P.K.A.I.E.T., BARGARH

ELECTRICAL MACHINE LABORATORY

COURSE AS PER *S.C.T.E & V T*, ORISSA

(SEMESTER – IV)
BRANCH- COMMON TO *ETC & AE&I*

Total Period:- 45
No. of Period:- 3 P/W

Examination:- 4 Hours
Exam:- 25 Marks
Sessional:- 25 Marks

Performable Experiment:-

1. Study of different parts of D.C .Machine.
2. Run a D.C. Shunt Generator and measure the no load voltage.
3. Connect and run D.C. motor of different types.
4. Study of 3-Point and 4-Point starter.
5. Study of D.C. Series motor starter.
6. Study & Speed control of D.C. Shunt motor.(Field and Armature Voltage control method.)
7. Study of 3-Phase Alternator.
8. Study of 3-Phase Induction motor.
9. Study of Star-Delta starter.
10. Identify the terminals of a transformer.
11. Determine Voltage regulation of a transformer by direct loading.
12. Connect switch board using Cut out, Switches, Plugs, Holder and two way switch.

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INSTITUTE OF ENGINEERING & TECHNOLOGY,
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DIFFERENT PARTS OF D.C. GENERATOR

AIM OF THE EXPERIMENT: To study the different parts of D.C. Generator.
APPARATUS REQUIRED: A model of D.C. Generator.
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.

DIFFERENT PARTS OF D.C. GENERATOR

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

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

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. generator are of rectangular shape.

ii. ***Main poles:*** It is the stationary part of the generator, 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.

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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. generator and their parts.

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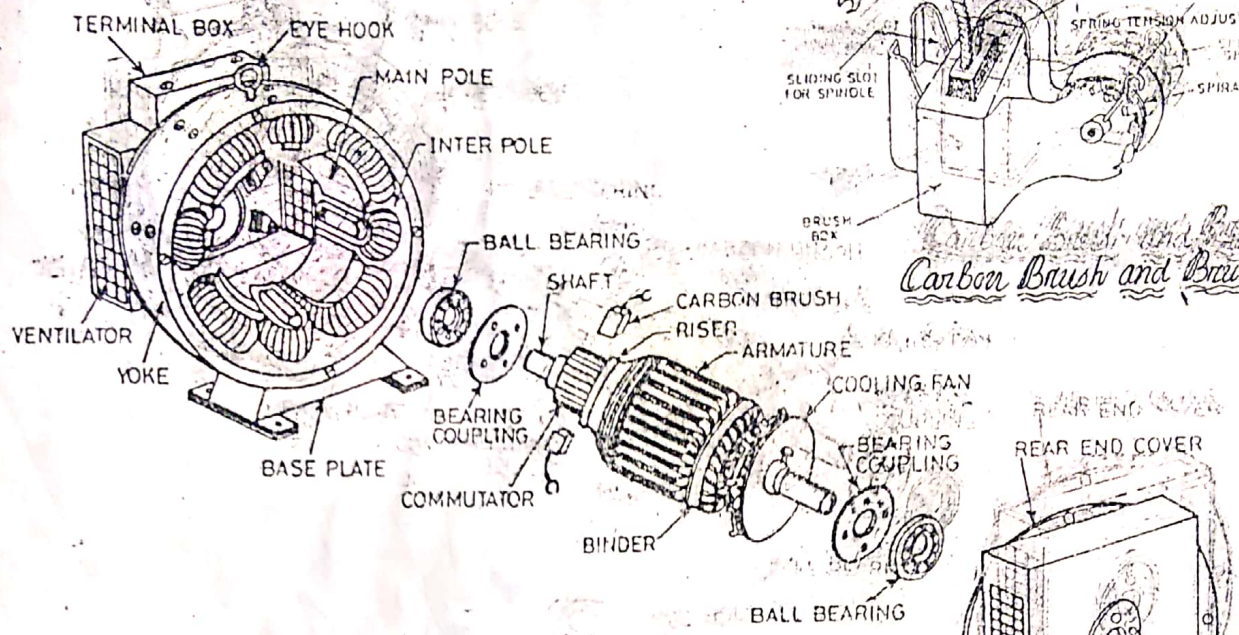
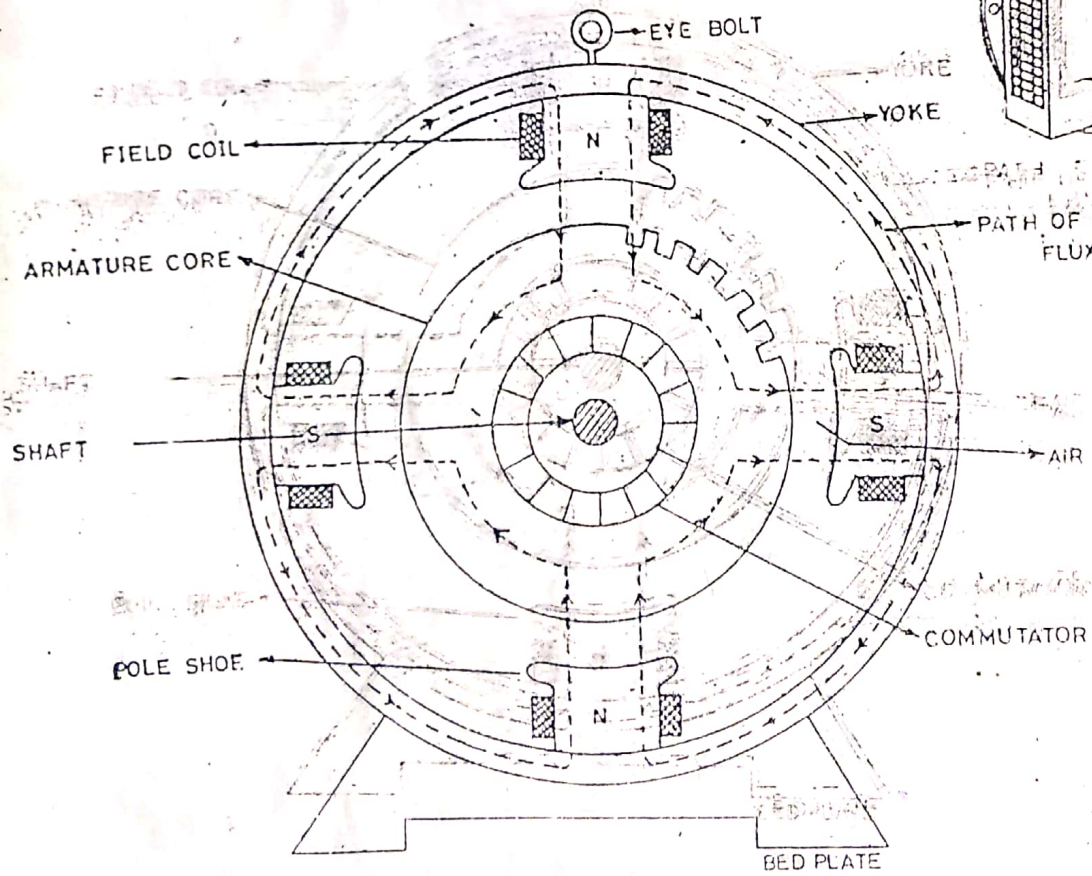


Carbon Brush and Brush Holder



DIFFERENT PARTS OF D.C. MACHINE

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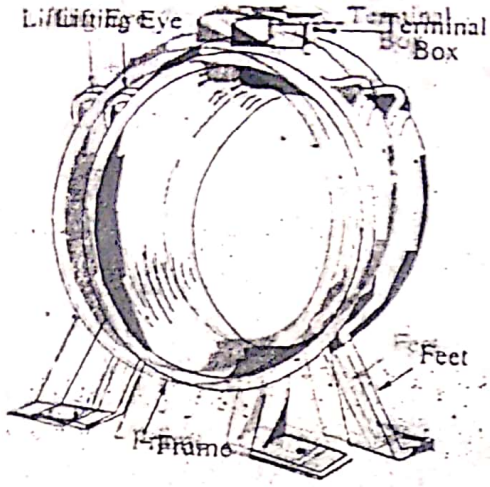
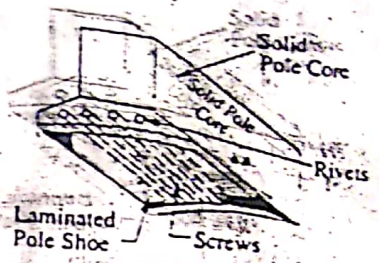
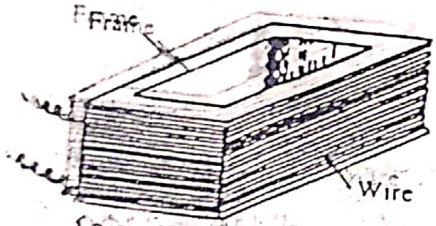


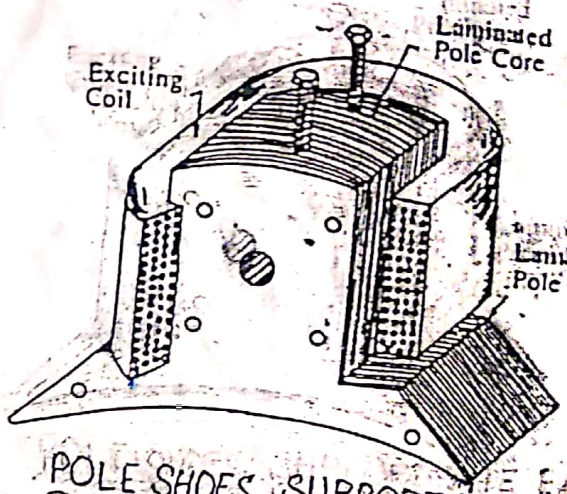
YOKE



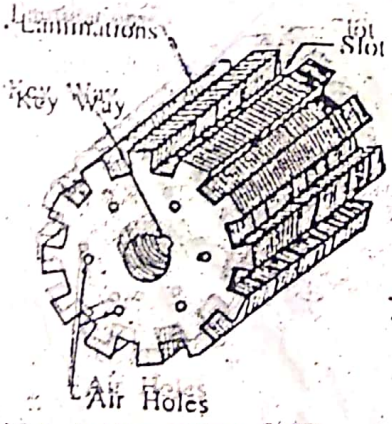
POLE CORE & POLE SHOE



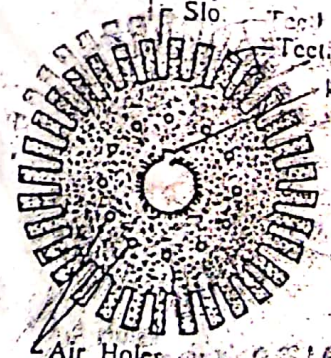
POLE COILS



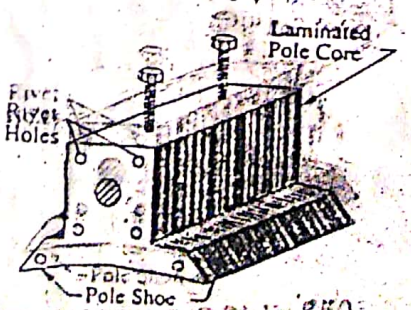
POLE SHOES SUPPORT THE EXCITING COIL



ARMATURE CORE & SLOTS



FRONT VIEW OF SLOTS & TEETH



POLE CORE & POLE SHOES RIVETTED TOGETHER

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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

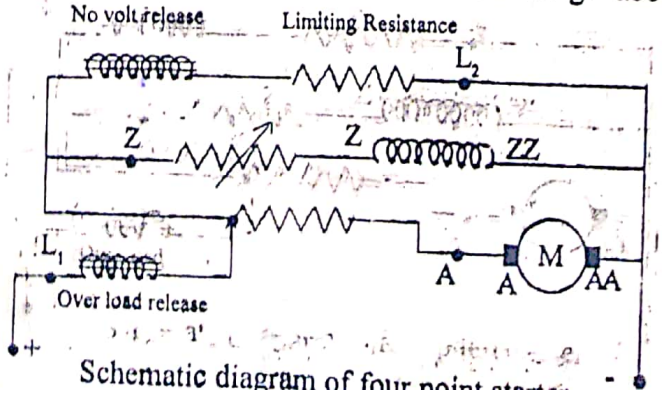
This starter is used with shunt and compound motors where much variations of speed is required. As compared to three point starter, one important change has been made i.e. **No-volt release coil** has been taken out of shunt field circuit and has been connected directly across the line through a limiting 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 armature, (ii) the second part passes through the shunt field and its field rheostat **Rli** 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

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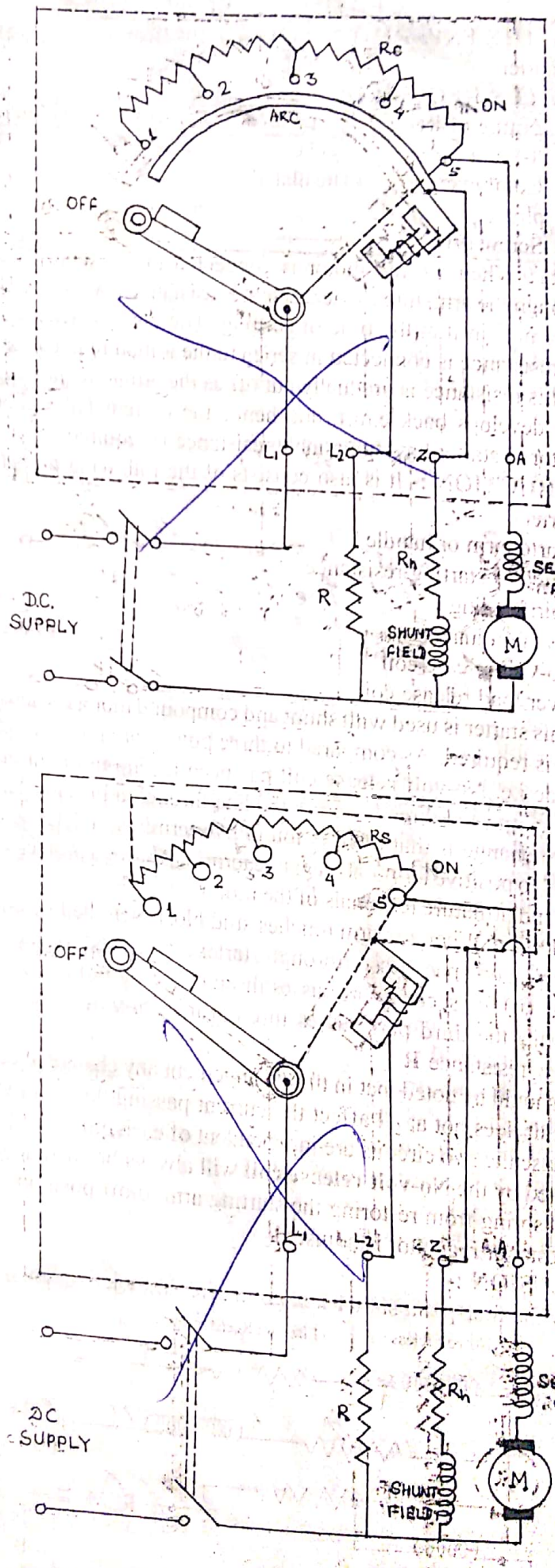

CONNECTION DIAGRAM OF FOUR POINT STARTER

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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 demagnetized 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

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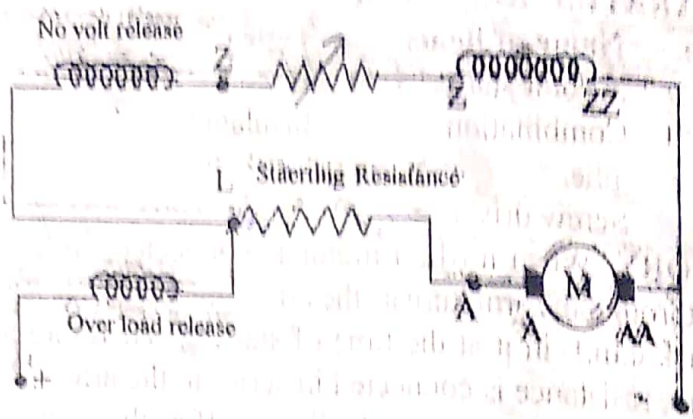
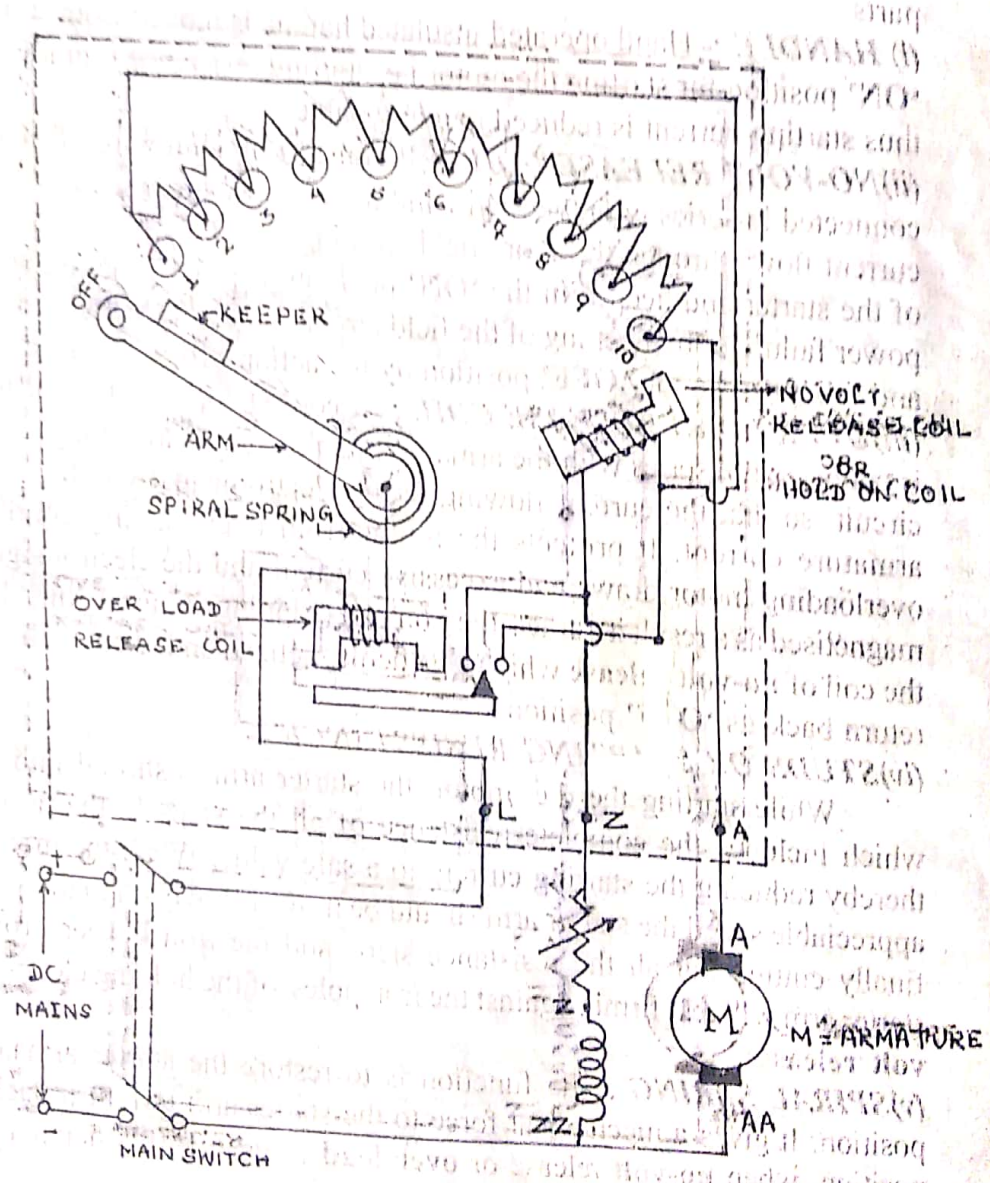


Schematic diagram of three point starter



CONNECTION DIAGRAM OF THREE POINT STARTER

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5

D.C. SERIES MOTOR

AIM OF THE EXPERIMENT: To make connecting and running of d.c. series motor.

APPARATUS/MACHINE REQUIRED:-

Sl.No.	Name of items	Type	Range	Quantity
1	Drum controller	D.C.	———	1
2	D.C.Series motor	D.C.	———	1
3	Connecting wire	S.W.G	———	1
4	Combination Plier	Insulated	———	As per required
5	Screw driver	———	———	1
6	Line tester	———	———	1

THEORY :- In the d.c. series motor the field winding is connected in series with the armature. The line current taken by the motor is equal to the armature current or field current;

$$I_L = I_a = I_f$$

where, I_L = Load current.

I_a = Armature current

I_f = Field current.

The applied voltage is given by

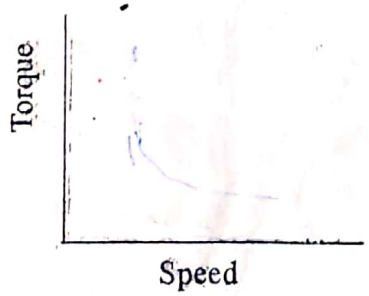
$$V = E_b + I_a R_a + I_f R_f$$

Where, E_b = Back emf.

$I_a R_a$ = Voltage drop in the armature

and $I_f R_f$ = voltage drop in the series field winding.

At no load the armature current is low and hence the speed of motor become dangerously high. Therefore the d.c. series motor is always started and operated at load condition. The above facts can be observed from the ***speed-torque characteristics*** of a d.c. series motor. Drum controller is used for high speed regulation of d.c. series motor.



PROCEDURE:

(i) Connect the circuit as per the circuit diagram.
(ii) Ensure that the machine and drum controller should be connected properly or not.
(iii) Give load to the machine.
(iv) Switch-on the supply.
(v) With the help of drum controller start the motor.
(vi) Switch-off the supply to stop the motor.

OBSERVATION:- At no load, the motor produce high torque and a very heavy r.p.m.

PRECAUTION :

(i) The connection should be properly tightened.
(ii) The internal connection of panel board should be checked properly.
(iii) Never start the motor without load.
(iv) The r.p.m. should not be more than the rated r.p.m.

CONCLUSION : From the above experiment we know about the connection of d.c series motor and it should be always started with load

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N.B.

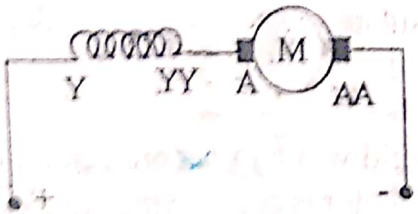
To change the direction of rotation of D.C.Series motor

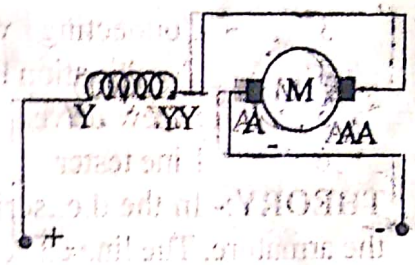
(i) Interchange armature terminals direction will be anti-clockwise.(Fig.a)

(ii) Interchange field terminals direction will be anti-clockwise.(Fig.b)

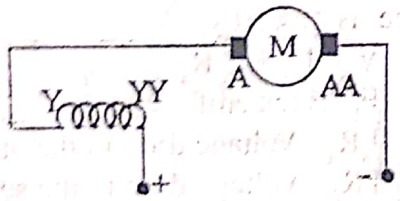
(iii) Never interchange the field and armature terminals at the same time .

"For starting d.c. series motor Drum controller or two point starter is used.





Interchanging Armature terminals(Fig.a)



Interchanging field terminals(Fig.b)

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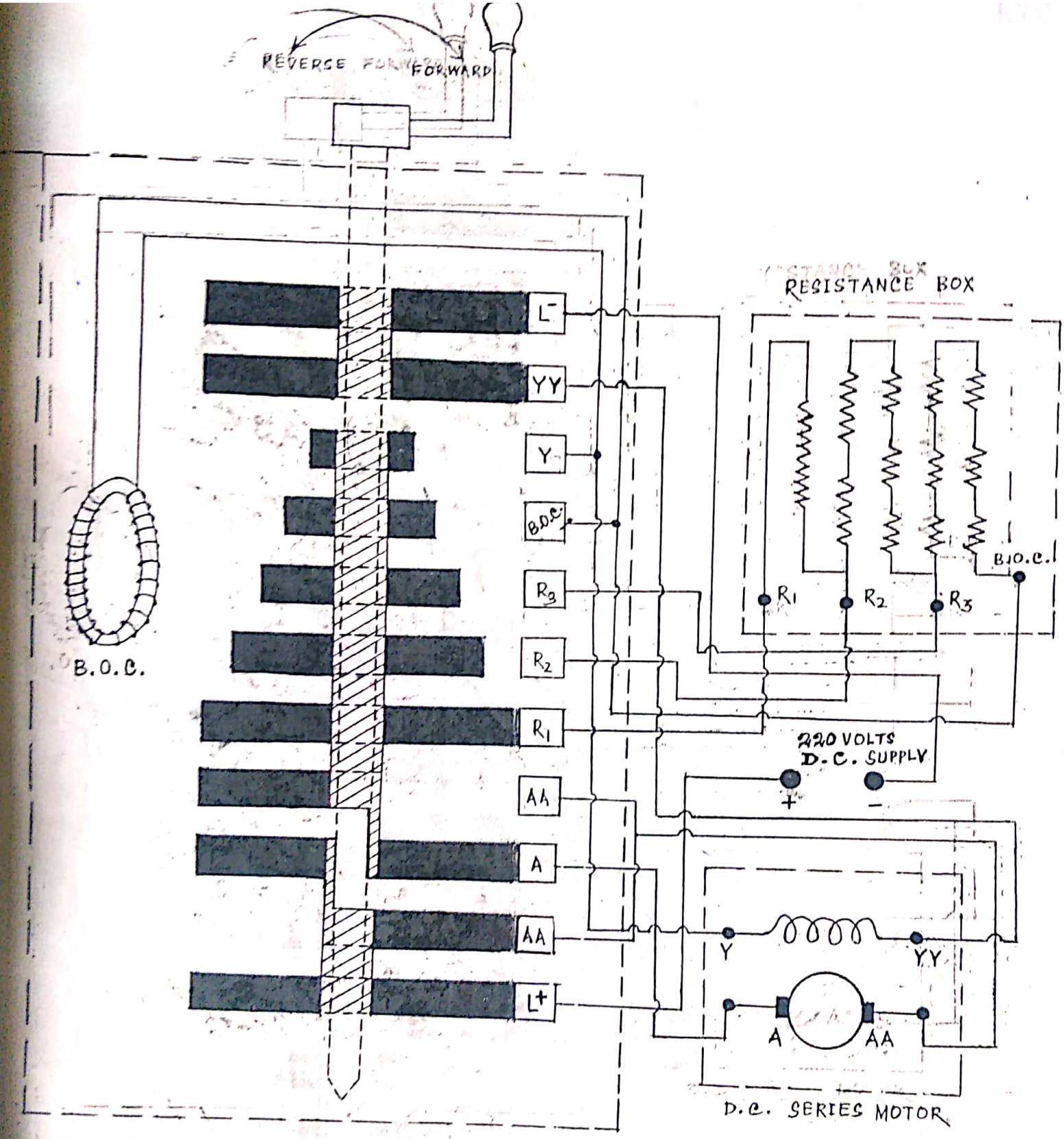
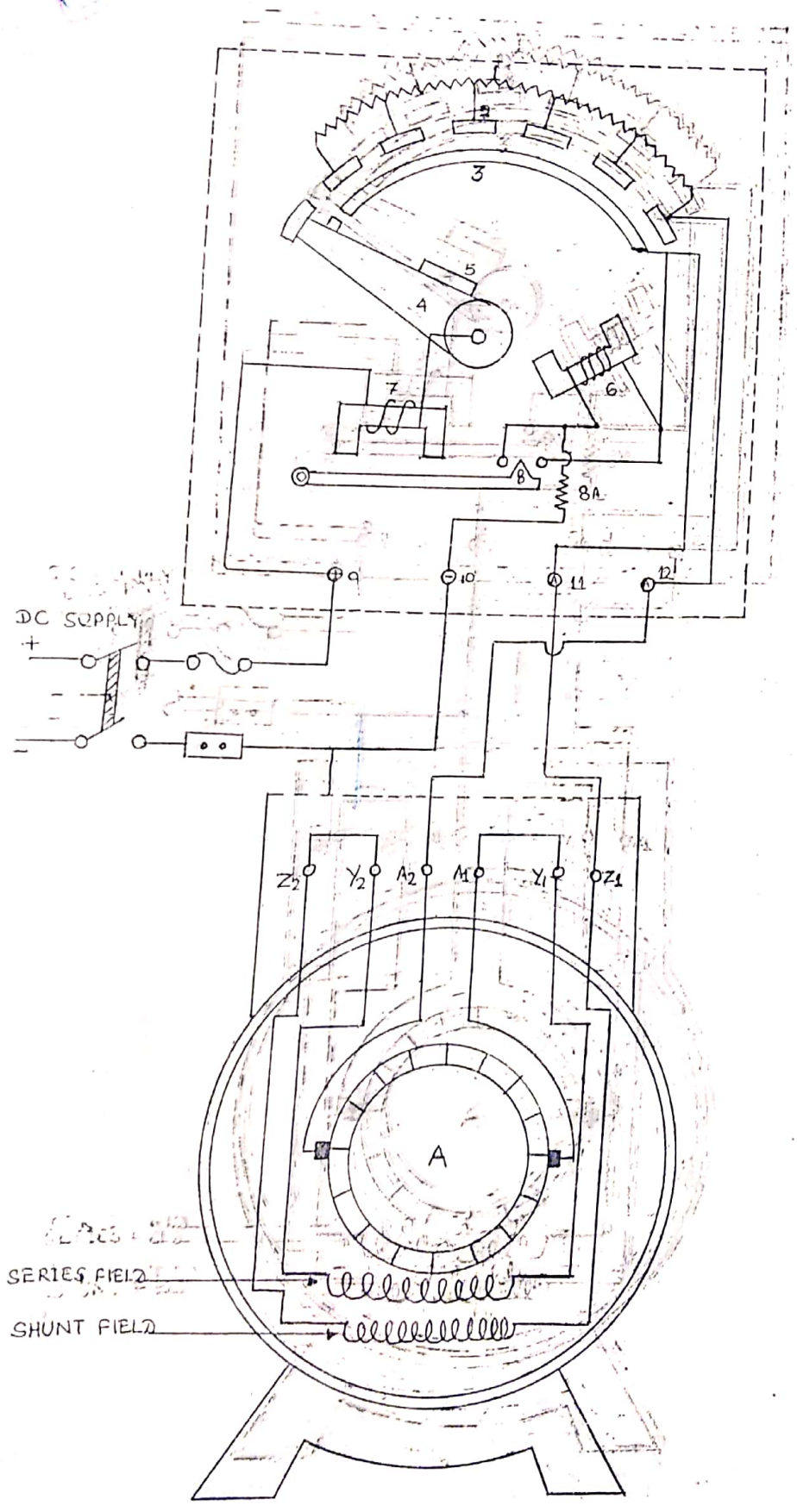


DRUM CONTROLLER

1. It is a starter-cum-speed controller.
2. It is used only for D.C. series motors.



CIRCUIT DIAGRAM OF COMPOUND MOTOR WITH FOUR-POINT STARTER

① STARTING RESISTANCE
② BRASS
③ BRASS STRIP
④ STARTING HANDEL
⑤ IRON BAR (KEEPER)
⑥ NOVOL RELEASE COIL
⑦ OVER LOAD RELEASE COIL
⑧ TRIPPING REVERSE WITH CONTACT POINT
⑨ POSITIVE TERMINAL (L_1)
⑩ NEGATIVE TERMINAL (L_2)
⑪ SHUNT FIELD TERMINAL (Z)
⑫ ARMATURE TERMINAL (A)
⑬ DPIC MAIN SWITCH
⑭ DC MOTOR

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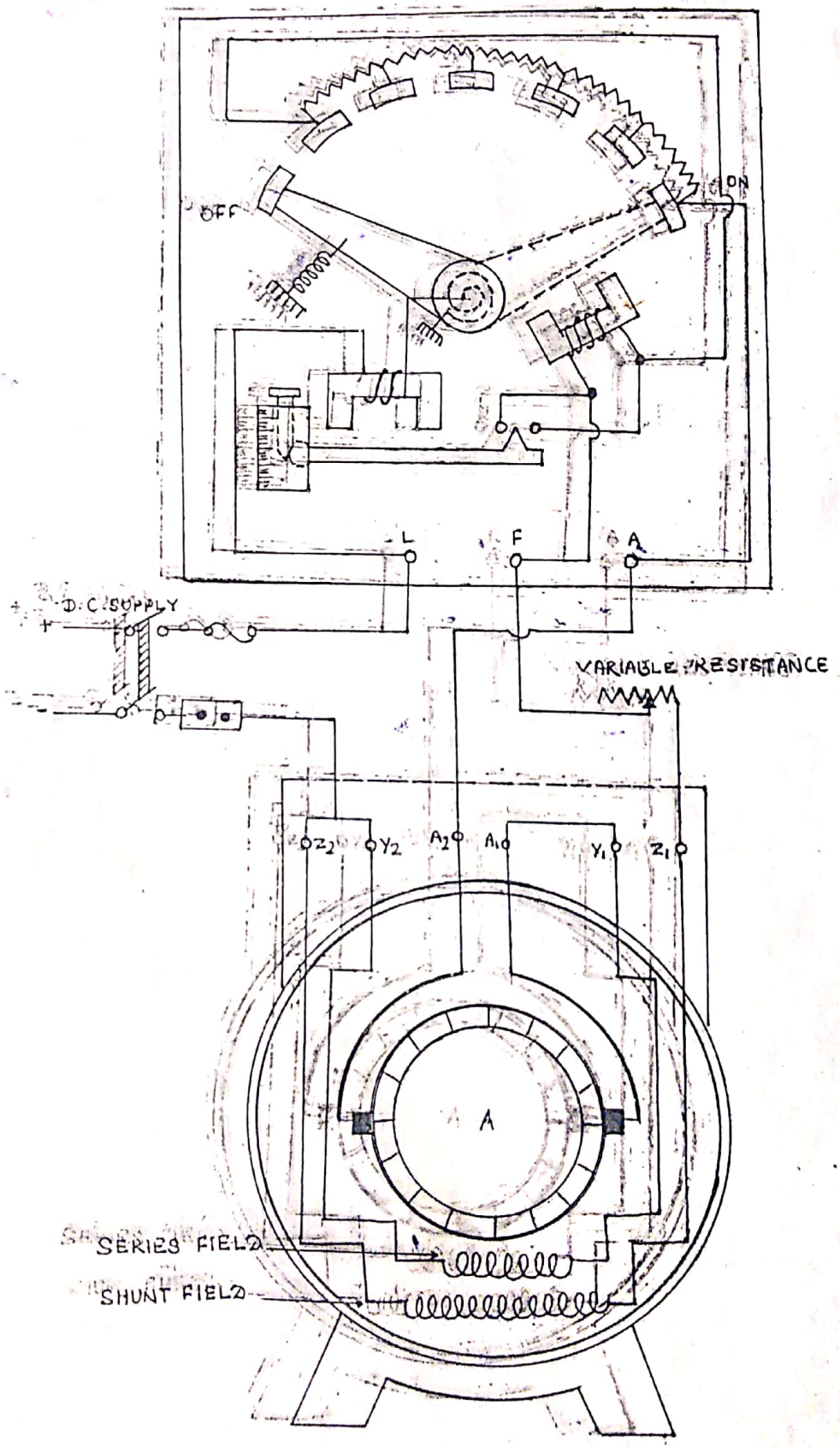

CIRCUIT DIAGRAM OF COMPOUND MOTOR WITH THREE POINT STARTER

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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,

$E_b = \Phi PZN/60A$

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

$\Rightarrow N = KxE_b/\Phi$, 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:

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

(ii) 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, $N \propto 1/\Phi$.

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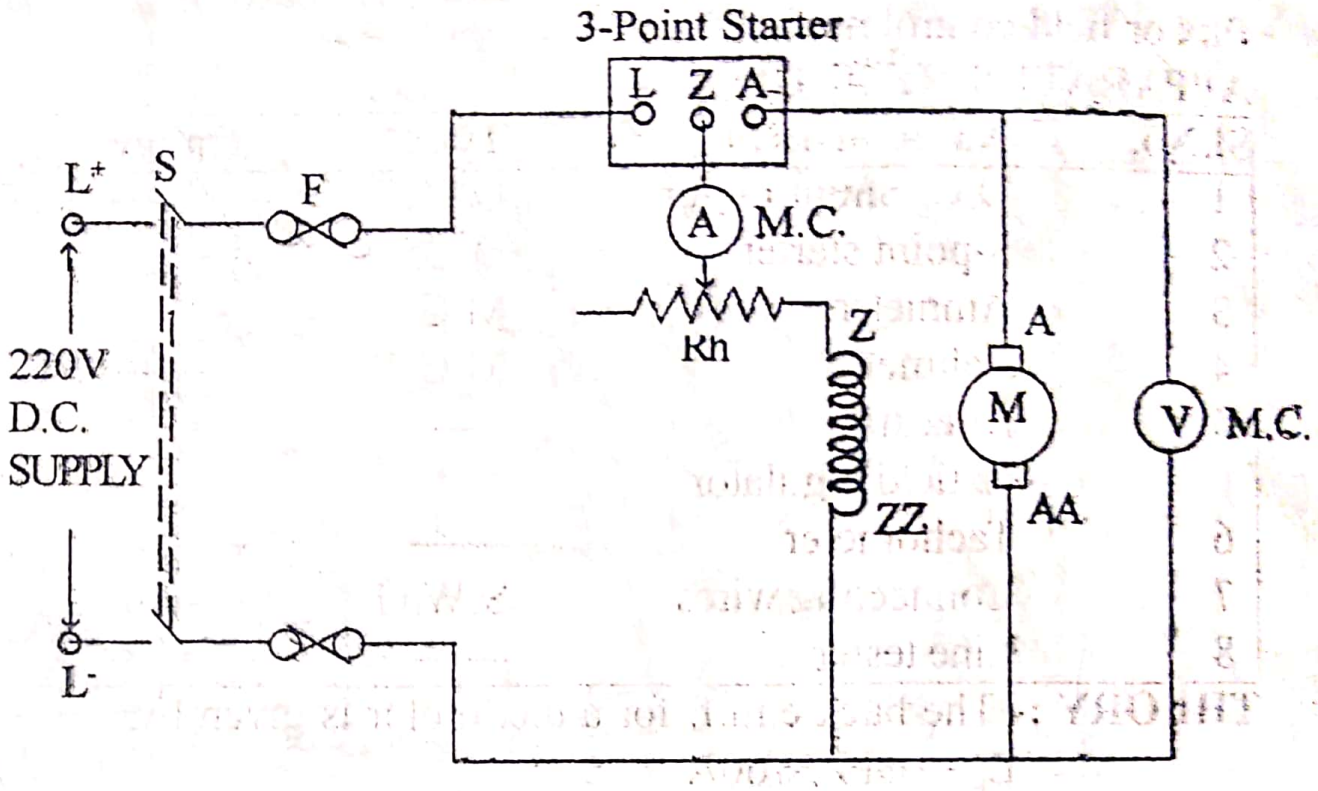

Speed control by flux control method of D.C. shunt motor

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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

$E_b = \Phi PZN/60A$

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

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

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

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

$\Rightarrow N \propto V - I_a(R_a + R)$, (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.

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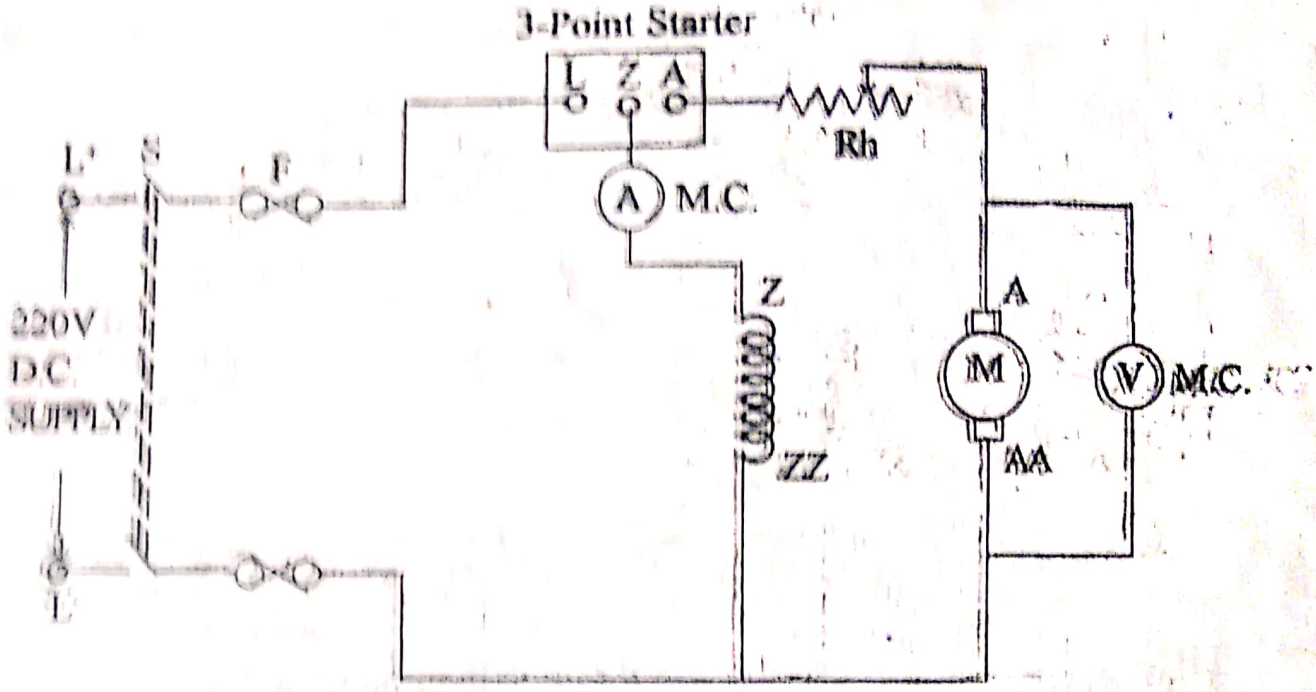

Speed control by Armature resistance control method of D.C. shunt motor

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D.C.SHUNT MOTOR

AIM OF THE EXPERIMENT: To study, connecting and running of a d.c. shunt motor.

APPARATUS/MACHINE REQUIRED:-

Sl.No.	Name of items	Type	Range	Quantity
1	3-Point Starter	D.C	———	1
2	D.C.Shunt motor	D.C	———	1
3	Connecting wire	S.W.G	———	As per requirement
4	Combination Plier	Insulated	———	1
5	Screw driver	———	———	1
6	Line tester	———	———	1

THEORY: A d.c. machine that converts electrical power into mechanical power is known as d.c. motor. It is basically works on the principle that when a current carrying conductor is placed in a magnetic field, a force acts on the current carrying conductor as a result the current carrying conductor starts rotating in a direction depending upon the direction of current and the field as given by Fleming's left hand rule.

The back e.m.f. for d.c. motor is ;

$$E_b = (PN\Phi/60) \times (Z/A)$$

or, $E_b = V - I_a R_a$ ($I_a R_a$ = Armature drop)

Where, Φ = Flux per pole in wb.

Z = No. of armature conductor

N = Speed of motor in r.p.m.

P = No. of poles

A = No. of parallel paths.

PROCEDURE:

(1) Connect the circuit as per the circuit diagram.

(2) Ensuring that the three line terminals of the 3-point starter, L,Z and A are properly connected to the positive line terminal, shunt field terminal and the armature terminal of the motor respectively or not.

(3) Switch on the supply.

(4) Slowly move the starter arm or handle on the first stud, which reduces the starting current.

(5) As the motor gain appreciable speed the starter arm should be moved slowly on the studs, 2,3,4 etc.

(6) Motor should run in its rated speed.

(7) Switch off the supply to stop the motor.

OBSERVATION :- Motor will run at constant speed.

PRECAUTION:

(i) Do not give direct supply to the machine because initially the back emf is zero, which causes an extremely large current through the armature winding and damage it.

(ii) The starting current drawn by the motor is limited to a safe value by using a starter.

(iii) Connection should be properly tightened.

(iv) Use proper rated wires depending upon the full load current of the motor.

(v) Field circuit should never be disconnected or never be loose connected while the armature is connected across the supply or else the motor may attain dangerously high speed.

CONCLUSION :- From above experiment we got knowledge about the connection of d.c. shunt motor and we obtain that after starting the motor is of constant speed assuming that the supply voltage is constant.

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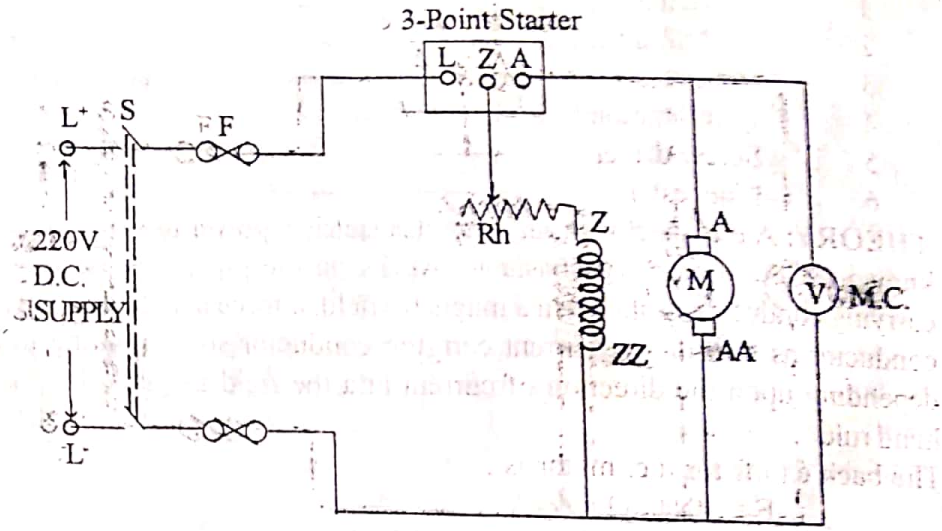
N.B.

To change the direction of rotation of D.C. Shunt motor

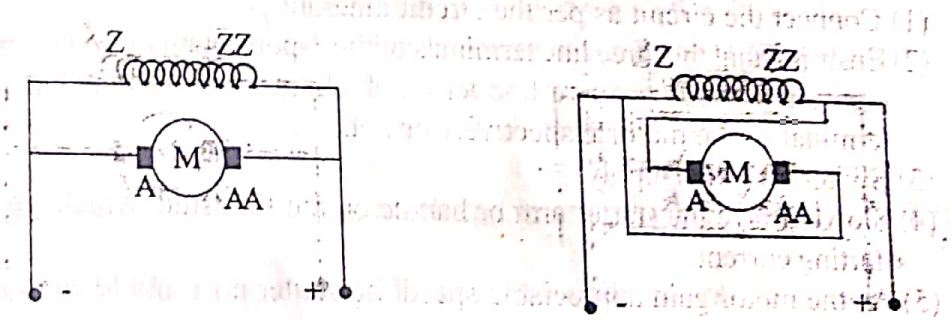
(i) Interchange armature terminals direction will be anti-clockwise.(Fig.a)

(ii) Interchange field terminals direction will be anti-clockwise .(Fig.b)

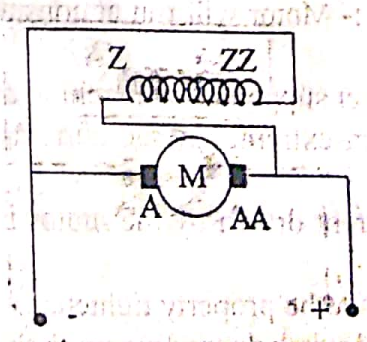
(iii) Never interchange the field and armature terminals at the same time.



Circuit diagram for running D.C. shunt motor



Interchanging the armature terminals (Fig.a)



Interchanging the field terminals (Fig.a)

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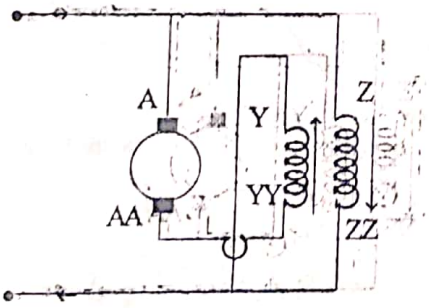
D.C. COMPOUND MOTOR

AIM OF THE EXPERIMENT: To study connecting and running of a d.c. compound motors.

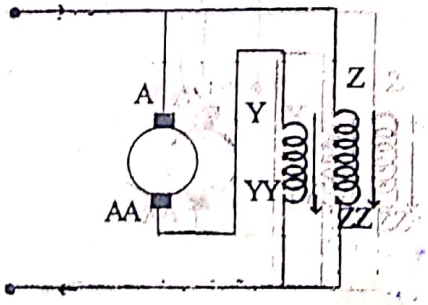
APPARATUS/MACHINE REQUIRED:

Sl.No.	Name of items	Type	Range	Quantity
1	3 or 4-Point Starter	D.C	———	1
2	D.C.Compound motor	D.C.	———	1
3	Connecting wire	S.W.G.	———	As per requirement
4	Combination plier	Insulated	———	1
5	Screw driver	———	———	1
6	Line tester	———	———	1

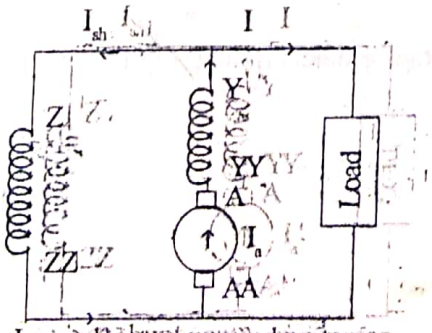
THEORY: Compound motors are a combination of series and shunt motor. It has two field windings, one is series field winding and is connected in series with the armature winding which is made of thick wire of few turns. Second winding is shunt field winding and connected in parallel with the armature and is made of thin wire of many turns. The series field winding is wound above the shunt field winding is wound above the shunt field winding on the same pole shoe. In this motor the major portion of the flux is produced by shunt field winding. It is of two types (i) Commulative compound and (ii) Differential compound motor. When series field aids the shunt field motor is said to be commulative compound and on the other hand if series field opposes the shunt field is said to be differential compound as shown in fig.(a) & fig.(b)



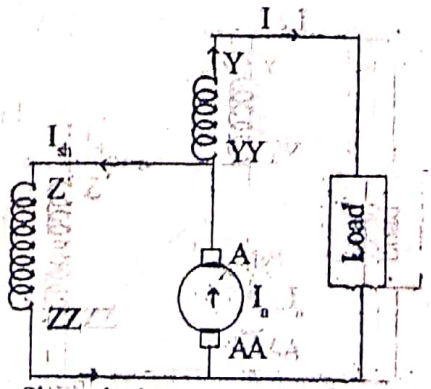
Differential compound motor(Fig.b)



Commulative compound motor(Fig.a)



Long shunt compound motor



Short shunt compound motor

PROCEDURE:

(i) Connect the circuit as per the circuit diagram.

(ii) Ensure that the live terminals of 3-point or 4-point starter is properly connected to the machine or not.

(iii) Switch-on the supply.

(iv) The starter arm or handle is slowly moved from stud No.1 to stud No. 2,3,4 etc. respectively.

(v) Motor should run in its rated speed.

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

OBSERVATION: It is observed that it has good starting torque and is used where high torque and constant speed is required.

PRECAUTION:

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

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

(iii) Other common precaution for the electrical laboratory should also be strictly observed.

CONCLUSION : The motor was running smoothly as the rating of the machine.

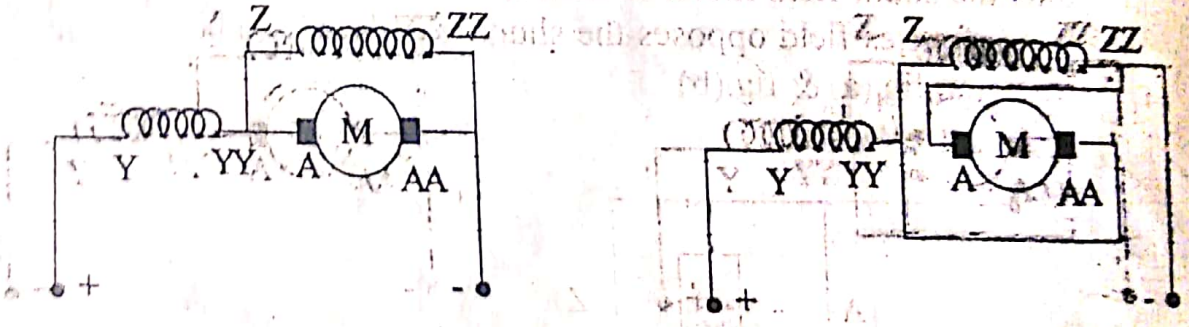
N.B.

To change the direction of rotation of D.C.Compound motor

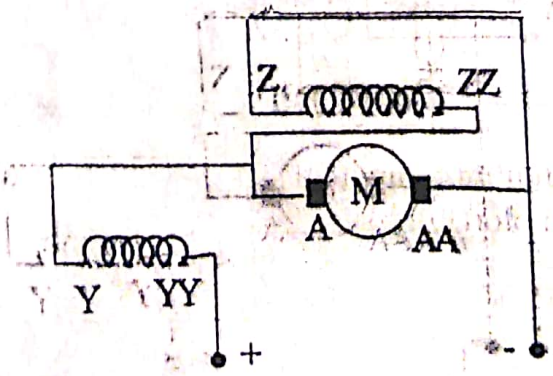
(i) Interchange armature terminals direction will be anti-clockwise as shown in (Fig. i)

(ii)Interchange field terminals direction will be anti-clockwiseas shown in (Fig. ii).

(iii)Never interchange the field and armature terminals at the same time.



Interchanging armature terminal (Fig. i)



Interchanging field terminal (Fig.ii)

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STUDY OF STAR-DELTA (Y-Δ) STARTER

AIM OF THE EXPERIMENT : To study the different parts of star-delta (Y-Δ) starter and their operation with the help of 3-Φ squirrel cage Induction motor .

APPARATUS/MACHINE REQUIRED:

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

It consist of the following essential parts.

a) **A FOUR POLE DOUBLE THROW-SWITCH :-** It is generally used to change over the connection from star to delta , when the motor gains about 75% speed.

b) **NO-VOLT RELEASE COIL :-** It safe guard the motor against sudden failure of supply by releasing the handle of the starter .

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c) **OVER LOAD RELEASE COIL :-** It protects the motor against over current beyond the setting of current . Normally current setting is adjusted at 110% of the rated full load current, till which the over load release of the starter will not operate. At any value of current beyond 110%, the over load device will operate and release the handle of the starter by de-magnetizing the no-volt coil.

d) **STOP-PUSH BUTTON SWITCH :-**This switch is used to stop the motor.

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 $1/3^{rd}$ 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:-

1. First read out the name plate of the starter as well as rating of it .
2. Remove the cover of the starter .
3. Then study about the over load circuit and no-volt-coil .
4. 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 .
5. Connect the motor as per ckt. diagram .
6. Switch-on the main switch and make the handle in **"STAR"** position of the starter.
7. When motor attains 75% of the synchronous speed ,make the handle in "DELTA" position quickly.

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 .

CONCLUSION :- The Star-Delta starter was studied and we got a brief knowledge about it and a 3-Φ squirrel cage Induction motor was connected and running successfully .

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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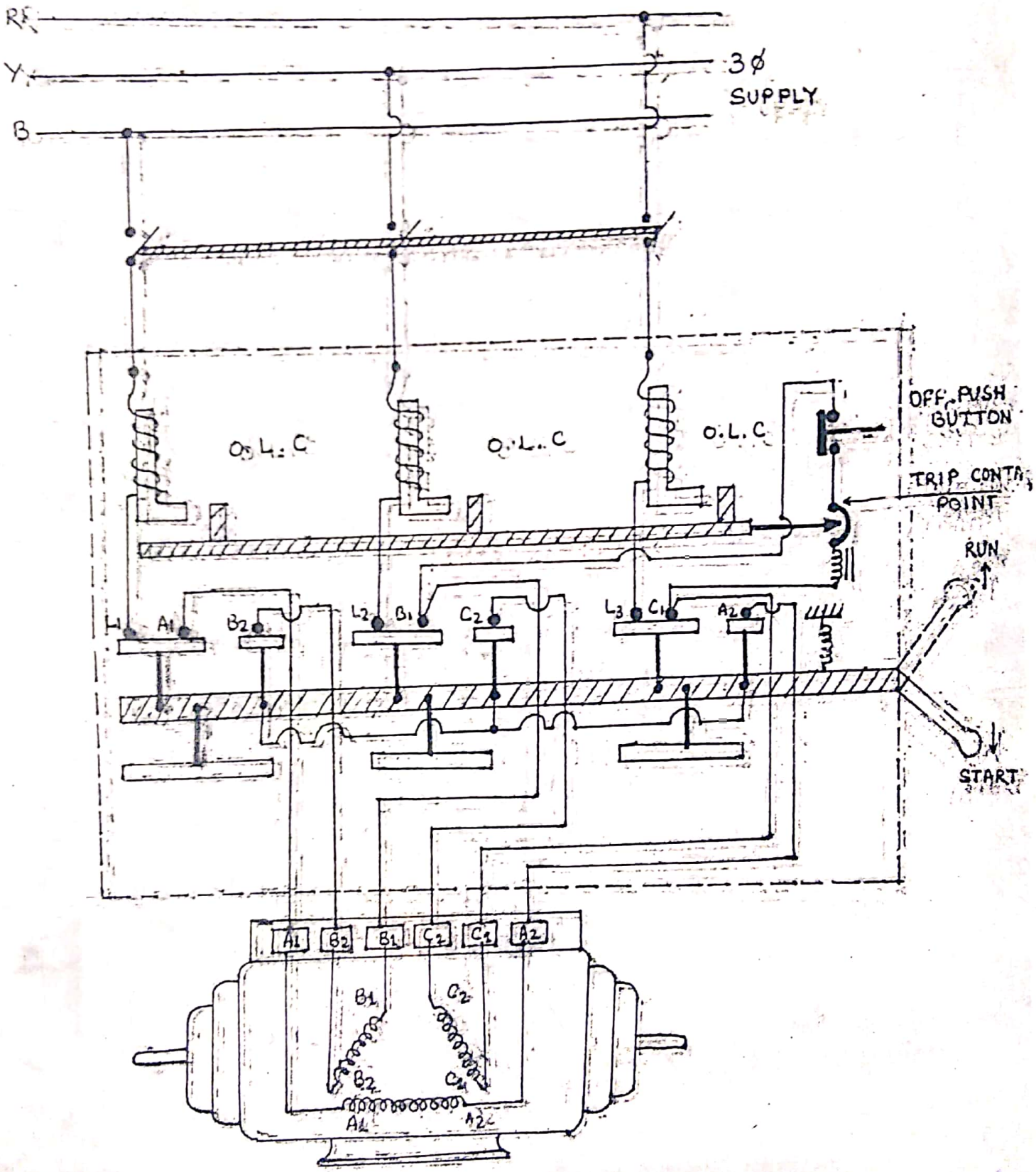

CONNECTION DIAGRAM OF STAR-DELTA STARTER

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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.

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.

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 of an single phase transformer.

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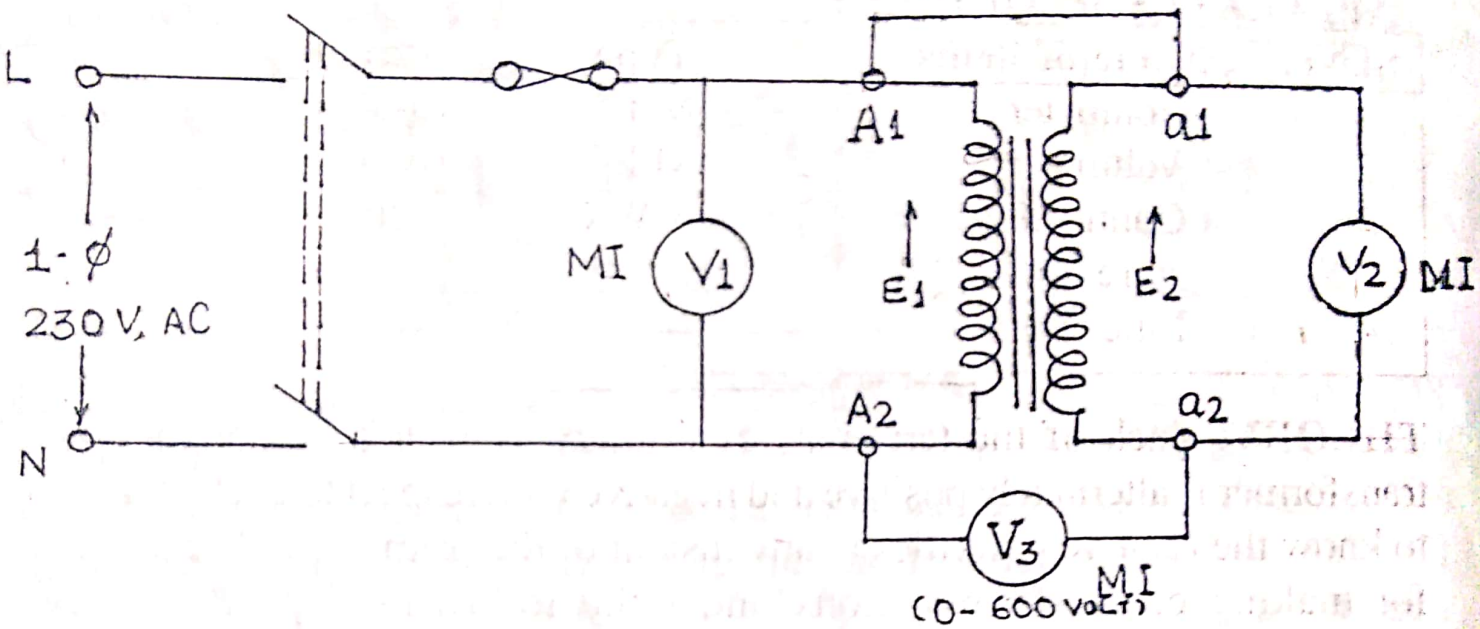

POLARITY TEST

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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.			

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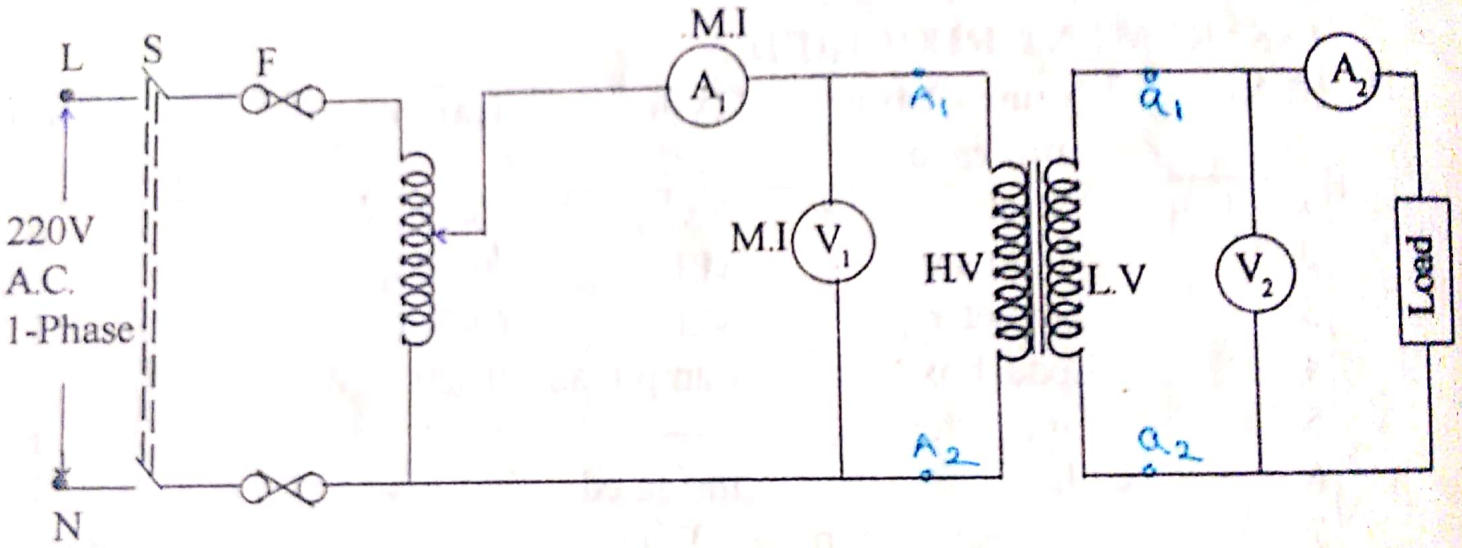
CALCULATION:

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

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STUDY OF 3-PHASE INDUCTION MOTOR

AIM OF THE EXPERIMENT :- To study, the different parts of a 3 - ϕ Induction motor.

MACHINE REQUIRED :- A Model of an Induction motor.

MACHINE SPECIFICATION :-

Volt;---------- Amp;---------- Wound;--------

PH ;---------- K.W.;---------- Speed ---------- No ;--------

THEORY : When a three phase stator winding in supplied by a three -phase supply a rotating magnetic field of constant magnitude is set up. This rotating flux cuts the stationary rotor conductors and induces e.m.f. in them which causes the heavy circulating current to flow due to very small resistance of rotor. (The induced e.m.f. is according to Faraday's law's of electromagnetic induction and direction of rotation is given by Flemings Right hand rule). The frequency of the induced current at the time of starting is equal to the supply frequency (as the stationary rotor is similar to the secondary of a transformer). The rotor induced current, according to Lænz's law, flows in such a direction that it opposes the cause which is inducing the current. In this case the cause producing the rotor current is the relative speed between the rotating magnetic field of stator and the stationary rotor. Hence to reduce this relative speed, rotor conductors start to rotate in the same direction in which the field is rotating and tries to catch it up.

DIFFERENT PARTS OF INDUCTION MOTOR.

An induction motor consists of the following parts :

(i) Stator (ii) Rotor (iii) Frame (iv) Bearings (v) Shaft
(vi) Cooling fan (vii) Eye bolt (viii) Terminal Box (ix) Name plate
(x) End Shield

1) **STATOR :-** The stator winding of an induction motor is identical to the stator winding of an alternator and is held in frame of the motor. It is made up of a number of stampings (silicon laminations) which are slotted to receive the winding. The stator carries a 3-phase windings and is fed from a 3- phase supply. It is wound for a definite number of poles, the exact number of poles being determined by the requirements of speed. Greater the number of poles, lesser the speed and vice verse. When the stator windings is supplied with 3-phase current, produce a magnetic field or flux which is of constant value but which revolves or rotates at synchronous speed (Ns =120f/p).This revolving magnetic flux induces and e.m.f. in the rotor by mutual induction.
2) **ROTOR :-** It is of two types (a) Squirrel-cage rotor (b) Slip ring rotor. The name of the induction motor named according to the type of rotor.
3) **SQUIRREL CAGE ROTOR :-** This type of rotor consists of a cylindrical laminated core with parallel slots for carrying the rotor conductors which are not wires but consist of heavy bars of copper, aluminium or alloys. One bar is placed in each slots. The rotor bars are brazed or electrically welded to two heavy and stout short circuiting end-rings. This type of rotor has very low resistance and is cheap as compared to other types. The gap between rotor and stator is kept very small which varies from 0.25 to 0.4 mm. It is simple and most rugged in construction and almost indestructible.
4) **SLIP-RING ROTOR :-** The other name of this rotor is Phase-wound or wound rotor. The rotors of Slip-ring induction motors are wound with a winding which is identical to that of the stator of the motor. The rotor winding is wound for the same number of poles and phases as that of the stator winding. For a three phase rotor winding, the three ends of the three phases are generally connected in star at one junction (internally) and the remaining three free ends are brought out for connection to the Slip-rings mounted on the shaft

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of the motor. The Slip-rings are then connected to the external starting resistances connected in star through the carbon brushes placed on the Slip-rings. At the time of starting, the rheostatic resistances are put in the rotor circuit to improve the starting torque and to decrease the starting current. As soon as the motor attains its normal speed the rheostatic resistances are cut off gradually from the rotor circuit and finally Slip-rings are short circuited.

5) **FRAME :-** The outer portion of the machine is known as the frame which serves mechanical support for the entire assembly of the machine or covers the entire part of the machine.
6) **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. Mostly ball bearings are used at both the end shields.
7) **SHAFT :-** It is made of mild steel and rests on the two bearings provided in the end shields. The squirrel case rotor or slip ring rotor is mounted on the shaft.
8) **COOLING FAN :-** A cooling fan made of cast iron is also fitted on the shaft. As the rotor starts rotating it also rotates and give fresh air for cooling the rotor.
9) **EYE BOLT :-** The eye-bolt provided with the frame generally on the top for lifting the machine.
10) **TERMINAL BOX :-** This is an insulated box which carries the brass nuts and bolts to which 3-phase windings from the stator is brought out for connection with the 3- phase input supply.
11) **NAME PLATE :-**It is the most essential part of the machine which gives the rating of the machine. Like - Make, Volt, Amp, Phase, HP, KW, r.p.m. etc.
12) **END SHIELDS:-**These are the two end covers of the machine which supports the bearing and covers the machines.

CONCLUSION :- From the above experiments we get brief knowledge about the Induction motors and their essential parts.

N.B.:-

1) In squirrel cage induction motor Rotor bars are permanently short circuited on themselves, hence it is not possible to add any external resistance in series with the rotor circuit for starting purpose.
2) Cost of sq. cage induction motor is low
3) Sq. cage induction motor is of constant speed and have low starting torque due to low pf of the motor at starting.
4) These are used where low starting torque is required such as lathes, water pumps, drill machines, grinder etc.
5) The D.O.R. can be changed by interchanging any of the two phase of the supply line.

1) If the rotor resistances of a Slip-ring motor are connected in delta, they will form a parallel circuit. In parallel circuit total resistance will be less than the least resistance connected in parallel. Therefore the resistance when connected in delta will not fulfil the condition of getting maximum torque. Hence the rotor resistances are connected in star instead of delta.
2) Slip ring rotors are more costly
3) Starting torque is maximum.
4) Can be used where high starting torque is required such as cranes, planers, rolling mills, lifts etc.

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STUDY OF A 3-PHASE ALTERNATOR

AIM OF THE EXPERIMENT :- To study, the different parts of a 3 - ϕ Alternator .

MACHINE REQUIRED :- A Model of an Alternator

MACHINE SPECIFICATION :-

D.C.	A.C.
Volt:-	
Amp:-	
Wound:-	
PH :-	
K.W.:-	
Speed :-	
No :-	

THEORY :- Alternator or A.C. generators operate on the same fundamental principle of electromagnetic induction . It also consists of an armature winding and a magnetic field. In this case armature is stationary called **"STATOR"** and field winding on a rotating element called **"ROTOR"**. When the rotor is rotated by the prime-mover, the stator winding or conductors are cut by the magnetic flux of the rotor poles. Hence, an e.m.f. is induced in the stator conductors. Because the rotor poles are alternately N and S, they induce an alternating e.m.f. in the stator conductors. The frequency of this induced e.m.f. is given by $f = PN/120$ and its direction can be found by applying Fleming's right hand rule. The e.m.f. generated in the stator conductors is taken out from the three leads connected to the stator winding.

DIFFERENT PARTS OF ALTERNATOR

An Alternator has the following three main parts (i) Stator
(ii) Rotor
(iii) Excitor

(i) STATOR:- The stationary part of the alternator in which the e.m.f.is induced is know as the stator .The stator is made of laminated stamping with slots on its circumference to receive the winding .These stampings are insulated from each other with varnish and housed in the yoke (frame) consisting of magnetic material , such as cast iron or silicon steel.

*(ii) ROTOR:-*The rotor has the rotating magnetic field poles, which are separately excited from a D.C. source known as exciter .There are two types of rotor in use .(a) Salient pole rotor or Projecting pole rotor. (b) Cylindrical rotor .

(a) SALIENT POLE ROTOR :- It is like a fly-wheel which has a large number of alternate North and South poles bolted to it .It is made of cast iron or steel of good magnetic quality .The magnetic poles are excited by a small d.c generator mounted on the shaft of the alternator itself .Such rotors are suitable for low and medium speed alternator .This type of rotor has a large diameter and is short in axial length .Alternator driven by diesel, gas engine or hydro have salient pole rotors .(Maximum speed 375-500 r.p.m.)

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(b) SMOOTH CYLINDRICAL ROTOR:- It consists of smooth coils forged steel cylinder having a number of slots milled out at intervals along the outer periphery for accommodating field coil. Two or four region corresponding to the central polar areas are left unslotted. The central polar area are surrounded by the field windings placed in slots. This type of winding is suitable for high speed turbo alternators having two or four poles in the winding and the maximum speed of this rotor is 1500 to 3000 r.p.m . As this type of rotor run at very high speed so it has small diameter and very long axial length.

(iii) EXCITOR :- The excitor is a small d.c shunt or compound dynamo fixed at one end of the alternator shaft .The d.c supply from the excitor is supplied to the field winding through the two slip-rings fixed on the shaft of the alternator. The voltage rating of excitor is usually 110 to 250 Volt d.c.

CONCLUSION:- From the above experiments we get brief knowledge about the alternator and their parts.

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PREPARATION OF SWITCH BOARD

AIM OF THE EXPERIMENT: Preparation of a small wiring(switch) board using holders, switches, cut outs, socket and indicators.

TOOLS AND MATERIALS REQUIRED:

Sl.No.	Name of items	Type	Range	Quantity
1	Teak wood board.	———	———	1
2	Holder	———	———	1
3	Switch	———	———	1
4	Socket	———	———	1
5	Indicator	———	———	1
6	Cutout	———	———	1
7	Connecting wires	———	———	As per req.
8	Screw driver	———	———	1
9	Plier	———	———	1
10	Line tester	———	———	1
11	Hand drill machine	———	———	1

PROCEDURE :

I. First make the layout diagram of the electrical circuit.
II. Adjust the electrical accessories e.g. switch, holder, socked etc on the board. And then mark their position by pencil.
III. Remove the marked position from the board by hacksaw.
IV. Make the holes on the board by drill machine, where the points have just been marked.
V. Fix all the accessories on the board by wooden screw according to their required size after making their guide holes.
VI. Loose the screws of the terminals of electrical accessories.
VII. Insert the portion of the conductor in the terminals after removing the insulation from them and tight it with screw.
VIII. In this way insert other wires in other electrical accessories.
IX. After completing the circuit check it completely.

PRECAUTIONS:

I. The circuit should be checked by series test lamp.
II. All the fittings e.g. switches, holders etc should be well fitted.
III. No necked portion of the conductor should remain visible.
IV. The screws in the accessories fitted should be well tightened.
V. All the switches should be connected in positive wire.
VI. The negative terminals of load holders, socket etc should be connected in negative wire.
VII. Earth must be given to the socket.

INFERENCE

Taking all the equipment we have a good experience of connecting the electrical wiring appliances according to the ckt. diagram. We saw that the bulb glow when switch was ON & other appliances were found tested.

CONCLUSION:

From this experiment we have a good knowledge of connecting the electrical wiring accessories and an idea about making a switch board.

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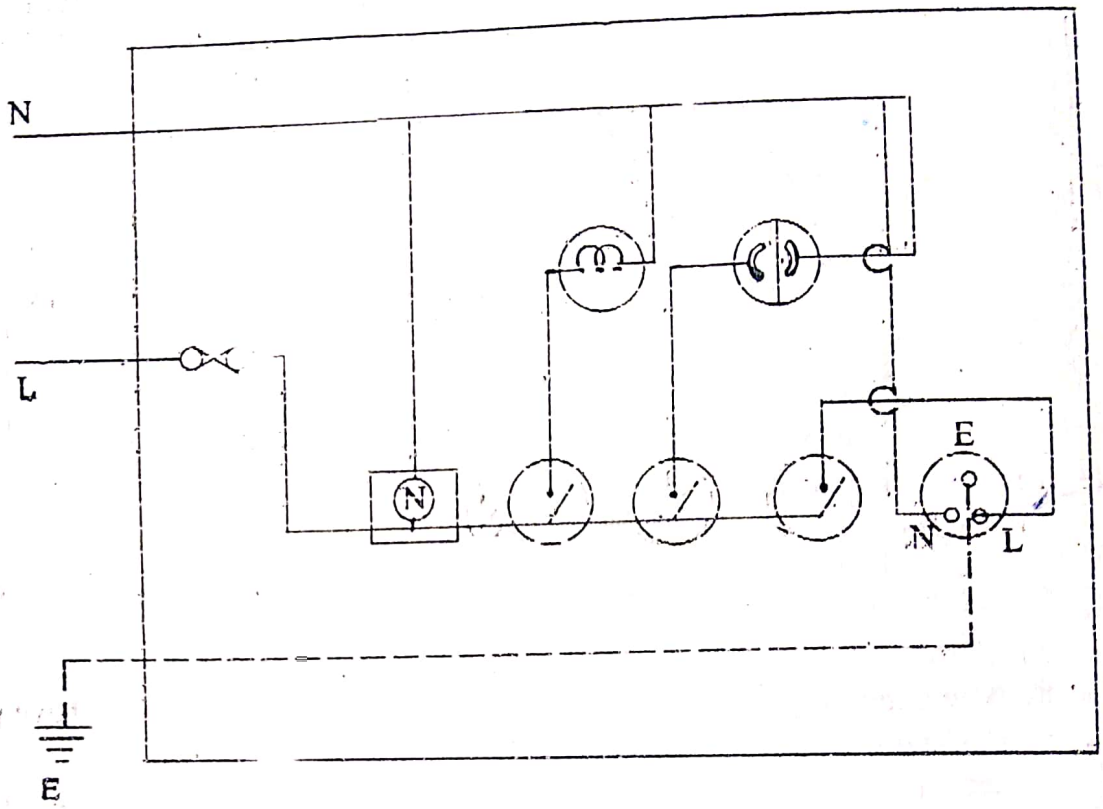

	--	Fuse
	--	Lamp load
	--	Ceiling rose
	--	One way switch
	--	Five pin shocket
N	--	Indicator

Preparation of switch board

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