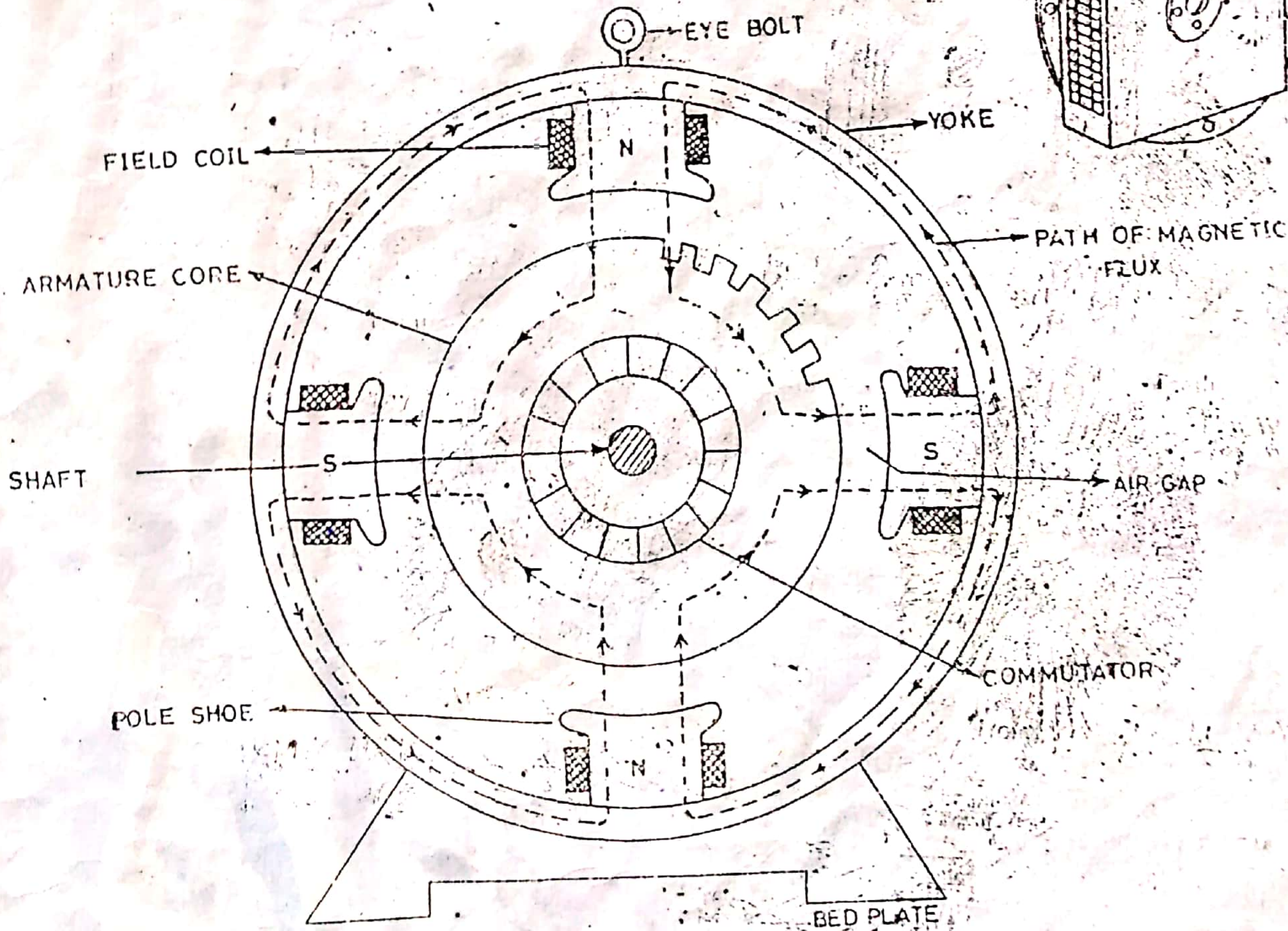
xvi. *Name plate :-* It is the most essential part of the machine which gives the rating of the machine. Like make, volt, amp, wound. r.p.m., H.P., K.W., output etc.

xvii. *Enclosures :* It protects the machine from external agencies.

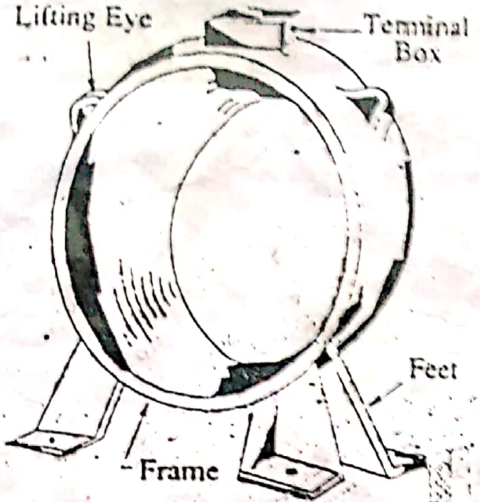
CONCLUSION :- From the above experiment we get brief knowledge about the D.C. machine (motor or generator) and their parts.



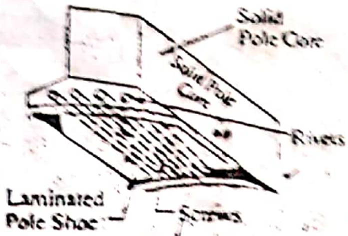
Carbon Brush and Brush Holder



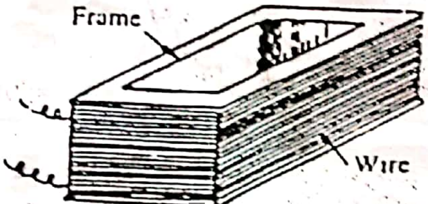
DIFFERENT PARTS OF D.C. MACHINE



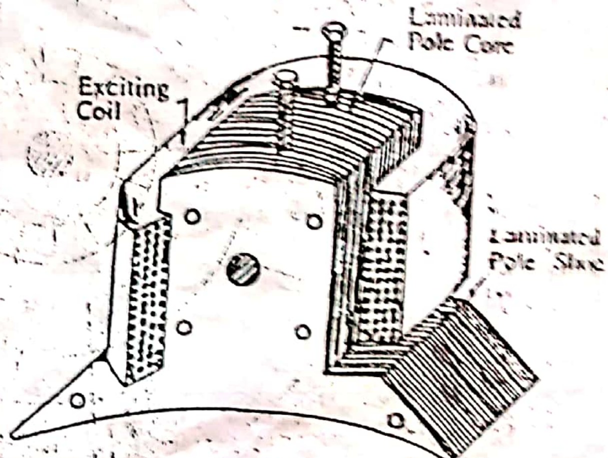
YOKE



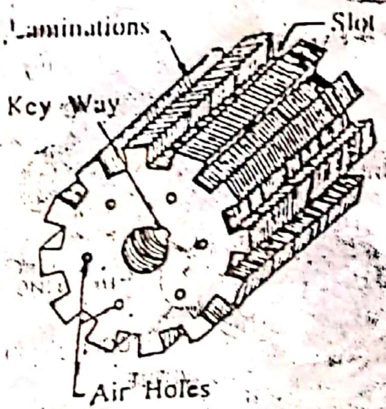
POLE CORE & POLE SHOE



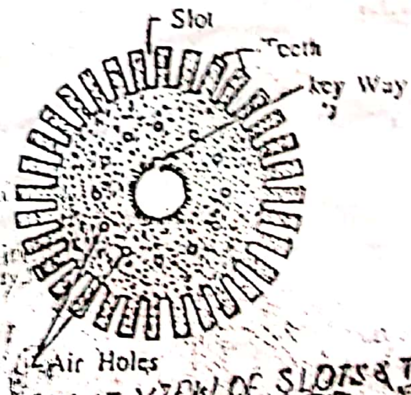
POLE COILS



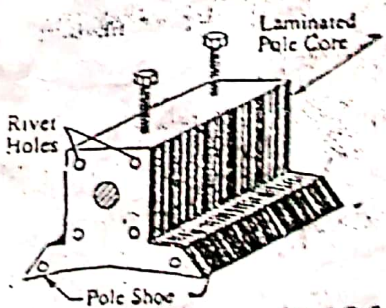
POLE SHOES SUPPORT THE EXCITING COIL



ARMATURE CORE & SLOTS



FRONT VIEW OF SLOTS & TEETH



POLE CORE & POLE SHOES RIVETTED TOGETHER

IDENTIFICATION OF TERMINALS OF D.C. MACHINE

AIM OF THE EXPERIMENT: To identify the pair of terminals of a D.C. compound machine (D.C. generator or D.C. motor) by using series testing board.

APPARATUS REQUIRED :

Sl. No	Name of the Apparatus	Type	Specification	Qty.
1	D.C. compound machine	D.C.	------	1
2	Series testing board with 100W lamp	----	-------	1
3	Pair of leads	--	------	1nts
4	Combination plier	Insul-ated	-------	---
5	Screw driver	--	-------	1

INTRODUCTION:-According to I.E. rules whenever a newly machine is installed, it must be tested. To know the terminal of shunt field, series field, armature winding and inter-pole winding before starting the D.C Motor. One can do the correct connection of the motor after knowing the terminals. So to identify the pairs of terminals series testing should be performed.

PROCEDURE:

1. Connect series testing board with the supply mains and make it sure that the phase in the test lead is coming through the lamp to avoid earth leakage circuit.
2. Connect phase lead with one of the terminals and neutral with another terminals one by one. The terminals at which lead give spark or lamp glow is the pair of the same coil. Also observe the light (illumination) of the lamp, if any.
3. Similarly find out remaining two pairs and observe the light or sparking.
4. The pair on which lead give spark or lamp glow very dim are the terminals of shunt field winding i.e. Z_1 and Z_2 . Fig. (a).
5. Connect phase lead on any of the brush and neutral lead with remaining four terminals one by one. The two terminal on which lamp glows bright is pair of armature terminal i.e. A_1 and A_2 . Fig. (b).
6. Remaining two terminal which give bright light on connecting testing leads are terminals of series field winding i.e. Y_1 and Y_2. Fig. (c).

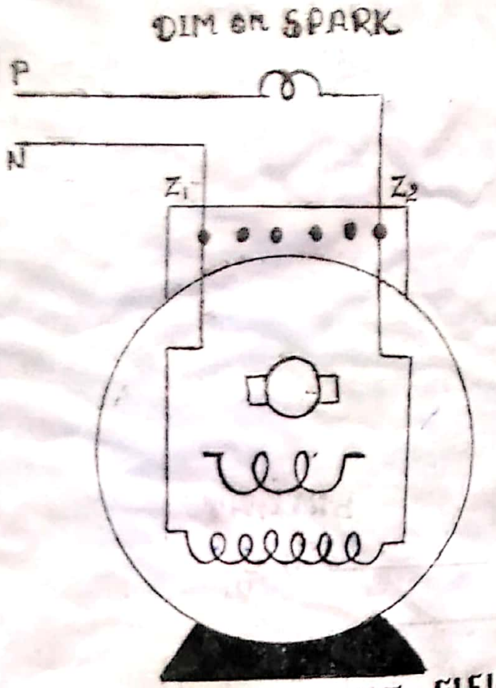
CONCLUSION:-

Sl. No	Illumination of lamp	Pairs of terminal
1	Dim or spark	Shunt winding Z_1, Z_2
2	Bright (with carbon brush)	Armature winding A_1, A_2
3	Bright	Series winding Y_1, Y_2

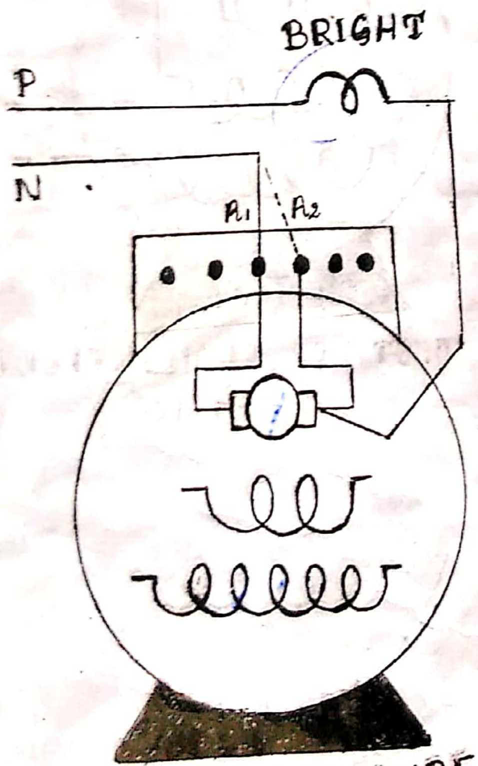
1. The lamp glow dim or lead give sparking because it has resistance.
2. The lamp glow bright while connecting lead to series because it has low resistance.
3. The lamp glow bright while connecting lead to carbon brush and armature terminals because one terminal is connected directly to the carbon brush and another terminal through the armature which has very low resistance.

PRECAUTIONS:

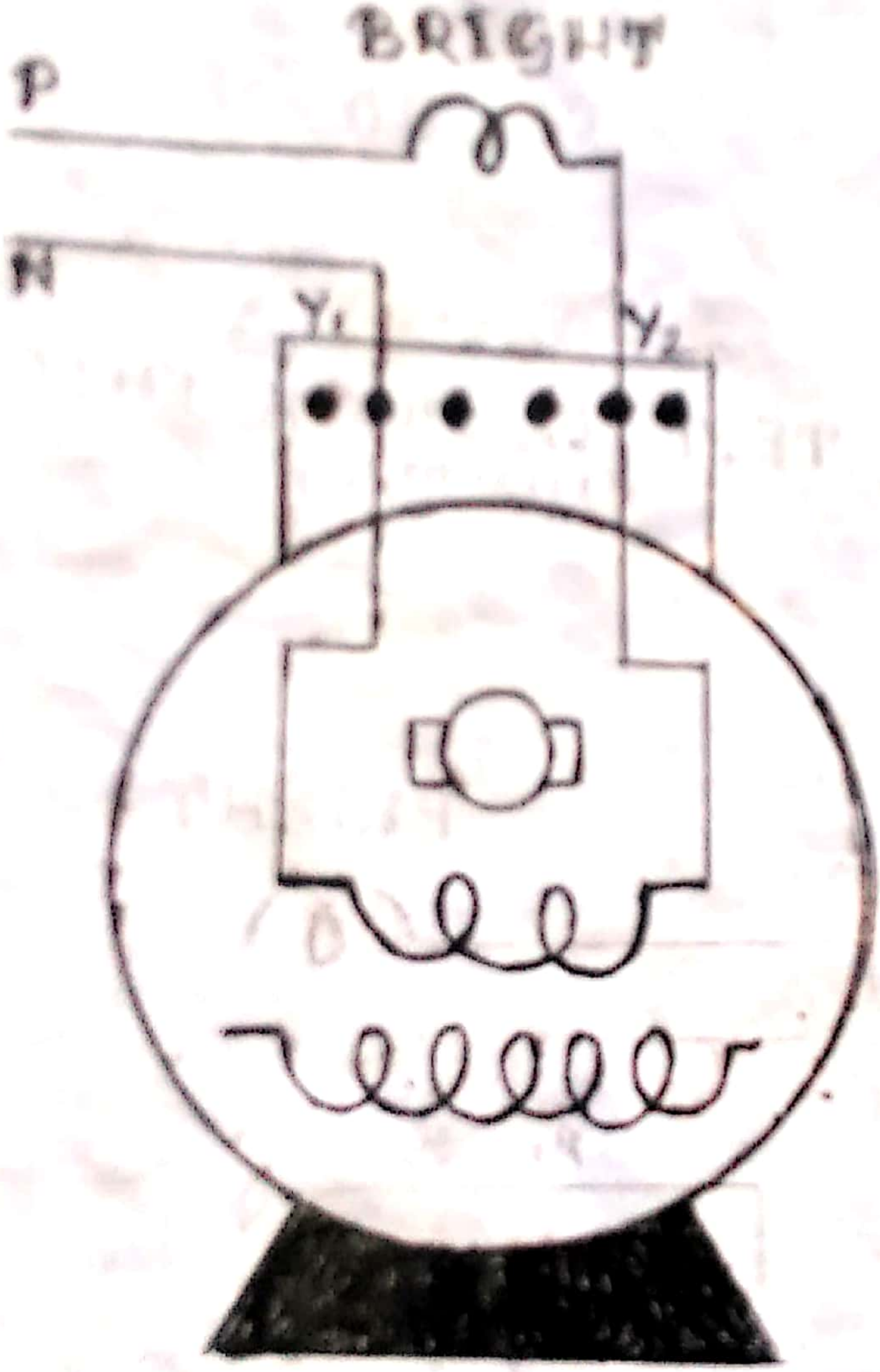
1. Before testing, the machine should be disconnected from the supply.
2. Use 100W or 200W, 250V lamp for series testing board.
3. While testing use thin fuse wire in testing board.
4. The phase leas should be connected through the lamp.



TEST FOR SHUNT FIELD WINDING



TEST FOR ARMATURE WINDING



TEST FOR SERIES FIELD WINDING

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STUDY OF THREE POINT STARTER

AIM OF THE EXPERIMENT: To study the different parts of three point D.C motor starter

APPARATUS REQUIRED:

Sl.No.	Name of Items	Type	Range	Quantity
1	3-Point starter	D.C	--	1
2	Combination plier	Insulated	--	1
3	Screw driver		--	1

THEORY: When a (d.c.) motor is connected to the supply, heavy current will flow through the armature as the armature resistance is very low. Moreover there is no back e.m.f. in it at the time of starting. Therefore to reduce this high starting current, resistance is connected in series to the armature at the time of starting the motor. This resistance is gradually cut off as the armature gains speed because the armature develops back e.m.f. and hence the current falls. Therefore, to start a (d.c) motor ,a starter having variable resistance is required .

CONSTRUCTION OF THREE POINT STARTER:

Three point starter is used for d.c. shunt motor and consists of the following parts.

(i) HANDLE :- Hand operated insulated handle is moved from **'OFF'** position to **'ON'** position for starting the motor i.e. starting resistance is gradually cut off and thus starting current is reduced to a low value.

(ii)NO-VOLT RELEASE COIL :- It consists of thin wire of many turn and is connected in series with the field winding of the motor. It is magnetized when the current flows through the shunt field winding. It's function is to attract the handle of the starter and keep it in the **'ON'** position. It protect the motor from sudden power failure or by opening of the field circuit which demagnetised the starter arm and falls back to the **'OFF'** position by the action of spiral spring.

(iii)OVER LOAD RELEASE COIL :- It consists of few turn of thick wire and is connected in series with the armature. Its function is to demagnetize the no-volt circuit, so that the current flowing in the electromagnet winding is equal to the armature current. It protects the motor from over loading conditions. Under overloading motor draws and excessive current and the electromagnet gets more magnetised as a result it attracts the iron part (tripping plunger), thus short circuiting the coil of **no-volt release** which gets demagnetized and releases the starter arm to return back its **'OFF'** position.

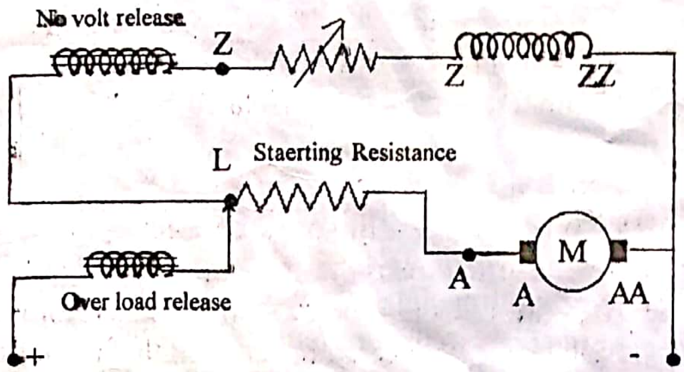
(iv)STUDS OR STARTING RESISSTANCE :-

While starting the d.c. motor, the starter arm is shifted into the first stud which includes the complete resistance of all the steps in the armature circuit, thereby reducing the starting current to a safe value. When the motor has gained appreciable speed the starter arm should be moved slowly on to the studs 2,3,4 etc, finally cutting out all the resistance steps and the iron keeper provided on the starter arm will rest firmly against the iron poles of the holding electromagnet (**No-volt release**).

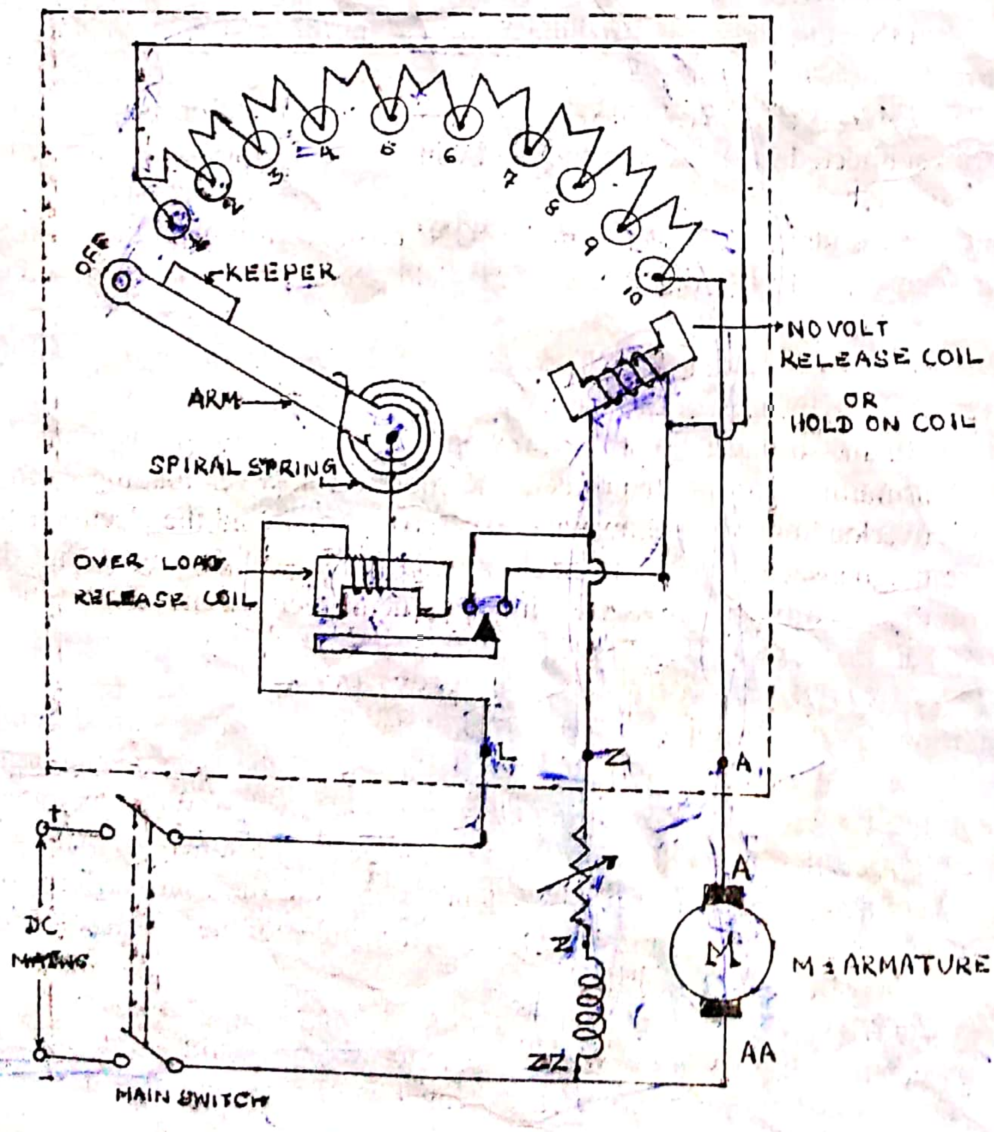
(v)SPIRAL SPRING :- Its function is to restore the starter arm to the **'OFF'** position. It gives a mechanical force to the starter arm to return back its original position, when no-volt release or **over load release** coil is demagnetised under sudden power failure or overload.

(vi)LIVE TERMINALS :- Generally three terminals of the starter **L,Z and A** are brought out which are connected respectively to the positive line terminal shunt field terminal and the armature terminal of the motor.

CONCLUSION :- From the above experiment we come to know about the 3-point starter and its necessity for starting a d.c. shunt motor



Schematic diagram of three point starter



CONNECTION DIAGRAM OF THREE POINT STARTER

STUDY OF 4-POINT STARTER

AIM OF THE EXPERIMENT: To study the different parts and functions of 4-point starter.

APPARATUS REQUIRED:

Sl.No.	Name of items	Type	Range	Quantity
1	4-Point starter	D.C.	——	1
2	Combination plier	Insulated	——	1
3	Screw driver	——	——	1

THEORY: When a (d.c.) motor is connected to the supply, heavy current will flow through the armature as the armature resistance is very low. Moreover there is no back e.m.f. in it at the time of starting. Therefore to reduce this high starting current, resistance is connected in series to the armature at the time of starting the motor. This resistance is gradually cut off as the armature gains speed because the armature develops back e.m.f. and hence the current falls. Therefore, to start a (d.c) motor ,a starter having variable resistance is required .

CONSTRUCTION :- It is also consists of the following parts (as in case of 3-point starter).

(i) Starter arm or handle
(ii) Studs or starting resistance
(iii) Spiral spring
(iv) Live terminals
(v) No-volt release coil
(vi) Over load release coil

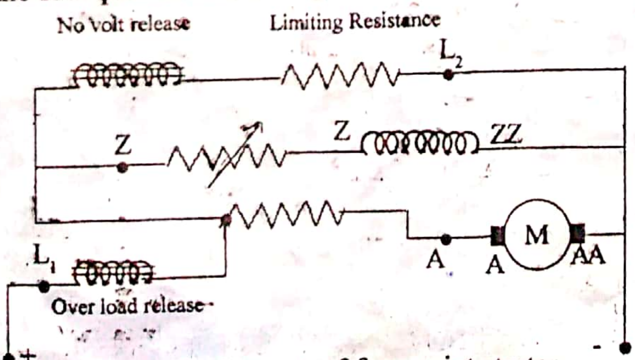
This starter is used with shunt and compound motors where much variations of speed is required. As compared to three point starter, one important change has been made i.e. **No-volt release coil** has been taken out of shunt field circuit and has been connected directly across the line through a limiting resistance in series. One more change is that there is found live terminals **L1,L2,Z & A** respectively connected to positive terminal, negative terminal through protective resistance, field terminal and armature terminals of the motor.

WORKING :- When the arm touches stud No.1 then the line current divides into three parts (i) one part passes through starter resistance **Rs.**, series field and motor armat ure, (ii) the second part passes through the shunt field and its field rheostat **Rh** and (iii) the third part passes through the **No-volt release coil** and current protecting resistance **R.**

It should be noted that in this arrangement any change of current in the shunt field circuit does not at all affect the current passing through the **No-volt release coil** because the two circuits are independent of each other. So the electromagnetic pull exerted by the **No-volt release coil** will always be sufficient and will prevent the spiral spring from restoring the starting arm to off position no matter how the field rheostat or regulator is adjusted.

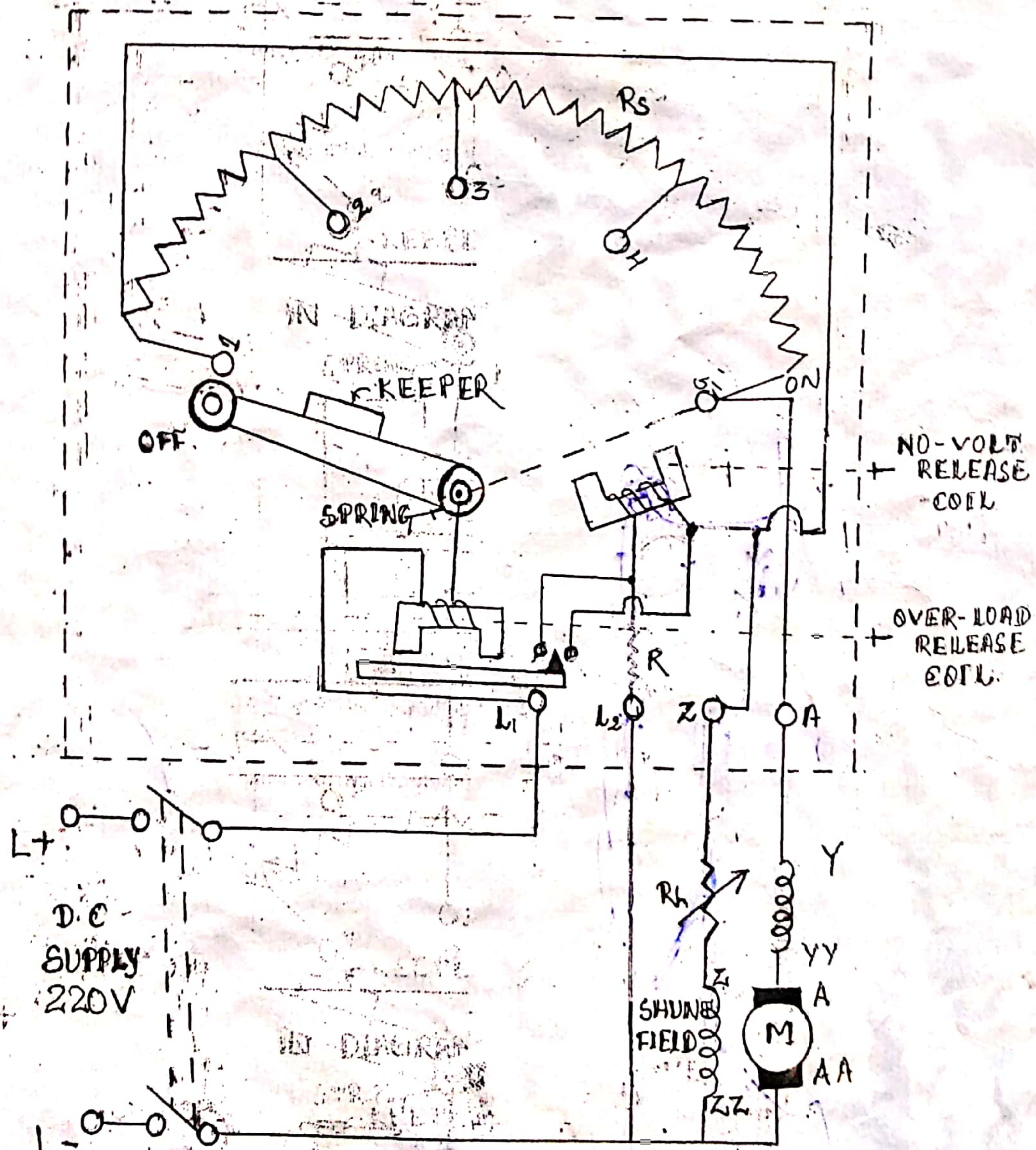
CONCLUSION :-

We study the four-point starter and got a brief knowledge about it.



Schematic diagram of four point starter

4point Starter



CONNECTION DIAGRAM OF FOUR POINT STARTER

SPEED CONTROL OF D.C. SHUNT MOTOR BY FLUX OR FIELD CONTROL METHOD

AIM OF THE EXPERIMENT: To control the speed of a d.c. shunt motor by flux or field control method.

APPARATUS REQUIRED

Sl.No.	Name of items	Type	Range	Quantity
1	D.C. Shunt motor	D.C.	———	1
2	3-point starter	D.C.	———	1
3	Ammeter	M.C	———	1
4	Voltmeter	M.C.	———	1
5	Rheostat or field regulator	———	———	1
6	Tachometer	———	———	1
7	Connecting wires	S.W.G	———	As per req.
8	Line tester	———	———	1

THEORY :- The back e.m.f. for a d.c. motor is given by,

$E_b = \Phi PZN/60A$

$\Rightarrow N = 60\, E_b A/\Phi PZ$

$\Rightarrow N = K \times E_b/\Phi$, Where $K = 60A/PZ$ is a constant.

$\Rightarrow N \propto E_b/\Phi, \Rightarrow N \propto E_b/I_f$, ($\because \Phi \propto I_f$), Where If is field current.

Hence this equation clearly states that, speed of the d.c. motor can be controlled above the normal range of speed by decreasing the flux i.e. by decreasing the current in the field circuit by including an external resistance in the form of a rheostat as variable resistance.

PROCEDURE :

(i) Connect the d.c. motor as per the ckt. Diagram

(ii) Ensure that the external resistance in the field circuit is minimum.

(iii) After ensuring step (ii), switch-on the d.c. supply.

(iv) Keep the applied voltage to the armature constant at its rated value. Vary the field current of the motor by inserting external resistance in the field circuit and record the field current and the corresponding speed of the motor.

(v) Repeat step (iv) for various values of field current, till the speed of the motor is about 1.4 times the rated speed of the motor.

(vi) Switch-off the main supply to stop the motor.

(vii) Plot the graph of field current (I_f) Vs change in speed of motor(N).

TABULATION:

Sl. No.	Field current (I_f) in Amp.	Speed(N) in RPM	Armature voltage(V) in Volt.

PRECAUTION:

(ii) Right terminals should be properly connected according to circuit diagram.

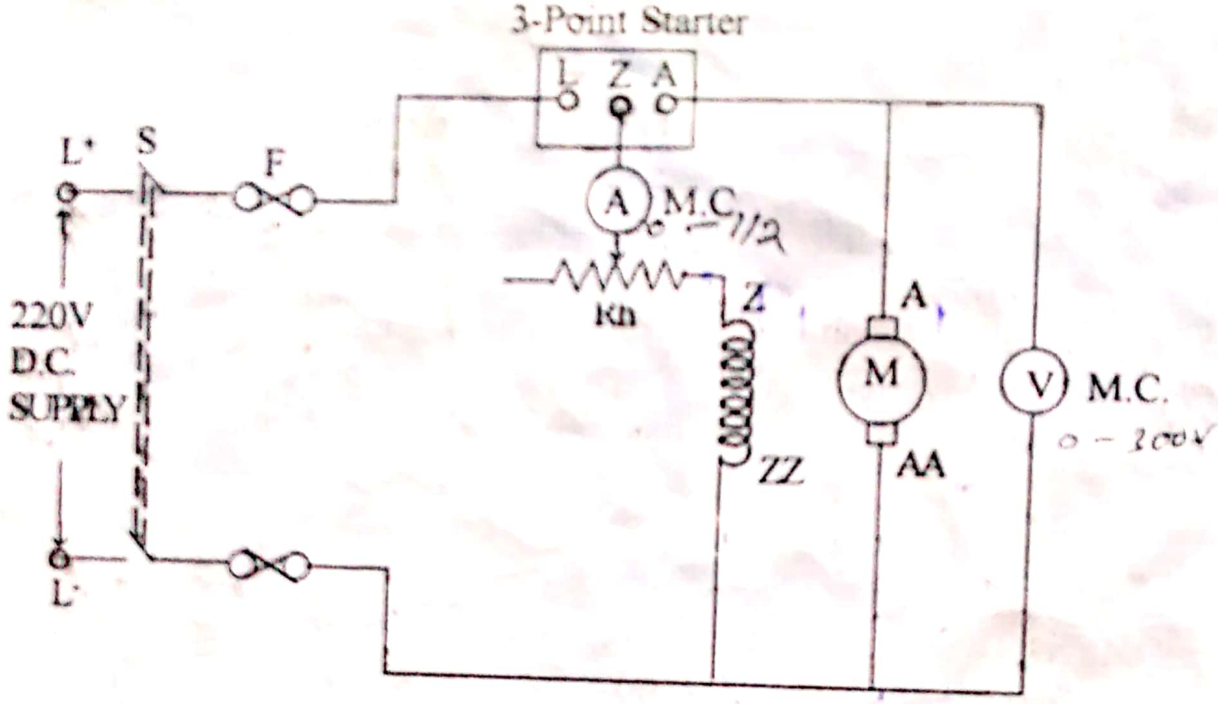
(iii) Fuse wire of proper current capacity to be used.

(iv) Do not increase the speed of motor beyond 1.4 times the rated speed, otherwise mechanical stresses will be high, which may damage the motor.

(v) Field current should not be decreased to a very low value.

CONCLUSION: From the above experiment it was found that the shunt motor changes its speed by varying the field flux. So satisfying the working formula, $N \propto 1/\Phi$ (10)

$N \propto \frac{1}{\Phi}$



Speed control by flux control method of D.C. shunt motor

SPEED CONTROL OF D.C. SHUNT MOTOR BY ARMATURE RESITANCE OR RHEOSTATIC CONTROL METHOD

AIM OF THE EXPERIMENT: To control the speed of d.c. shunt motor by armature resistance control method.

APPARATUS REQUIRED:

Sl.No.	Name of items	Type	Range	Quantity
1	D.C. Shunt motor	D.C.	——	1
2	3-point starter	D.C.	——	1
3	Ammeter	M.C	——	1
4	Voltmeter	M.C.	——	1
5	Rheostat or field regulator	——	——	1
6	Tachometer	——	——	1
7	Connecting wires	S.W.G	——	As per req.
8	Line tester	——	——	1

THEORY :- The back e.m.f. of a d.c. machine is given by

$$E_b = \Phi PZN/60A$$

$$\Rightarrow N = 60 E_b A/\Phi PZ$$

$$\Rightarrow N = K \times E_b/\Phi, \text{ Where } K=60A/PZ \text{ is a constant.}$$

$$\Rightarrow N \propto (V-I_a R_a)/\Phi, \text{ Where } E_b=V-I_a R_a$$

$$\Rightarrow N \propto (V-I_a R_a) \text{ (Keeping field current constant)}$$

$$\Rightarrow N \propto V-I_a(R_a+R), \text{ (R is the external resistance in armature)}$$

Hence this is clearly states that speed of the d.c. motor can be controlled below the normal range of speed by varying the resistance in the armature circuit included in the form of a rheostat as a variable.

PROCEDURE :

(i) Connect the d.c. motor as per circuit diagram.

(ii) Ensure that the external resistance in the armature circuit is maximum.

(iii) After ensuring step-(ii), switch-on the d.c. supply, as a result motor will start running at a low speed.

(iv) Keeping the field current to the shunt field constant, vary the voltage applied to the armature by varying the external resistance in the armature circuit.

(v) Record the applied voltage and the corresponding speed.

(vi) Repeat step (iv) for various values of applied voltage to the armature till the rated voltage of the motor and record the corresponding speed.

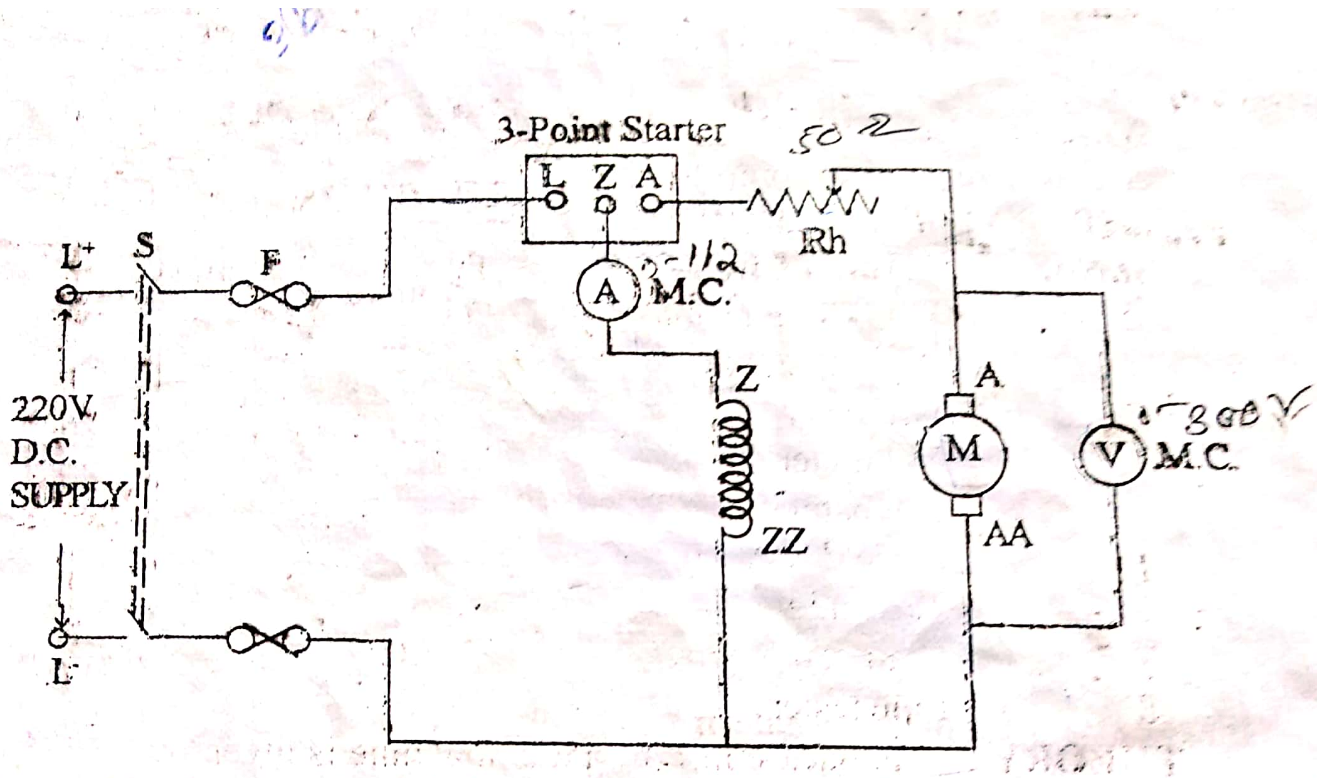
(vii) Switch-off the supply to stop the motor.

(viii) Plot the graph of armature voltage(V) Vs speed of the motor(N).

TABULATION

Sl. No.	Armature voltage (V)in volts	Speed of motor (N)in RPM	Field current(I_f) in amp.

CONCLUSION:- Hence we conclude that the speed can be controlled below rated speed by using armature resistance control method.



Speed control by Armature resistance control method of D.C. shunt motor

IDENTIFICATION OF TERMINALS OF 1-Φ TRANSFORMER OR POLARITY TEST OF 1-Φ TRANSFORMER.

AIM OF THE EXPERIMENT: To identify the terminals ~~of a 1-Φ transformer~~ and determination of transformation ratio of a 1-Φ transformer

APPARATUS REQUIRED:

Sl.No.	Name of items	Type	Range	Quantity
1	Voltmeter	M.I	(0-300)	2
2	Voltmeter	M.I.	(0-500)V	1
3	Connecting wire	S.W.G.	3/20	As per requirement
4	Line tester	---	---	1

THEORY: Each of the terminals of primary as well as secondary winding of a transformer is alternately positive and negative with respect to each other, It is essential to know the relative polarities at any instant of the primary and secondary terminals for making correct connections under the following type of operation of the transformer.

a)When two single phase transformers are to be connected in parallel to share the total load on the system.

b)For connecting three single phase transformers to form a 3-phase bank with proper connections of primary and secondary windings.

If at any instant, the induced emf. E_1 in the primary winding acts from the terminals marked A_2 to A_1 the induced emf E_2 in the secondary winding will act from a_2 to a1 i.e. if at any instant A_1 is positive and A_2 negative with respect to the applied voltage V_1 across the primary winding then the terminal voltage V_2 across the secondary winding will be positive at a1 and negative at a_2.

If the two windings are connected by joining A_1 to a_1 as shown in fig. and an alternating voltage V_1 applied across the primary, then the marking are correct if the voltage V_3 is less than V_1. Such a polarity is generally termed as subtractive polarity, in which the induced emfs in the primary and secondary windings are subtractive polarity for transformer connections, because it reduces the voltage stress between the adjacent leads. In case V_3 is greater than V_1 the emfs induced in the primary and secondary windings have an additive relation and the transformer is said to have additive polarity. Transformation Ratio(K) $= \frac{V_2}{V_1} = \frac{E_2}{E_1} = \frac{N_2}{N_1} = \frac{I_2}{I_1}$

PROCEDURE :-

1.Connect the circuit as per circuit diagram.

2.Switch-on single phase ac supply.

3.Record the voltages V_1, V_2 and V_3. It is advisable to use a single voltmeter with probes to measure these three voltage. In case $V_3 < V_1$, the polarity is subtractive.

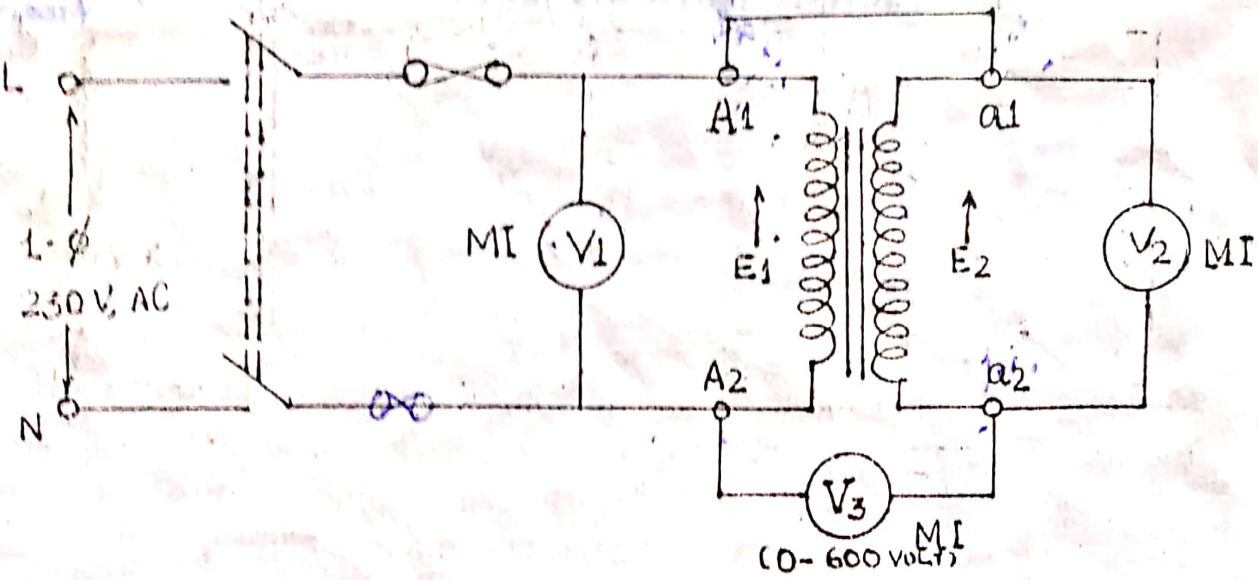
4.Repeat step 3, after connecting the terminals A_1 and a_2. The transformer should be disconnected before making this change. In this case $V_3 > V_1$, which indicates additive polarity.

5. Switch-off the ac supply.

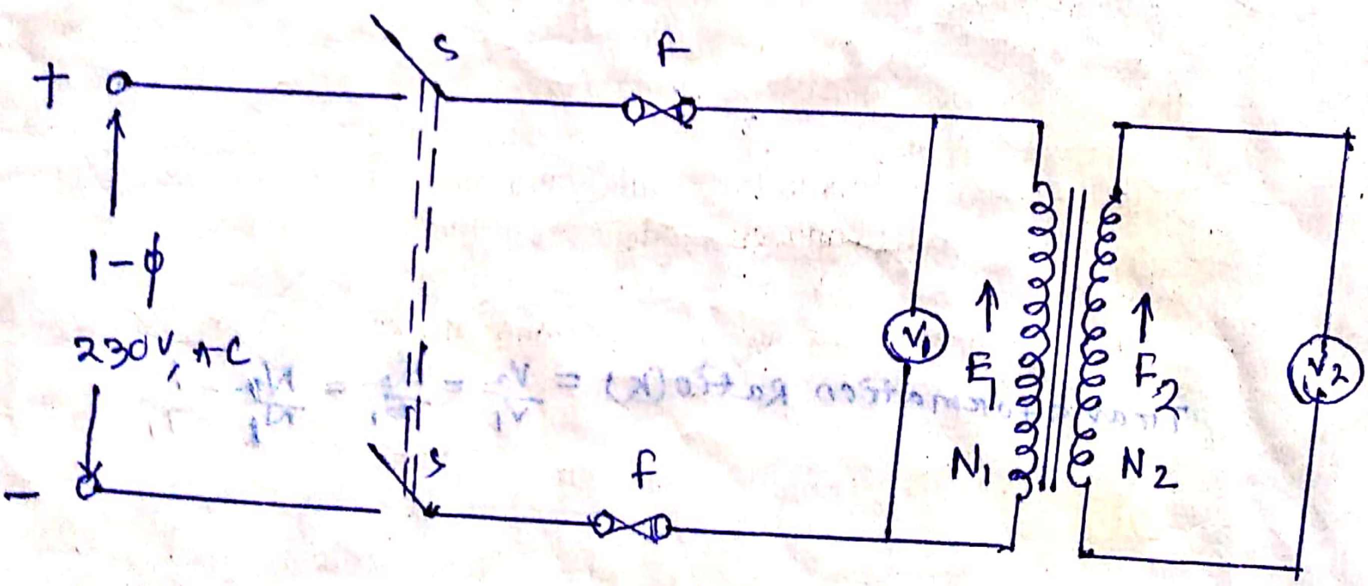
TABULATION :-

Sl. No.	Voltmeter Reading in Volt(V_1)	Voltmeter Reading in Volt(V_2)	Voltmeter Reading in volt(V_3)	Remark
1				
2				

CONCLUSION :- From this experiment we can identify the terminals and determination of transformation of an single phase transformer.



POLARITY TEST



TRANSFORMATION RATIO

REGULATION OF A TRANSFORMER

AIM OF THE EXPERIMENT :- Determination of voltage regulation of a single phase transformer by direct loading.

APPARATUS REQUIRED :- A 1-PHASE TRANSFORMER

MACHINE SPECIFICATION

Transformer :-Phase - 1,Cycles/sec - 50

KVA - 1 ,Voltage-230/230V

INSTRUMENT REQUIRED :-

Sl.No.	Name of the apparatus	Type	Range	Quantity
1	Variac	A.C.	(0-270)V	1
2	Voltmeter	M.I.	(0-300)V	2
3	Ammeter	M.I.	(0-5)A	1
4	Load box	Lamp load	(0-2000)W	1
5	Line tester	——	-	1
6	Plier	Insulated	-	1
7	Connecting wire	S.W.G	3/20	As per requirement

THEORY :- The change in secondary terminal voltage from no load to full load at constant primary voltage expressed as a percentage or per unit of the rated voltage is known as voltage regulation of the transformer.

If E_2 = Secondary terminal voltage at no load.

V_2 = Secondary terminal voltage at full load.

Then % of voltage regulation = $(E_2 - V_2)$/Rated voltage × 100

But no load terminal voltage E_2 is taken as rated % voltage regulation

$= (E_2 - V_2) / E_2 \times 100$

and, per unit regulation $= (E_2 - V_2) / E_2$

PROCEDURE :-

i. Connect the circuit as per circuit diagram.

ii. All the loads is made zero by switch-off all the switches.

iii. Give A.C. supply to the variac .

iv. Adjust the variac in a position such that full load primary voltage is fed to the transformer.

v. Record the voltmeter reading in the secondary side which is secondary terminal voltage at no load.

vi. Switch -on the load box switches in steps .

vii. Record the ammeter reading .

viii. Record the corresponding voltmeter reading when the ammeter shows the rated current of the secondary side . This voltage is the secondary terminal voltage at full load.

ix. Hence calculate the voltage regulation using the formula.

TABULATION:

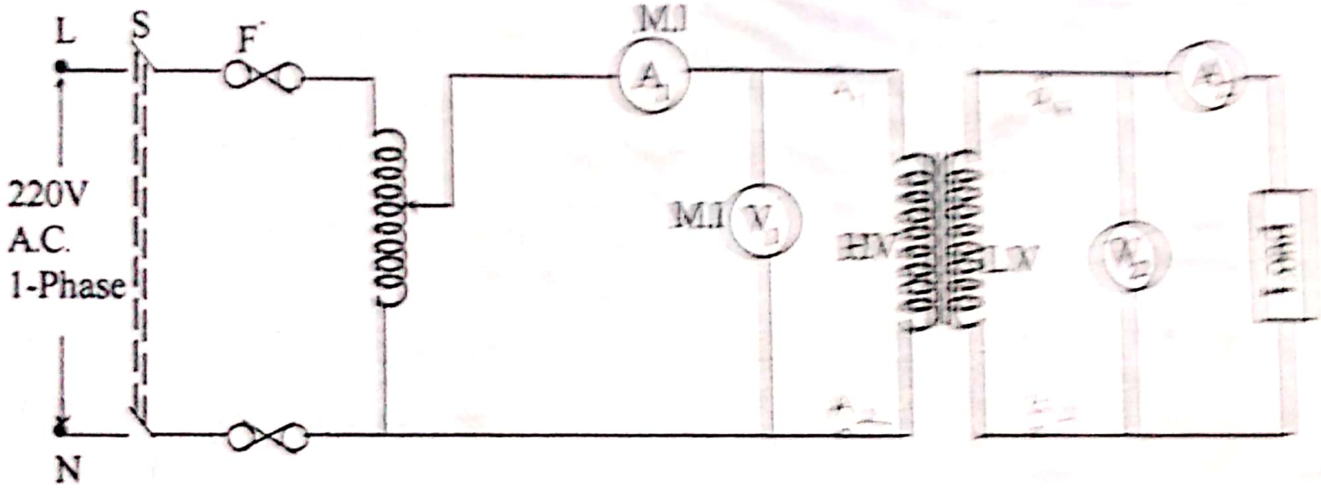
Sl. No.	Load current (I_2) in Amp.	Voltmeter(V_1) reading in volt	Voltmeter(V_2) reading in volts
1.			
2.			

CALCULATION:

Per unit voltage regulation = $(E_2 - V_2)/E_2$ = ______%

Percentage voltage regulation = $(E_2 - V_2)/E_2 \times 100$ = ______%

CONCLUSION :- The voltage regulation of the transformer is found to be ____% in per unit & _____% in percentage.



Connection diagram to determine voltage regulation of single phase transformer

10.14. Moving-coil Instruments

There are two types of such instruments (*i*) *permanent-magnet type* which can work only and (*ii*) the *dynamometer type* which can be used both for a.c. and d.c.

10.15. Permanent Magnet Type Instruments

The operation of a permanent-magnet moving-coil type instrument is based ciple that when a current-carrying conductor is placed in a magnetic field, it is acted which tends to move it to one side and out of the field.

Construction

As its name indicates, the instrument consists of a permanent magnet and a re many turns wound on a light aluminium or copper former inside which is an iron

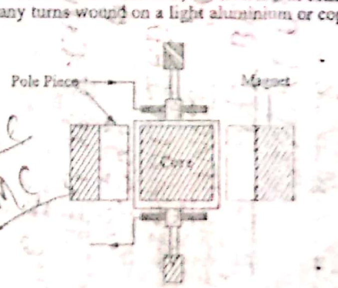


Fig. 10.16.

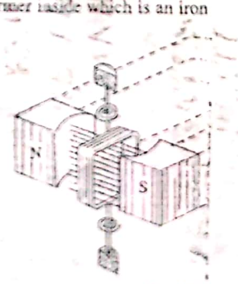


Fig. 10.17

Fig. 10.16 The powerfull U-shaped permanent magnet is made of Alnico and has pieces which are bored out cylindrically. Between the magnetic poles is fixed a whose function is (*i*) to make the field radial and uniform and (*ii*) to decrease the re path between the poles and hence increase the magnetic flux. Surrounding the co coil of many turns wound on a light aluminium frame which is supported by delica which is attached a light pointer. The aluminium frame not only provides support f provides damping by eddy currents induced in it. The sides of the coil are free to m gaps between the poles and core as shown in Fig. 10.16 and Fig. 10.17. Control of t is affected by two phosphor-bronze hair springs, one above and one below, which the purpose of lending the current in and out of the coil. The two springs are spi direction in order to neutralize the effects of temperature changes.

Deflecting Torque

When current is passed through the coil, force acts upon its both sides which produce a deflecting torque as shown in Fig. 10.18. Let

Fig. 10.18

B = flux density in Wb/m^2

l = length or depth of the coil in metre

b = breadth of coil in metre

the coil, the ovalshaped iron disc is pivoted in such a way that the greatest bulk of iron centre of the coil. If a pointer is fixed to the spindle carrying the disc, then the pas through the coil will cause the pointer to deflect. The amount of deflection prod greater when the current producing the magnetic field is greater. Another point wort *whatever the direction of current through the coil, the iron disc would always be such a way that it is pulled inwards.* Hence, such instruments can be used both for alternating currents.

A sectional view of the actual instrument is shown in Fig. 10.9. When the current is passed through the coil or solenoid, a magnetic field is produced, which attracts th mounted disc inwards, thereby deflecting the pointer, which moves over a calibrated

Deflecting Torque

Let the axis of the iron disc, when in zero position, subtend an angle of ϕ with a d dicular to the direction of the field H produced by the coil. Let the deflection produ sponding to a current I through the coil. The magnetisation of iron disc is proportion nent of H acting along the axis of the disc *i.e.* proportional to $H \cos [90 - (\phi + \theta)]$ The force F pulling the disc inwards is proportional to MH or $H^2 \sin (\theta + \phi)$. If the iron is assumed constant, then, $H \propto I$. Hence, $F \propto I^2 \sin (\theta + \phi)$. If this force acted from the pivot of the rotating disc, then deflecting torque $T_d = FL \cos (\theta + \phi)$. Puttin we get

$$T_d \propto I^2 \sin (\theta + \phi) \times l \cos (\theta + \phi) \propto I^2 \sin 2 (\theta + \phi) = KI^2 \sin 2 (\theta + \phi)$$

If spring-control is used, then controlling torque $T_c = K' \theta$

In the steady position of deflection, $T_d = T_c$

$\therefore \quad KI^2 \sin 2 (\theta + \phi) = K'\theta$; Hence $\theta \propto I^2$

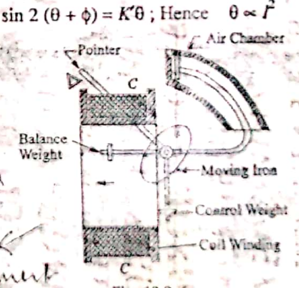


Fig. 10.9

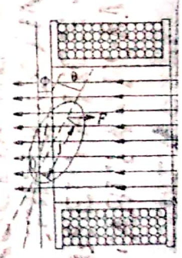


Fig. 10.10

If A.C. is used, then $\theta \propto I^2_{r.m.s.}$

However, if gravity-control is used, then $T_c = K_1 \sin \theta$

$\therefore \quad KI^2 \sin 2 (\theta + \phi) = K_1 \sin \theta \quad \therefore \sin \theta \propto I^2 \sin 2 (\theta + \phi)$

In both cases, the scales would be uneven.

Damping

As shown, air-friction damping is provided, the actual arrangement being a l in an air-chamber.

AIM OF THE EXPERIMENT : To study the star-delta starter (Y-Δ) starter, connecting and running of 3-Φ squirrel cage Induction motor and measurement of the starting and running current .

APPARATUS/MACHINE REQUIRED:

Sl.No.	Name of items	Type	Range	Quantity
1	Star-delta starter	A.C.	--------	1
2	3-Φ squirrel cage Induction motor	A.C.	--------	1
3	Ammeter	M.I.	--------	1
4	Connecting wire	S.W.G	--------	As per req.
5	Combination plier	Insulated	--------	1
6	Screw driver	--------	--------	1
7	Line tester	--------	--------	1

THEORY :- Star-delta starter can be used ,provided the starter winding of the motor is designed for delta connection during its normal operation .This starter starts the motor first in "STAR" condition and when the motor gains about 75% speed',the connection is changed to "DELTA" by moving the handle quickly in run position. A four pole double throw-switch is generally used to change over the connection from star to delta .It is also provided with no-volt release and over load release which protect the motor against sudden failure of supply and over loading on the motor respectively and to stop motor a STOP-PUSH button is used .By connecting the motor in star connection during starting the applied voltage to each phase of the winding is reduced to $1/\sqrt{3}$ or 58% of the line voltage in delta connection .Thus the starting line current in star is only one third that in delta .

I_{st} per phase = $(1/\sqrt{3})\ I_{sc}$ ------ (i)

Where I_{st} → Starting current per phase if the motor is started in star.

I_{sc} → Starting current per phase if the motor is started in delta.

In star connection line current is equal to phase current so I_{st}/phase $=I_{st}$/line

But in delta connection line current is equal to $\sqrt{3}$ times of phase current.

Hence I_{sc} /phase $=(1/\sqrt{3})I_{sc}$ line.

Putting the above values in equation (i)

we have I_{st} line. $=(1/\sqrt{3})\ (1/\sqrt{3})I_{sc}$ line$=(1/3)I_{sc}$ line

Hence we found that line current is 3 times more if the motor is started without starter.

The torque in "STAR" connection is also decreased and is only one third that in delta .Hence the Star-Delta starter can be used only with motors where the load torque at the moment of starting is not more than about 50% of the rated torque. This starter is used for motor having output from 5 H.P. to 15 H.P.

OPERATION:

When the handle operated in "STAR" position the ends A_2, B_2 and C_2 of the motor become short circuited and A_1, B_1 and C_1 get the supply .The motor becomes in star and gets $1/\sqrt{3}$-times or 58% of the full voltage by which the motor take 1/3rd current of that which the motor takes by starting directly in delta giving full voltage. After taking 75% speed the handle is moved to delta .In this position the ends C_1A_2, A_1B_2 and B_1C_2 are short-circuited and each joint gets supply which connects the supply in delta .Now the motor is on full speed and the back e.m.f. is full .The motor is taking full current thereby giving the full torque .

PROCEDURE:-

(2) First read out the name plate of the starter as well as rating of it .

(3) Remove the cover of the starter .

(4) Then study about the over load circuit and no-volt-coil .

(5) There are 9 terminals of the starter in which 3 of them are of line and remaining 6 terminals are for motors i.e. A_1B_2 ,B_1C_2 and C_1A_2 .

(6) Test phase sequence of the motor .

(7) Connect the motor as per ckt. diagram .

(8) Switch-on the main switch and make the handle in "STAR" position of the starter and measure the starting current and steady starting current in star connection .

(9) When motor attains 75% of the synchronous speed ,make the handle in "DELTA" position quickly. Note the running current and steady running current in delta connection .

PRECAUTION :-

(1) Setting of the O.L. current of the motor should be same as per given rating on the name plate of the motor .

(2) Starter should be well earthen .

(3) All contacts should be well cleaned .

(4) Check whether all strips are making contacts with fixed contacts at a time while making handle in star and delta position .

(5) The connection should be right and tight .

TABULATION :-

Sl.No.	In STAR(Starting)		In DELTA(Running)	
	Starting current in amp.	Steady Starting current in amp.	Running current in amp.	Steady Running current in amp.

CONCLUSION :- The Star-Delta starter was studied and we got a brief knowledge about it and the motor was connected and running successfully and the starting current and running current was found to be ______ amp &______amp.

N.B.

(1) Mechanically operated Star-Delta starters are generally used with motor having an output from 5H.P. to 10 H.P.

(2) Automatic air break Star-Delta starters are employed with 20 H.P.

(3) Oil immersed Star-Delta starters are suitable for 50 H.P.

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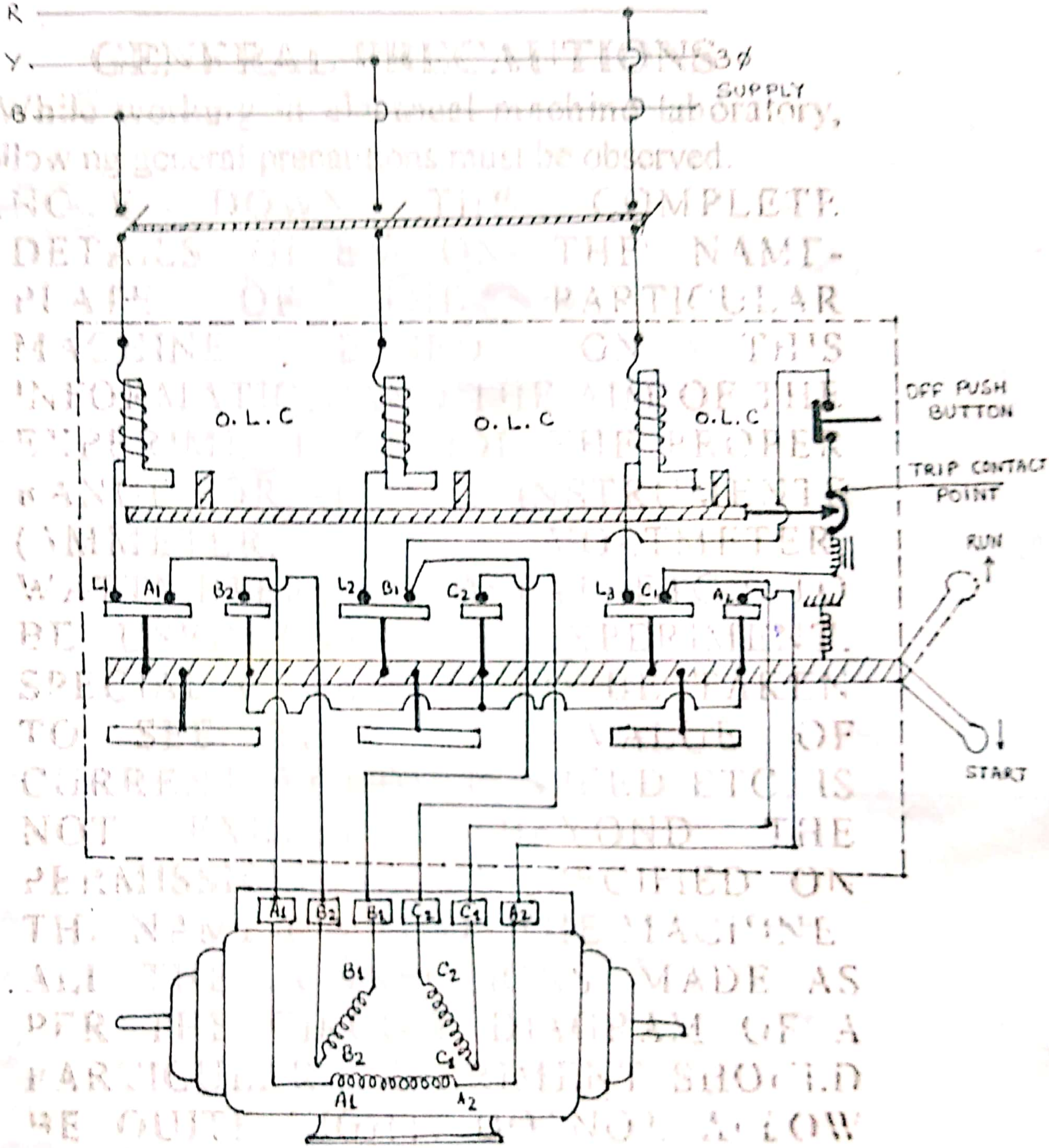

CONNECTION DIAGRAM OF STAR DELTA STARTER