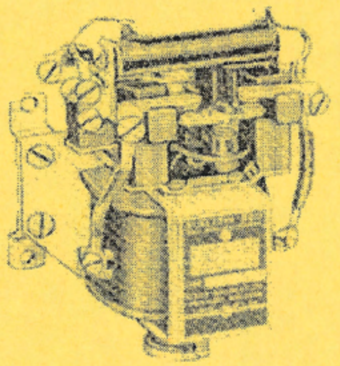
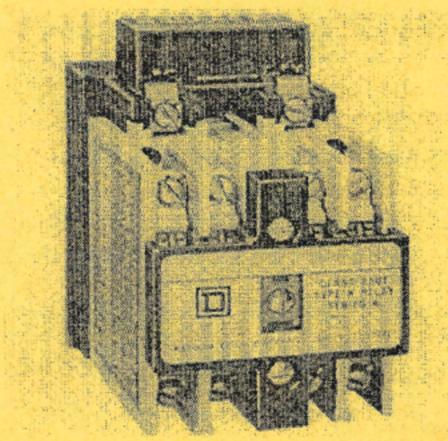
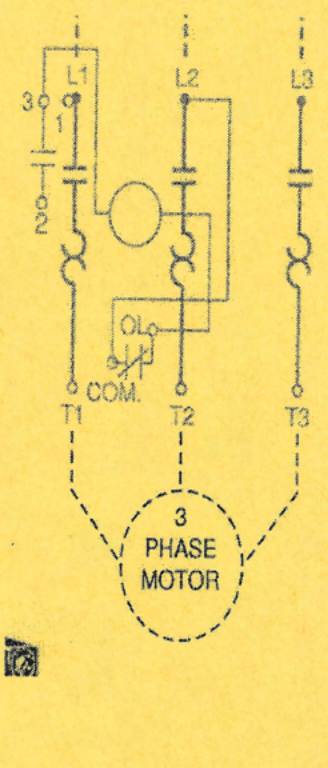
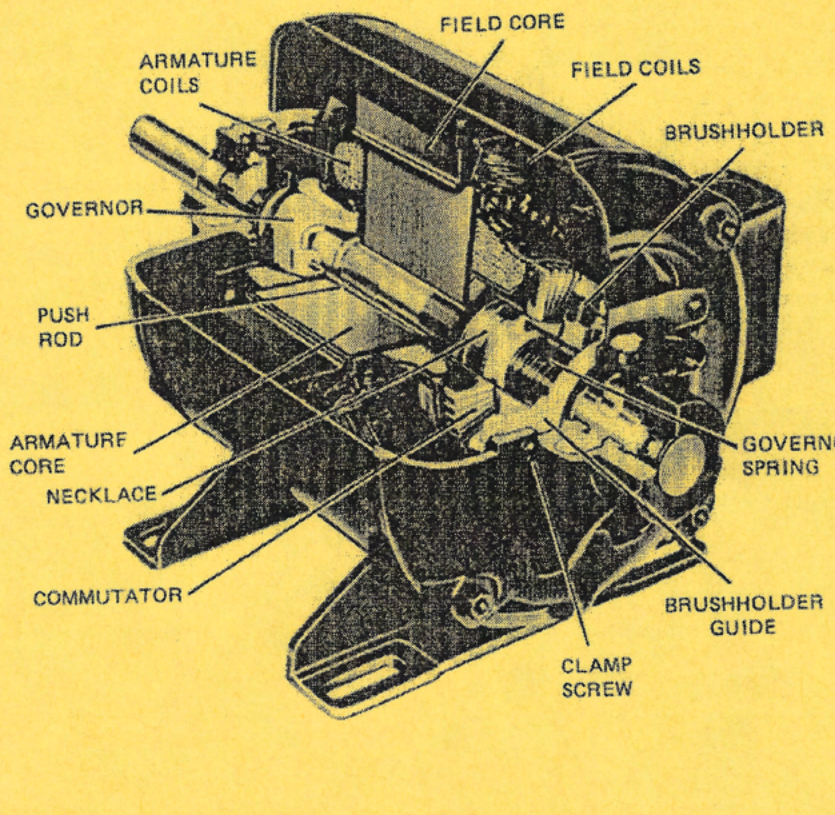
AET – 1285 DC and AC Machine

LAB 1 of 4









AET – 1285 (1 of 4) Lab Projects

NAME:________________________________

HAND IN COMPLETED BY DUE DATE TO THE INSTRUCTOR

__The instructor must__ **date and initial each project upon completion!!**

PROJECT NAME & NUMBER	DATE	INITIALS	BRIEF DESCRIPTION
Lab Volt #39			The Single-Phase Transformer
Lab Volt #40			Transformer Phasing
Lab Volt #41			Transformer Phasing
Lab Volt #42			The Autotransformer
Lab Volt #43			Transformers in Parallel
Lab Volt #44			Distribution Transformer
Lab Volt #11			The Direct Current Motor, Part 1
Photo Tachometer			Lab Manual
DC Motor Principles #1			
DC Motor Construction Project #2			Lab Manual
DC Motor Construction Project #3			Lab Manual
Lab Volt #12			The Direct Current Motor, Part 2
Coil Testing			Lab Manual
Testing Fuses #1			
Testing Fuses #2			
Testing Fuses #3			

The instructor must **date and initial each project upon completion!!**

PROJECT NAME & NUMBER	DATE	INITIALS	BRIEF DESCRIPTION
Three Phase Fuses No. 1			Lab Manual
Lab Volt # 24			The DC Shunt Motor
Lab Volt # 25			The DC Series Motor
Lab Volt # 26			The DC Compound Motor
Lab Volt # 27			The DC Separately Excited Shunt Generator
Lab Volt # 28			The DC Self Excited Shunt Generator
Lab Volt # 29			The DC Compound Generator
Lab Volt # 30			The DC Series Generator
Relays and Contactors			Lab Manual
Megger #1			Lab Manual
Megger #2			Lab Manual
Megger #3			Lab Manual
Megger #4			Lab Manual
DC. Motor Project #1			Building Motor

PHOTO TACHOMETER

Pioneer Phot Tachometer is a relatively simple instrument to use and understand. The very nature of their design makes it impossible not to take a correct RPM reading under normal circumstances.

Pioneer Photo Tachometer utilizes the basic principle of the photoelectric cell. The cell as the "Eye" responding to variation of incident radiation of reflective light from the object being measured. Transistorized computer circuitry serves as the "Brain". It translates the photoelectric impulses into RPM.

RPM reading are shown instantly and continuously through any variation within their range of the tachometer. Such readings appear on the indicator dial. There is no electrical or mechanical contact with the device being measured. Operation is virtually fool proof when Pioneer Tachometers are used according to the explicit instructions in this unit. Therefore, it is urged that the material be read carefully and thoroughly in order to understand the application and use of Pioneer Tachometers.

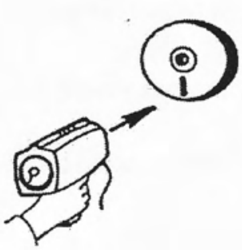
USING A PHOTO TACHOMETER

A Pioneer Photo Tachometer operates upon the principle of recognizing contrasts—the difference between light and dark. To measure any moving object, a contrasting mark mist be added. The Tach is pointed at this mark, and every time the mark passes in front of the Tach's eye, the contrasting light reflections activates the photocell. This is instantly translated into and RPM reading.

It is necessary to understand this procedure because the contrasting mark must be large enough to register a light change that the photocell will read. Use the special Pioneer #G5-29 reflective tape supplied with the Tach. Smooth surface reflective tapes reflective tapes reflect AC light cycles and can give false readings.

SIZE OF MARKER

Because of variation in ambient light and environment, the exact size of the mark will vary somewhat. However, in the majority of applications a mark of 10 percent of the periphery or circumference is adequate. The Digital Tachometers are designed for a 50 percent duty cycle and require a greater percentage of the periphery to be covered by the marker. Usually 20 percent coverage is adequate, but larger coverage may be required to secure steady readout. The Tach carries its own light source which is activated when turned on at the same time the Tach is pointed at the rotating object.



PHOTOTACHOMETER

Remember, if the dial needle is steady, you are obtaining a correct reading. On Digital Tachs, observe three or four readings, which are presented at two second intervals, to assure correct readings.

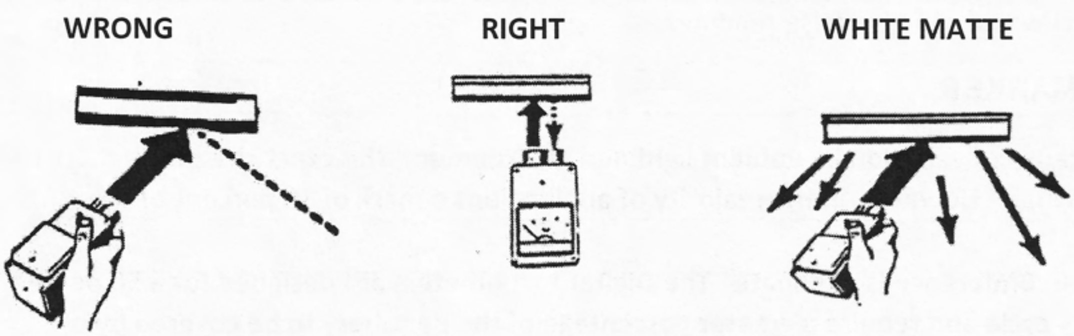
To start the procedure, take a reading before making a contrasting mark. If you obtain an RPM indication, it shows there is enough variation on the surface of the object to activate the photocell. On a wheel with highlights or marks from the basic material or just wear and tear, care must be taken to provide a marker sufficiently large so that the tack can distinguish the desired mark from the "Hash".

The tack is designed to reject the low-level signals when there is present one major signal source such as a wide contrasting marker. It will equally have recognized multiple markers if they are of essentially the same size. See the procedure comments below. Markers should be made with the Pioneer #G5-29 reflective tape for the best results. Smooth surface reflecting tape can cause false readings from ambient light. Keep in mind that it is necessary to make the reflected flashes as clear and sharp as possible.

TYPES OF SURFACES

The Tach is active by light reflection. Consequently, the reflective characteristics of various types of surfaces must be understood. There are three "pure" kinds of surface. All objects encountered will be some combination of these "pure surfaces.

HIGHLY POLISHED SURFACE

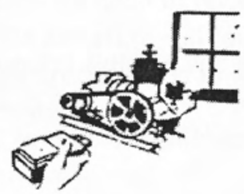


SURFACE

Figure 2

If the light from the Tach hits a highly polished surface at an angle, the reflected beam will shine away (like a billiard ball). If lights hits this surface head-on it will be reflected

THE DULL BLACK SURFACE



RPM READING USING BACK LIGHT

THE WHITE MATTE SURFACE

No matter from what angle the light hits this surface, some will get back to that Tach. The light is diffusely scattered.

THE DULL BLACK SURFACE

Light striking this surface at any angle will be absorbed. No light will get back to the Tach.

For some locations back, lighting from natural or artificial sources is possible. Pick-up distances can become several feet in this case. Wheel or pulley spokes, fan blades and the like are easily measured. Do not confuse natural light used as a back light with AC sources nearby. Any reading of AC source lighting will result in counting cycles and a false RPM. If supplementary light is needed, use a flashlight or other battery powered source. Be certain to divide the RPM reading by the number of spokes or blades of the rotating object.

DO'S

DO- Use the PHOTOTACH with confidence for all types if RPM and reciprocating rate measurements.

DO- Remember to use the PHOTOTACH within distances of approximately 12 inches, unless you are using black lighting.

DO- Remember to divide the reading from the 0 to 2400 RPM or 0 to 12,000 RPM scale by the number of markers used to get the correct RPM.

DO- Check the calibration with your local fluorescent lights.

DO- Shield the PHOTOTACH from fluorescent fixtures when used for a reading.

DO's cont.

DO- Remember that the fluorescent light may be reflecting from some bright surface on the device which you are measuring and can cause a false reading.

DO- Shield mark from any possible bounce light pattern if the RPM measurement varies or seems out of line.

DO- Check battery mounting if unit does not operate, and make sure that all batteries make contact at both ends.

NOTE: **DO NOT make any adjustments without checking with your instructor.**

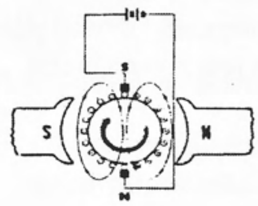
CALIBRATION:

Dial model TACHS the meter should be checked for correct 0 setting before taking a reading or calibrating. This may be adjusted by use of the plastic screw on the lower section of the meter face. It is suggested that before adjusting for the "0" reading, tap the instruments face lightly with the finger tips to loosen any residual friction of the bearings and let the needle come to rest.

To check calibration, the TACH should be pointed at a fluorescent light fixture at any convenient distance. Then push the operating button and read the meter scale. If properly calibrated, the meter will read 7200 RPM which, of course, is the rate at which the fluorescent bulb varies in intensity with 60 cycles A.C. current. If the needle does not register 7200 RPM, the instrument can be adjusted by turning the "calibrate" screw on the base of the case to set the reading at exactly 7200 RPM.

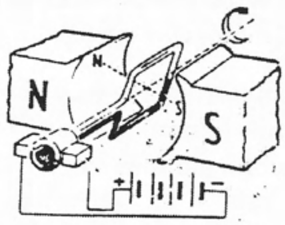
D.C. MOTOR

D.C. MOTOR PRINCIPLES #1

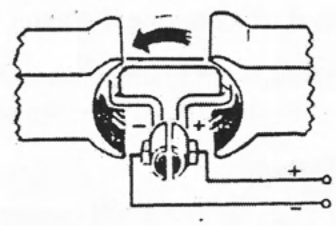


D.C. Motor Principle

There are a few basic motor principles we need to review before we start this project. Current flow through the armature coil causes the armature to act as a magnet. The armature poles are attracted to field poles of opposite polarity, causing the armature to rotate.



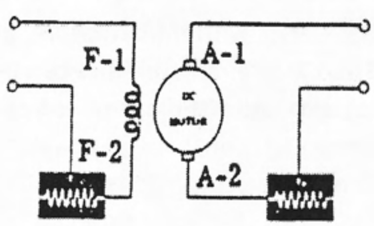
D.C MOTOR COMMUTATION



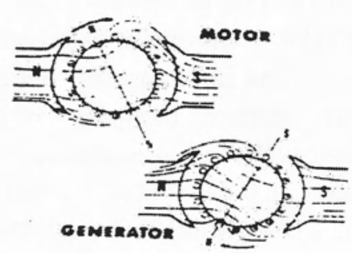
D.C. MOTOR COUNTER ELECTROMOTIVE FORCE

The commutator reverses the armature current at the moment when unlike poles of the armature and field are facing each other, reversing the polarity of the armature field. Like poles of the armature and field then oppose each other causing continuous armature rotation.

The rotating armature coil of a DC motor generates an electromotive force which opposes the applied voltage. This generated counter-emf limits the flow of armature current.

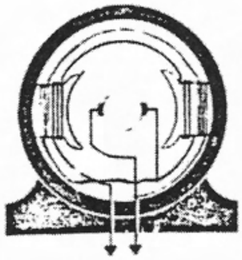


D.C. MOTOR SPEED CONTROLS



ARMATURE REACTION

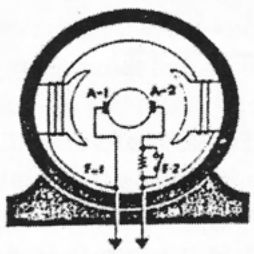
The speed of a DC motor can be varied with a variable resistance connected either in series with the field coil or in series with the armature coil. Increasing the armature circuit resistance decreases motor speed.



The armature field causes distortion of the main field in a motor, causing the neutral plane to be shifted in the direction opposite to that if armature rotation. Interpoles, compensating windings, and slotted pole pieces are used to minimize the effect of armature reaction on motor operation.

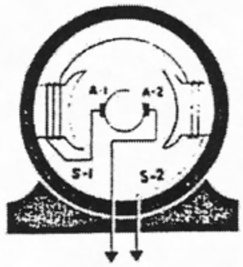
SERIES MOTORS

The series field windings are connected in series with the armature coil and the field strength varies with changes in armature current. When its speed is reduced by a load, the series motor develops greater torque, and its starting torque is greater than that of other types of DC motors.



The shunt field windings are connected in parallel across the armature coil and the field strength is independent of the armature current. Shunt motor speed varies only slightly with changes in load and the starting torque is less than that of other types of DC motors.

SHUNT MOTORS



One set of field winding is connected in series with the armature, and one set is parallel-connected. The speed and load characteristics can be changed by connection the two sets of fields to either aid or oppose each other.

COMPOUND MOTORS

D.C. MOTOR CONSTRUCTION PROJECT #2

OBJECTIVES:

After completing this module, you will be able to:

1. Identify the leads of a series motor. 2.
Identity the leads of a shunt motor.
3. Identify the leads of a compound motor.
4. Vary the speed of a D.C. motor.
5. Reverse the direction of rotation of a D.C. motor.

Discussion:

The base speed or nameplate speed of a motor is its speed when operating with rated shaft load, at its rated temperature, with rated voltage applied, and no external resistors or rheostats connected in series with the armature of shunt field.

Adding external resistance in series with the armature reduces the armature current: this in turn reduces the mechanical force developed on the armature conductor, and the motor slows down.

Adding external resistance to the shunt field reduces flux, with less shunt field flux the counter voltage (CEMF) induced in the armature is less. The reduced CEMF permits a higher armature current and hence a higher motor speed.

PROCEDURE:

1. Obtain D.C. Motor Board No. 1.
2. Now looking at the D.C. Motor Board No. 1, you will notice that the armature, series field, and shunt field are protected by fuses. Check these fuses and make sure they are all good.
3. Looking at the board you will also notice that there are two series coil that must be connected in series to make the series field complete. There also are two shunt coils that must be series to make the shunt field complete.
4. Read pages 197 to 200 in your test (Electrical Principles and Practices). Now identify the A and S leads of your motor. Connect up the motor to operate as a series motor and have it rotate in a counter clockwise direction. Now apply 50 VDC to it and measure its speed of rotation with a tachometer. RPM. Turn the power off. Connect the motor to rotate in a clock-wise direction. Apply 50 VDC to it and measure its speed of rotation. RPM. Turn the power off. Does it go the same speed in both directions? Yes/No?
5. Now connect the armature rheostat (the one with the red terminals and heavy wire) in series with armature of your motor. Apply 50 VDC to your motor and vary the rheostat and notice the effect it has on the speed of rotation. What is the lowest speed you can obtain? ________________RPM. Turn the power to off and disconnect your motor.
6. Now identify the A and F leads. Connect the motor to operate as a shunt motor and have it rotate in a counter clockwise direction. Now apply 120 VDC to it and measure the speed of rotation. ____________RPM. Turn the power off and connect the motor to rotate in a clockwise direction. Apply 120 VDC to the motor and measure its speed of rotation. ___________RPM. Turn the power to off. Does it rotate at the same speed in both directions? YES/NO?

7. Now connect the field rheostat (the one with high resistance) in series with the shunt field of your motor. Apply 120 VDC to your motor and vary the rheostat and notice the effect it has on the speed of rotation. What is the lowest speed you can obtain? ___________RPM. What is the highest speed you can obtain? ___________RPM. Turn the power off and disconnect your motor.
8. Now identify the A, S, and F leads. Connect the motor to operate as a compound motor and have it rotate in a counter clockwise direction. Now apply 120 VDC to it and measure the speed of rotation. ___________RPM. Turn the power off and connect the motor to rotate in a clockwise direction. Apply 100 VDC to the motor and measure its speed of rotation. __________RPM. Turn the power off. Does it rotate at the same speed in both directions? YES/NO?
9. Now connect the armature rheostat in series with the armature of your compound motor. Apply 120 VDC to your motor. What is the highest speed you can obtain? ________RPM. What is the lowest speed you can obtain? _________RPM. Turn the power off and disconnect the armature rheostat from the armature circuit.
10. Now connect the field rheostat in series with the shunt field of your compound motor. Apply 120 VDC to your motor. What is the highest speed you can obtain? ________RPM. What is the lowest speed you can obtain? ________RPM. Turn the power off and disconnect your motor.

DISCUSSION:

A reversing compound motor will have six leads. Two for the armature, two for the series field and two for the shunt field. The shunt field will have a high resistance while both the armature and series field will have a low resistance by lifting one of the brushes off the commutator, you can identify which are the armature leads, and which are the series field leads.

MOTOR CONSTRUTION PROJECT #3

"BODINE ELECTRIC CO."

PROCEDURE:

1. Obtain a regular D.C. compound motor.

2. Identify the motor leads by the resistance method.
   a. Shunt field resistance ohms
   b. Series field resistance ohms
   c. Armature resistance ohms

3. Now identify the A1, A2, S1, and S2 leads by the method that was given in your test. When you have these leads identified, connect the motor as a series D.C. motor. Remember, a series motor can run away with no load on it. Apply 24 VDC to your motor and measure its speed of rotation in both directions.
   a. Series Motor speed (CCW)________RPM.
   b. Series Motor speed (CW) _________RPM.

4. Now identify the A1, A2, F1 and F2 leads by the method that was given in your text. When you have these leads identified, connect the motor as a shunt D.C. motor. Apply 24 VDC to your motor and measure its speed in both directions. a. Shunt motor speed (CCW)________RPM

   b. Shunt motor speed (CW) _________RPM

5. Now you should have all the motor leads identified and marked. Connect you motor as a compound motor with CCW direction of rotation. Apply 24 VDC to the motor and measure its speed of rotation.
   a. Compound motor (CW) ________RPM

6. Now connect your motor as a compound with a CW direction of rotation. Apply 24 VDC to the motor and measure its speed of rotation. a. Compound motor (CW) ________RPM

7. Disconnect your motor and remove the lead identification and return the motor.

8. Is the speed of rotation the same for a compound in both directions?
   a. Explain____

9. How does the speed of the compound motor compare with that of the series motor? (Faster, slower, the same)?

10. How does the speed of the compound motor compare with that of the shunt motor? (Faster, slower, the same)?

MOTOR QUESTIONS #1

Now answer the following questions and then hand this completed project into your instructor for grading....

1. What happens when the load is removed from a series D.C. motor?

2. How do you reverse the direction of rotation of a series D.C. motor?

3. How do you reverse the direction of rotation of a shunt D.C. motor?

4. How do you reverse the direction of rotation of a compound D.C. motor?

5. Why doesn't reversing the power lead of a D.C. motor change its direction of rotation?

6. What happens to a compound D.C. motor it its shunt field opens?

7. What happens to a compound D.C. motor if its shunt field shorts?

8. What happens to a compound D.C. motor if its series field opens?

9. What happens to a compound D.C. motor if its series field shorts?

10. What happens to the starting torque of a compound D.C. motor if it loses its series field?

11. The counter emf of a D.C. motor is zero when the
    a. Motor is at its rated speed.
    b. Armature is not turning.
    c. Armature has just begun to turn.
    d. Motor is almost up to its rated speed.

12. The generated voltage (CEMF) of a motor.
    a. Opposes the impressed (source) voltage.
    b. Opposes any change in load.
    c. Aids the impressed (source) voltage.
    d. None of the above

13. The primary advantage of the differentially compound motor is that
    a. It is stable under heavy loads.
    b. Its speed regulation is very good if load is not excessive.
    c. It has good speed regulation under varying loads.
    d. It will start under a heavy load.

14. A motor which has an output of 820 watts and an input of 960 watts has an efficiency of approximately a. 90%
   b. 85%
   c. 75%
   d. 70%

15. When a load is applied to a shunt motor, which one of the following will happen?
   a. Speed decreases—CEMF goes up
   b. Speed increases—-CEMF goes down
   c. Speed increases—-CEMF goes up
   d. Speed decreases—CEMF goes down

16. The speed of a shunt motor, with an increase of resistance in series with the shunt field will, a. Not be affected
   b. Decrease
   c. Increase
   d. Fluctuate rapidly

17. The speed of a shunt motor with a decrease of resistance is series with the shunt field, will a. Not be affected
   b. Decrease
   c. Increase
   d. Fluctuate rapidly

18. The speed of a shunt motor with an increase of resistance in series with the armature, will a. Not be affected
   b. Decrease
   c. Increase
   d. Fluctuate rapidly

19. The speed of a shunt motor with a decrease of resistance in series with the armature, will a. Not be affected
   b. Decrease
   c. Increase
   d. Fluctuate rapidly

20. How do you change the direction of rotation of a D.C. motor? Explain:

COIL TESTING

INTRODUCTION:

The armature coils can be the source of trouble in a D.C. machine. Some of the trouble that can occur are opens, shorts, and high resistance connections.

DISCUSSION:

A bar-to-bar test of a winding basically is determining the amount of voltage drop across each coil in a circuit. The circuit is formed by putting a D.C. voltage across a section of the commutator and then measuring the voltage drop across each coil in the circuit. Since the coils each have the same number of turns. Each should have the same voltage drop. The voltage across each coil would depend on the amount of voltage applied to the circuit.

PROCEDURE:

1. Obtain the bar-to-bar testing board.

2. With the fault switches all in the "up" position 25 V.D.C. across coils 1 through 5 and measure the voltage drop across each coil.

   Coil 1_____________V
   Coil 2_____________V
   Coil 3_____________V
   Coil 4_____________V
   Coil 5_____________V

   Sum of the voltage drops ___________V

3. (a) Now put fault switch 1 in the "down" position and measure the voltage drop across each coil.

   Coil 1_____________V
   Coil 2_____________V
   Coil 3_____________V
   Coil 4_____________V
   Coil 5_____________V

   Sum of the voltage drops ___________V

   3(b) Which coil is faulty?

   3(c) What is wrong with the coil?

4. (a) Now put fault switch 1 in the "up" position and fault switch "2" to the "down" position. Measure the voltage drop across each coil.

Coil 1____________V
Coil 2____________V
Coil 3____________V
Coil 4____________V
Coil 5____________V

Sum of the voltage drops __________V

4(b) Which coil is faulty?

4(c) What is wrong with the coil?

5. (a) Now put fault switch 2 in the "up" position and fault switch 3 in the "down" position. Measure the voltage drop across each coil.

Coil 1____________V
Coil 2____________V
Coil 3____________V
Coil 4____________V
Coil 5____________V

Sum of the voltage drops _________V

5(b) Which coil is faulty?

5(c) What is wrong with the coil?

6. Turn Off power

7. Now with the fault switches in the "up" position, measure the resistance of each coil and the total resistance of the circuit.

Coil 1____________ohms
Coil 2____________ohms
Coil 3____________ohms
Coil 4____________ohms
Coil 5____________ohms
Total ____________ohms

8. (a) Now with fault switch 1 in the "down" position measure the resistance of each soil and the total resistance.

Coil 1____________ohms
Coil 2____________ohms
Coil 3____________ohms
Coil 4____________ohms
Coil 5____________ohms
Total ____________ohms

8(b) Which coil is faulty?
8(c) What is wrong with the coil?

9. (a) Now with fault switch 1 and 3 in the "up" position and fault switch 2 in the "down" position, measure the resistance of each coil and the total resistance.

Coil 1____________ohms
Coil 2____________ohms
Coil 3____________ohms
Coil 4____________ohms
Coil 5____________ohms
Total ____________ohms

9(b) Which coil is faulty?
9(c) What is wrong with the coil?

10. (a) Now with fault switches 1 and 2 in the "up" position and fault switch 3 in the "down" position. Measure the resistance of each coil and the total resistance.

Coil 1____________ohms
Coil 2____________ohms
Coil 3____________ohms
Coil 4____________ohms
Coil 5____________ohms
Total ____________ohms

10(b) Which coil is faulty?

10(c) What is wrong with the coil?

11. Now turn this completed project into your instructor for grading.

TESTING FIELD COILS

Before installing a new or repaired coil, it should be tested for shorts, opens, and grounds and its polarity determined. A small magnetic compass may be used to determine the polarity of a field coil by holding it several inches away from the coil along its axis. A small battery or low D.C. voltage is connected in the coil leads, and if the south compass needle points toward the center of the coil, the face of the coil Nearest the compass will be north pole. This will indicate that the coil should be placed on a north pole in the same position it was in during the test and the field current should flow through the coil in the same direction.

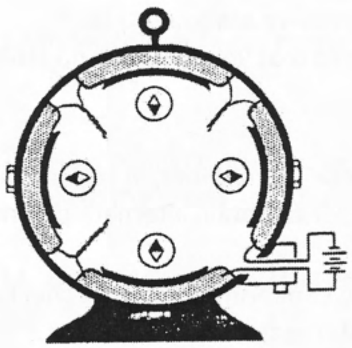


Figure 1- Testing Polarity of Field Coils

To protect the armature, the same precautions that were observed during removal of the coil should be observed when installing it. All of the shims originally removed from the pole piece must be in position when it is replaced. With the coil in position in the machine, it should be temporarily connected to the other coils in the field circuit and a compass and battery again used to check its polarity. For this test connect the battery to the proper field leads and check the polarity of all the coils with the compass. (see Figure 1) Adjacent poles must be of opposite polarity. If need be, polarity of the new coil can reversed by reversing its leads. When the polarity is correct, the coil is connected, and the pole piece bolts are tightened. Air gaps should be measured to ensure uniformity.

OBJECTIVES:

After completing this module, you will be able to:

1. Connect a motor coil for alternate polarity.
2. Test motor coils for alternate polarity by two methods.
3. Test motor coils for faults.
4. Connect up the stator field coil for a compound motor.

DISCUSSION:

All motors both D.C. and A.C. must have the stator poles coils connected for alternate polarity. This is true regardless of the numbers of poles the motor has. If this is not done, the motor cannot develop its rated horse power.

PROCEDURE:

1. Obtain Coil test Project.

2. Now looking at Coil Test Project, you will notice that is consistent of a D.C. motor frame with its stator coil leads brought out to jacks. This is a compound motor with four stator poles. This means you will have four shunt stator coils labeled 1A, 2A, 3A and 4A. You will also have four series stator coils labeled 1B, 2B, 3B and 4B. You also notice that there are four (4) fault switches. Make sure the fault switches are in the "up" position so that you will have no faults in your circuit when you start.

3. Connect up the four (4) shunt coils for a four (4) pole shunt motor. Remember, in connecting up these coils, connect them start to start and finish to finish in order to obtain alternate polarity.

4. Now you must check them for alternate polarity. There are two common methods of checking the polarity of the stator poles. Obtain a bar magnet and a center scaled microammeter. Connect the microammeter to your two-stator field leads. Now take the bar magnet, move it inward to each motor pole going around the stator frame. If you have the coils connected properly, as you move the bar magnet into the first pole it will cause the meter to deflect in one direction. When you move the bar magnet into the second coil, the meter should deflect in the opposite direction. The third coil should deflect the meter in the same direction as the first and the fourth the same as the second. If your circuit did not do this, change your connections so it will.

   Another method is explained at the start of this project. There is information in your module explaining this and other methods.

5. Now put fault switch "1" in the "down" position. With the aid of an ohmmeter, what is wrong with your circuit?
   Which coil is at fault?

6. Put fault switch "1" in the "up" position and put fault switch "4" in the "down" position. What is wrong with your circuit?
   Which coil is at fault?

7. Now put fault switch "4" in the "up" position and disconnect your circuit.

8. Now connect the series coils for a series four pole motor. Check for alternate polarity by one of the two methods you used above. Make sure your coils are connecter properly.

9. Now put the fault switch "2" in the "down" position. What is wrong with your circuit? Which coil is at fault?

10. Now put the fault switch “2” in the “up” position and put the fault switch “3” in the “down” position. What is wrong with your circuit?
    Which coil is at fault?

11. Now put fault switch “3” in the “up” position and disconnect your circuit.

12. Now connect your motor coils up for a cumulative compound motor and check it for alternate polarity.

13. Now connect your motor coils up for a differential compound motor and check the polarity of both the series and shunt windings.

14. Disconnect your circuit and return the bar magnet, microammeter and compass.

15. Now turn this completed project into your instructor for grading.

VOLTAGE TESTER

A voltage tester is a piece of test equipment used very frequently by electricians. This type of voltage tester, originally manufactured by a company called "WIGGINS", is sometimes called a "wiggie". On many jobs, it will be the only piece of test equipment you will have, so learn to use it well.

Most voltage testers will test for A.C. or D.C. voltage. The A.C. voltage range is from 110 to 550 volts. The D.C. voltage range is from 110 to 600 volts. It will also tell you polarity of D.C. voltage.

A neon lamp is the device used to indicate D.C. polarity. A neon lamp has two electrodes in it. Whichever, electrode is connected to the negative side of the line will glow. When a neon lamp is connected across an A.C. source, both electrodes will glow, because the polarity is constantly changing.

Figure #1 will give you some idea of how the voltage tester is constructed.

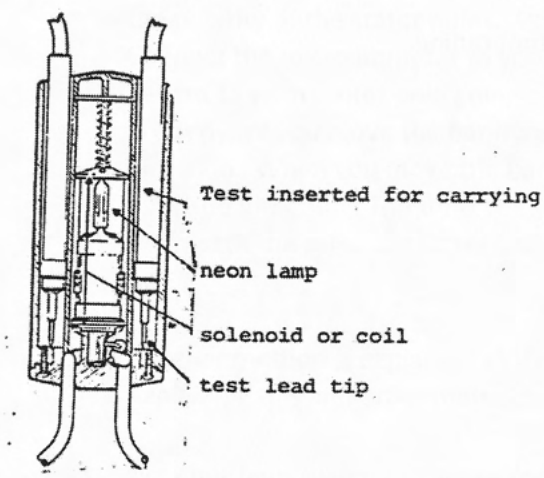


Figure 1

As you can see from Figure 1 the solenoid is the voltage device. The indicator is attached to the core of the solenoid. As voltage is applied to the solenoid, it will pull the core into the solenoid against the spring pressure. The more voltage the greater will be the pull.

VOLTAGE TESTER APPLICATIONS

DETECTING AND MEASURING THE VOLTAGE

When the tester prods are applied to the circuit and voltage is present, the indicator moves, the lamp lights, and when you make and break the circuit with a prod, there is a clicking sound. In addition, the instrument hums and vibrates, except on "pure" D.C. The amount of voltage is shown by the position the indicator reaches on one of the two scales, the left-hand is for direct current, the right-hand is for alternating current.

DISTINGUISHING BETWEEN A.C. and D.C.

ALTERNATING CURRENT

When applied to alternating current, the instrument vibrates and hums, and at the same time both electrodes of the neon lamp glow. The glowing of BOTH electrodes, not just one, proves the presence of A.C. Use the A.C. (right-hand) voltage scale.

DIRECT CURRENT

When applied to any type of direct current, regardless of its source, only **ONE** electrode of the neon lamp glows, proving the presence of D.C., either "pure" or pulsating. Use the D.C. (left-hand) voltage scale. Pulsating D.C. causes the tester to hum, whereas the instrument is silent on "pure" D.C. This provides, when needed, a means of distinguishing between the two.

DETERMINING D.C. POLARITY

On D.C. only one electrode glows, and the polarity of the red prod is positive or negative according to whether the glowing electrode is above the + sign or the – sign on the polarity plate. When considerable polarity checking is done, it is recommended that a practice as indicated by the neon lamp will always be the polarity of the mounted prod, the red one.

FINDING GROUNDED SIDE OF LINE APPATATUS

Touch one test prod to normal ground such as conduit, motor frames etc. Touch other prod to each of the terminal connections. No scale indication shows grounded side.

DISTINGUISHING BETWEEN 60 AND 25 HERTZ (CYCLES/SEC.)

On 60 Hz the electrodes glows, and the polarity of the red prod is positive or negative according to whether the glowing electrode is above the + sign or the – sign on the polarity plate. When considerable polarity checking is done, it is recommended that a practice be made of mounting the red prod in the prod socket. In this way the polarity as indicated by the neon lamp will always be the polarity of the mounted prod, the red one.

TESTING FUSES #1

An electrical system may consist of a comparatively small number of circuits. In larger systems, the installation may be equal to that of a small city.

From the main power supply, the total electrical load of divided into several feeder circuits and each feeder circuit is further divided into several branch circuits. Each feeder and branch circuit is fused individually to safely carry its own load. This minimizes the possibility of one circuit failure interrupting the power for the entire system.

When trouble occurs, a systematic procedure will enable you to isolate and correct GROUND, SHORT, AND OPEN circuits safely and in a short period of time.

A **grounded** circuit occurs when current flows from a hot conductor to a metallic conduit system, any ground surface, or earth.

A **short** circuit exists when two or more conductors come into contact with each other due to improper wiring or breakdown of insulation.

Application of voltage to either of the above circuits will cause fuses to blow if the current ratings of the fuses are exceeded.

An **open** circuit exists when there is a break in the continuity of the circuit. An undesired open circuit is generally found in junction boxes or equipment terminals. They are caused either by splices coming apart from vibration, or when screws become lose from expansion and contracting caused by changes in current flow.

Suppose a fuse blows in a 110-volt circuit with a ground neutral. It might have been the result of overloading the circuit. But suppose a new fuse is installed, and it, too, blows. In most cases this means that short or grounded is causing the trouble. Also, if the trouble is an overload, the fuse will heat gradually and then blow.

A visual inspection of the defective circuit will often reveal the difficulty. Perhaps some equipment has been pushed against the line, smoke or sparks were seen coming from a box just before the fuse burned. If inspection and questioning of personnel cannot pinpoint the trouble, you must "dig into" the circuit with systematic tracing.

Let's take a typical branch circuit for lighting or convenience outlets, consisting of two wires, a black (hot) wire and a white (neutral) wire. Normally, the current will pass through each fixture and appliance connected to the circuit. When it fails to do so, your first thought should be that there is an opening somewhere in the circuit between the panel board and the fixture or appliance which fails to function. Essentially all you have to do is trace the wires systematically, starting at the last point where you do have voltage, until you find the opening.

There are several types of testing devices you can use to check for a ground or short, but the Wiggins type voltage indicator shown in figure 1 is one of the best.

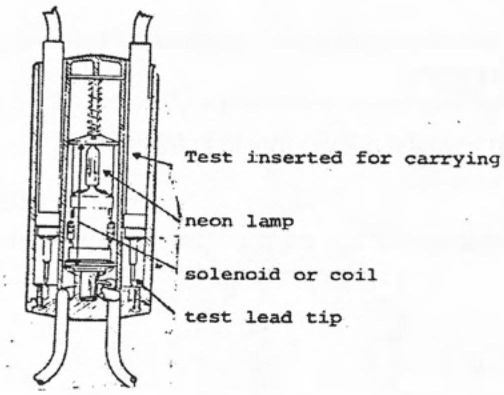
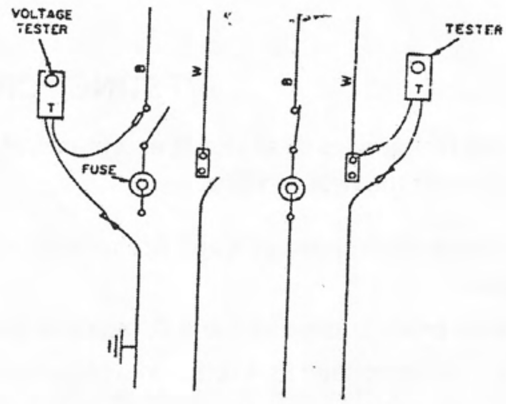


Figure 1- Voltage Indicator



A: reading shows Ground B: reading shows Short

Figure 2- Testing for (a) Ground, (b) Short

To locate the trouble, first open the switch, remove the fuse, remove all the application cords and lamps for the circuit, disconnect the black and white wires from the source of power. Then replace the fuse and lose the switch. Now touch one lead of the tester to the power source and the other lead to the black wire. If you get a reading on the voltage tester the trouble is a ground in the circuit. If you get no reading, you will probably find that you have short. This situation is illustrated in (figure-2A).

Recheck for a short by connection the black wire to the power source and the black wire to the power source and test from white wire to the ground connection with the tester as shown in (figure-2B). A reading here will verify that you have a short. If you don't get a reading, replacing the wires, one at a time, and test after replacing each until you do get a reading. You will then know that this is the wire causing the trouble.

If you have a plug fuses in the switch or panel, another way to test is to remove the fuse where the trouble is and replace it with a 100-watt lamp. If there is a short or ground in the circuit, the lamp will burn. If it continues to burn with all cords and lamps removed, open the circuit about the middle and test. This cuts your area of search into half, and by this process of elimination you can trace the trouble to its source.

Use the grates caution when checking wires in boxes. **BEFORE YOU DISCONNECT OR CONNECT ANY WIRE, BE SURE THE CIRCUIT IS DEAD.**

Open the switch first, then remove the fuse or fuses. When disconnection wires, always disconnect the hot wire or wires first. When reconnecting, always connect the neutral first and the hot wire or wires last.

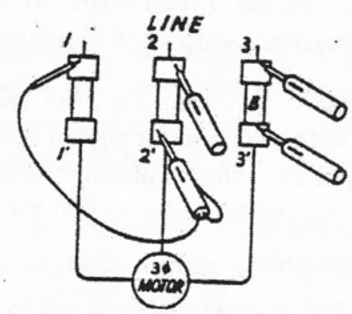
You will often find that the cause of a short or ground was careless tapping or connecting of wires by the person who wired the building. Remember this when you are wiring a building or equipment yourself. Do your tapping and connecting properly so that some other electrician will not have to locate trouble caused by your carelessness.

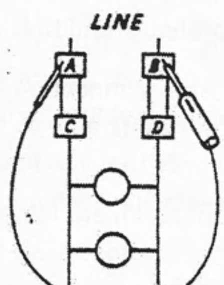
TESTING FOR BLOWN FUSES

This test applies to all circuit except polyphase motor circuit, the latter condition being discussed under the next heading.

1. With prods applied at A and B, check for presence of voltage. Voltage must be present for these tests.
2. With prods applied at C and D, indicator shows either:
   a. Some voltage as A to B, - in which cases fuses are both good, or
   b. No voltage – om which case one or both fuses are blown; so, proceed as follows:
3. With prods applied at A and D indicator show either:
   a. Same voltage A to B, in which case fuse B - D is good and fuse A - C is blown; or
   b. No voltage, in which case fuse B – D is blown and fuse A – C may be so do test 4.
4. With prods applied at C and B, indicator shows either.
   a. Same voltage as A to B, in which case fuse A – C is good, or
   b. No voltage, in which case A – C is blown.

LOCATING TROUBLE IN POLYPHASE MOTOR CIRCUIT





If a polyphase motor is running badly, the cause may be an open circuit on one phase, possibly a blown fuse. In checking for a blown fuse, make use of the fact that the voltage of the motor side of a blown fuse is lower than the line voltage. To find any difference, first determine the voltage between line terminals 1 and 2 then compare it with the voltage between points 1' and 2'.

EXPLANATION:

The voltage on the motor side of the blown fuse is the back emf generated by the motor. The difference between it and the line voltage is frequently small, but usually detectable.

NOTE: Moving the instrument from point to point, as shown in the diagram rather than moving the free prod, is usually found more convenient as it makes it possible to keep your eye on the instrument.

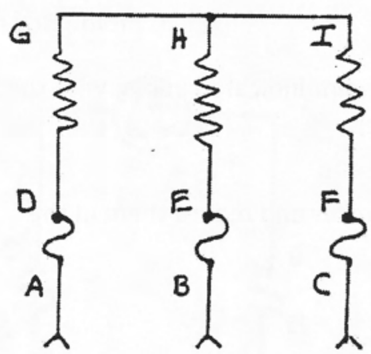
PROJECT #2

OBJECTIVE:

After completing this project, you will be able to:

1. Identify a good fuse by voltage testing.
2. Identify a blown fuse by voltage testing.

DISCUSSION:



In many industrial applications the electrician needs to locate a blown fuse without turning power off. This project gives you a chance to learn how to do this.

(Figure 1) 3Ø 208V

Points	Voltmeter	Tester	Fuse Removed
a. A and B =	________ =	________ =	________
b. A and C =	________ =	________ =	________
c. B and C =	________ =	________ =	________
d. D and E =	________ =	________ =	________
e. D and F =	________ =	________ =	________
f. E and F =	________ =	________ =	________
g. A and D =	________ =	________ =	________
h. B and F =	________ =	________ =	________
i. C and F =	________ =	________ =	________
j. D and G =	________ =	________ =	________
k. E and H =	________ =	________ =	________
l. F and I =	________ =	________ =	________
m. A and E =	________ =	________ =	________
n. A and F =	________ =	________ =	________
o. B and D =	________ =	________ =	________
p. B and F =	________ =	________ =	________
q. C and D =	________ =	________ =	________
r. C and E =	________ =	________ =	________

(Figure 2)

PROCEDURE:

1. Obtain the fuse test board, shown in (figure 1).

2. When applying power to this board only apply power long enough to make the indicated voltage tests.

3. Apply power to the board and measure the voltage between the point indicated above with the voltmeter and record them in the "Voltmeter" column in (figure 2).

4. Now measure the point indicated in step 3 above with a voltage tester and record them in the "Voltage Tester" column in (figure 2).

5. Turn the power off and remove the fuse from between point B and E. Apply power to the board with the fuse removed. Now measure the voltage between the points indicated in step 3 above and record them in the "Fuse Removed" column.

6. Turn the power off.

7. Now compare the readings in the column of step 3. Now looking at these readings explain how you can tell if a fuse is blown, both by voltmeter and a voltage tester.
   Explain: ____

8. Put the fuse back in the board. Return the board and turn this complete project into your instructor for grading.

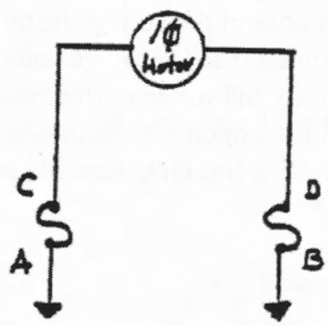
FUSE PROJECT #3

OBJECTIVE:

After completing this project, you will be able to:

1. Identify a good fuse in a single-phase circuit.
2. Identify a blown fuse in a single-phase circuit.

DISCUSSION: Blown fuses may cause many shut downs in industry. Because you cannot always turn power off. An electrician must be able to check the condition of a fuse with power on. This project is to help you obtain this skill.



(Figure 1)

120 VAC 1Ø

1. Obtain the project board shown in (Figure 1).
2. When applying power to this board, only apply power long enough to make the indicator voltage tests. Read the total project before you start so that you will know what is required.
3. Apply power to the board and measure the voltage between the indicated points with your voltmeter and record them in the proper column.
4. Now measure the points indicated in step 3 above with a voltage tester and record them in the proper column.
5. Turn the power off and remove the fuse form between points B and D. Apply power to the board with the fuse removed. Now measure the voltage between the points indicated in step 3 above and record them in the proper column.
6. Turn power off and put the fuse back. Now explain how you can tell if a fuse is blown both by use of a voltmeter and a voltage tester.
7. Return the project board, and hand this completed project into your instructor for grading.

<u>POINTS</u> <u>VOLTMETER</u> <u>TESTER</u> <u>FUSE REMOVED</u> a.

A and B = __________ = __________ = __________

b. C and D = __________ = __________ = __________

c. A and D = __________ = __________ = __________

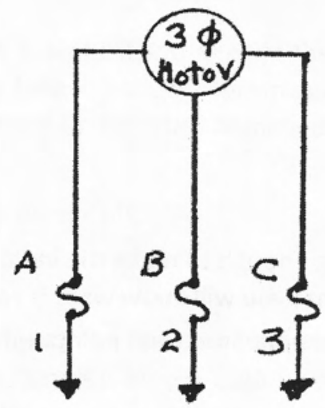
d. B and C = __________ = __________ = __________

e. A and C = __________ = __________ = __________

f. B and D = __________ = __________ = __________

THREE PHASE FUSED NO. 1

1. On many jobs the only piece of test equipment an electrician has is a voltage tester. Therefore, he must be able to use a voltage tester (wiggers) in his trouble shooting procedure.
2. Remember that the amount of voltage that drops across any device depends on its resistance. The larger the resistance, the greater the voltage drops. A short circuit has zero resistance and therefore has zero voltage drop. An open circuit has very high resistance and therefore nearly all the voltage is dropped across an open circuit. When a voltage tester or voltmeter is connected across an open circuit if completes the circuit and allows current to flow in the circuit. Normally the resistance of the voltage tester or voltmeter is so high compared to the rest of the electrical circuit that full source voltage appears across the voltage tester or voltmeter, so they indicate full voltage. This means that if you put a voltage tester or voltmeter across an open fuse, open set of contacts or open circuit, you would measure full source voltage. By knowing this fact, it can aid you in troubleshooting equipment.



208 VAC 3Ø (Figure 1)

3. Now looking at (figure1) you can see there is a three-phase motor connected to a three-phase source and there are fuses between the motor and the power source. If one of those fuses was bad it could be found with the aid of a voltage tester. If you put a voltage tester between any two leads on the (source) side, you should measure full supply voltage. If a fuse is blown on the motor (load) side, only between two leads should you measure source voltage. Let us say that the center fuse is blown, then between A and C you should measure zero volts because there is no complete path for current to flow. You should get full voltage indication between 1 and C, 3 and A, 2 and C, but you should get zero indication between 1 and B, 3 and B. Remember that for a voltage indication device to indicate there must be a complete path for current to flow.

4. Now ask your instructor for the three-phase fuse board. Hold the shaft of the motor while making your voltage checks.

5. Which fuse is bad? A-1 B-2 C-3

QUESTIONS

Now answer the following questions and then hand this completed project into your instructor for grading.

1. Let's say that you have an open in a circuit and you are trying to find it with a voltage indicating device. You put the voltage indicating device across the open and it completes the circuit. Let is assume that the voltage indication device has as much resistance as the rest of the circuit. Let us assume that the voltage indicating device has as much resistance as the rest of the circuit.

- What Voltage will the voltage indication device indicate if the source voltage is 220 VAC?

2. You have two 100-ohm resistors in series across a 200-volt source.

- How much voltage is dropped across each resistor?

3. You have a 225, 50, and 100-ohm resistor in series across a 175-volt source.

- How much voltage is dropped across each resistor?

4. You have a 2-meg ohm and a 100-ohm resistor is series across a 100-volt source. This is the type of circuit you have in most electrical circuits when you put a voltmeter across an open circuit. The 2-meg ohm resistor would be the voltmeter or voltage indication device and the 100 ohms would be the circuit.

- How much voltage is dropped across each resistor?

RELAYS AND CONTACTORS

OBJECTIVES:

1. To determine the pull-in, drop out properties of the Electromagnetic relay and contactor.

DICUSSION:

Pilot device such as push buttons energize and deenergize the coils of relays and contractors, and they in turn, close and open the power lines of the main machine. Relays and contractors are electromechanical devices because mechanical forces are produced when electric currents pass through coils of wire. In response to such forces, contacts are closed or opened by the motion of plungers or pivoted armatures.

A relay is a low power electrically operated switch which closed or opens a set of control contacts when its coil is energized. A contactor, on the other hand, is an electric power circuit. Although the distinction, from a manufacturing point of view, is well defined, it should be pointed out that relays can be used as contactors where the power requirements are within the relay's capabilities and that contactors can be used in heavy-current relay circuits.

A number of advantages are gained by using magnetic contactors instead of manually operated controls. Large currents and high voltages can be handled with relative ease by pushbutton control of the contactor coil. The control equipment can be mounted at a remote location and the motor may be controlled from a number of different points. Automatic sequencing, acceleration, reversing and stopping can readily be accomplished.

In A.C. contactor coils the current through the coil is limited by its impedance, and the reactance generally has a greater effect than the resistance. The coil reactance is very low When the contractor is open because of the large air gap in the magnetic circuit. Therefore, a high inrush correct flows through the coil when it is first connected to the power source. The inrush may be five to twenty times as high as the current which flows through the coil when the contractor is closed.

Automatic control circuits almost invariably contain one or more relays, primarily because the rely lends flexibility to control circuits.

When we energize the coil of a relay with 24 volts and the contacts are controlling a circuit of 460 volts, we are amplifying the voltage through the use of a relay. Relay coils require only a very low current in their operation and are used to control circuits of large currents. So again, they would amplify the current. The relay is inherently a single-input device in that it requires only a single voltage of current to activate its coil. Through the use of multiple contacts, however, the relay can be a multiple outlet device which amplifies the number of operations controlled by the single input.

Suppose we have a relay whose coil operates on 115 volts at 1 amp, and the contacts of this relay control three separate circuits operating at 460 volts and 15 amps each. This relay then becomes a power amplifier in that it controls considerably more power in its output circuits than it consumes in its input circuit. It also becomes an amplifier in terms of the number of circuits, as its single input controls three separate outputs.

A relay will close after the current through its coil reaches a high enough value to produce the necessary magnetic flux. There are a few terms used in connection with relays that must be understood.

PULL-IN CURRENT is the amount of current through the relay coil necessary to close or pull in the relay.

DROP-OUT CURRENT is the value of current below which the relay will no longer remain closed after having been pulled in.

DIFFERENTIAL is difference is value of the pull-in and drop-out currents for the relay in question.

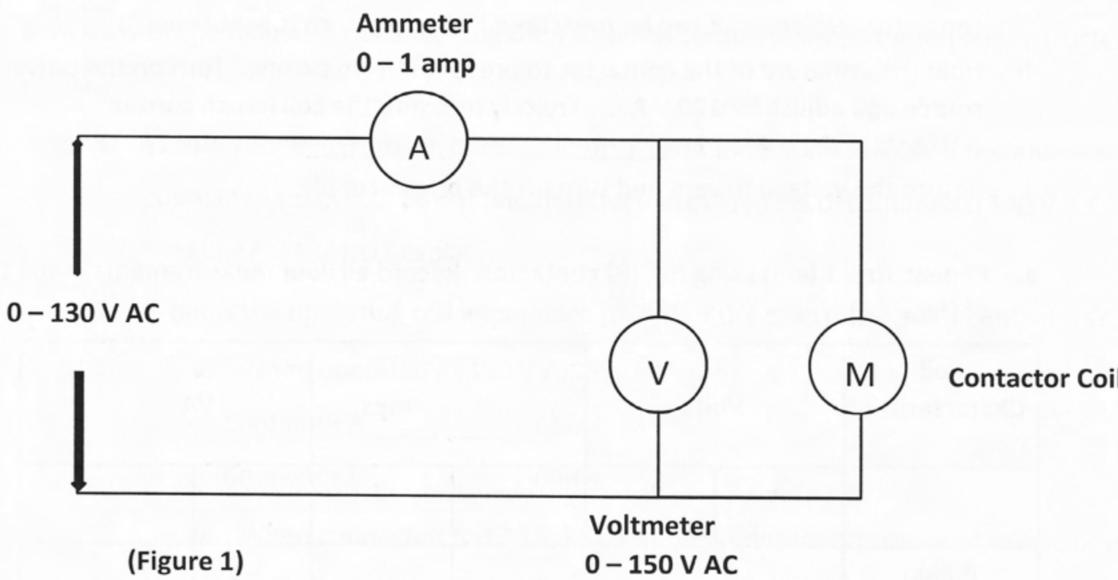
For example, if a relay is energized or pulled in at 5 amps and drops out at 3 amp, then the pulling current is 5 amp, the drop-out current is 3 amp, and the differential is 2 amp.

Many relays are provided with spring tension and contact spacing adjustments which allows a reasonable variation of pull-in, drop-out, and differential values.

MATERIALS NEEDED:

- Relay and contactor Board*
- A.C. Ammeter, 0-1 amp
- 120-volt A.C. Source
- Clip Leads

PROCEDURE:



(Figure 1)

1.

a. We will now measure the operating coil characteristics for each of the two electromagnetic contactors. Using (A) contactor, A.C. ammeter (0 – 1amp A.C.) connect up the circuit shown in (figure 1). Note that the circuit is connected to a variable 0 – 130 V A.C. supply.

b. Turn on the power supply and gradually increase the voltage until the contactor pulls in. Repeat several times while noting the voltage and current just before pull-in.

V = __________ I = __________ VA = __________

c. Gradually lower the voltage until the contactor drops-out. Repeat several times while noting the voltage and current just before drop-out.

V = __________ I = __________ VA = __________

d. Return the voltage to zero and turn off the power source.

e. Turn on the power supply and adjust for 120 V A.C., the nominal operating coil voltage value. Measure the coil current.

V = 120 V A.C. I = __________ VA = __________

f. Return the voltage to zero and turn off the power source.

g. It is difficult to measure the peak inrush coil current because of the rapid closure of the contactor. However, it can be measured if the armature is kept "open".

h. Hold the armature of the contactor to prevent it from closing. Turn on the power source and adjust for 120 V A.C. Quickly measure the coil inrush current.

V = 120 V A.C. I = __________ VA = __________

i. Return the voltage to zero and turn off the power supply.

2.

a. Repeat step 1 (a- i) using the (B) contactor. Record all your measurements in the table of (figure 2).

Coil Characteristic	Volts		A mps		VA	
	A	B	A	B	A	B
Pull-in						
Normal	120 V A.C.	120 V A.C.				
Drop-out						
In-rush	120 V A.C.	120 V A.C.				

(figure2)

b. The current and voltage rating of contactor "A" is 25 A at 200 volts.
The current and voltage rating of contactor "B" is 15 A at 110 V A.C.

c. What load can each pair of contacts control?

Load per contact __________VA (A)

Load per contact __________VA (B)

d. What total load can the contactor control for all pairs of contacts?

Total load _________VA (A)

Total load __________VA (B)

e. How much continuous power, in volt- amperes, must be supplied to the coil to control this total load power?

Coil "A" power __________VA

Coil "B" power __________VA

QUESTIONS

Now answer the following question and then turn this complete project into your instructor for grading.

1. Would your electromagnetic contactors (A and B) operate reliably if their coils were connected to an A.C. power line that fluctuates +/- 10% of its nominal 120 V A.C. rating? YES/ NO? Explain:

2. What is the operating coil impedance (z=V/I) of the electromagnetic contactors?
   a. When operated at 120 V A.C.?

      Contactor A___________ ohms

      Contactor B ___________ohms

   b. When connected to 120 V A.C. and the armature is prevented from closing?

      Contactor A __________ohms

      Contactor B __________ohms

MEGGER #1

Why insulation resistance testing?

The primary purpose of insulation is to keep electricity flowing in the desired path. The "perfect" insulation would have infinite resistance, which would prevent the flow of any current through the insulation to ground. However, there isn't any "perfect" insulation material so there is always some current flow. Good insulation is one that has and keeps a high resistance value in order to minimize the current flow.

Unless there is accidental damage of some sort, insulation failure is generally gradual rather than sudden. This is because failure is generally a wearing down process due to repeated heating and cooling, the related expansion and contraction, dirt, physical abrasion, vibration, moisture, and chemicals.

When insulation starts to fail, its resistance decreases, allowing more current to flow through the insulation. If the resistance continues to decrease, the condition of the insulation may reach a point where it may permit a large enough current flow through the insulation to cause (1) a single blowing of a fuse, (2) equipment damage, or (3) even fatal shock. That's why, if you're responsible for the servicing, maintenance or installation of electrical equipment, you must be concerned about insulation resistance.

An Insulation Resistance Testing Program helps reveal failing insulation before it becomes a serious problem. Such a testing program consists of periodic insulation resistance tests on critical equipment and systems. The results are recorded on a control card or file for each piece of equipment or each test point in a system. Any trend that indicates a decreasing insulation resistance value is an indication that the insulation is failing, and that corrective maintenance should be scheduled.

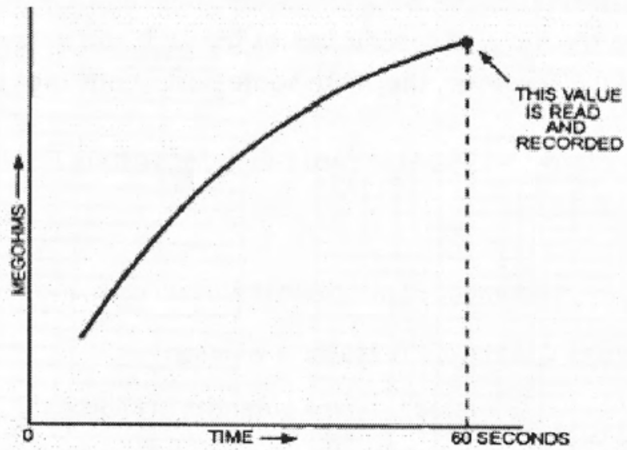
Measuring Insulation Resistance:

Without going into great deal of technical explanation, let us state that insulation resistance measurements are affected by a number of factors. Temperature and the duration of the measurement are two primary ones. Humidity may also affect readings; it is a good idea to make a note as to whether the air is dry or humid at the time of the measurement. You may find that insulation resistance reading is lower on humid days and higher on dry days. Wet or flooded equipment should be dried and cleaned as much as possible before measurements are taken. Lastly, dirt or other contaminants (corrosion, chemicals, etc.) can also affect readings, either raising or lowering them. Therefore, steps should be taken to make certain that the contact points at which measurements are to be taken are reasonably clean.

Temperature:

Insulation resistance can vary significantly with temperature. If your periodic insulation resistance measurements cannot be taken at the same temperature, it is important that resistance measurements be adjusted to a base temperature.

For temperature correction factors cable insulation, refer to specifications of the Insulated Power Cable Engineers Assn.



Typical curve of insulation resistance (in meg-ohms) versus time

(Figure 1)

Time:

The duration of the resistance measurement also affects the reading. If the insulation is good, the reading will continually increase as long as the megohmmeter is connected to the insulation. See (figure 1). The most common megohmmeter measurement is taken at the end of a 60 second increment as this time period generally gives a satisfactory measurement of the insulation resistance.

A second type of test involves taking a reading after 30 seconds and 60 seconds. The 60 second readings divided by the 30 second readings are known as the Dielectric Absorption Ratio. Comparing periodic Dielectric Absorption Ratios may prove more useful than comparing one-minute readings. Generally speaking, a ratio of 1.25 is the bottom limit for borderline insulation. An extension of this test is one that involves readings taken after 60 seconds and 10 mins. The ratio of the 10-minute reading to the 60 second readings is referred to as the Polarization Index. The resistance measurement taken at the end of 10 minutes should be considerably high than at 60 seconds. The measured insulation resistance of a dry motor winding in good condition should reach a relatively steady value in 10 minutes. If the winding is wet or dirty, the steady value will usually be reached in one or two minutes. The Polarization Index is helpful in evaluating the winding dryness and fitness for over-potential testing.

For a fuller explanation of these ratios and safe values, see *IEEE Std. 43-1961 IEEE Standard Guide for Testing Insulation Resistance of Rotating Machinery.

*IEEE Standard 62-1058 and Recommended Guide for Making Dielectric Measurements in the Field.

As a guide, the recommended minimum value of the Polarization Index for alternating current and direct current rotating machines is 1.5 for 105C (Class A) insulation systems and 2.0 for 130C (Class B) insulation systems.

WHAT THE READINGS MEAN:

As has already been pointed out, insulation resistance measurements are affected by temperature, humidity, and the time duration of the measurement. They are also affected by such things as the type of insulation, its thickness, cleanliness and even the design of the equipment. Therefore, to try and give specific values for each and every situation would represent an impossible job. However, there are some basic guidelines that are usable.

From the IEEE Standard 43-1961 Standard Guide for Testing Insulation Resistance of Rotating Machinery:

When; R_m = recommended minimum insulation resistance in $R_m = K_v + 1$

megohms at 40 degrees C of the entire machine winding.

K_v = rated machine potential, in Kilovolts.

If the winding is mot at a temperature of 40 degrees C, temperature corrections should be made.

This essentially follows on old rule of thumb which set a minimum value of 1 megohm for every thousand volts of equipment rating.

For specific information about individual products, contact the manufacturer for specifications on insulation resistance values and test procedures.

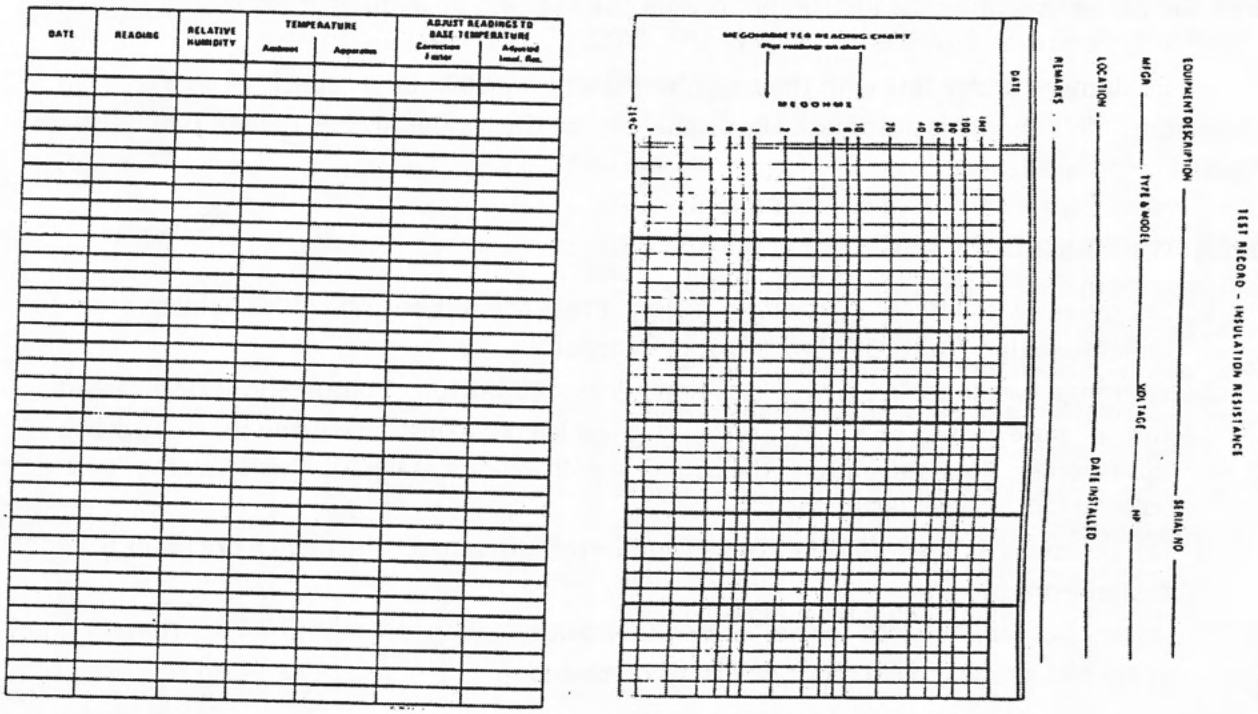
The important thing to remember is that periodic testing is the primary method of picking up sudden decrease in insulation resistance and this is the key to detecting insulation that is failing. Because it is possible for insulation to fail between tests, testing should be scheduled based on the type of equipment. Generally speaking, equipment that involves movement (e.g. motors) should be checked more frequently than stationary equipment (e.g. cables). In addition, the more critical the equipment is to a company's operation, the more frequent it should be checked.

What to record:

So that your periodic insulation resistance measurements can be compared meaning fully, you must have certain information recorded. Each piece of equipment should have its own record card on file, typical information that should be included:

1. Equipment description including rating and serial number. 2.
Equipment location (department, floor, etc.)
3. Date of installation.
4. Dates of repairs and description.
5. Specific test points (e.g., motor frame and motor lead disconnected at motor junction box). In some cases, a sketch might help another person performing the test at a later time.
6. Equipment temperature at the time of reading.

7. Room (ambient) temperature at the time of reading.
8. Relative Humidity measurement.
9. Correction factor used to adjust reading to base temperature.
10. The adjusted insulation resistance, with this information, you can make meaningful comparison between readings. See (figure 3) for typical record cards.



(Figure 3) Record cards

DISSCUSSION:

The following are the specifications of the model AMB-1 megger.

RANGES:

0-100 Megohms (2.5 Megohms mis-scale)
Test voltage 500 V D.C.
0-100 ohms (4 ohms mid-scale)
Open circuit voltage 300 mV
0-600 V A.C. test band (may also be used for DC)
Battery Ok test band

ACCURACY:

Megohm range
0.1
0.2 – 10 Megohms: + 5% of reading
Over 10 Megohms: +10% of reading
Ohmmeter range: + 3% of arc **POWER:**
8 AA batteries

PRECAUTIONS:

Although there is high voltage at the tips of the test leads when AMB – 1 is used as a megohmmeter, low current flow reduces any danger to relatively safe levels. However, contact with the probe tips while the instrument is energized should be avoided.

Equipment under test with the megohmmeter may build up a capacitive charge from the testing. This charge is automatically discharged by the Model AMB – 1 when the "Press-to Read" button is released.

OPERATING INSTRUCTIONS:

1. Set range switch to "B" (Battery) position. Press the red button. If the pointer does not indicate within "Batt. OK" box tell your instructor.
2. Set range switch to "ACV/MQ" position. Press red button. Pointer should indicate at the "∞" scale division on the M Q scale. Plug test leads into instrument and short and probe tips together. Press red button. The pointer should indicate at the "0" division on the "M Q" scale. If not, tell your instructor.
3. (a) To use as a megohmmeter or an ohmmeter, disconnect the device or circuit to be tested from the line.

   (b) Set range switch to the "ACV/MQ" position. Plug test leads into instrument and apply test probes to circuit or device to be tested.

DO NOT PRESS RED BUTTON: If the pointer moves up the Red ACV band, there is voltage present in the circuit of the device. Disconnect the device or current from any voltage supply before proceeding.

(c) Set range switch to appropriate position "ACV/MQ" for megohms, "Q" for low ohms.

(d) Connect test leads to device or circuit to be tested.

(e) Press red button.

(f) Take reading on scale corresponding to range switch position.

CONNECTING THE MEGONMMETER:

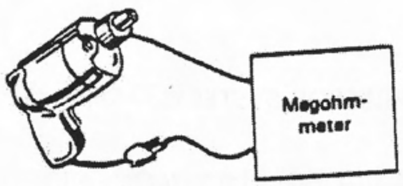
The basic purpose of an insulation resistance measurement is to test the insulation. Connections, therefore, must be made so that the megger test voltage is applied across or through the insulation. Within any system or piece of equipment, there may be more than one set of points that should be tested. The illustrations and related descriptions that follow will serve as a guide for testing the specific equipment shown. The approached shown can also be used as guides for other similar equipment.

NOTE: Disconnected equipment or circuits to be tested from the power supply. Verify that the equipment or circuit is de-energized by checking with a voltmeter.

POWER TOOLS AND SMALL APPLIANCES:

This test would also apply to other similar equipment that has a line cord. For double insulated power tools, the megohmmeter lead shown connected to the housing would be connected to some metal part of the tool (e.g., chuck, blade). See (figure 3)

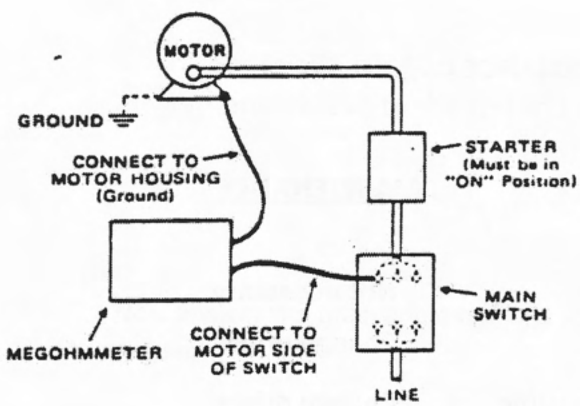
(Figure 3)



NOTE: The switch of the device must be in the "ON" position.

MOTORS:

AC---Disconnect the motor from the line by disconnecting the wires at the motor terminals or by opening the main switch. If the main switch is used and the motor also has a starter, then the starter must be held, by some means, in the "ON" position. In the latter case, the measured resistance will include the resistance of the motor, wire and all other components between the motor and the main switch. If a weakness is indicated, the motor and other components should be checked individually.



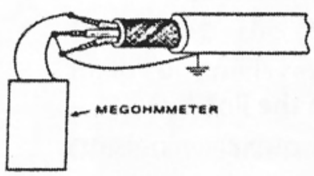
(figure 4) Motor Test

If the motor is disconnected at the motor terminals, connect on megohmmeter lead to the grounded motor housing and the other lead to one of the motor leads.

DC—Disconnect the motor from the line. To test the brush rigging, field coils and armature, connect one megohmmeter lead to the grounded motor housing and the other lead to the brush on the commutator. If the resistance measurement indicates a weakness, raise the brushes off the commutator and separately test the armature, field coils, and brush rigging by connecting one megohmmeter lead to each of them individually, leaving the other lead connected to the grounded motor housing. The above also applies to D.C. Generators.

CABLES

Disconnect the cables from the line. Also disconnect opposite end to avoid errors due to leakage from other equipment. Check each conductor to ground and/or lead sheath by connecting one megohmmeter lead to a ground and/or lead sheath and the other megohmmeter lead to each of the conductors in turn. Check insulation resistance between conductors by connecting megohmmeter leads to conductors in pairs.



HERMETIC COMPRESSOR SYSTEMS:

The following table may be used as a guide to determine the extent to which a system may have been contaminated by moisture.

SUGGESTED PREVENTIVE MAINTENANCE

MEGOHMMETER READING	COMPRESSOR CONDITION	MAINTENANCE
100 Megohms to infinity	Good	Not necessary
50 – 100 megohms	Moisture's present	Change drier
20 – 50 Megohms	Severe moisture and possible Contamination oil	Change driers Change oil
0 – 20 Megohms	Severe Contamination	Dump oil and entire refrigerant. Evacuate system, Install liquid and suction line driers, recharge system with new oil and refrigerant.

CIRCUIT BREAKERS AND SWITCHES:

Disconnect from line. To test each terminal to ground, connect one megohmmeter lead to the frame or ground and connect the megohmmeter lead to each terminal, one after the other. To test between terminals, connect megohmmeter leads to pairs of terminals.

RELAYS AND COILS:

Disconnect from line to test coil, connect one megohmmeter lead to one of the coil leads and the other megohmmeter lead to ground. Then connect megohmmeter between one coil lead and core.

For relays, connect one megohmmeter lead to the relay contact and the other megohmmeter lead to the coil and core, one after the other.

QUESTIONS

Now answer the following questions and then turn this completed project into your instructor for grading.

1. What is the primary purpose of insulation? Explain:
2. Is there such a thing as a perfect insulation material? Explain:
3. Does insulation failure normally occur suddenly? Explain:
4. What three things can insulation breakdown cause? Explain:
5. What are the two primary factors affecting insulation resistance measurements? Explain:
6. The most common megohmmeter measurement taken at the end of seconds? Explain:
7. What is Dielectric Absorption Ratio?
8. What is the old rule of thumb for resistance measurements?
9. What is Polarization Index?

MEGGER PROJECT #2

OBJECTIVES: After completing this project, you will be able to:

1. Test a D.C. Motor with a megger.

DISSCUSSION: Read over the discussion above. Be sure you understand the section on meggering a motor.

PROCEDURE:

1. Obtain the motor megger board.
2. You will notice that the motor you are going to megger is a shunt motor. The armature leads, and shunt leads are connected to jacks on the board, you also have a jack which is connected to the frame of the motor.
3. You would need an ohmmeter to measure the resistance of the armature and shunt field. You will use the megger to find out if the armature or shunt field is grounded to the frame. The megger is also used to see if the insulation of the armature or shunt field are breaking down under high voltage.
4. You will also notice that this board has five fault switches. When you make your first measurements, these switches should be in the up position.
5. Now with the fault switches in the up position measure the resistance the motor leads and frame(ground) with a meter. Also measure them with an ohmmeter. Then measure with an ohmmeter, the armature and shunt.

OHMMETER	MEGGER	OHMMETER
A1 – A2 = __________ Ohms	A1 = __________ Ohms	A1 = __________ Ohms
F1 – F2 = __________ Ohms	A2 = __________ Ohms	A2 = __________ Ohms
	F1 = __________ Ohms	F1 = __________ Ohms
	F2 = __________ Ohms	F2 = __________ Ohms

6. Now put fault switch No. 1 in the down position and measure the leads again.

OHMMETER	MEGGER	OHMMETER
A1 – A2 = __________ Ohms	A1 = __________ Ohms	A1 = __________ Ohms
F1 – F2 = __________ Ohms	A2 = __________ Ohms	A2 = __________ Ohms
	F1 = __________ Ohms	F1 = __________ Ohms
	F2 = __________ Ohms	F2 = __________ Ohms

What is wrong with the motor? Explain: ______________________________

7. Now put the fault switch No. 1 in the up position and the fault switch No. 2 in the down position and measure the leads again.

OHMMETER	MEGGER	OHMMETER
A1 – A2 = ________ Ohms	A1 = ________ Ohms	A1 = ________ Ohms
F1 – F2 = ________ Ohms	A2 = ________ Ohms	A2 = ________ Ohms
	F1 = ________ Ohms	F1 = ________ Ohms
	F2 = ________ Ohms	F2 = ________ Ohms

What is wrong with the motor? Explain:

____

8. Now put the fault switch No. 2 in the up position and the fault switch No. 3 in the down position and measure the leads again.

OHMMETER	MEGGER	OHMMETER
A1 – A2 = ________ Ohms	A1 = ________ Ohms	A1 = ________ Ohms
F1 – F2 = ________ Ohms	A2 = ________ Ohms	A2 = ________ Ohms
	F1 = ________ Ohms	F1 = ________ Ohms
	F2 = ________ Ohms	F2 = ________ Ohms

What is wrong with the motor? Explain: ____

9. Now put the fault switch No. 3 in the up position and the fault switch No. 4 in the down position and measure the leads again.

OHMMETER	MEGGER	OHMMETER
A1 – A2 = ________ Ohms	A1 = ________ Ohms	A1 = ________ Ohms
F1 – F2 = ________ Ohms	A2 = ________ Ohms	A2 = ________ Ohms
	F1 = ________ Ohms	F1 = ________ Ohms
	F2 = ________ Ohms	F2 = ________ Ohms

What is wrong with the motor? Explain: ____

10. Now put the fault switch No. 4 in the up position and the fault switch No. 5 in the down position and measure the leads again.

OHMMETER	MEGGER	OHMMETER
A1 – A2 = __________ Ohms	A1 = __________ Ohms	A1 = __________ Ohms
F1 – F2 = __________ Ohms	A2 = __________ Ohms	A2 = __________ Ohms
	F1 = __________ Ohms	F1 = __________ Ohms
	F2 = __________ Ohms	F2 = __________ Ohms

What is wrong with the motor? Explain: ______________________________

QUESTIONS #3

Answer the following questions and then turn this completed project into your instructor for grading. Read Megger above in answering these questions. <u>There may be more than on correct answer.</u>

1. A Megger uses high voltage to check the insulation leakage in the megohm range. What is the source of this high voltage? a. A.C. supply voltage
   b. Batteries
   c. A hand-driven D.C. generator
   d. D.C. supply voltage

2. What should a resistance of infinity, read on a Megger, indicate to the electrician? a. The reading is faulty
   b. The reading is above the highest value the instrument is capable of indicating accurately.
   c. The reading is the highest value the instrument can record accurately.

3. Which of the following voltage ratings is most commonly found in Megger's? a. 500 volts
   b. 750 volts
   c. 1,000 volts
   d. 2,500 volts

4. Which of the following output voltages does a 500-volt Megger produce when the crank is rotated faster than the designed rate? a. 100 volts maximum
   b. 550 volts maximum
   c. 500 volts maximum
   d. 600 volts maximum

5. A rotating Megger is prevented from exceeding its rated output voltage by the action of:
   a. An inherent current leakage through its internal insulation.
   b. A battery discharge limiter
   c. A voltage regulation
   d. A slip clutch
6. Meggers can be used to test the insulation resistance of which the followings? a. Motors
   b. Capacitors
   c. Transformers
   d. All the above

MEGGER PROJECT #4

OBJECTIVES: After completing this project, you will be able to:

1. List the six personal safety precautions that should be observed while testing electrical circuitry.
2. Give the purpose of a megger; 3. Tell and show how to use a megger.

DISCUSSION:

There is always inherent danger in testing electrical equipment. The electrician should thoroughly familiarize himself with the equipment under test before working on it. Keep in mind that high voltage may appear at unexpected points in defective equipment. The following list of safety precautions should always be observed.

1. It is good practice to remove power before connecting test leads to high-voltage points. If this is impractical, be especially careful to avoid accidental contact with equipment racks and other objects that can provide a ground. Working with one hand in your pocket and standing on a properly insulated floor lessens the danger of shock.
2. Filter capacitors may store a charge large enough to be lethal. Therefore, discharge filter capacitors before attaching test leads.
3. Remember that leads with broken insulation provide the additional hazard of high voltages appearing at exposed points along the leads. Check test leads for frayed or broken insulation before working them.
4. To lessen the danger of accidental shock, disconnect test leads after they are used.
5. Remember that the risk of sever shock is only one of many possible hazards. Even a minor shock can place the operator in jeopardy of more serious risks, such as a bad fall or contact with a source of higher voltage.
6. The experienced electrician continuously guards against injury and does not work on hazardous circuits unless another person is available to assist in case of an accident.

An instrument that is particularly designed for measuring high resistance is the "megger" (Mega from Greek for million). The megger is used chiefly in measuring insulation values of such equipment as electric motor coils, high-voltage insulation values of such equipment as electric motor coils, high-voltage insulators for transmission lines, capacitors, transformers and so on. By being able to measure the resistance of the insulation of coils of motors, electricians can often detect possible failures before they occur and prevent expensive shut downs by replacing a motor when the megger indicates the resistance is below that recommended by the manufacturer.

The megger consists of a direct-reading ohmmeter and a hand-turned direct-current generator assembled together in a molded case.

(figure 1)

The resistance to be measured is connected to the two leads of the megger, and when the small crank of the generator armature is turned, a pointer then indicates resistance value on a scale. The ohmmeter of the megger has two coils, the potential coil and the current coil which moves together in the field of a permanent magnet. Within the air-gap of this magnet is a Cshaped permanent magnet, around which the coils pivot. Since there are no restraining springs for these coils, there is as little resistance to their rotation as possible. When the meter is not in use, the pointer moves freely across the scale. When the meter is in operation, both coils develop torque, tending to turn the system in opposite directions. When the forces become equalized, the pointer comes to a stop, indicating the value of the resistance that is being measured. When an electrician wants to measure very high resistance of insulation around the wires of a coil, he connects on terminal of a megger to the outside of the insulator, the other terminal to the bare wire if the coil, ad turns the small crank of the instrument at a sufficiently rapid rate to cause the clutch to slip. When this slippage occurs, it signifies that the machine is maintaining the voltage value for which it is calibrated. The pointer will then indicate the resistance of the insulation in millions of ohms, or megohms. Most megger of this type are equipped with 500,1000,2500 or 5000-volt generators. Some meggers have two scales, one for low resistance and one for measuring extremely high resistance.

When making an insulation breakdown test with a megger, continue the test for at least a minute to see if the reading of the meter changes. If the windings are good, the resistance will increase because of capacity effect but if there is a slight leak, the resistance will remain constant. Insulation that shows perfectly good for low voltage, such as that produced by an ohmmeter, will sometimes breakdown under the high voltage of the megger. Two precautions to observe when using a megger are to make sure the circuit being tested is disconnected from the power and de-energized and not to use a megger to test something the high voltage might damage.

Meggers are available with voltage ranges, ranging from 100 to 5000 volts. The correct selection should be based on the voltage of equipment to be tested. If the rated voltage of the equipment =under test is 100 volts or less, 100 or 250-volt megger may be used. A 440 and 550 -volt apparatus may be tested at 500 and 1000-volts: 2,400-volt apparatus at 1,000 to 2,500 volts; 4.150-volt apparatus at 1,000 to 5,000 volts.

When a megger is being operated, the behavior of the pointer should be carefully observed, because much can be learned from its movements. The leakage of current along the surface of dirty insulation is generally indicated by slight kicks down scales whereas the response of the pointer when testing good insulation is a downward dip followed by a gradual climb to the true resistance value. The initial dip of the pointer toward zero is caused by the capacitance of the windings and is especially noticeable in large machines, cables, and capacitors. However, the charging time is short, seldom more than several seconds. The gradual rise in pointer reading with continued cranking is caused by the dielectric-absorption effect of the insulation. It may take hours of days before the electrification is complete and the pointer ceases to rise.

WARNING: All large machines that under-go a long-time insulation test should be discharged after the test is completed. This may be accomplished by grounding the wiring to the frame work if the apparatus and the discharge time should be at least as long as the charging time. When making the ground discharge connection, one end of the grounding wire must first be solidly connected to the frame work of the apparatus(ground), and then the other end clipped to the wiring.

There is no establishment rule or method for determining the minimum value of insulation resistance at which a machine may operate without breaking down. However, standard values of insulation resistance have been recommended and are defined at the least value that a winding should have after cleaning or if an appropriate over potential test is to be applied. Although it is possible to operate machines with much lower values of insulation resistance, the standard should be used as a guide to safe operation.

The recommended minimum insulation resistance for A.C. machine rotor and armature winding and for field winding can be determined from the following formula:

$$R_m = K_v + 1$$

Where Rm = recommended minimum insulation resistance corrected to 40 degrees C, in megohms (measured with a 500-volt megger).
K_v = rated machine voltage, in Kilovolts.

The recommended minimum insulation resistance for dry-type transformers is 2 megohms per 1,000 volts of name plate voltage rating, but in no case less than 2 megohms. The test should be conducted for 60 seconds with a 500=volt megger.

The megger is a portable device that generates its own power. Therefore, it is very necessary for jobs where power is not readily available. For shop and laboratory use, instruments are available that operate on a 60-cycle, single phase, 110 V A.C. to serve the same purpose.

PROCEDURE:

1. Obtain the capacitor test board.

2. You will notice that there are three capacitors on this board. Capacitor No. 1 is oil filled type, capacitor No. is a n electrolyte type and capacitor No. 3 is a mica type. You will notice that the electrolytic capacitor has its terminals marked plus and minus. With electrolytic capacitor you must observe polarity.

3. You will also notice that this board has three fault switches. When you make your first measurements, these switches should be discharge each capacitor by connecting a test lead across its terminals.

4. Now with the fault switches in the up position, measure the resistance of each capacitor with an ohmmeter. Use your highest ohm scale.

   Capacitor No. 1 __________ohms
   Capacitor No. 2 __________ohms
   Capacitor No. 3 __________ohms

Now discharge all capacitor by plugging a test lead into both terminals of each capacitor.

5. Now with the fault switches in the up position measure the resistance of each capacitor with a megger.

   Capacitor No. 1 __________ohms
   Capacitor No. 2 __________ohms
   Capacitor No. 3 __________ohms

Now discharge the capacitor again.

6. Which device, the ohmmeter or the megger gives you the best reading on these capacitors?

7. Now put fault switch No. 1 in the down position and the megger capacitor No. 1. How much resistance do you measure __________ohms?
   What is wrong with capacitor No. 1?
   Discharge capacitor No. 1.

8. Now put fault switch No. 1 in the up position and faulty switch No. 2 in the down position.
   Megger capacitor No. 1.
   How much resistance do you measure? __________ohms What is wrong with capacitor No. 1?
   Discharge capacitor No. 1

9. Now put faulty switch 2 in the up position and faulty switch No. 3 in the down position.
   Megger capacitor No. 1.
   How much resistance do you measure? ___________ohms What is wrong with capacitor No. 1?
   Discharge capacitor No. 1

10. Obtain the transformer test board.

11. You will notice that there are five test jacks on this board. Jacks A and B are the primary terminals. Jacks C and D are the secondary terminals. Jack F is connected to the transformer frame. There are also five fault switches on this board. Make sure that these switches are in the "up" position unless you are told otherwise.

12. With the fault switches in the "up" position, megger and measure the resistance between the following jacks.

    A to B __________ ohms
    C to D __________ ohms
    A to F __________ ohms
    B to F __________ ohms
    C to F __________ ohms
    D to F __________ohms
    A to C __________ohms

13. Now with fault switch No. 1 in the "down" position, Make the same you made in step 12. Is there a fault? Yes/No
    With the aid of an ohmmeter, and a megger what is wrong with the transformer? Explain:

14. Now put fault switch No. 1 in the "up" position and fault switch No. 2 in the "down" position and fault switch No. 2 in the "down" position. Make the same measurements made in step 12. Is there a fault? Yes/No
    With the aid of an ohmmeter and megger, what is wrong with transformer? Explain:

15. Now put fault switch No. 2 in the "up" position and fault switch No. 3 in the "down" Position. Make the same measurements made in step 12. Is there a fault? Yes/No With the aid of an ohmmeter and megger, what is wrong with transformer? Explain:

16. Now put fault switch No. 3 in the "up" position and fault switch No. 4 in the "down" position. Make the same measurements made in step 12. Is there a fault? Yes/No With the aid of an ohmmeter and megger, what is wrong with transformer? Explain:

17. Now put fault No. 4 in the "up" position and fault switch No. 5 in the "down" position. Make the same measurements made in step 12. Is there a fault? Yes/No
    With the aid of an ohmmeter and megger, what is wrong with transformer? Explain:

18. Now turn this completer project into your instructor for grading.

MAGNETISM & ELECTROMAGNETISM

D.C. MOTOR PROJECT #1

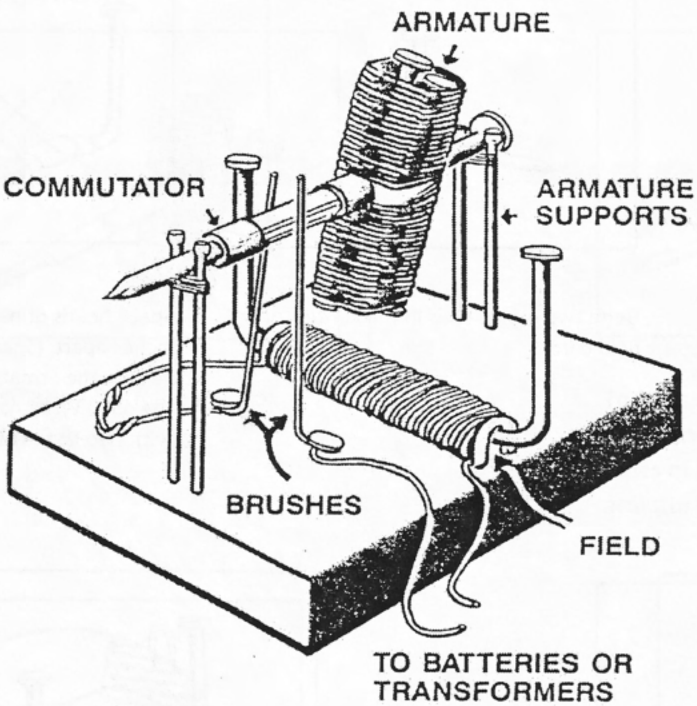
BUILDING A MOTOR

OBJECT:

To examine the construction of a DC motor and Generator.

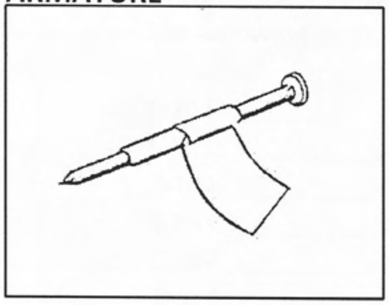
MATERIAL.

Three 3 1/2" nails
Four 2 1/2 "nails
Four 3" nails
6-volt power supply DC
#25 gage enameled wire
Wood boards Plastic tape
Masking tape

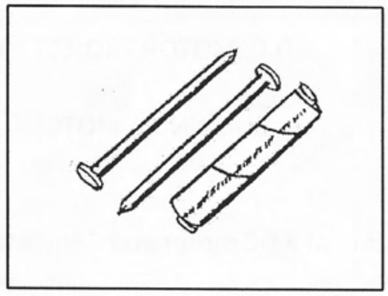


Finished product: Note- Adjust position of the commutator & tension of brushes against it for best operation.

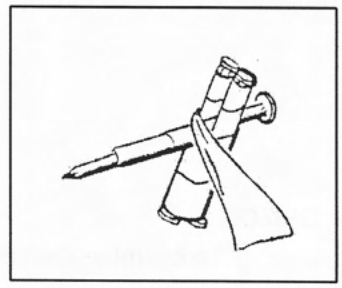
ARMATURE



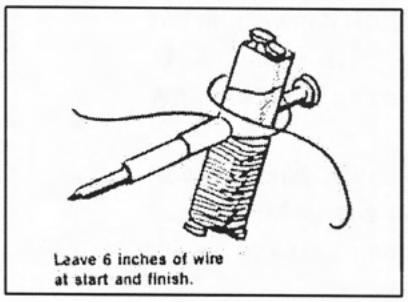
For armature shaft, wrap 1 ½ inches of a 4-inch nail with two layers of tape



For armature core, tape two pairs of 2 ½ inch nails, alternating heads and points.

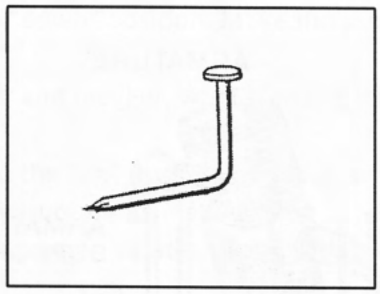


Center one pair of core nails on each side of shaft about 1 inch from head. Wrap with two layers of tape from tip to tip.

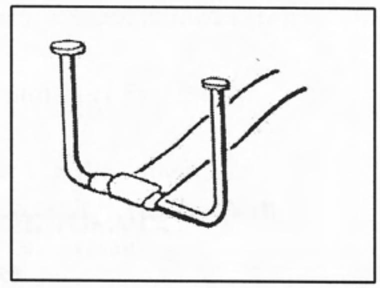


Wind Armature with two layers of wire. Start at shaft, wind out and back on Each half of core. Always wind in the Same direction.

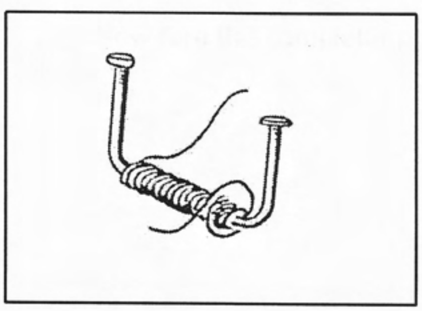
FIELD



Bend two 4-inch nails in the center for field core.

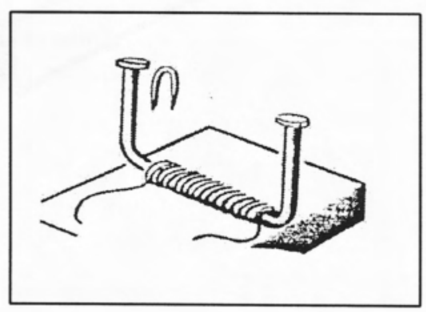


Space heads of nails at least 3 Inches apart. (Spacing is critical be sure the armature will clear the nail.) Wrap nails together with two layers of tape.



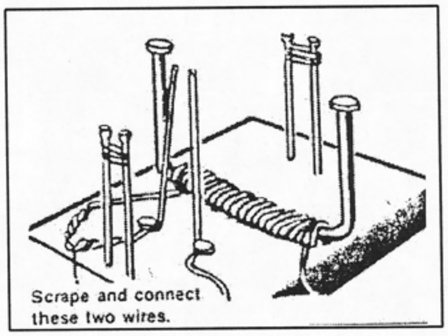
Leave 3 or 4 inches of wire at the start and finish. Wrap the field core with about 400 turns of wire.

After one layer is down, it may be difficult to see the spacing of the next layer. To make turns more visible, you can put down a thin strip of masking tape across the coil before wrapping additional layers. Leave room at each end of coil for attaching to wood base.

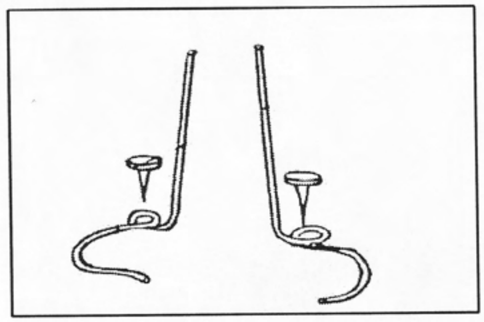


Attach to the wood base with staples Or bent-over brads.

ARAMATURE SUPPOTS AND BRUSHES

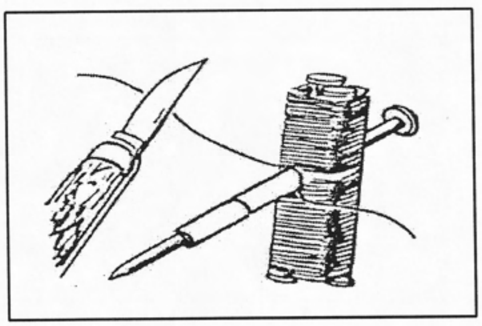


For armature supports, drive four 3-inch Finishing nails into the base, locating them so that the armature turns exactly between The field poles. Wrap wire around the Armature supports to form armature bearings

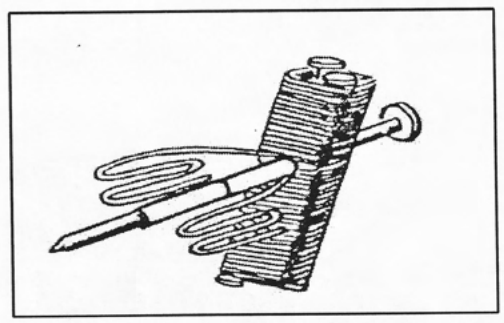


Scrape insulation from the ends of two 6-inch pieces of wire. Tack them to the base and bend as shown to form brushes.

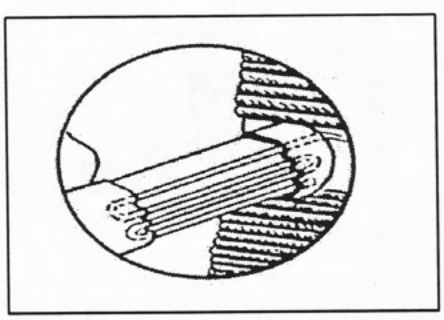
COMMUTATOR



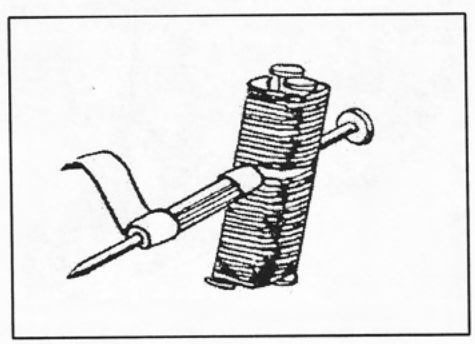
Scrape all insulation from the ends of Armature windings.



To form commutator, bend bare ends of the Wires as shown. Lay against the tape on the Sides of the shaft halfway between the armature coils



Position is critical.



Hold commutator down with narrow Strips of tape as shown.