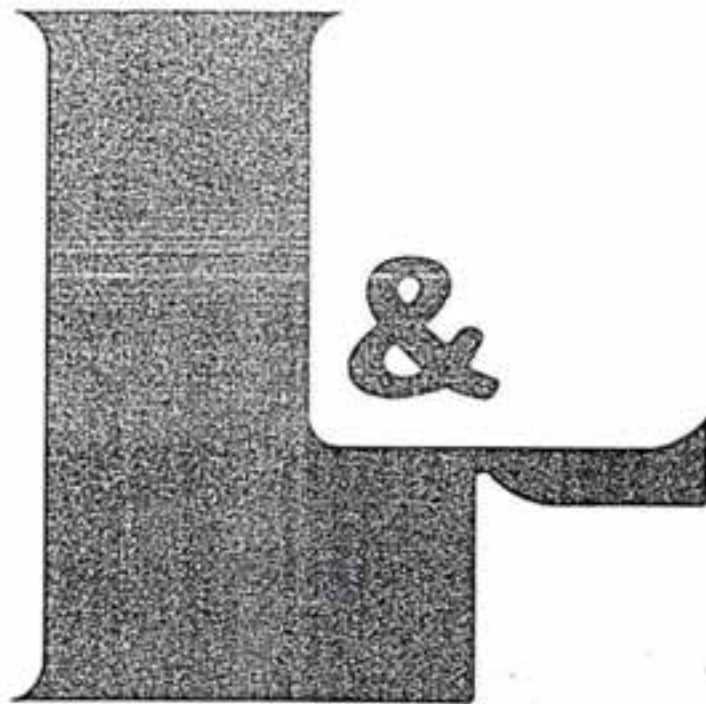


*Hand*



ELECTRIC INC.

**DC MOTOR THEORY,  
OPERATION & MAINTENANCE**

# D.C. MOTOR THEORY, OPERATION & MAINTENANCE

## I. Review of Name Plate Data

## II. Components of D.C. Motors

### A. D.C. Motor Theory

## III. 3 Types of D.C. Motors

### A. Series Motors

- 1) All windings in series
- 2) High starting torque

### B. Shunt Wound Motors

- 1) Medium starting torque
- 2) Good for constant loads

### C. Compound Wound Motors

- 1) Used in variable torque loads
- 2) Minimum speed variations with changes in load

## IV. Identifying Different Fields and Circuits

### A. Shunt Fields

- 1) Many turns of small wire
- 2) Speed can be varied by raising or lowering field volts

### B. Series Fields

- 1) In series with, and same polarity as, shunt field for accumulative or opposite polarity for differentially compounding

### C. Interpoles

- 1) Needed to prevent arcing because of changing loads

## V. Commutation

### A. Brush Shorts Two Commutator Bars Together Reversing Current in Armature Circuits

## VI. Checking Neutral

### A. Interpole Method

### B. Flash Field Method

## **VII. Checking Polarity**

- A. Interpole
- B. Shunt Field
- C. Series Field
- D. Reversing DC Motors

## **VIII. Identifying Leads**

## **IX. Machining and Undercutting**

- A. Removal of Side Mica
- B. Chamfering of Corners

## **X. Seating of Brushes**

## **XI. Checking Brush Tension**

- A. 3 - 4# Per Square Inch

## **XII. Review of Commutator Problems**

## **XIV. Maintenance and Testing of D.C. Motors**

- A. Armature Tests
  - 1) Megger test
  - 2) Growler test
  - 3) Bar-to-bar test
- B. Testing of Series and Interpole Fields
  - 1) Megger test
  - 2) D.C. drop test
- C. Testing of Shunt Fields
  - 1) Megger test
  - 2) A.C. drop test

## **XV. Bearings and Lubrication**

- A. Grease With a Bleed Rate of 10
- B. Synthetic Versus Lithium
- C. Sealed Versus Shielded Bearings
- D. Greasing Procedures
- E. Installation Procedures
- F. Heat in Oven to Maximum of 200°F

# DIRECT CURRENT MOTOR FACTS

## NAMEPLATE INFORMATION

<b>Frame Number:</b>	Indicates mechanical dimensions.
<b>Horsepower:</b>	Number indicates available horsepower when motor is running at rated field volts and rated armature volts.
<b>Volts - Armature:</b>	Maximum volts to produce rated horsepower and speed.
<b>Field:</b>	Field voltage to produce rated torques, horsepower and speed.
<b>R.P.M.:</b>	Full load speed if motor is run at rated armature and field volts. If a nameplate has a speed range such as 1050 - 1600, the first number is the base speed when full rated armature and field volts are applied. The second number is the maximum increase in speed when the field is weakened.

## ELECTRICAL CHARACTERISTICS FOR SHUNT D.C. MOTORS

- 1) All D.C. motors are a "constant torque" motor with full field applied from zero speed to full base speed.
- 2) The D.C. motor is a constant horsepower machine when run with field weakening above base speed and full armature voltage applied.
- 3) When modern day D.C. machines are run below 60% speed for continuous duty, they should be force-cooled by a separate blower.
- 4) The torque produced by a D.C. motor is directly proportional to the armature current for a given field strength.
- 5) The speed of a D.C. motor is directly proportional to the armature voltage for a given field strength.
- 6) The shunt motor is used for speed regulation on S.C.R. tachometer feedback drives or on voltage regulated drives.

## ELECTRICAL CHARACTERISTICS FOR SERIES D.C. MOTORS

- 1) A series D.C. motor should never be run at full nameplate voltage without load as the speed will increase and become excessive and will destroy itself.
- 2) The torque of a series motor is equal to the square of the current on the circuit - for example, if the current is doubled the torque is increased four (4) times.
- 3) The speed reduces considerably as the load on the motor increases.

## ELECTRICAL CHARACTERISTICS FOR COMPOUND WOUND MOTORS

- 1) These motors have characteristics that are a combination of the shunt and series characteristics. The motor can be speed regulated with the same rules as the shunt motor but the speed is not exactly proportional to the applied armature voltage because the current load on the motor affects the field strength, thereby making the speed vary according to the load. If this motor has tachometer feedback control, it will hold the speed constant with continually varying armature voltage.

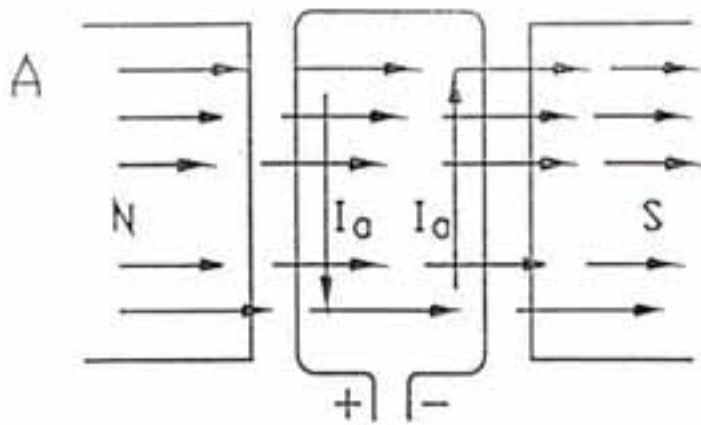
## ELECTRICAL CHARACTERISTICS FOR PERMANENT MAGNET D.C. MOTORS

- 1) The PM motor has the same characteristics as the shunt wound motor when the armature voltage is varied from 0 to maximum. The PM motor cannot be field weakened so the speed cannot be adjusted above base speed of the motor.

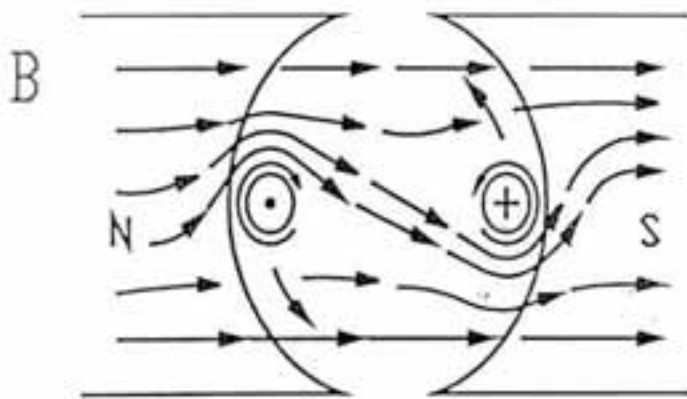
Refer to Engineering Handbook for proper NEMA number designations.

# D.C. MOTOR NAMEPLATE

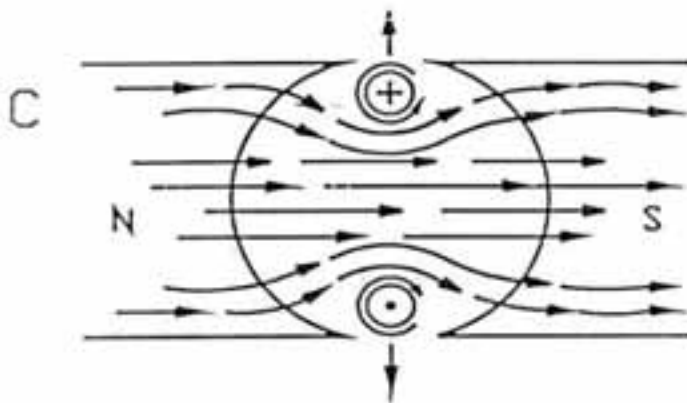
RPM D.C. MOTOR				
FRAME	HP	TYPE	IDENTIFICATION NO.	
UB409ATZ	250	TR	M27345 NE	
VOLTS	AMPS	RPM	DUTY	AMBIENT
500	399	1750/2000	CONT.	40°C
INSULATION	F			
FIELD VOLTS	FIELD MAX AMPS	FIELD AMPS	WINDING	
240	4.92	3.84 / 1.4	STAB	SHUNT
P CODE C				
T40R2 - 330				



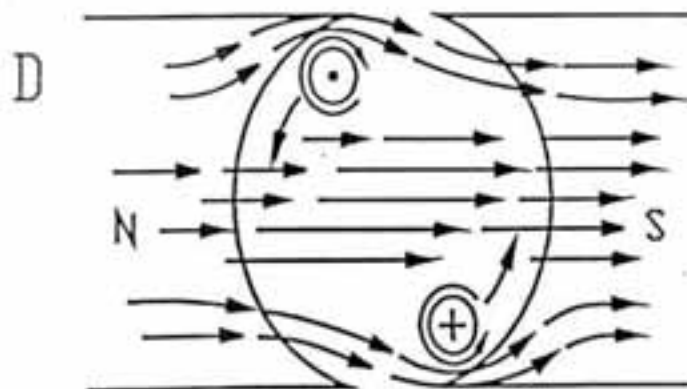
A shows a single conductor in a magnetic field. Any time there is a current carrying conductor in a magnetic field and an increase in flux density is produced on one side of the conductor. This will cause the conductor to move.



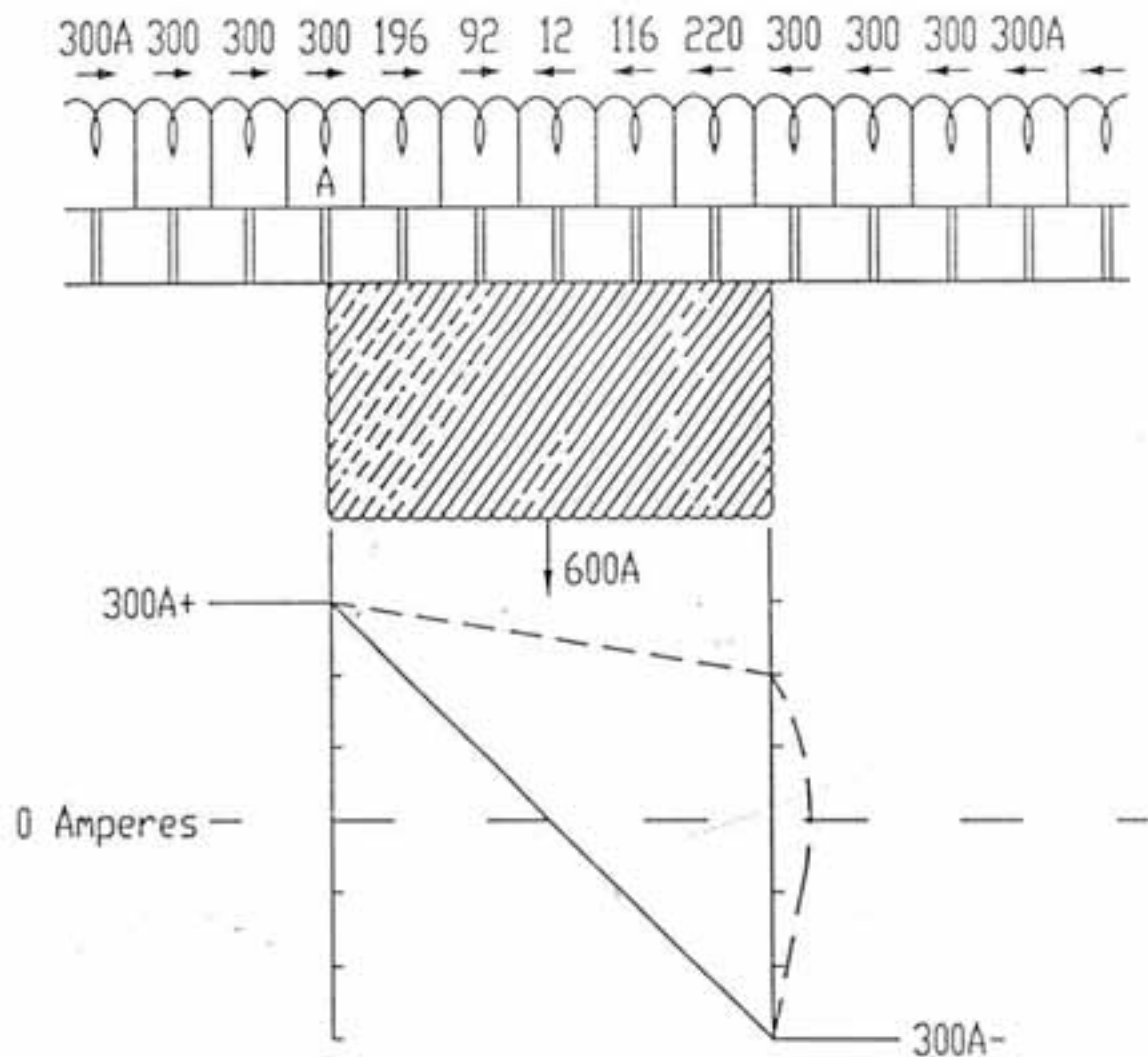
B shows the conductor moving in a counter-clockwise position.



When the conductor gets to position C, it will no longer turn because it is no longer cutting lines of force.



If in position D we reverse the current flow, the conductor will then continue to move in the counter-clockwise position. The force exerted on the loop is called *torque*. When the conductor reaches the position shown in C it is said to be in its *Neutral Plane*. The reversal of current is accomplished by using a ring with insulated segments. This process is called *commutation*.



If commutation is perfect, the change of current will be linear as shown by the dark line.

Because the conductors lie in steel slots, self and mutual inductances cause voltages in the coils short-circuited by the brushes. These result in circulating currents that tend to prevent the current change, delaying the reversal.

The higher the current flow, the longer the delay. Under extreme conditions, the delay may be as severe as indicated by the dotted line.

## RELATIONSHIP OF MAIN AND INTERPOLE POLARITIES IN D.C. MACHINES

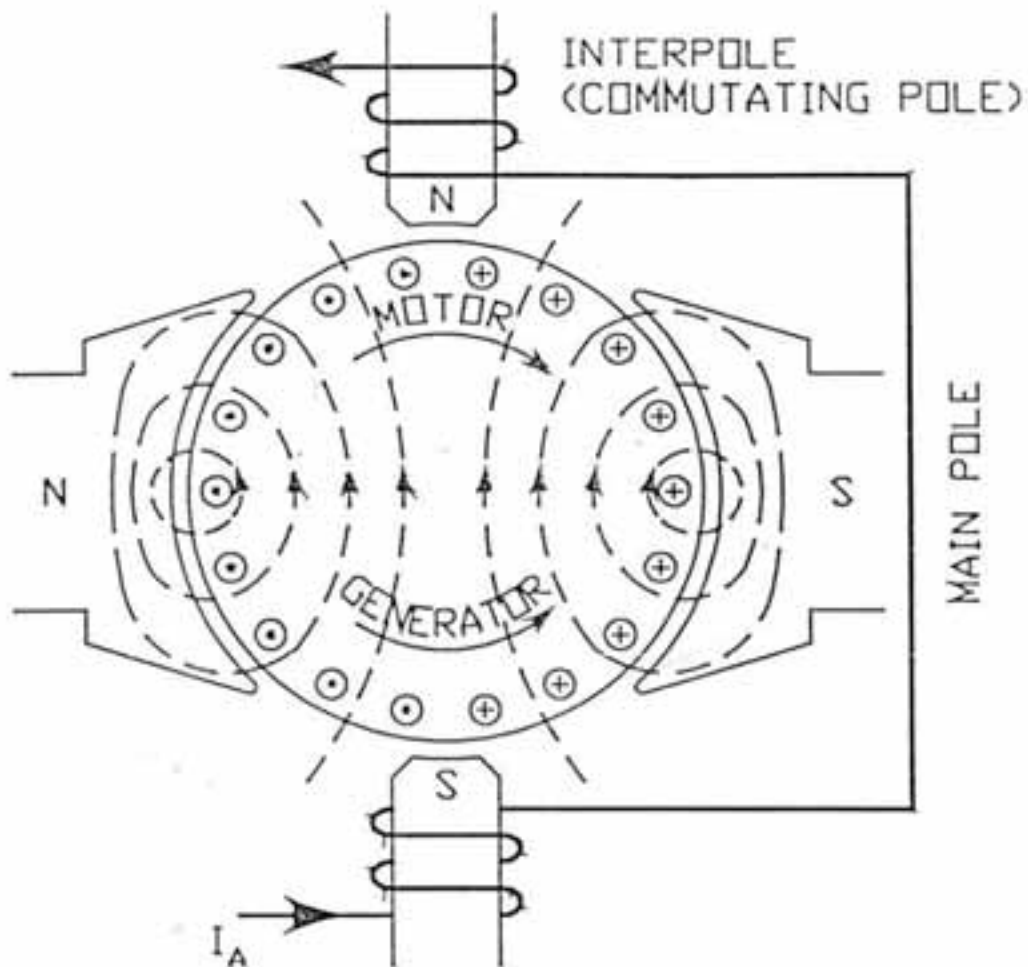


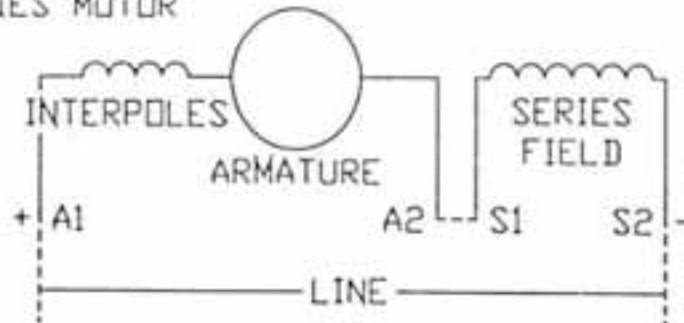
Diagram shows polarity of interpoles with respect to the polarity of the main poles.

For a **MOTOR**, the polarity of the interpole is the same as that of the main pole **PRECEDING** it in the direction of rotation.

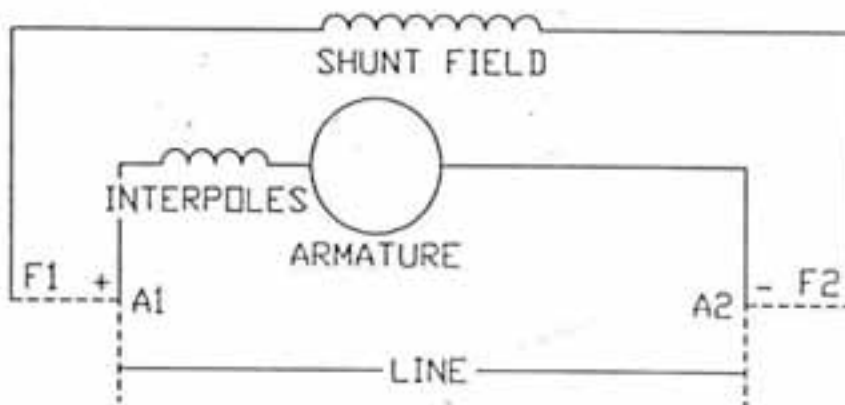
For a **GENERATOR**, the polarity of the interpole is the same as that of the main pole **FOLLOWING** it in the direction of rotation.

# TERMINAL MARKINGS AND CONNECTIONS D.C. MOTORS

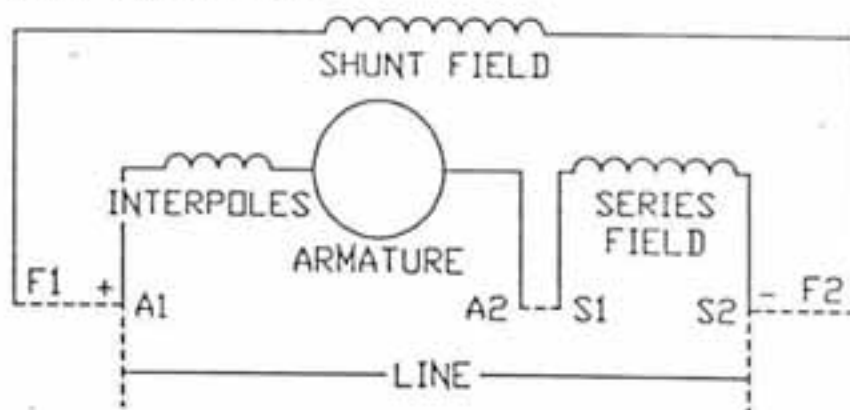
SERIES MOTOR



SHUNT MOTOR



COMPOUND MOTOR

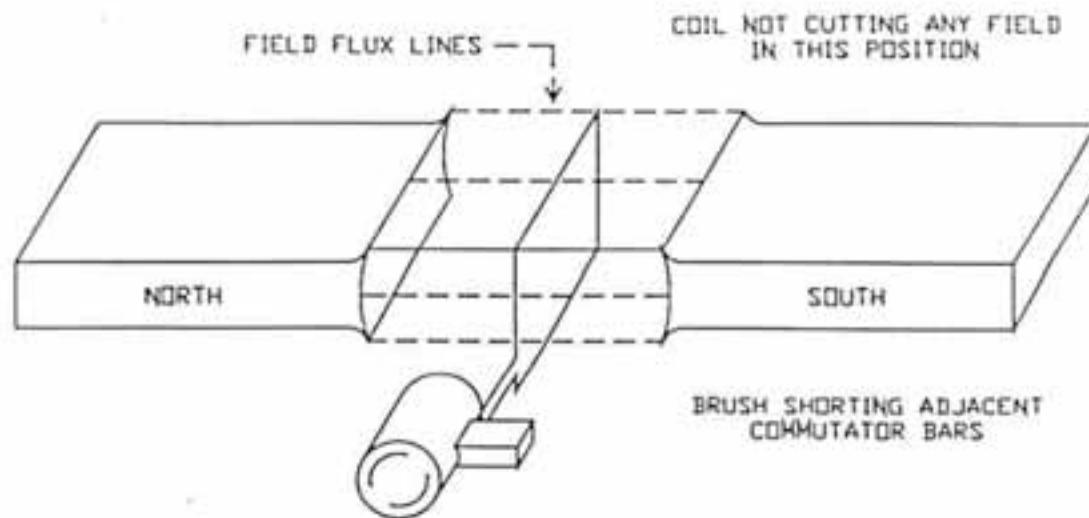


All connections are for counterclockwise rotation facing end opposite drive. For clockwise rotation, interchange A1 and A2.

Some manufacturers connect the interpole winding on the A2 side of armature.

When shunt field is separately excited, same polarities must be observed for a given rotation.

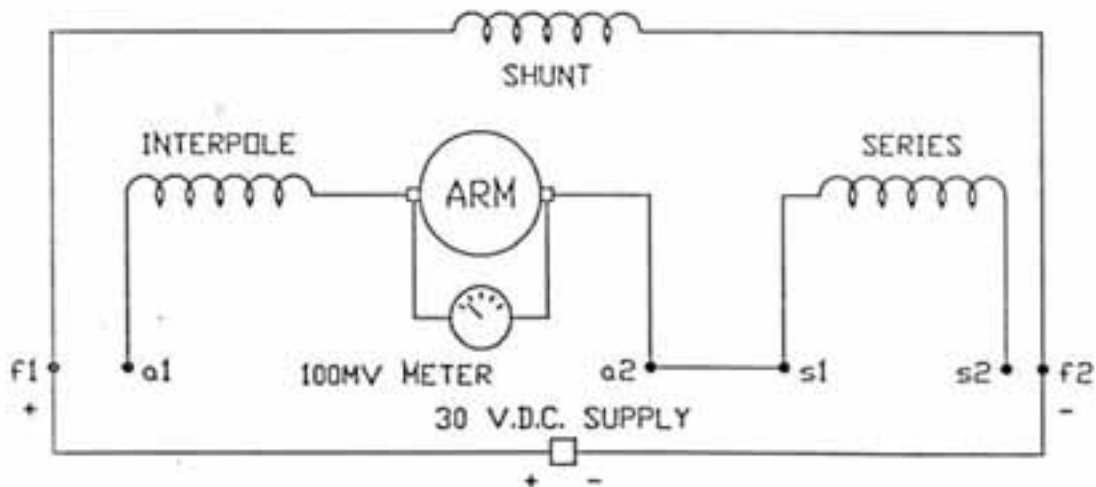
# LOCATING BRUSH HOLDER NEUTRAL POSITION



## THEORY

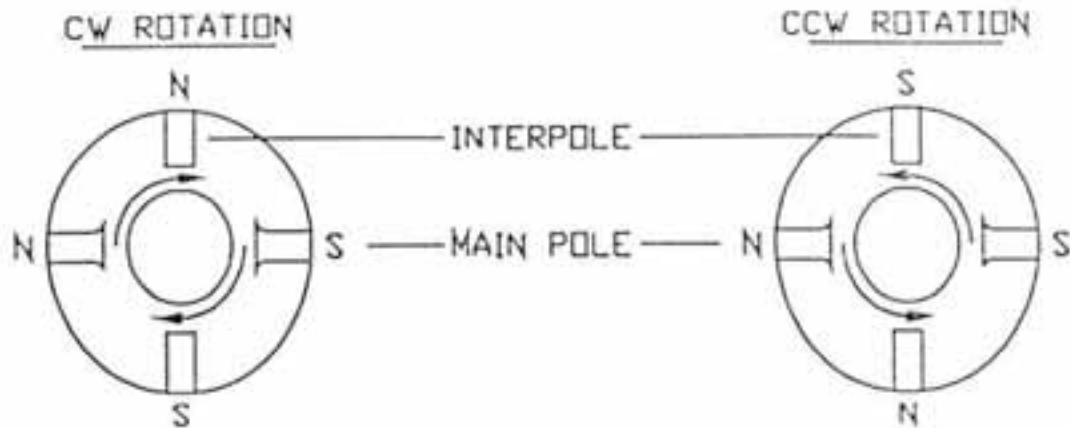
At any moment in time, each brush always shorts two adjacent commutator bars together. If the coil of wire that is connected between these bars is in the position shown above, it will not cut any flux lines. Consequently, it will not generate any voltage so that when the brush shorts them together no sparking will occur. If the brush holders are shifted, the brush will short a voltage that is generated in the coil since it is now cutting field flux lines.

## PROCEDURE



1. Loosen brush holder.
2. Connect as shown.
3. Flash 30V + to F1. Note meter deflection.
4. Move brush holders to cause meter deflection to be minimum.
5. Tighten brush holders.

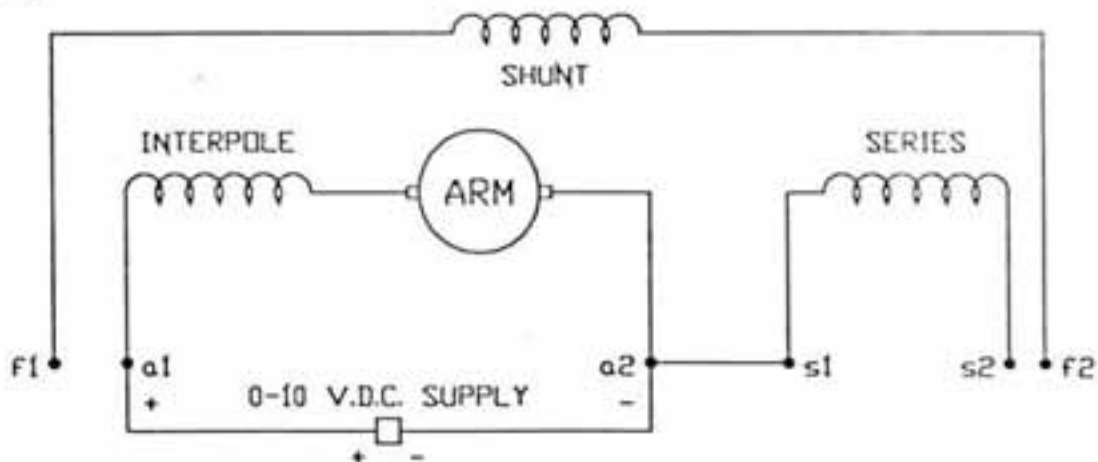
# CHECKING INTERPOLE POLARITY



## THEORY

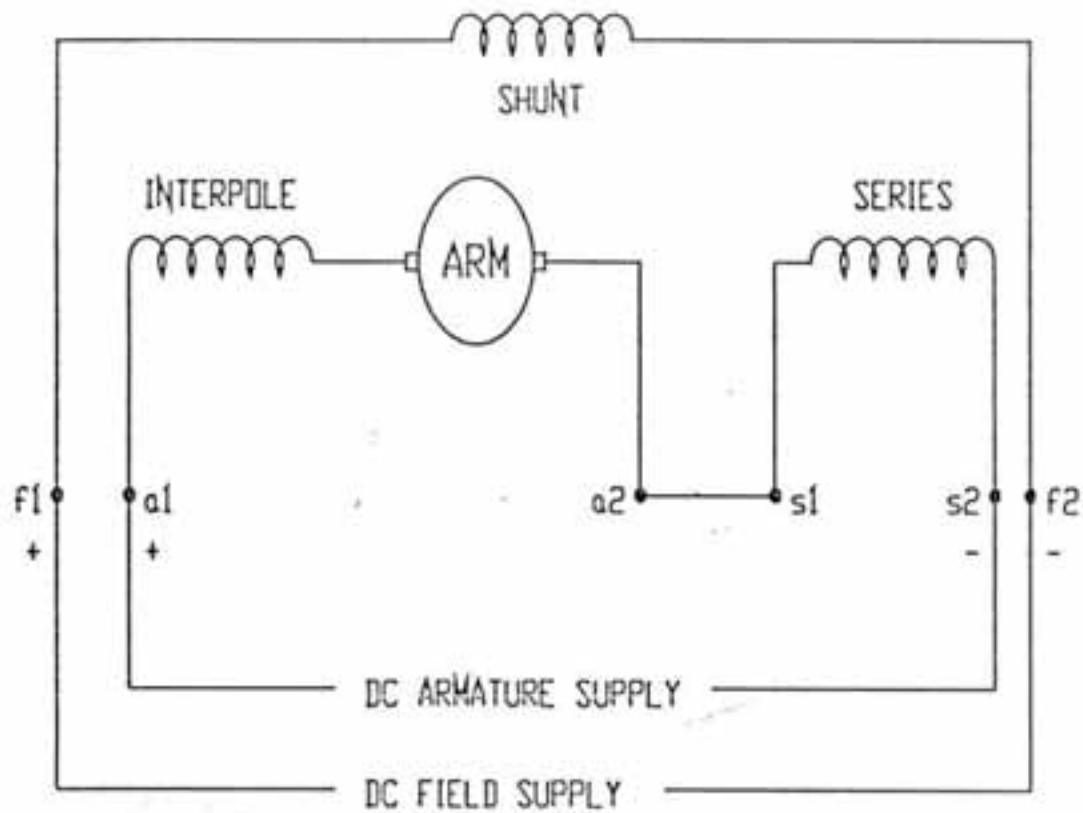
In a DC machine, the current through the armature coils must be continuously reversed or commutated. For sparkless commutation, the current in a coil must decrease linearly with time as the brush contact area on a commutator bar decreases and the brush begins to short the coil connected to adjacent commutator bars. Ideally, at this time it should be "0." The current should then increase linearly as the brushes connect the coil with the opposite polarity, forcing current through it in the opposite direction. However, the current does not change linearly due to transformer coupling with other coils and the coil's own inductance which opposes current changes. Small poles placed between the main field poles, called *interpoles*, help balance out these effects by creating flux in the direction to cancel the nonlinear flux.

## PROCEDURE



1. Mark correct brush position.
2. Shift brush holder so brushes are midway between previous position.
3. Increase voltage on armature starting at "0." Note which way armature turns. Return brushes to previous position.
4. Interpole polarity is correct if armature moves in the direction you shift the brushes.

# COMPOUND MOTOR CONNECTIONS



## PROCEDURE

1. Connect the motor as above. This is a cumulative compound connection. The motor should turn CCW with the above polarities.
2. Disconnect the shunt field power and bump the motor over. Note the direction of rotation. If it is the same as in step 1, connections are correct. If it is opposite, the series and shunt fields are connected in opposition (differential compound motor).