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AUTHOR	Ziller, T.
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ABSTRACT

This Electric Motor Repair Course is designed to provide the student with practical information for winding, repairing, and troubleshooting alternating current and direct current motors, and controllers. The course is comprised of eight units: (1) Electric Motor Fundamentals, (2) Rewinding, (3) Split-phase Induction Motors, (4) Capacitor Motors, (5) Repulsion Motors, (6) Polyphase Motors, (7) Direct Current Motors and Generators, and (8) Universal and Shaded Pole Motors. Each unit begins with a Unit Learning Experience Guide that gives directions for unit completion. The remainder of each unit consists of Learning Activity Packages (LAP) that provide specific information for completion of a learning activity. Each LAP is comprised of the following parts: objective, evaluation procedure, resources, procedure, supplemental sheets, study guide, and a LAP test with answers. The course is preceded by a pretest which is designed to direct the student to units and performance activities. (LRA)

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MOUNTAIN PLAINS LEARN'NG EXPERIENCE GUIDE:

Electric Motor Repair.

CE 027 790

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Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Learning Experience Guide

COURSE: ELECTRIC MOTOR REPAIR

DESCRIPTION:

This course deals with various kinds and types of electric motors. It will help you to understand theory and enable you to apply theory to motor repair.

RATIONALE:

The Electric Motor Repair Course will provide you with practical information for winding, repairing, and troubleshooting AC and DC motors, and controllers.

OBJECTIVES:

Given service information, tools, supplies and equipment, student will service, diagnose difficulties, dissassemble, order, repair, and replace components for selected AC/DC motors and generators. Successful achievement will be indicated by:

1. Motors function according to manufacturer's standards.
2. Following procedures given on performance checklist.
3. 80% accuracy on multiple choice objectives tests.

PREREQUISITES:

Foundation Education Skills

RESOURCES:

A course resource list is attached.

GENERAL INSTRUCTIONS:

This course has eight units. Each unit has a Unit Learning Experience Guide (LEG) that gives directions for unit completion. Each unit consists of Learning Activitiy Packages (LAPs) that provide specific information for completion of a learning activity. Pretesting results direct the student to units and performance activities.

Principal Author(s): T. Ziller

The general procedure for this course is as follows:

(1) Read the assigned unit LEG for this course.
(2) Begin and complete the first assigned LAP.
  a. Take and score the LAP test.
  b. Turn in the LAP test answer sheet.
  c. Determine the reason for any missed items on the LAP test.
  d. Proceed to the next assigned LAP in the unit.
  e. Complete all required LAPs for the unit by following steps (a) through (d).
(3) Take the unit tests as described in the Unit LEG "Evaluation Procedures".
(4) Proceed to the next assigned unit in this course.
(5) Follow steps 1 through 4 for all required units for this course.
(6) Proceed to the next assigned course.

You will work independently unless directed to do otherwise. When questions or problems arise, you are expected to discuss them with the instructor. At all times remember to follow correct safety procedures during the performance activity.

UNIT TITLES:

.01 Electric Motor Fundamentals
.02 Rewinding
.03 Split-phase Induction Motors
.04 Capacitor Motors
.05 Repulsion Motors
.06 Polyphase Motors
.07 Direct Current Motors and Generators
.08 Universal and Shaded Pole Motors

EVALUATION:

FOLLOW-THROUGH:

After completing this course guide, you may begin with the first unit guide. If you have any questions, consult with your instructor.

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Mountain-Plains Education & Economic Development Program, Inc.
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COURSE TEST: ELECTRIC MOTOR REPAIR

78.01.01.01

1. The ability of a material to permit the setting up of magnetic lines of force is called:

   a. reluctance
   b. permeance
   c. acceptance
   d. reliability

2. The flux lines that represent magnetic force:

   a. follow straight lines
   b. occur only at the magnetics
   c. are uniformly distributed in the area
   d. are concentrated at the ends, or poles, of the magnet

3. If the N pole of one magnet and the S pole of another magnet are brought close together:

   a. the lines of magnetic force will cross each other
   b. they will repel each other
   c. they will demagnetize each other
   d. they will attact each other

4. The magnetic field that forms around a current-carrying conductor is:

   a. a series of closed circles running
   b. a series of concentric circles, or rings, around the conductor
   c. a pattern of lines radiating out from the conductor
   d. parallel to the conductor

5. To determine the direction of the magnetic field around a current-carrying conductor by means of the left-hand rule, you must know:

   a. the direction of current flow in the conductor
   b. the direction of the lines of force
   c. the magnitude of the current
   d. the number of turns per inch

78.01.01.02

6. According to Faraday's law, the voltage generated by the relative motion of a conductor and a magnetic field is:

   a. indirectly proportional to the cross sectional area of the field
   b. directly proportional to the cross sectional area of the field
   c. directly proportional to the rate at which the conductor cuts the lines of magnetic force
   d. always in the same direction, negative to positive

7. When a circuit in which current has been flowing reaches a steady state and the switch is then opened, the magnetic field around the conductor starts to collapse and:

   a. all current flow immediately ceases
   b. the voltage induced by the collapsing field tends to keep the circuit current flowing
   c. a resistance is set up by the induced voltage
   d. mutual inductance increases

8. Which of the following are physical factors that affect inductance?

   a. flux density
   b. the applied voltage
   c. the amount of current flow
   d. the length of the core

9. The amount of inductance in a coil is:

   a. the resistance in a coil
   b. directly proportional to change in current
   c. always in reference to polarity
   d. the number of turns in a coil

10. The strength of induced voltage depends upon:

   a. fields relative motion
   b. the battery applied to the generator
   c. inverse mutual inductance ratio
   d. the number of magnetic lines of force cut by the coil and the speed at which the conductor moves through the field

78.01.01.03

11. Total current used by the motor is determined by:

    a. the power reduction ratio
    b. the field and armature currents
    c. the constant speed of the motor
    d. the percent of speed regulation

12. If the starting winding were burned out in a split-phase motor, when the power is turned on it would:

    a. short circuit the winding
    b. not start
    c. burn out the run winding
    d. reverse the rotation

13. If the load is removed from a series motor:

    a. it will decrease its speed
    b. it will run normally
    c. it will increase its speed
    d. it will destroy itself by centrifugal force

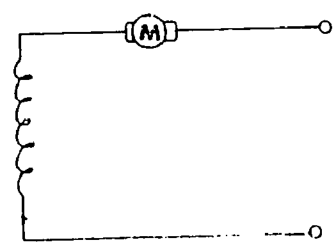


Fig. 1

14. Identify the schematic in Fig. 1.

    a. dyna motor
    b. parallel motor
    c. series motor
    d. syncro motor

15. Identify the schematic in Fig. 2.

    a. syncro motor
    b. compound motor
    c. parallel motor
    d. dyna motor

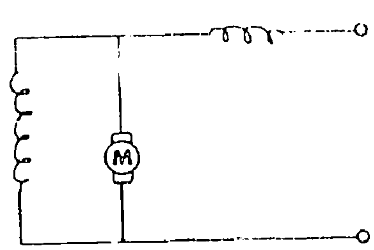


Fig. 2

78.01.01.04

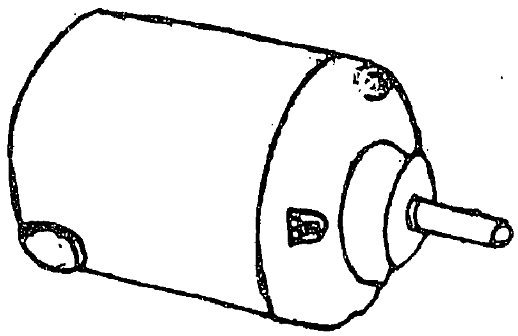
16. On the illustration of the universal motor, what number would identify the field coils:

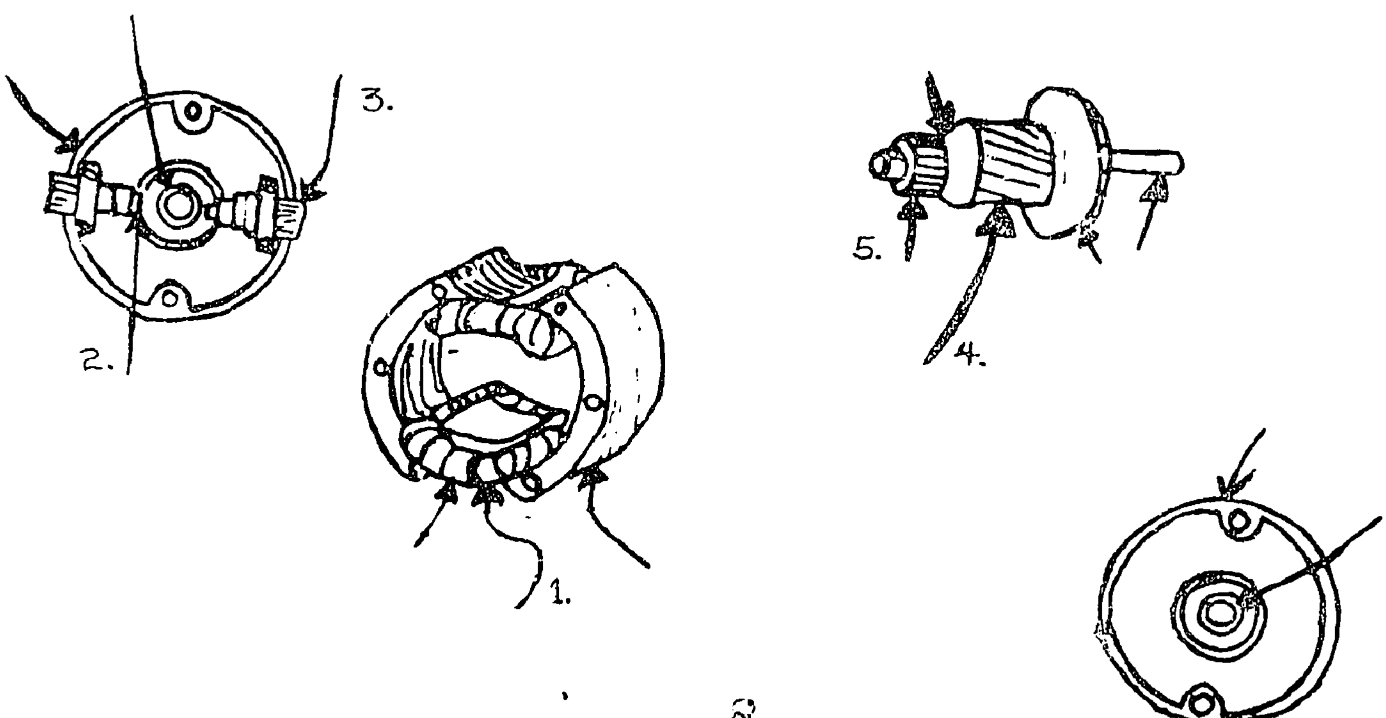
    a. 3
    b. 2
    c. 1
    d. 4

17. On the illustration of the universal motor, which number would identify the commutator?

    a. 2
    b. 1
    c. 4
    d. 3

UNIVERSAL MOTOR





78.01.01.04 (continued)

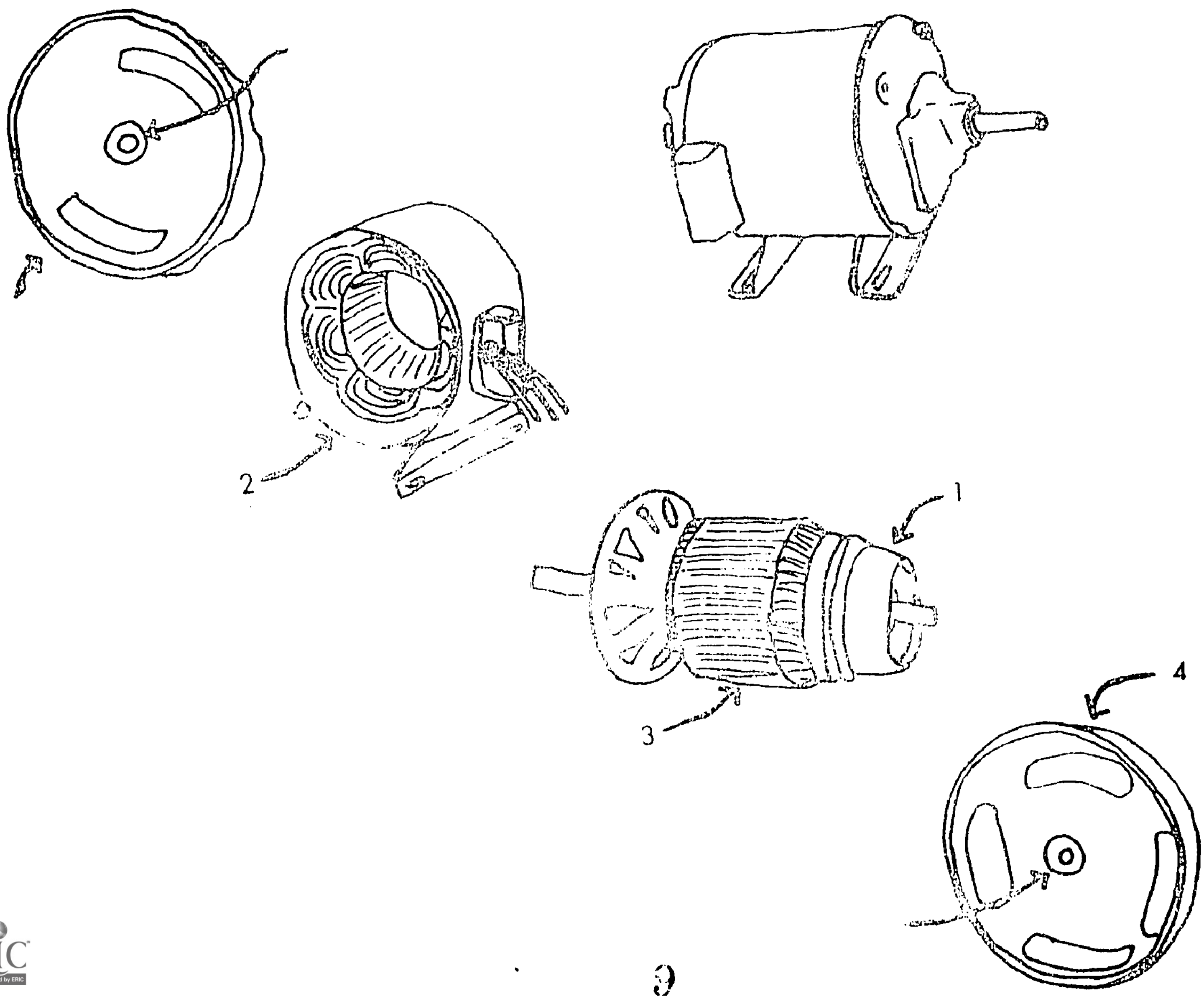
18. On the illustration of the repulsion type motor, which number would identify the commutator?

    a. 4
    b. 2
    c. 3
    d. 1

19. On the illustration of the repulsion type motor, which number would identify the stator and winding?

    a. 3
    b. 1
    c. 2
    d. 4

REPULSION-TYPE MOTOR

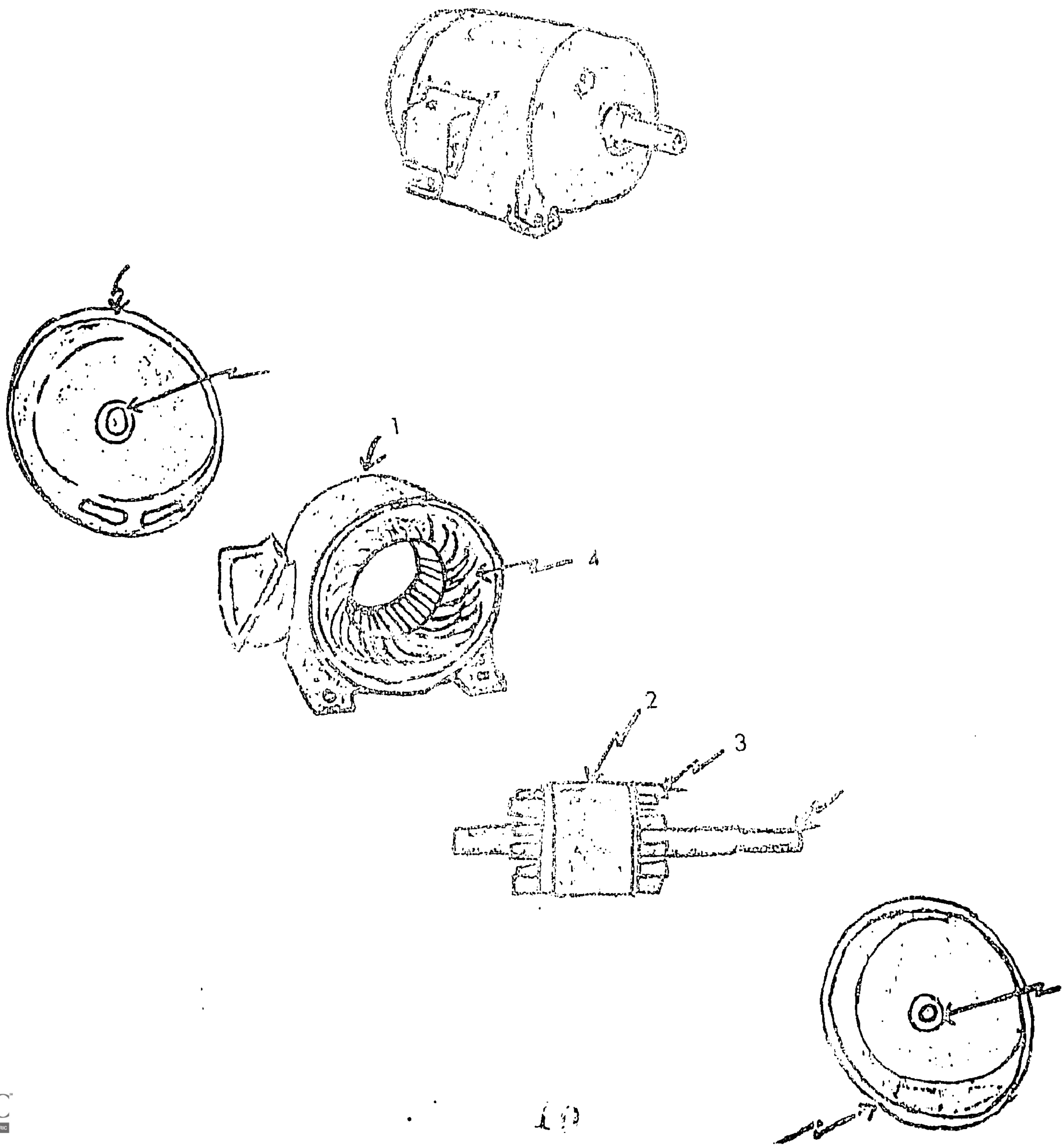


78.01.01.04 (continued)

20. On the illustration of the polyphase motor, which number would identify the stator?

a. 2
b. 1
c. 3
d. 4

POLYPHASE MOTORS



78.01.01.05

21. What are the two classes of induction motors?

    a. squirrel cage and wound rotor
    b. split phase and capacitor start
    c. wound rotor ard syncronous
    d. squirrel cage and shaped pole

22. What rotates in a shaded-pole motor?

    a. field coil
    b. armature
    c. squirrel cage
    d. shade coil

23. What device is used in a capacitor start motor to connect the AC voltage from the start to the run winding?

    a. resistor
    b. capacitor
    c. centrifugal switch
    d. inductor switch

24. A machine that converts mechanical energy to electrical energy is called:

    a. an armature
    b. a generator
    c. a motor
    d. a capacitor

25. A machine that converts electrical energy into mechanical energy is called:

    a. a generator
    b. a motor
    c. an alternator
    d. a capacitor

78.01.02.01

26. Why is the term "end room" important, when taking data on a motor?

    a. only because of the run winding
    b. only because of the start winding
    c. because the end plates may press against the coils and cause a short
    d. because of insulation paper

78.01.02.01 (continued)

27. Identify the information necessary in taking data for the rewinding of a motor.

    a. none of the following
    b. obtain information on both the run and start windings
    c. note specific information concerning the old windings
    d. obtain as much data as possible

28. What information would you put on your data sheet if the start winding on a motor was shorted?

    a. don't put anything on the data sheet
    b. put just the start winding on the information sheet
    c. put just the run winding on the data sheet
    d. put both the run winding and start winding information

29. Why is taking the proper data, when working on a motor, important?

    a. it is just something we do in schools
    b. it is added paper work to increase the price it costs the consumer
    c. so that no difficulty will be encountered upon reassembly
    d. it is not needed

30. What is meant by the pitch of a coil on a motor?

    a. the number of slots separating the sides of a coil
    b. the number of groups of coils
    c. the number of degrees they are apart
    d. how far the coil protrudes from the slots

78.01.02.02

31. While stripping the stator on a motor, why is it important to count the turns of wires and number of coils per pole?

    a. to check the manufacturer's specifications
    b. to get it on the data card, so when it is rewound, it will have the same number of turns per pole
    c. to guard against a change in polarity
    d. because when it is rewound, it should have 5 less coils per pole than are unwound

32. If only the start winding on a motor is to be changed, you should:

    a. cut one end of each coil and pull
    b. change both start and run windings
    c. lift out the start winding and remove the wedges with a hacksaw
    d. remove the wedges and lift out the start winding

<u>78.01.02.02</u> (continued)

33. How long should the stator on a motor be on the burning pit?

    a. 30 minutes
    b. several hours
    c. one hour
    d. 24 hours

34. While stripping the stator on a motor, should you check wire size?

    a. Yes, you have to determine new winding sizes
    b. No, anyone can guess the wire size
    c. Sometimes you should just in case you lose the stator
    d. Never, it's not that important

35. One method of stripping a stator is to:

    a. cut both sides off
    b. cut each coil on one side and pull the coil out the other
    c. pull
    d. cut each coil on one side and pull

<u>78.01.02.03</u>

36. When insulating a motor stator, when would you use a paper cutter?

    a. to cut insulation only to be cuffed
    b. to cut insulation to proper width
    c. to cut the cuff only
    d. to cut only the wedges

37. The best procedure to follow when reinsulating a core on a motor is to:

    a. it isn't necessary to reinsulate the core
    b. replace it with thinner insulation than was originally used
    c. replace it with thicker insulation than was originally used
    d. replace it with the same type and thickness of insulation as used in the original winding

38. Class A insulation is used when rewinding a motor and is made of:

    a. ragstock paper
    b. heavy paper
    c. dacron-mylar
    d. mylar

39. What type of insulation is used when reinsulating a core on a motor because it is resistant to high temperature and has high tensile strength?

    a. ragstock paper
    b. mylar combination
    c. nylon paper
    d. dacron-mylar

78.01.02.03 (continued)

40. When reinsulating a core on a motor, the cuff should be turned back:

a. 1/4 inch
b. 5/8 inch
c. 1/2 inch
d. 1/8 inch

78.01.02.04

41. What two ways are usually used to measure wire for a motor?

a. micrometer
b. American screw gauge and depth gauge
c. American wire gauge and feeler gauge
d. micrometer and wire gauge

42. Which of the following ways of winding will produce the tightest winding possible?

a. skein
b. form winding
c. motor winding
d. hand winding

43. Before winding a motor, which of the following should be completed first?

a. remove end bells
b. collect necessary data
c. remove stator
d. insulate slots

44. In a skein winding, which of the following is of prime importance, when winding the stator of a motor?

a. radius must be exact
b. circumference must be exact
c. shape (round) must be exact
d. shape (rectangular) must be exact

45. Which of the following types of windings should not be used, if the wire size is over 21 A.W.G.?

a. hand
b. firm
c. skein
d. machine

78.01.02.05

46. In a motor, all the coils are wound with the same size:

    a. start winding
    b. magnetic wire
    c. set of coils
    d. leads

47. Series field coils consist of which of the following in a DC motor?

    a. light wire with many turns
    b. heavy wire with many turns
    c. heavy wire with a few turns
    d. light wire with a few turns

48. Shunt fields in a DC motor consist of which of the following?

    a. heavy wire with a few turns
    b. light wire with many turns
    c. light wire with many turns
    d. heavy wire with many turns

49. Interpole fields in a DC motor consist of which of the following?

    a. heavy wire with a few turns
    b. heavy wire with many turns
    c. light wire with a few turns
    d. light wire with many turns

50. Most generally, the poles in a DC motor are connected:

    a. in a series
    b. in a parallel
    c. in a series parallel
    d. alternately series than parallel

78.01.02.06

51. Before dipping, the stator from a motor should be placed in a baking oven for:

    a. 10 minutes
    b. 45 minutes
    c. 60 minutes
    d. 30 minutes

52. At what approximate temperature should the stator on a motor be preheated?

    a. 200 degrees F.
    b. 112 degrees F.
    c. 250 degrees F.
    d. 250 degrees C.

78.01.02.06 (continued)

53. When varnishing a motor, the entire process of dipping or trickling the varnish should take no longer than:

    a. 5 to 10 minutes
    b. 20-30 minutes
    c. 15-20 minutes
    d. 10-15 minutes

54. When varnishing a motor, a type of varnish that does not require baking is:

    a. orange varnish
    b. resin varnish
    c. air drying varnish
    d. polyester varnish

55. When do you varnish the new windings in a stator of a motor?

    a. after installing the windings in the stator and before installing flexible leads
    b. after installing the windings, completing a test and installing flexible leads
    c. after installing the windings in the stator
    d. before installing the windings in the stator

78.01.03.01

56. When repairing an electric motor, is it necessary to know the number of hours worked to fill out a work order?

    a. Yes, for billing purposes
    b. Yes, for complete records
    c. No, only if trying to do it faster then someone else
    d. No, this information isn't necessary

57. On a work order sheet for repairing an electric motor, the job description is:

    a. a description of location
    b. a description of the customer
    c. a description of the trouble
    d. a description of parts used

58. Why is the date received on a work order for repairing an electric motor important?

    a. it makes no difference
    b. it identifies the oldest routine order to work on
    c. only if it's routine is it important
    d. always leave blank

78.01.03.01 (continued)

59. What does the grand total column on a work order for repairing an electric motor include?

   a. cost of material used only
   b. dollars per hour of labor only
   c. total cost of all material and labor
   d. total cost of labor only

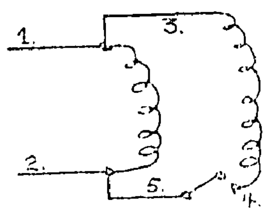
60. When would you put something in the "Needed By" block of a work order when repairing a motor?

   a. always fill it in
   b. always leave blank
   c. only if it's needed immediately
   d. only if it is routine

78.01.03.02

61. On a split phase induction motor, the start winding is located between:

   a. 4-5
   b. 1-2
   c. 1-4
   d. 3-4



62. What is the other name used to refer to the start winding on a split phase induction motor?

   a. run winding
   b. main winding
   c. auxiliary winding
   d. squirrel cage winding

63. When [illegible] a split phase induction motor, the current flowing through both the running and starting windings:

   a. causes a centrifugal force
   b. causes a rotor to turn
   c. closes centrifugal switch
   d. causes a magnetic field

64. The run winding on a split phase induction motor is located between:

   a. 1-4
   b. 4-5
   c. 3-4
   d. 1-2

(see diagram for question 61)

78.01.03.02 (continued)

65. In the run winding of a split phase induction motor, how many poles are there?

a. 3
b. 2
c. 1
d. 4

78.01.03.03

66. Where is the squirrel-cage winding found on a split phase induction motor?

a. inside the rotor
b. inside the stator
c. inside the rear end plate
d. inside the front end plate

67. The stator on a split phase induction motor is labeled by what number?

a. 8
b. 7
c. 2
d. 3

(see diagram 1 on next page)

68. On a split phase induction motor, of the two windings inside the stator, which is the run winding?

a. the smallest diameter wire
b. heavy copper bars
c. the thin flat bars on the rear endplate
d. the largest diameter wire

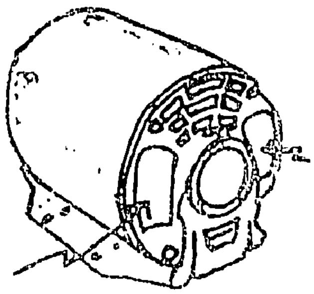
69. Which end of a split phase induction motor has the two punch marks on the stator housing and end plates?

a. the rear endplate
b. the shaft end
c. on the shaft
d. both ends

70. On a split phase induction motor which end plate should be taken off first?

a. bottom plate
b. rear end plate
c. shaft end plate
d. front end plate

SPLIT PHASE INDUCTION MOTOR



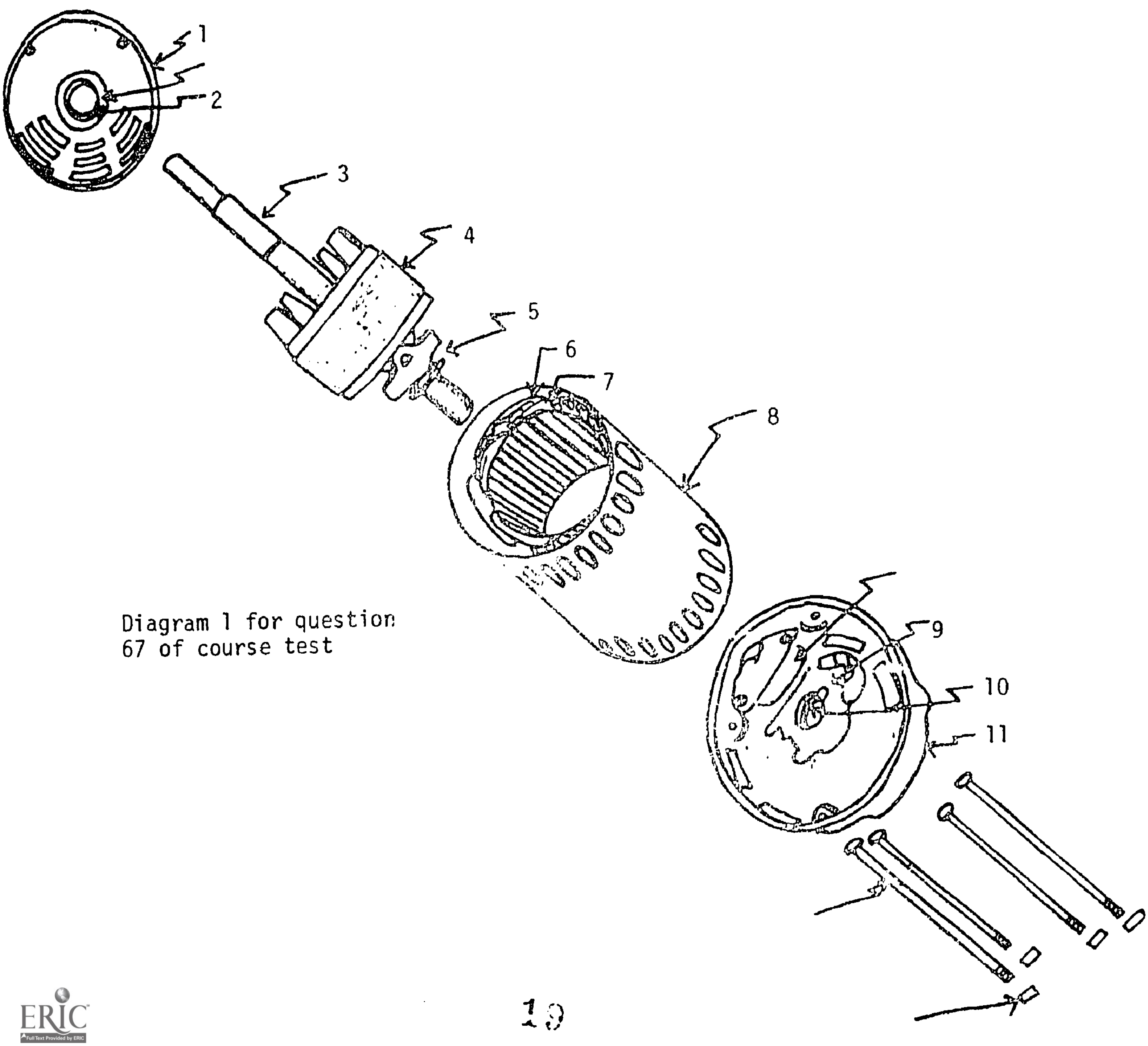


Diagram 1 for question
67 of course test

78.01.03.04

71. If the start winding of a split phase induction motor remains in the circuit, the:

    a. contact points are burnt
    b. centrifugal switch is not closing
    c. centrifugal switch is not opening
    d. start winding is shorted

72. To determine whether a winding on a split phase induction motor is grounded, while using a test lamp you would:

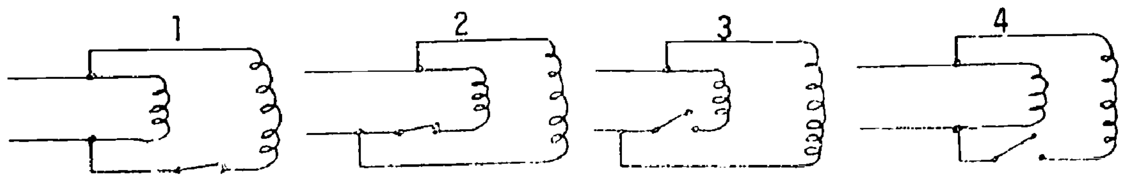
    a. connect one test lead to centrifugal switch and one to power lead
    b. connect test lead in series with the run or start windings
    c. connect one test lead to the rotor and one to the power line
    d. connect one test lead to power lead and other lead to core

73. If a split phase induction motor smells and feels hot, the probable cause is:

    a. a bad connection
    b. a shorted winding
    c. the centrifugal switch is not closing
    d. an opening in the winding

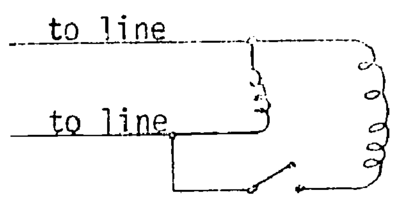
74. In which schematic below is the split phase induction motor in the starting position?

    a. 2
    b. 1
    c. 3
    d. 4



75. In the schematic below, the split phase induction motor:

    a. has reached 75% of normal speed
    b. is in starting position
    c. will not run
    d. has reached 25% of normal speed



78.01.03.05

76. How would you check for an over loaded motor?

    a. use a watt meter
    b. use an ohmmeter
    c. look for excessive heat or use an ammeter
    d. look for cold or use a voltmeter

77. What might be the cause if the split phase induction motor won't start?

    a. loose end-bell
    b. loose bearing
    c. bad run winding
    d. bad start winding

78. If a split phase induction motor draws more current than its rated load, it will:

    a. open
    b. short
    c. ground
    d. produce excessive heat

79. If a split phase induction motor runs slower than normal speed, it may be because of a :

    a. short squirrel cage winding
    b. bad centrifugal switch
    c. bad start winding
    d. short in the run winding

80. If a split phase induction motor runs at a reduced speed, it may indicate:

    a. an open in the start winding
    b. an open in the centrifugal switch
    c. loose rotor bars
    d. an open run winding

78.01.04.01

81. On a two valve capacitor motor, what purpose does the centrifugal switch serve?

    a. to substitute a lower capacity
    b. takes the capacitor and run winding out of circuit
    c. takes the capacitor and start winding out of circuit
    d. takes the start winding and capacitor out of the circuit

78.01.04.01 (continued)

82. What is taken off the line after a motor reaches approximately 75% full speed?

a. start winding and capacitor
b. capacitor and centrifugal switch
c. start winding and rotor
d. run winding and centrifugal switch

83. How are the two valves of capacitance housed?

a. two capacitors are in series
b. by using a transformer
c. two capacitors are in parallel
d. dual capacitors are in one can

84. What is connected to the line after the motor reaches approximately 75% full speed?

a. run winding
b. capacitor
c. centrifugal switch
d. start winding

85. What happens to the capacitor when approximately twice normal voltage is applied?

a. capacity increases as the square of the voltage
b. capacity decreases by 1/2 the voltage
c. capacity remains the same, the voltage is doubled
d. capacity decreases as voltage increases 4 times

78.01.04.02

86. Where is the centrifugal switch located in a capacitor start motor?

a. inside the stator
b. on the rear end plate
c. on the top of stator
d. on the front end plate

87. Normally, where is the capacitor located on a capacitor start motor?

a. inside the rear end plate
b. inside the stator
c. on top of the stator
d. in the rotor

88. What is the only difference between a capacitor start motor and a split phase motor?

a. run winding
b. none
c. capacitor
d. centrifugal switch

78.01.04.02 (continued)

89. How is a capacitor rated?

a. by amps
b. by farads
c. by OHMS
d. by WVDC

90. In a capacitor start motor the capacitor is in parallel with:

a. run winding
b. bearings
c. start winding
d. centrifugal switch

78.01.04.03

91. If a capacitor start motor has difficulty starting with no load applied, the trouble may be:

a. open windings
b. defective capacitor
c. over load
d. bad centrifugal switch

92. The capacitance of a motor starting capacitor should be within what % of the rated capacity?

a. 10%
b. 30%
c. 20%
d. 40%

93. On a capacitor start capacitor run motor, what type of capacitor is used?

a. oil capacitor
b. two valve paper capacitor
c. two valve oil capacitor
d. paper capacitor

94. What will the ohmmeter show if the capacitor is shorted?

a. + lead on + terminal = lead on - terminal on high - reverse
b. the ohmmeter will give a different reading
c. the ohmmeter will show zero OHMS
d. the ohmmeter will show infinity reading

78.01.04.03 (continued)

95. How is a capacitor checked using an ohmmeter?

a. the ohmmeter will give a different reading
b. lead on + terminal - lead on = terminal ohmmeter on high
c. the ohmmeter will show zero OHMS
d. the ohmmeter will show infinity reading

78.01.04.04

96. In a capacitor start motor, if the varnish is scraped or nicked in one spot, should it be installed in the starter?

a. occasionally
b. never
c. always
d. sometimes

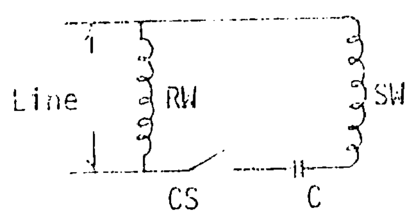
97. When you apply current to a capacitor start motor and the fuse burns out look for:

a. shorted winding
b. open capacitor
c. too small fuse
d. wrong connections

98. Which is the proper schematic for a capacitor start motor?

a.
b.
c.
d.

a.



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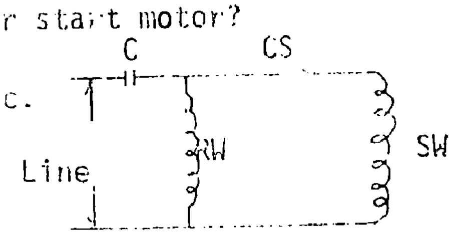

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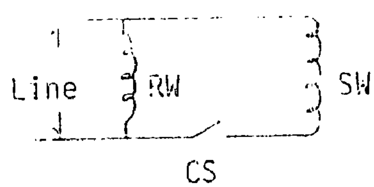

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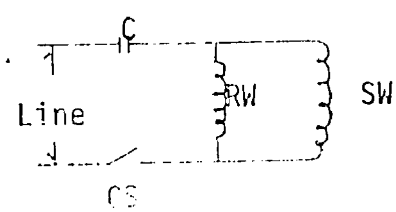


99. When a capacitor start motor is first put on the work bench, which of the following should be done?

a. plug it into a voltage source and see what doesn't work properly
b. refer to manufacturers booklet
c. dismantle and look inside
d. use a test lamp or ohmmeter and check for grounds, shorts, opens

78.01.04.04 (continued)

100. If a capacitor start motor without a load hums, but does not run, suspect:

a. overload
b. defective capacitor
c. shorted winding
d. grounded winding

78.01.05.01

101. What are the two types of repulsion start induction motors?

a. brush-lifting and brush-riding
b. brush-riding and commutator
c. centrifugal devices and commutator
d. brush-lifting and centrifugal device

102. The one advantage of a repulsion induction motor is:

a. no commutator
b. no centrifugal switch mechanism used
c. that it can be called an inductive series motor
d. no compensating winding

103. What is one feature common in all types of repulsion motors?

a. each has a centrifugal switch
b. each uses a capacitor
c. each has slip rings
d. each has a rotor containing a winding connected to a commutator

104. On a repulsion start induction motor using an axial commutator, the brushes:

a. remain [illegible] same
b. lift
c. ride
d. can do both ride and lift

105. On a brush-lifting type of repulsion start induction motor when does the brush move away from the commutator?

a. at approx. 85% of full speed
b. at approx. 50% of full speed
c. at approx. 25% of full speed
d. at approx. 75% of full speed

78.01.05.02

106. What is the purpose of the spring barrel on a repulsion start induction motor?

a. it has no real purpose
b. it holds the short circuiting necklace in place
c. it moves the governor weights
d. it helps remove the governor springs

107. On repulsion type motors, what is the purpose of the governor weights?

a. it causes the short circuiting necklance to short cut the commutator
b. it controls the speed of the rotor
c. it pushes the brushes away from the commutator
d. it moves only the push rods

108. What is the purpose of the stator of a repulsion type motor?

a. to hold the core
b. to hold the brushes
c. to hold the armature winding
d. to hold the laminated core and field winding

109. What is the purpose of the short circuiting necklace in repulsion type motors?

a. to hold the push rods in center position
b. to move the governor weights
c. to short cut the commutator windings
d. to hold the spring barrel

110. On a repulsion start induction run motor, the copper bars that are perpendicular to the shaft are called:

a. commutator threads
b. axial commutator
c. spring barrel commutator
d. radial commutator

78.01.05.03

111. What is used in testing for grounds on a repulsion motor?

a. volt meter
b. internal growler
c. DC battery and compass
d. test lamp

<u>78.01.05.03</u> (continued)

112. If the repulsion type motor keeps burning out fuses, the trouble may be:

a. worn bearings
b. open field
c. shorted armature
d. worn brush holder

113. If the repulsion type motor hums but does not run, the trouble may be:

a. loose centrifugal device
b. grounded stator
c. high MICA
d. overload

114. Open armature coils will cause the repulsion type motor to:

a. hum but not run
b. become excessively hot
c. spark internally
d. burn out fuses

115. A growler is used to test the:

a. stator for shorts
b. armature for shorts
c. armature for opens
d. stator for grounds

<u>78.01.05.04</u>

116. If a repulsion start induction motor is set on the soft neutral position, how can this be checked?

a. with an ohmmeter
b. with a voltmeter
c. by moving brushes so motor will not run, then to right slightly
d. with an ammeter

117. On a brush lifting repulsion motor, if the brushes are shifted to the right, the armature will rotate:

a. clockwise
b. counterclockwise
c. varying the speed
d. 90 degrees

78.01.05.04 (continued)

118. What type of material are brushes made of for repulsion type motors?

   a. carbon or graphite
   b. carbon post
   c. graphite post
   d. copper or lead

119. In repulsion type motors, if the brushes are moved clockwise, the armature will rotate in a:

   a. clockwise direction
   b. the motor will stop
   c. the direction will not be changed
   d. counterclockwise direction

120. What is commonly referred to as a "pigtail" [illegible] for a repulsion type motor?

   a. the type of connection in armature
   b. the copper wire on one end of the brush
   c. the type of connection in the commutator
   d. the type of connection in stator

78.01.06.01

121. The rotor of a three phase motor contains a:

   a. die-cast core
   b. wound core
   c. laminated core
   d. solid core

122. The operation of practically all polyphase motors depends on a:

   a. revolving magnetic field
   b. stationary magnetic field
   c. stationary solenoid
   d. revolving solenoid

123. Polyphase motors are:

   a. unive[illegible] motors
   b. A-C/D-C motors
   c. A-C motors
   d. D-C motors

78.01.06.01 (continued)

124. Three phase motors vary from fractional/horsepower size to:

a. several thousand HP
b. several hundred HP
c. a few HP
d. several HP

125. The three main main parts of a three phase motor are end plates, stator, and:

a. armature
b. commutator
c. field coils
d. rotor

78.01.06.02

126. Three phase motors have a fairly constant characteristic of:

a. torque
b. voltage
c. frequency
d. speed

127. An AC motor that is designed for either three phase or two phase operation is called a:

a. repulsion type motor
b. polyphase motor
c. split phase motor
d. split phase capacitor start motor

128. What is the purpose of the stator of a three phase motor?

a. [illegible] the rotor
b. to hold the bearings
c. to house the laminated core and windings
d. to enable the shaft to turn

129. What is the [illegible] of the end bells of a polyphase motor.

a. to hou[illegible] [illegible]ngs and to hold [illegible]
b. to en[illegible] [illegible] to turn
c. to house [illegible] stator
d. to house the w[illegible]

78.01.06.02 (continued)

130. What is the difference internally in two types of polyphase motors?

a. the coils are the same but the internal connections are different
b. the coils and internal connections are the same
c. the coils are wound differently but the connections are the same
d. both the coils and internal connections are changed

78.01.06.03

131. In what way is an internal growler used to test a polyphase motor, parallel-connected, for shorts:

a. parallels disconnected-growler in position = bad coils become hot
b. parallels disconnected - note vibrations of hacksaw blade
c. by noting the vibrations of a hacksaw blade
d. hold the growler in position-defective coils will become hot

132. In a polyphase motor, if there is a reversed phase, the motor will:

a. run properly
b. fail to start
c. become excessively hot
d. not run properly

133. In a polyphase delta-connected motor using a test lamp, how would you determine which phase is open?

a. disconnect at delta point and test each phase separately
b. place one lead at delta point and the other on each phase lead
c. you can not test delta connected motors for opens
d. disconnect the phases and test each phase separately

134. Reverses in a polyphase motor may occur in:

a. groups
b. coils
c. phases
d. all answers are correct

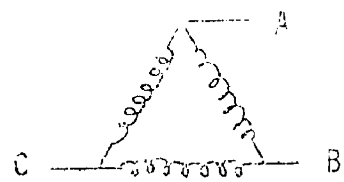
135. In a polyphase delta connected motor, using a test lamp, how would you locate a grounded phase?

a. disconnect at delta point and test each phase separately
b. place one test lead at delta point and the other test lead to power leads
c. disconnect phases at leads and test each phase separately
d. place one test lead to motor frame and one test lead to one of the power leads

78.01.06.04

136. This schematic symbol is for what type of three phase connection?

a. WYE
b. star
c. pigtail
d. delta



137. If you have only a rectangular form for a three phase motor coil, how can you make it into a diamond?

a. by pulling at the center of opposite sides
b. can't be done
c. only by using a diamond-shaped head
d. can only make a diamond if using a rounded form

138. How are Wye-connected coils of a three phase motor connected?

a. the ends of each coil together, the beginning of each to a phase
b. beginning of each coil connected together
c. the ends of each phase connected together
d. the beginning of each phase connected together

139. What type of tape is preferred on a coil in a three phase motor?

a. black electrical tape
b. varnished cambric or fiberglass tape
c. rubber tape
d. cotton tape

140. What type of tape is often used to tape the coils of a three phase motor?

a. cotton
b. electrical
c. paper
d. rubber

78.01.07.01

141. What is the first step in disassembling a D C motor?

a. mark the end bells and frame with a pin punch
b. remove the retaining bolts
c. lift the brushes out of their holders
d. unscrew the pigtail connections and remove the brushes

78.01.07.01 (continued)

142. On which part of a D C motors' armature do the brushes ride?

a. on the commutator
b. on the armature coils
c. on the field coil
d. on the brush holder

143. On all D C motors, current must be conducted to the armature winding through the:

a. brushes
b. end bells
c. bearing
d. brush holders

144. In a D C motor, the field poles hold the:

a. armature
b. field coils
c. run and start windings
d. run winding

145. In a D C motor, the brushes are held stationary by the:

a. commutator
b. brush holders
c. brush rigging
d. end plates

78.01.07.02

146. A shunt field and armature connected in series is characteristic of what type of motor?

a. universal
b. series
c. compound
d. shunt

147. Which of the following is characteristic of a D C shunt motor?

a. variable speed
b. low speed
c. high speed
d. constant speed

78.01.07.02 (continued)

148. Which of the following components in a D C shunt motor prevents a rise in speed?

a. heavy shunt field
b. carbon brushes
c. centrifugal switch
d. light series field

149. A stabilized shunt motor contains which of the following?

a. a rotor
b. a heavy series field
c. variable field
d. a light series field

150. Which of the following characteristics does a D C series motor have?

a. heavier load, higher speed
b. variable speed
c. low starting torque
d. lighter load, lower speed

78.01.07.03

151. In a two-pole D C series motor the fields are connected in:

a. series
b. tandem
c. parallel
d. unison

152. To reverse the rotation of a D C series motor, all that is necessary is to interchange the leads on the:

a. terminal block
b. starter
c. armature
d. brush holders

153. In a D C compound motor, if the current flows through the series-field and shunt-field coils of a pole in the same direction, and the shunt field is connected across the line. It is known as a:

a. long-shunt cumulative motor
b. long-shunt differential motor
c. short-shunt differential motor
d. short-shunt cumulative motor

78.01.07.03 (continued)

154. In a D C compound motor, the shunt fields are connected in:

a. tandem
b. series
c. parallel
d. unison

155. On a four-pole, compound-interpole motor, if the leads on the brushholder are reversed, it will cause:

a. the motor to operate correctly
b. the interpoles to overload
c. the brushes to spark
d. the motor to stop

78.01.07.04

156. If a D C motor fails to run when the switch is turned on, the trouble may be:

a. the wrong voltage applied
b. off-set brushes
c. an open armature circuit
d. a dirty commutator

157. Why does the NEC require that all permanently installed D C motors be grounded to a pipeline which is connected to the earth?

a. if not properly grounded, the operator may be severely shocked
b. it causes the motor to burn open
c. it has nothing to do with motor operation
d. it adds cost to the overall installation

158. If a D C motor runs slowly, the trouble might be:

a. open coils
b. wrong interpole polarity
c. worn bearings
d. grounded coils

159. How many circuits are in a shunt motor?

a. 2
b. 1
c. 3
d. 4

78.01.07.04 (continued)

160. In a D C motor, if a bare wire touches the laminated pole, the motor is said to be:

a. interpoled
b. open
c. grounded
d. shorted

78.01.07.05

161. When is a generator said to be separately excited?

a. when the field coils are connected to an outside source of electricity
b. at 110 V
c. when the commutator is connected to an outside source of electricity
d. when the armature is connected to a battery

162. How many types of self-excited generators are there?

a. 4
b. 1
c. 2
d. 3

163. When a conductor is moved across the lines of force in a magnetic field, a voltage will be induced in the:

a. conductor
b. flux
c. magnetic field
d. force

164. A machine converting mechanical energy into electrical energy is called:

a. starter
b. motor
c. generator
d. engine

165. A wire moved to cut lines of magnetic force will produce:

a. mechanical energy
b. electromotive force
c. heat energy
d. static pressure

78.01.07.06

166. The direct current generator is constructed similar to the
    a. three phase motor
    b. split phase motor
    c. D C motor
    d. shaded pole motor

167. D C generators are rated in terms of:

    a. horsepower
    b. volts
    c. kilowatts
    d. AMPS

168. To discover the current output of a generator, the ammeter should be connected in:

    a. series with the generator
    b. series with the load
    c. parallel with the load
    d. parallel with the generator

169. Generator voltage can be varied by using a resistor across the series field to vary the current through it. This is called a:

    a. exciter
    b. diverter
    c. commutator
    d. shunt

170. Direct current from a battery is used to:

    a. energize the commutator
    b. run the generator
    c. keep the current flowing in the same direction
    d. excite the field coils of a generator

78.01.07.07

171. If a generator has too much resistance in the field circuit, the generator will:

    a. not generate
    b. rotate
    c. operate only slightly
    d. operate normally

78.01.07.07 (continued)

172. If a generator has too much resistance in its field circuit, the trouble may be:

a. shorted field coils
b. loose connections
c. bad bearings
d. grounded field coils

173. If a generator does not generate power, the trouble may be:

a. loss of residual magnetism
b. an overload
c. a differential connection
d. too slow a speed

174. What would be the probable cause of a smoking D C generator?

a. the wrong field connection
b. a completely shorted armature
c. a loss of residual magnetism
d. a bad bearing

175. Why would a wrong field connection result in a non-operational generator?

a. the lines of force would be produced opposite of the residual lines
b. the armature would short and burn
c. a high resistance force would be created
d. the lines of force would be produced in the direction of the flux

78.01.07.08

176. What could prevent sufficient current from flowing in the field coils of a generator?

a. loss of residual magnetism
b. wrong field connection
c. faulty field rheostat
d. wrong rotation

177. Why is it important to replace a D C generator's brushes with replacements of the same type and size?

a. severe sparking may result if brushes are different
b. the generator will not operate at all
c. the bearing will freeze up
d. it is not necessary, any size and type can be used

78.01.07.08

178. If after repairing a generator the voltage does not build up what is a possible cause?

   a. resistance in the field circuit
   b. bad bearings
   c. brushes are the wrong type
   d. the case is shorted out

179. If after repairing a generator you find only a low voltage will develop which of the following may be the cause:

   a. bad brushes
   b. shorted armature
   c. bad bearings
   d. field windings connected improperly

180. If after repairing a generator you discover that no voltage is produced what has happened to the magnetic lines of flux in the generator?

   a. they are intersecting the residual lines at 45^0
   b. they are running opposite to the residual lines of flux
   c. they are not the cause of the problem
   d. they are not being broken

78.01.08.01

181. What are the two major characteristics of a universal motor?

   a. high starting torque and variable speed
   b. low starting torque and variable speed
   c. low starting torque and lots of power
   d. high starting torque and constant speed

182. Why is the universal motor the most popular type in the fractional horsepower size?

   a. it is inexpensive
   b. it is used on most household appliances
   c. it doesn't have field coils
   d. it can be used as a generator

183. What is the purpose of the field core in a universal motor?

   a. it houses the bearings
   b. it supports the outer housing
   c. it holds the armature
   d. it holds the coils

78.01.08.01 (continued)

184. What type of motor is very similar to the D C series motor?

a. shaded pole
b. universal
c. compound
d. split phase

185. The type of motor that can be used on either A C or D C voltage is:

a. a shaded-pole motor
b. a split-phase motor
c. a universal motor
d. a repulsion motor

78.01.08.02

186. How is the commutator of a universal motor connected to the shaft?

a. it is glued on
b. set-screwed on
c. pressed on
d. welded on

187. Where is the frame located on a universal motor?

a. end plates
b. outer housing
c. coil bracket
d. field core

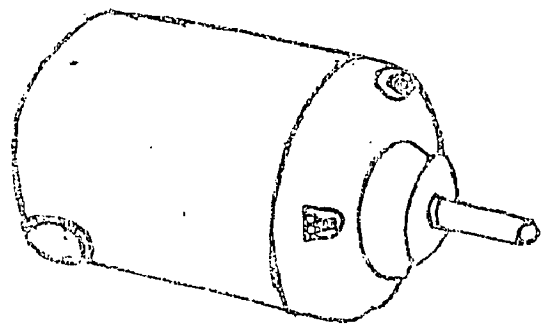
188. Why are universal motors usually built into the device they drive?

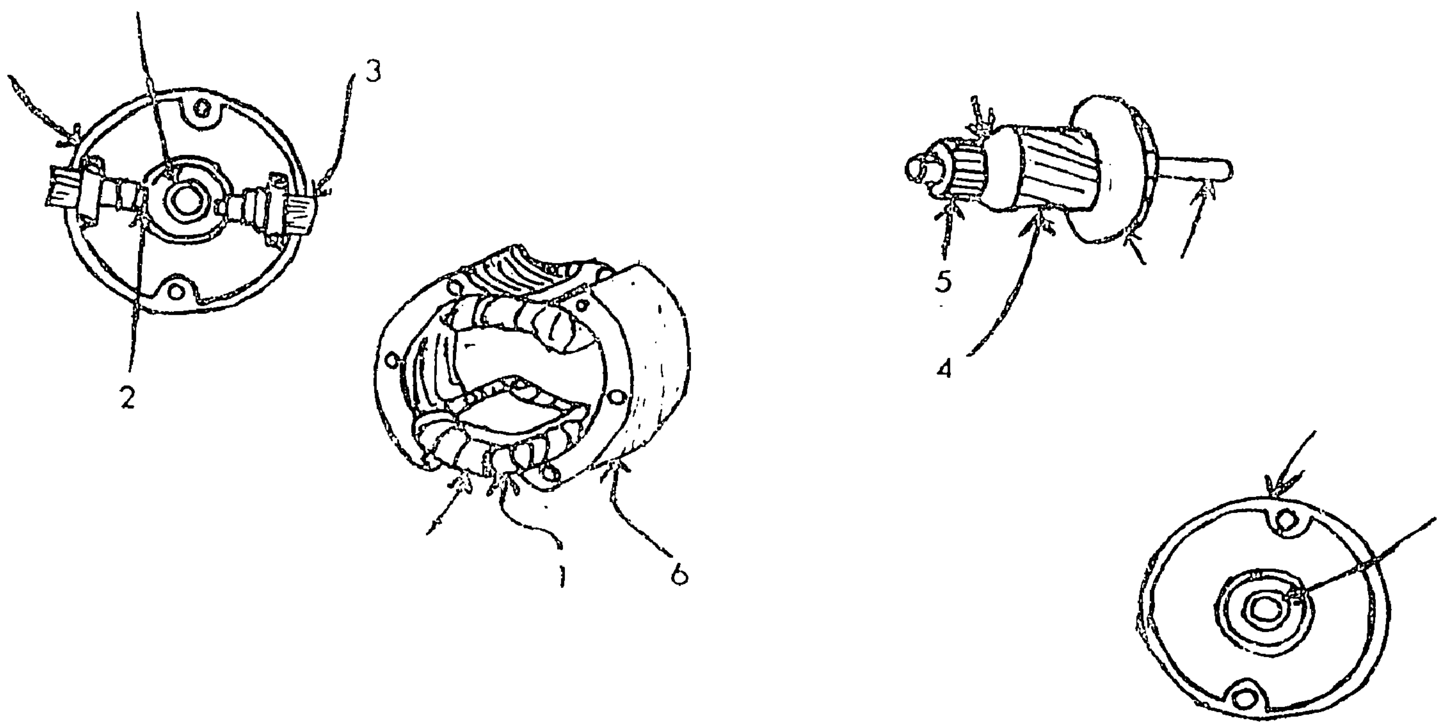
a. they run at very low speed and cause vibration
b. they don't have any moving parts
c. they run at dangerously high speed without load
d. the bearings don't have to be lubricated

189. Identify #6 on the exploded view of a universal motor (attached).

a. bell housing
b. metal clamps
c. field coils
d. laminated core

UNIVERSAL MOTOR





78.01.08.02 (continued)

190. Identify #5 on the attached figure. (See page 34a)

a. laminated core
b. armature
c. commutator
d. fan

78.01.08.03

191. Shorted coils will cause a universal motor to:

a. have poor torque
b. smoke
c. run hot
d. spark badly

192. What piece of test equipment should be used to test for an open field coil winding in a universal motor?

a. a voltmeter
b. a wattmeter
c. an ohmmeter
d. an ammeter

193. When using a test lamp on an open field coil of a universal motor, the light would:

a. stay out
b. glow normally
c. glow dimly
d. glow brightly

194. What would the wrong brush position cause a universal motor to do?

a. run hot
b. smoke
c. spark badly
d. have poor torque

195. What is the problem in a universal motor that causes it to rotate CCW?

a. short in the armature
b. short in the switch
c. open field coil
d. reversed motor leads

78.01.08.04

196. How many start windings are required by a shaded-pole motor?

   a. three
   b. four
   c. two
   d. one

197. If a universal motor has poor torque, the trouble may be:

   a. brushes off neutral
   b. shorted armature
   c. overload
   d. shorted field

198. If a universal motor sparks badly, the trouble may be:

   a. brushes off neutral
   b. overload
   c. wrong voltage
   d. shorted field poles

199. How many coils are usually found in a universal motor armature slot?

   a. two
   b. one
   c. three
   d. four

200. When installing new insulation in a universal motor armature, how far should the insulation extend above the end of the slots?

   a. 1/4 in.
   b. 1/16 in.
   c. 3/8 in.
   d. 1/2 in.

78.01.08.05

201. Single phase induction motors require an auxiliary winding to provide the motor starting torque. How is this done in a shaded-pole motor?

a. one closed turn of heavy, copper wire embedded in one side of each stator pole
b. there is no need because it has very little torque
c. many turns of light copper wire in the stator or frame
d. it is wound at same time as the field coils

202. Shaded-pole motors have stators constructed similarly to what other motor?

a. split-phase
b. universal
c. polyphase
d. shunt wound

203. During the part of the sine curve where the current drops near maximum to 0, current in the shaded coil will again be:

a. lagging
b. opposed
c. dropped
d. induced

204. Where are shaded-pole motors used?

a. timing devices
b. compressor motors
c. large appliances
d. power tools

205. How are shaded-pole motors reversed?

a. reverse the current
b. reverse the brushes
c. reverse field coils
d. one shaded-winding is closed one shaded winding is open

78.01.08.06

206. A shaded-pole motor consists of:

a. two end bells, one stator, one rotor, and one set of brushes
b. two end bells, two stators, and one rotor
c. two end bells, one rotor, one stator, and one fan
d. two end bells, one rotor, and one stator

78.01.08.06 (continued)

207. Identify figure number 5 on the attached illustration:

a. rotor
b. end bell
c. bearing
d. stator

208. Identify item number 2 on the attached illustration.

a. stator
b. winding
c. end bell
d. rotor

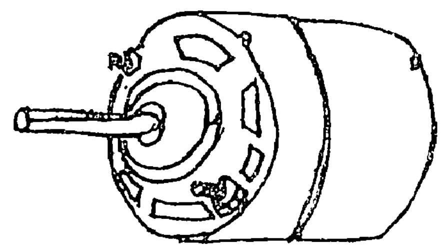
209. All shaded-pole motors have rotors of what type?

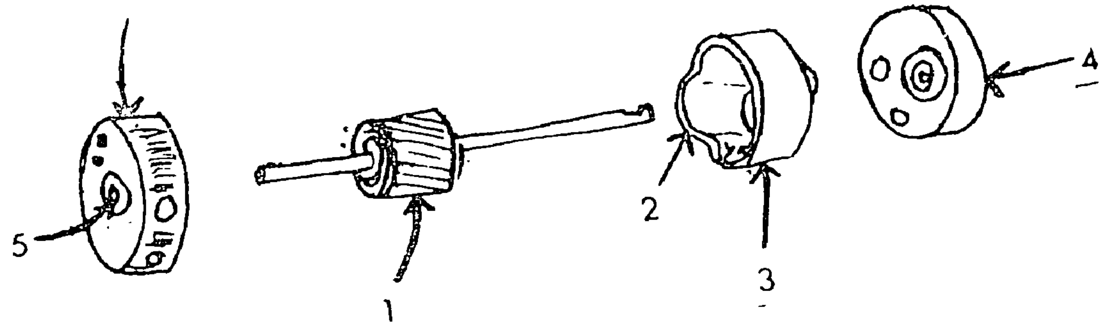
a. squirrel-cage
b. slotted
c. split-phase
d. fast starting torque

210. Why can only one end plate be removed on a shaded pole motor?

a. it's part of the frame
b. it's spot welded
c. it has a special bearing
d. it's part of the rotor

SHADED POLE MOTOR





78.01.08.07

211. If a shaded-pole motor has poor starting torque, the trouble might exist in:

a. the voltage being applied
b. the load
c. the field
d. the armature

212. If a shaded-pole motor is plugged with dirt, one symptom will be:

a. change in polarity
b. change in armature direction
c. increased rpm
d. poor torque

213. When using a test lamp on an open-field coil of a shaded-pole motor, the light would:

a. stay out
b. glow brightly
c. glow normally
d. glow dimly

214. How many phases does a shaded pole motor have?

a. 2
b. 1
c. 3
d. 4

215. Windings in a stator in a shaded-pole motor must be connected so what will develop?

a. alike polarity results
b. variable polarity results
c. consistant polarity results
d. alternate polarity results

78.01.08.08

216. What method should be used to rewind a shaded-pole motor?

a. set winding
b. skein winding
c. hand winding
d. form winding

78.01.08.08 (continued)

217. Why should insulating paper be placed on the corners of a shaded-pole motor or around its core?

a. to prevent the coil from shorting
b. to prevent damage to the armature
c. to prevent the coil from grounding
d. to prevent a blown fuse

218. If after repairing a shaded-pole motor you find that the motor does not run, what may be the cause?

a. magnetic flux lines are intersecting a 45°
b. loose bearings
c. magnetic flux lines are parallel
d. shorted field windings

219. A shaded-pole motor has which of the following characteristics?

a. very long life
b. low starting torque
c. high starting torque
d. very high efficiency

220. The stator on most shaded-pole motors is constructed with what type of core?

a. laminated core
b. solid core
c. very soft non-metalic core
d. resistive non-metalic core

COURSE TEST ANSWER SHEET

Electric Motor Repair

Occupational Area: ____________________

File Code: 78.01.00.00.A2-2

Name: ____________________

ANSWERS

.01.01	1.	B	78.01.01.05	21.	A	78.01.02.04	41.	D
	2.	D		22.	C		42.	D
	3.	D		23.	C		43.	B
	4.	B		24.	B		44.	B
	5.	A		25.	B		45.	C
.01.02	6.	C	78.01.02.01	26.	C	78.01.02.05	46.	B
	7.	B		27.	C		47.	C
	8.	D		28.	B		48.	C
	9.	B		29.	C		49.	A
	10.	D		30.	A		50.	A
1.01.03	11.	B	78.01.02.02	31.	B	78.01.02.06	51.	C
	12.	B		32.	D		52.	C
	13.	D		33.	B		53.	B
	14.	C		34.	A		54.	C
	15.	B		35.	B		55.	B
1.01.04	16.	C	78.01.02.03	36.	B	78.01.03.01	56.	A
	17.	C		37.	D		57.	C
	18.	D		38.	A		58.	B
	19.	C		39.	C		59.	C
	20.	B		40.	D		60.	C

COURSE TEST ANSWER SHEET

Electric Motor Repair

Occupational Area: ____________________
File Code: 78.01.00.00 A2-2
Name: ____________________

ANSWERS

78.01.03.02	61. D	78.01.04.01	81. A	78.01.05.01	101. A
	62. C		82. A		102. B
	63. D		83. D		103. D
	64. D		84. A		104. C
	65. D		85. A		105. D
78.01.03.03	66. A	78.01.04.02	86. B	78.01.05.02	106. B
	67. A		87. C		107. A
	68. D		88. C		108. D
	69. B		89. B		109. C
	70. D		90. A		110. D
78.01.03.04	71. C	78.01.04.03	91. B	78.01.05.03	111. D
	72. D		92. C		112. C
	73. B		93. C		113. B
	74. B		94. C		114. C
	75. A		95. B		115. B
78.01.03.05	76. C	78.01.04.04	96. B	78.01.05.04	116. C
	77. D		97. A		117. A
	78. D		98. A		118. A
	79. D		99. D		119. A
	80. C		100. B		120. B

COURSE TEST ANSWER SHEET

Electric Motor Repair

Occupational Area: ________________
File Code: 78.01.00.00.A2-2
Name: ________________

ANSWERS

8.01.06.01	121. C	78.01.07.01	141. A	78.01.07.05	161. A
	122. A		142. A		162. D
	123. C		143. A		163. A
	124. A		144. B		164. C
	125. D		145. B		165. B
8.01.06.02	126. D	78.01.07.02	146. C	78.01.07.06	166. C
	127. B		147. D		167. C
	128. C		148. A		168. B
	129. A		149. D		169. B
	130. A		150. B		170. D
78.01.06.03	131. A	78.01.07.03	151. A	78.01.07.07	171. A
	132. D		152. D		172. B
	133. D		153. A		173. A
	134. D		154. B		174. B
	135. C		155. C		175. A
78.01.06.04	136. D	78.01.07.04	156. C	78.01.07.08	176. C
	137. A		157. A		177. A
	138. C		158. C		178. A
	139. B		159. A		179. B
	140. A		160. C		180. D

COURSE TEST ANSWER SHEET

Electric Motor Repair

Occupational Area: ____________________

File Code: 78.01.00.00.A2-2

Name: ____________________

ANSWERS

01.08.01	181. A	78.01.08.05	201. A	221. ____
	182. B		202. A	222. ____
	183. D		203. D	223. ____
	184. B		204. A	224. ____
	185. C		205. D	225. ____
.01.08.0 2	186. C	78.01.08.06	206. D	226. ____
	187. B		207. C	227. ____
	188. C		208. B	228. ____
	189. D		209. A	229. ____
	190. C		210. A	230. ____
78.01..08.03	191. A	78.01.08.07	211. C	231. ____
	192. C		212. D	232. ____
	193. A		213. A	233. ____
	194. D		214. B	234. ____
	195. D		215. D	235. ____
.01.08.04	196. D	78.01.08.08	216. D	236. ____
	197. D		217. C	237. ____
	198. D		218. D	238. ____
	199. A		219. B	239. ____
	200. B		220. A	240. ____

File Code: 78.01.01.00.A2-1

Date Published: 2-18-76

Mountain-Plains Education & Economic Development Program, Inc.

Glasgow AFB, Montana 59231

Learning Experience Guide

UNIT: ELECTRIC MOTOR FUNDAMENTALS

RATIONALE:

An electric motor is a machine that converts electrical energy to mechanical energy. Magnetism is used in the motor and generator for energy conversion. Understanding the characteristics of magnetism and how they are applied in the motor and generator is important for diagnosing problems that may occur with generator and motor.

PREREQUISITES:

Appliance Repairman Course.

OBJECTIVE:

Identify and describe basic operational characteristics of simple and complex types of motors and generators, using schematic diagrams.

RESOURCES:

Printed Materials

Electric Motor Repair. Second Edition, Rosenburg, Holt, Rinehart & Winston, 1970.
Electricity. Dvorak, Brodhead-Garrett Company, 1969.
Electricity and Electronics. Garrish, Goodheart-Wilcox Company, Inc., 1968.

Audio/Visual

Display Boards:

1. Shaded-pole motor.
2. Split-phase motor.
3. Universal motor.

Super 8 Films from Hubbard Scientific Company, Northbrook, Illinois, 1971.

4. Electric Generator.
5. Electromagnetic Force.
6. Electromagnetic Generator.

Principal Author(s): T. Ziller

7. Electromagnetic Polarity.
8. The Electromagnets.
9. Electromotive Force.
10. Inductive Field.
11. Magnetic Fields.
12. Magnetic Fields.
13. Magnetic Poles.
14. Poles Occur in Pairs.
15. Reversing Polarity.
16. The Solenoid.

Equipment

Learning Unit, Electricity/Electronics, "C" Case-Combination, Portable, Model BG850 A/C, Brodhead-Garrett, 161 Commerce Circle, Sacramento, California, 95815.
Power supply, variable DC (0-25 volts).
Equipment, special: chisel, coil stripping
coil shapers
insulation former
winder, armature
winder, coil.

GENERAL INSTRUCTIONS:

This unit consists of 5 Learning Activity Packages (LAPs). Each LAP will provide specific information for completion of a learning activity.

The general procedure for this unit is as follows:

(1) Read the first assigned Learning Activity Package (LAP).
(2) Begin and complete the first assigned LAP.
(3) Take and score the LAP test.
(4) Turn in the LAP test answer sheet.
(5) Determine the reason for any missed items on the LAP test.
(6) Proceed to and complete the next assigned LAP in the units.
(7) Complete all required LAPs for the unit by following steps 3 through 6.
(8) Take the unit test as described in the Unit LEG "Evaluation Procedures".
(9) Proceed to the next assigned unit.

PERFORMANCE ACTIVITIES:

.01 Electromagnet
.02 The Moving Coil
.03 Electric Motor Operational Theory
.04 Motor Construction
.05 Types of Motors

EVALUATION PROCEDURE:

When pretesting and post testing:

1. The student takes the unit multiple-choice pretest.
2. Successful completion is 4 out of 5 items for each LAP part of the test.

FOLLOW-THROUGH:

You may now begin the first LAP in this unit. Talk to your instructor if you need help.

Student: ______________________ File Code: 78.01.01.00.A2-2

Date: ______________________ Date Published: 12-11-74

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

UNIT PRETEST: ELECTRIC MOTOR FUNDAMENTALS

78.01.01.01

1. The ability of a material to permit the setting up of magnetic lines of force is called:

   a. reluctance
   b. permeance
   c. acceptance
   d. reliability

2. The flux lines that represent magnetic force:

   a. are concentrated at the ends, or poles, of the magnet
   b. occur only at the magnetics
   c. are uniformly distributed in the area surrounding the magnet
   d. follow straight lines

3. If the N pole of one magnet and the S pole of another magnet are brought close together:

   a. the lines of magnetic force will cross each other
   b. they will repel each other
   c. they will attract each other
   d. they will demagnetize each other

4. The magnetic field that forms around a current-carrying conductor is:

   a. a series of closed circles running from end to end of the conductor
   b. are parallel to the conductor
   c. a pattern of lines radiating out from the conductor
   d. a series of concentric circles, or rings, around the conductor

5. To determine the direction of the magnetic field around a current-carrying conductor by means of the left-hand rule, you must know:

   a. the direction of the lines of force
   b. the direction of current flow in the conductor
   c. the magnitude of the current
   d. the number of turns per inch

78.01.01.02

6. According to Faraday's Law, the voltage generated by the relative motion of a conductor and a magnetic field is:

   a. indirectly proportional to the cross sectional area of the field
   b. directly proportional to the cross sectional area of the field
   c. directly proportional to the rate at which the conductor cuts the lines of magnetic force
   d. always in the same direction, negative to positive

7. When a circuit in which current has been flowing reaches a steady state and the switch is then opened, the magnetic field around the conductor starts to collapse and:

   a. all current flow immediately ceases
   b. the voltage induced by the collapsing field tends to keep the circuit current flowing
   c. a resistance is set up by the induced voltage
   d. mutual inductance increases

8. Which of the following are physical factors that affect inductance?

   a. flux density
   b. the applied voltage
   c. the amount of current flow
   d. the length of the coil

9. The amount of inductance in a coil is:

   a. the resistance in a coil
   b. directly proportional to change in current
   c. always in reference to polarity
   d. the number of turns in a coil

10. The strength of induced voltage depends upon:

   a. fields relative motion
   b. the number of magnetic lines of force cut by the coil and the speed at which the conductor moves through the field
   c. inverse mutual inductance ratio
   d. the battery applied to the generator

78.01.01.03

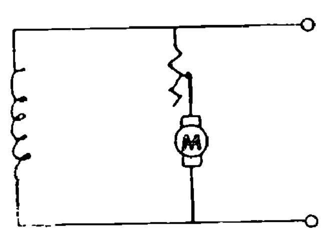
11. Interpoles are used on large DC motors:

    a. to reduce the sparking as a result of commutation
    b. to increase the current in the armature
    c. to increase torque in the motor
    d. to reduce the torque in the motor

12. A common method of splitting a single phase current to start a motor is:

    a. by using a relay switch
    b. by using a capacitor
    c. by using a resistor
    d. by using an inductor

Fig. 3

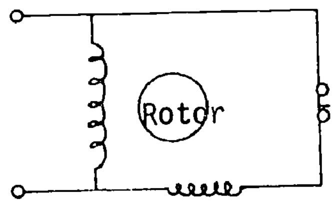


13. Identify the schematic in Figure 3.

    a. syncro-motor
    b. series motor
    c. series-parallel motor
    d. variable starting resistance

78.01.01.03 (continued)

Fig. 5



14. Identify the schematic in Figure 5.

    a. split-phase motor
    b. repulsion induction motor
    c. shade pole motor
    d. syncro motor

15. Motor starters are necessary on heavy duty motors:

    a. to release high voltage feed back
    b. to increase starting torque
    c. to increase starting resistance
    d. to bypass the capacitor

78.01.01.04

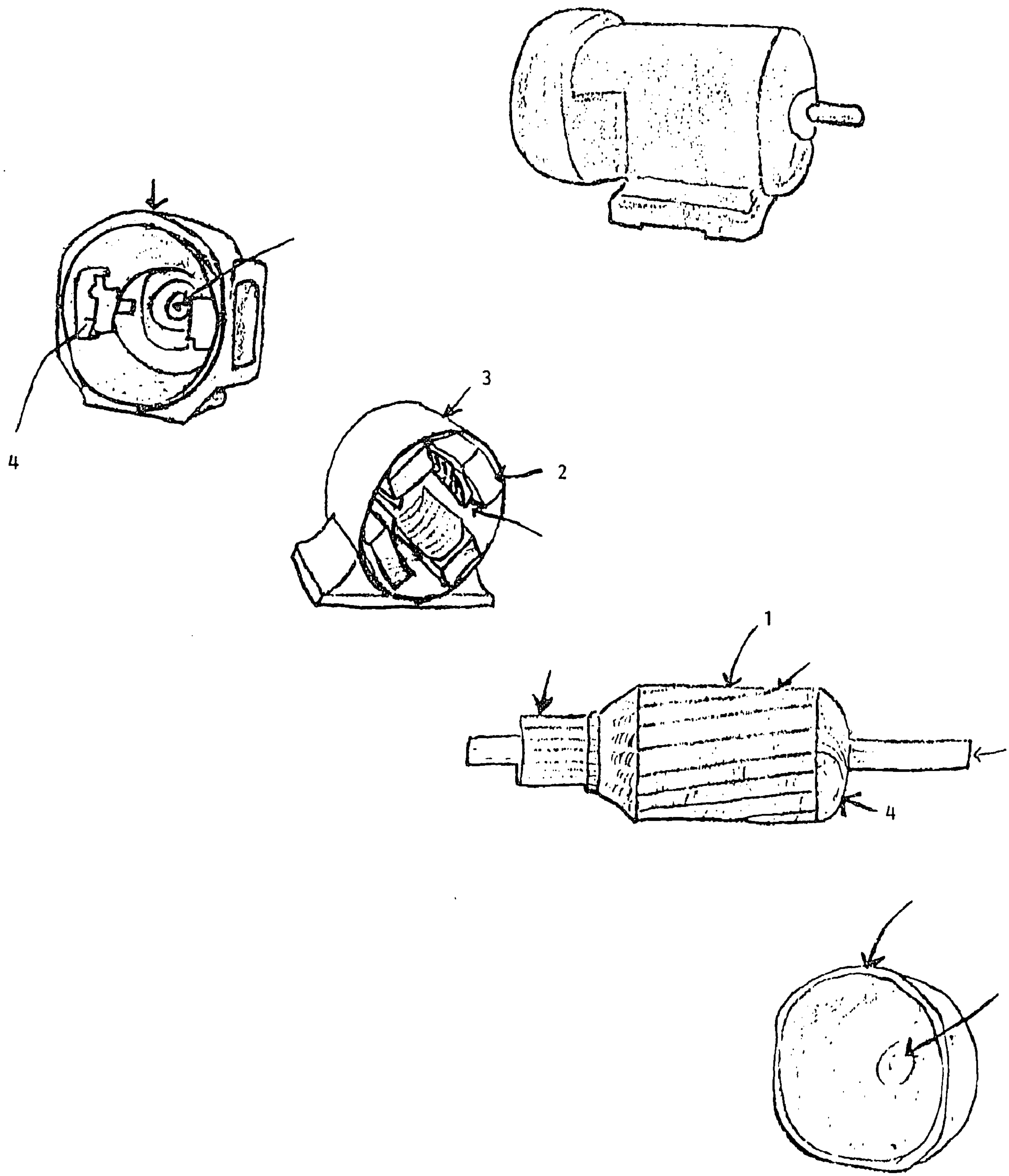
16. On the illustration of the repulsion type motor, which number would identify the armature?

    a. 3
    b. 1
    c. 2
    d. 4

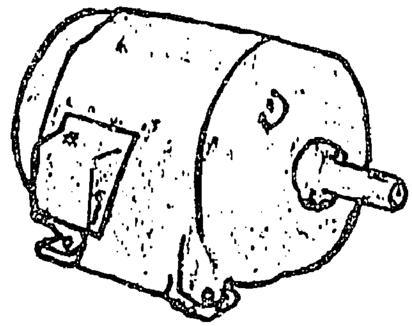
17. On the illustration of the polyphase motor, which number would identify the rotor?

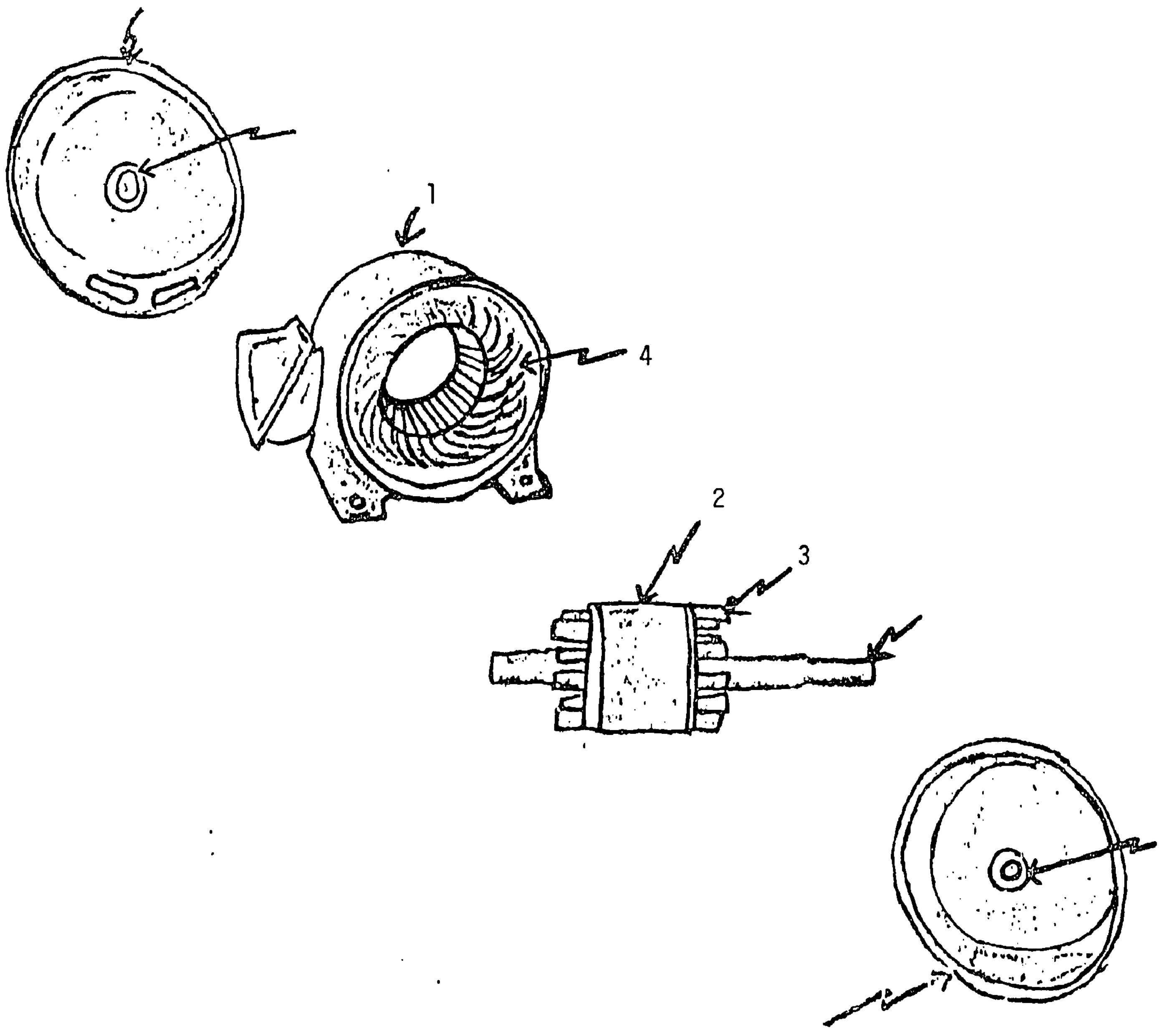
    a. 3
    b. 1
    c. 2
    d. 4

D. C. MOTOR AND GENERATOR

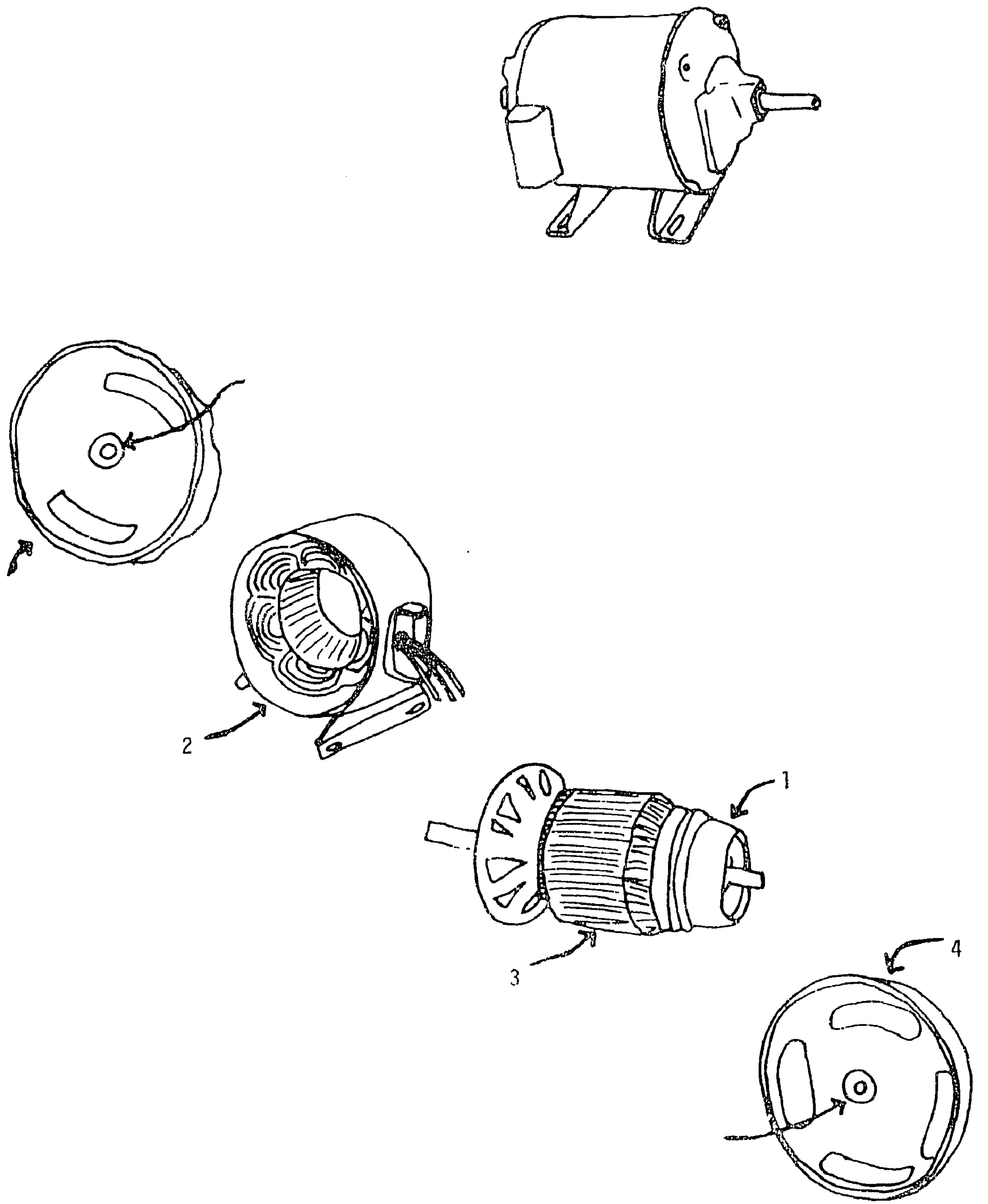


POLYPHASE MOTORS

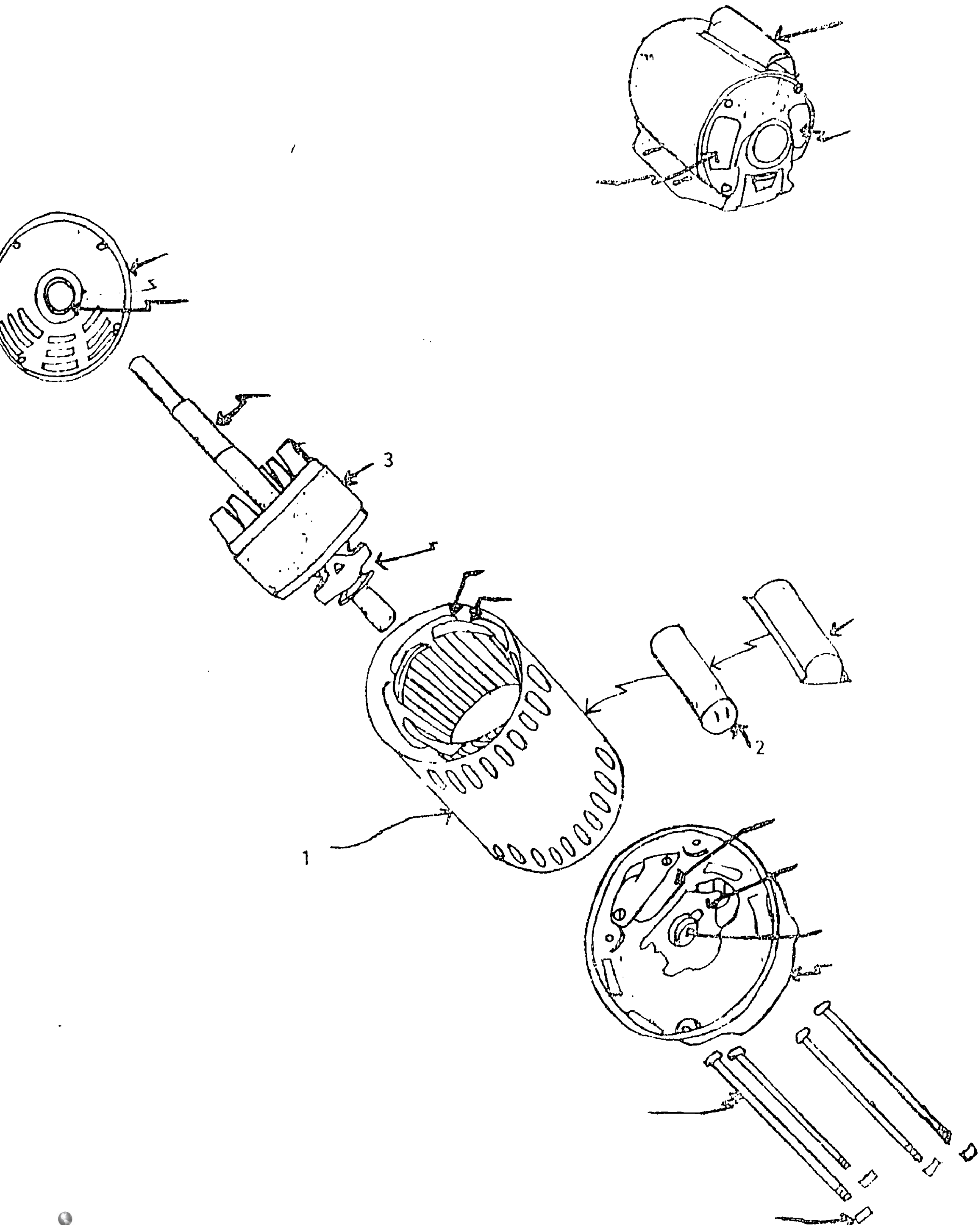




REPULSION-TYPE MOTOR



A SPLIT PHASE INDUCTION MOTOR



78.01.01.04 (continued)

18. On the illustration of the polyphase motor, which number would identify the balance and cooling fins?

    a. 4
    b. 1
    c. 2
    d. 3

19. On the illustration of a split phase motor, which number would identify the rotor?

    a. 2
    b. 1
    c. 3
    d. 4

20. On the illustration of the DC motor and generator, which number would indentify the field windings?

    a. 1
    b. 2
    c. 3
    d. 4

78.01.01.05

21. What percent of the rotor speed in a capacitor start motor causes the switch to connect from the start to the run windings?

    a. 25%
    b. 100%
    c. 50%
    d. 75%

22. A DC motor has a device that reverses the connection to the revolving conductors in the generator. What is the device called?

    a. fields
    b. brushes
    c. a commutator
    d. coils

78.01.01.05 (continued)

23. What are the two principle classes of single phase induction motors?

a. split-capacitor and capacitor start
b. split-phase and commutator
c. capacitor run and capacitor start
d. repulsion and series

24. A resistance start motor is a form of which of the following?

a. capacitor start
b. repulsion
c. series
d. split-phase

25. A motor that is commonly used in washing machines is called which of the following?

a. universal start motor
b. resistance start motor
c. capacitor start motor
d. repulsion start motor

UNIT TEST ANSWER SHEET

Occupational Area: UNIT PRETEST: ELECTRIC MOTOR FUNDAMENTALS

File Code: 78.01.01.00.A2-2

Name: ____________________

ANSWERS

.01.01.01	1.	A	78.01.01.05	21.	D	41.	
	2.	A		22.	C	42.	
	3.	C		23.	B	43.	
	4.	D		24.	D	44.	
	5.	B		25.	C	45.	
.01.01.02	6.	B		26.		46.	
	7.	D		27.		47.	
	8.	D		28.		48.	
	9.	A		29.		49.	
	10.	B		30.		50.	
6.01.01.03	11.	A		31.		51.	
	12.	D		32.		52.	
	13.	D		33.		53.	
	14.	A		34.		54.	
	15.	C		35.		55.	
8.01.01.04	16.	A		36.		56.	
	17.	C		37.		57.	
	18.	D		38.		58.	
	19.	C		39.		59.	
	20.	B		40.		60.	

File Code: 78.01.01.01.A2-0

Date Published: 2-18-76

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Learning Activity Package

Student: ______

Date: ______

PERFORMANCE ACTIVITY: Electromagnet

OBJECTIVE:

Identify and describe the operational characteristics of an electromagnet in a motor and generator.

EVALUATION PROCEDURE:

The description of the electromagnet includes the characteristics given on pages 60 and 61 of Electricity and Electronics.

Successfully complete at least 80% of the items on a multiple-choice test about this LAP.

RESOURCES:

Text: Electricity and Electronics, Gerrish, Howard H.; Goodheart-Wilcox Co., Inc., South Holland, Illinois, 1968.

Electricity, Dvorak, Neil; Brodhead-Garrett Co., Cleveland, Ohio, 1969.

Film Loops: Hubbard Scientific Company; Northbrook, Illinois, 1971.

The Electromagnets
Electromagnetic Force
Electromagnet Polarity
Inductive Field
Magnetic Fields
Magnetic Poles
Poles Occur in Pairs
The Solenoid

Equipment: DC power supply (variable)
Electricity/Electronics, "C" Case-Combination Learning Unit - Portable, Model BG850A/C, Brodhead-Garrett, 161 Commerce Circle, Sacramento, California, 95815.

Principal Author(s): T. Ziller

PROCEDURE:

1. Read and study carefully the information found in Electricity and Electronics, Chapter 4, pp. 55-70.
2. View film loops about electromagnet listed in the resources.
3. Complete Experiments 19 and 20 on "Permanent Magnets" and "Electromagnets" in Dvorak's Electricity, pp. 19-1-1 to 20-1-7. Complete the attached response sheets for the experiments.
4. Answer the attached "Review questions".
5. Write a short description of an electromagnet, using simple schematics.
6. Complete the multiple choice test items for this LAP.
7. Check your answers with the test key. If your answers are all correct, record your time for completing this LAP on your SPR. If you have missed any questions, try to find out why you missed the test items. If you have any further problems, check with your instructor. When you have correctly completed all the test items, you may record your time on your SPR.

Response Sheet: Experiment 19, Permanent Magnets

1. Induced Magnetism: What happens, when you remove and bring the two nails head to point?

   A. What happens?

   B. Choose the correct answer.

      (1) attract, repel

      (2) attract, repel

   C. What two things can you do to reverse the direction of the force if the magnets attract?

2. Determine magnetic polarity. Did you reason correctly? Explain how you proceeded.

3. Describe a magnetic field.

4. MAGNETIC MATERIALS: List each of the material's characteristic under the following headings:

   Magnetic Non-Magnetic

A. Which material was most attracted to the magnet?

REVIEW QUESTIONS:

1. In the accompanying figure, a nail has been induced as a weak bar magnet by contact as shown.

   A. What pole is the nail head?

   B. What pole is the nail tip?

   C. Why?

2. What is the true polarity of the north-seeking end of a compass needle?

3. What is the general rule for interaction between magnetic poles?

4. What is magnetic induction?

5. Would an electromagnet work on AC? Try it. Why did the magnet behave as it did?

6. Why should a permanent magnet always be stored with its keeper in place?

Response Sheet: Experiment 20, Electromagnets

1. Magnetism from a single wire: Assemble the circuit in Figure 20-1A, placing the wire on top of the compass and parallel to it with no current flowing.

   A. Adjust the power supply so that at least 7 amps of current flows. What direction is the compass deflected?

   B. Change the polarity of the power supply and repeat.

      Which direction is the compass now pointing?

2. Current and strength of field: Observe and compare the needle direction to the magnet current.

3. Remove the core from L1. Now repeat the above steps. Observe the needle action and make a statement about air cores vs. iron cores.

4. Ampere-turns:

   A. With only L1 switched in, adjust the power supply to give a current of 2 Amps. Note compass deflection.

   B. Switch in L2 and increase supply output until 2 Amps is flowing. Note the compass deflection in this case.

   C. Which coil gave the greatest deflection?

   D. Which coil has the greatest number of turns?

5. Attraction and Repulsion of Electromagnets: Reverse the lead connections on one of the coils and depress S1. What happens?

6. Representing the Magnetic Field: Sketch this result in the space provided.

REVIEW QUESTIONS:

1. What electrical quantity affects the strength of an electromagnet.

2. What two physical quantities affect the strength of an electromagnet?

3. Define the term ampere-turn.

4. If the current in an electromagnet wire doubled, but the number of wire turns was decreased by a factor of ¼, the magnet strength would a) double b) remains the same c) halve (d) none of these.

5. Explain how coils aiding mean a higher strength magentic field.

6. What effect do you think the iron core has on the magnetic lines of force?

7. What effect do you believe a carbon core would have on electromagnetic strength?

Student: ______________________ File Code: 78.01.01.01.A2-2

Date: ______________________ Date Published: 12-18-74

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

LAP TEST: ELECTROMAGNET

78.01.01.01

1. The strength of the magnetic field at any point is indicated by the:

   a. magnitude of the line
   b. flux density
   c. field line force
   d. intensity of the cross sectional area

2. The ability of a material to permit the setting up of magnetic lines of force is called:

   a. reluctance
   b. permeance
   c. acceptance
   d. reliability

3. Magnetic lines of force always form complete loops, running from the north magnetic pole to the south magnetic pole. Thus:

   a. the lines are circular with a radius equal to it's length
   b. flux lines run from north to south inside the magnet
   c. there are no flux lines within the magnetic material
   d. flux lines run from south to north inside the magnet

4. When an iron washer is placed near a magnet:

   a. the magnetic lines of force pass through the washer
   b. the lines of force pass around the washer
   c. the lines of force will repel each other
   d. the lines of force will cross each other

5. If the N pole of one magnet and the S pole of another magnet are brought close together:

   a. the lines of magnetic force will cross each other
   b. they will repel each other
   c. they will demagnetize each other
   d. they will attract each other

78.01.01.01 (continued)

6. According to the magnetic domain theory of magnetism, the individual molecules in magnetic material:

   a. constitute individual magnets, with a north pole and a south pole
   b. are always aligned so that their individual magnetic domains are additive
   c. never align therefore some metals are easy to bend
   d. intensify when the material is wound in a coil

7. The magnetic field that forms around a current-carrying conductor is:

   a. a series of closed circles running from end to end of the conductor
   b. a series of concentric circles, or rings, around the conductor
   c. a pattern of lines radiating out from the conductor
   d. are perpendicular to the conductor

8. To determine the direction of the magnetic field around a current-carrying conductor by means of the left-hand rule, you must know:

   a. the direction of current flow in the conductor
   b. the direction of the lines of force
   c. the magnitude of the current
   d. the number of turns per inch

9. The magnetic field that forms around a straight conductor wire has no:

   a. flux density
   b. force
   c. direction
   d. polarity

10. When a straight conductor is formed into a loop:

    a. only the north pole is created
    b. the flux lines acquire direction
    c. the magnetic field around the conductor becomes slightly stronger because the flux density is increased
    d. the magnetic lines of force spiral toward the center

LAP TEST ANSWER KEY: 78.01.01.01.A2-2

ELECTROMAGNET

1. B
2. B
3. D
4. A
5. D
6. A
7. B
8. A
9. D
10. C

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

File Code: 78.01.01.02.A2-0

Date Published: 2-18-76

Learning Activity Package

Student: ____________________

Date: ____________________

PERFORMANCE ACTIVITY: The Moving Coil

OBJECTIVE:

Identify and describe the operational characteristics of a moving coil in a generator using simple schematic diagrams.

EVALUATION PROCEDURE:

The description of a moving coil in a generator includes the characteristics found in Electricity and Electronics.

Successfully complete at least 80% of the items on a multiple-choice test about this LAP.

RESOURCES:

Text: Electricity and Electronics, Gerrish, Howard H., Goodheart-Wilcox, Co., Inc., South Holland, Illinois, 1968.

Film Loops: Hubbard Scientific Company, Northbrook, Illinois, 1971.

Electric Generator.
Electromagnetic Generator.
Electromotive Force.
The Moving Coil.
Reversing Polarity.

PROCEDURE:

1. Read and study carefully the information found in Electricity and Electronics, Chapter 5, pp. 71-86.
2. View film loops about moving coils listed in the resources.
3. Write a short description of a generator, using simple schematics.
4. Complete the multiple-choice test items for this LAP.
5. Check your answers with the test key. If your answers are all correct, record your time for completing this LAP on your SPR. If you have missed any questions, try to find out why you missed the test items. If you have any further problems, check with your instructor. When you have correctly completed all the test items, you may record your time on your SPR.

Principal Author(s): T. Ziller

Student: ______________________ File Code: 78.01.01.02.A2-2

Date: ______________________ Date Published: 12-18-74

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LAP TEST: THE MOVING COIL

78.01.01.02

1. In a circuit in which current has reached a steady flow and the magnetic field is steady, there is no voltage. Which requirement for inducing a voltage is lacking?

   a. a relative motion
   b. a conductor
   c. a magnetic field
   d. a circuit

2. When a circuit in which current has been flowing reaches a steady state and the switch is then opened, the magnetic field around the conductor starts to collapse and:

   a. all current flow immediately ceases
   b. the voltage induced by the collapsing field tends to keep the circuit current flowing
   c. a resistance is set up by the induced voltage
   d. mutual inductance increases

3. Which of the following are physical factors that affect inductance?

   a. flux density
   b. the applied voltage
   c. the amount of current flow
   d. the length of the core

4. The amount of inductance in a coil is:

   a. the resistance in a coil
   b. directly proportional to change in current
   c. always in reference to polarity
   d. the number of turns in a coil

5. If an increase in flux density increases the magnetic field, increasing permeability will:

   a. increase the magnetic field strength
   b. decrease the magnetic field strength
   c. not affect the magnetic field strength
   d. decrease the flux density

78.01.01.02 (continued)

6. Soft iron has:

   a. high permeability and high reluctance
   b. high permeability and low reluctance
   c. low permeability and high reluctance
   d. low permeability and low reluctance

7. The purpose of the commutator is:

   a. to oppose any change in current
   b. to convert D.C. in the rotating armature to a pulsating A.C. current
   c. to eliminate brushes
   d. to convert A.C. in the rotating armature to a pulsating D.C. current

8. A generator has a no-load voltage of 25 volts. When load is applied, terminal voltage drops to 24 volts. What is the percent at regulation?

   a. 50%
   b. 100%
   c. 4%
   d. 96%

9. The strength of induced voltage depends upon:

   a. fields relative motion
   b. the battery applied to the generator
   c. inverse mutual inductance ratio
   d. the number of magnetic lines of force cut by the coil and the speed at which the conductor moves through the field

10. Lenz's law states that the voltage induced in a circuit by a changing current always opposes the change causing it. This statement is the basis for the explanation of the property of:

   a. capacitance
   b. reactance
   c. inductance
   d. resonance

LAP TEST ANSWER KEY: 78.01.01.02.A2-2

THE MOVING COIL

1. A
2. B
3. D
4. B
5. A
6. B
7. D
8. D
9. D
10. C

File Code: 78.01.01.03.A2-0

Date Published: 2-18-76

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Learning Activity Package

Student: ____________

Date: ____________

PERFORMANCE ACTIVITY: Electric Motor Operational Theory

OBJECTIVE:

Describe the operational theory of an electric motor using simple schematic diagrams. Identify operational characteristics of electric motors.

EVALUATION PROCEDURE:

The description of an electric motor includes the characteristics found in Electricity and Electronics. Score at least 80% on a written multiple-choice test.

RESOURCES:

Text: Electricity and Electronics, Gerrish, Howard H., Goodheart-Wilcox, Co., Inc., South Holland, Illinois, 1968.

Electricity, Dvorak, Neil, Brodhead-Garrett Co., Cleveland, Ohio, 1969.

Equipment: Electricity/Electronics, "C" Case-Combination Learning Unit - Portable, Model BG850A/C, Brodhead-Garrett, 161 Commerce Circle, Sacramento, California, 95815.

D.C. power supply (variable).

PROCEDURE.

1. Read and study carefully the information found in Electricity and Electronics, Chapter 9, pp. 136-151.
2. Complete Experiments 39 and 40 on "Introduction to Motors." and "Universal Motors" in Dvorak's Electricity, pp.39-1-1 to 40-1-4. Also complete the attached "Response Sheets" for the experiments.
3. Answer the attached "Review Questions".
4. Write a short description of a motor/generator, using simple schematics.
5. Complete the multiple-choice test items for this LAP.
6. Check your answers with the test key. If your answers are all correct, record your time for completing this LAP on your SPR. If you have missed any questions, try to find out why you missed the test items. If you have any further problems, check with your instructor. When you have correctly completed all the test items, you may record your time on your SPR.

Principal Author(s): T. Ziller

Response Sheet: Experiment 39, Introduction to Motors

1. Magnetic Field Interaction: What difference does the position of the magnet make?

2. Permanent Magnet Motor:

   a. Adjust the supply to 10 volts or whatever is needed for ample rpm. Note the line current at this speed. ______________ amps.

   b. Stop the motor by carefully handling the slip rings. What is this static current? ________________ amps.

3. Commutation Angle: The brush assembly has been designed to rotate. While the motor is running, very slowly rotate the position of the brushes and note the motor speed. Adjust for maximum speed.

4. Slowly remove the magnet from the base while the motor is running. What happens.

5. Reverse the position of the magnet. What happens to the direction of rotation?

6. Turn S2 so that the motor comes up to full speed. Then switch the motor to the meter. What voltage does it register?

   What does this prove about some motors?

REVIEW QUESTIONS:

1. In the single wire-magnet experiment, what else besides reversing the position of the magnet could be done to change the direction of the force on the wire?

2. Explain the purpose of the commutator segments.

3. How can a device that has been designed as a motor produce a counter emf?

4. In most experiments the motor gets warm. It would overheat if overloaded. Why?

5. Based on your experience in Part 4, how does motor speed depend on field strength?

6. Why does motor current decrease as speed goes up?

Response Sheet:
Experiment 40 - Universal Motors

1. a. How much curr s drawn at this applied voltage?

   b. Touch a pencil eraser to the slip ring. Can the series motor reasonably maintain its speed under load?

2. Connect 10 VAC to the series connected motor.

   a. Does it run very well?

   b. Increase the voltage to 25 VAC. Why should a motor with inductive elements require more voltage when run on AC?

   c. Observe the commutator for sparking. Which type of operation is easier on these contacts -- AC or DC?

   d. While the motor is running, slowly rotate the brush assembly for maximum rpm. Is this commutation position (angle) the same (for maximum speed) as when the motor operated on DC?

3. Shunt Wound Motor

   a. Gradually increase the voltage up to 10 volts. Is the motor rpm noticeably different from the series connected experiment at 10 volts?

   b. What is the current at this applied voltage?

   c. As a load, touch the eraser end of a pencil to the slip rings. Does the shunt motor maintain its speed better than the series motor?

   d. Connect 10 VAC to the motor. Does it show any signs of running?

REVIEW QUESTIONS:

1. Compare the shunt and series motor as far as:

   a. current drawn

   b. speed regulation under load.

2. Find out why the shunt motor will not work on AC as the series type does. (Optional)

3. Should the field of a series motor be made out of fine wire or heavy wire? Why?

4. What possible advantages does an AC universal motor have over a series or shunt DC motor?

   What advantages does the DC motor have compared to an AC universal motor?

5. Why should a low friction DC shunt motor run away when the field is lost?

Student: ____________ ____________ File Code: 78.01.01.03.A2-2

Date: ____________ Date Published: 12-18-74

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LAP TEST: ELECTRIC MOTOR OPERATIONAL THEORY

78.01.01.03

1. The purpose of the commutator in the D.C. motor is to:

   a. de-energize the coils flux lines
   b. provide a path to energize the armature
   c. mechanically position the armature in the stator
   d. discharge the capacitor in the motor circuit

2. Interpoles are used on large D.C. motors:

   a. to reduce the sparking as a result of commutation
   b. to increase the current in the armature
   c. to increase torque in the motor
   d. to reduce the torque in the motor

3. If the starting winding were burned out in a split-phase motor, when the power is turned on it would:

   a. short circuit the winding
   b. not start
   c. burn out the run winding
   d. reverse the rotation

4. A common method of splitting a single phase current to start a motor is:

   a. by using a relay switch
   b. by using a capacitor
   c. by using a resistor
   d. by using an inductor

5. If the load is removed from a series motor:

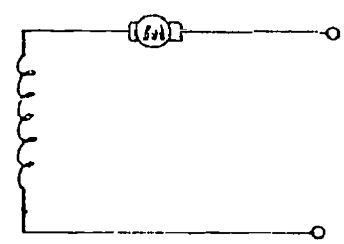
   a. it will decrease its speed
   b. it will run normally
   c. it will increase its speed
   d. it will destroy itself by centrifugal force

78.01.01.03 (continued)

6. Identify the schematic in Figure 1.

   a. dyna-motor
   b. parallel motor
   c. series motor
   d. syncro-motor

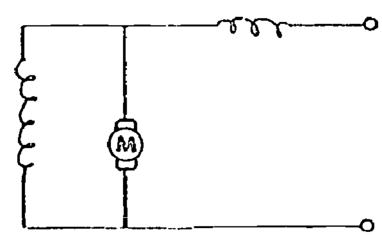
Fig. 1



7. Identify the schematic in Figure 2.

   a. syncro-motor
   b. compound motor
   c. parallel motor
   d. dyna-motor

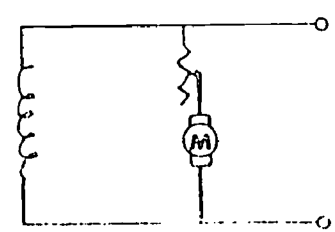
Fig. 2



8. Identify the schematic in Figure 3.

   a. syncro-motor
   b. series motor
   c. series-parallel motor
   d. variable starting resistance

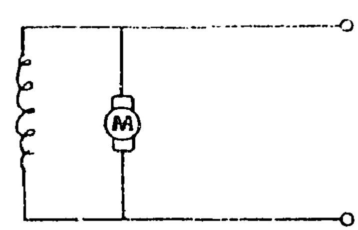
Fig. 3



9. Identify the schematic in Figure 4.

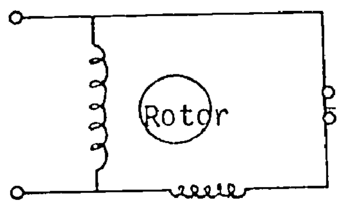
   a. dyna-motor
   b. compound motor
   c. shunt motor
   d. series motor

Fig. 4



78.01.01.03 (continued)

Fig. 5



10. Identify the schematic in Figure 5.

a. split-phase motor
b. repulsion induction motor
c. shade pole motor
d. syncro motor

LAP TEST ANSWER KEY: 78.01.01.03.A2-2

ELECTRIC MOTOR OPERATIONAL THEORY

1. B
2. A
3. B
4. D
5. D
6. C
7. B
8. D
9. C
10. A

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File Code: 78.01.01.04.A2-0

Date Published: 2-18-76

Learning Activity Package

Student: ____________________

Date: ____________________

PERFORMANCE ACTIVITY: Motor Construction

OBJECTIVE:

Identify the component parts of various motor types.

EVALUATION PROCEDURE:

Parts indentification must be without error.

Successfully complete at least 80% of the items on a multiple-choice test about this LAP.

RESOURCES:

Motor display boards: Shade-pole motor
Split-phase motor
Universal

PROCEDURE:

1. Label, using masking tape the component parts of each of the motors mounted on the motor display boards.
2. Have your instructor check for proper identification.
3. Complete the multiple-choice test items for this LAP.
4. Check your answers with the test key. If your answers are all correct, record your time for completing this LAP on your SPR. If you have any further problems, check with your instructor. When you have correctly completed all the test items, you may record your time on your SPR.

Principal Author(s): T. Ziller

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LAP TEST: MOTOR CONSTRUCTION

78.01.01.04

1. On the illustration of the universal motor, what number would identify the field coils:

   a. 3
   b. 2
   c. 1
   d. 4

2. On the illustration of the repulsion type motor, which number would identify the commutator?

   a. 4
   b. 2
   c. 3
   d. 1

3. On the illustration of the repulsion type motor, which number would identify the stator and winding?

   a. 3
   b. 1
   c. 2
   d. 4

4. On the illustration of the repulsion type motor, which number would identify the armature?

   a. 3
   b. 1
   c. 2
   d. 4

5. On the illustration of the polyphase motor, which number would identify the balance and cooling fins?

   a. 4
   b. 1
   c. 2
   d. 3

78.01.01.04 (continued)

6. On the illustration of the split phase motor, which number would identify the stator?

   a. 4
   b. 2
   c. 3
   d. 1

7. On the illustration of the split phase motor, which number would identify the capacitor?

   a. 3
   b. 1
   c. 4
   d. 2

8. On the illustration of a split phase motor, which number would identify the rotor?

   a. 2
   b. 1
   c. 3
   d. 4

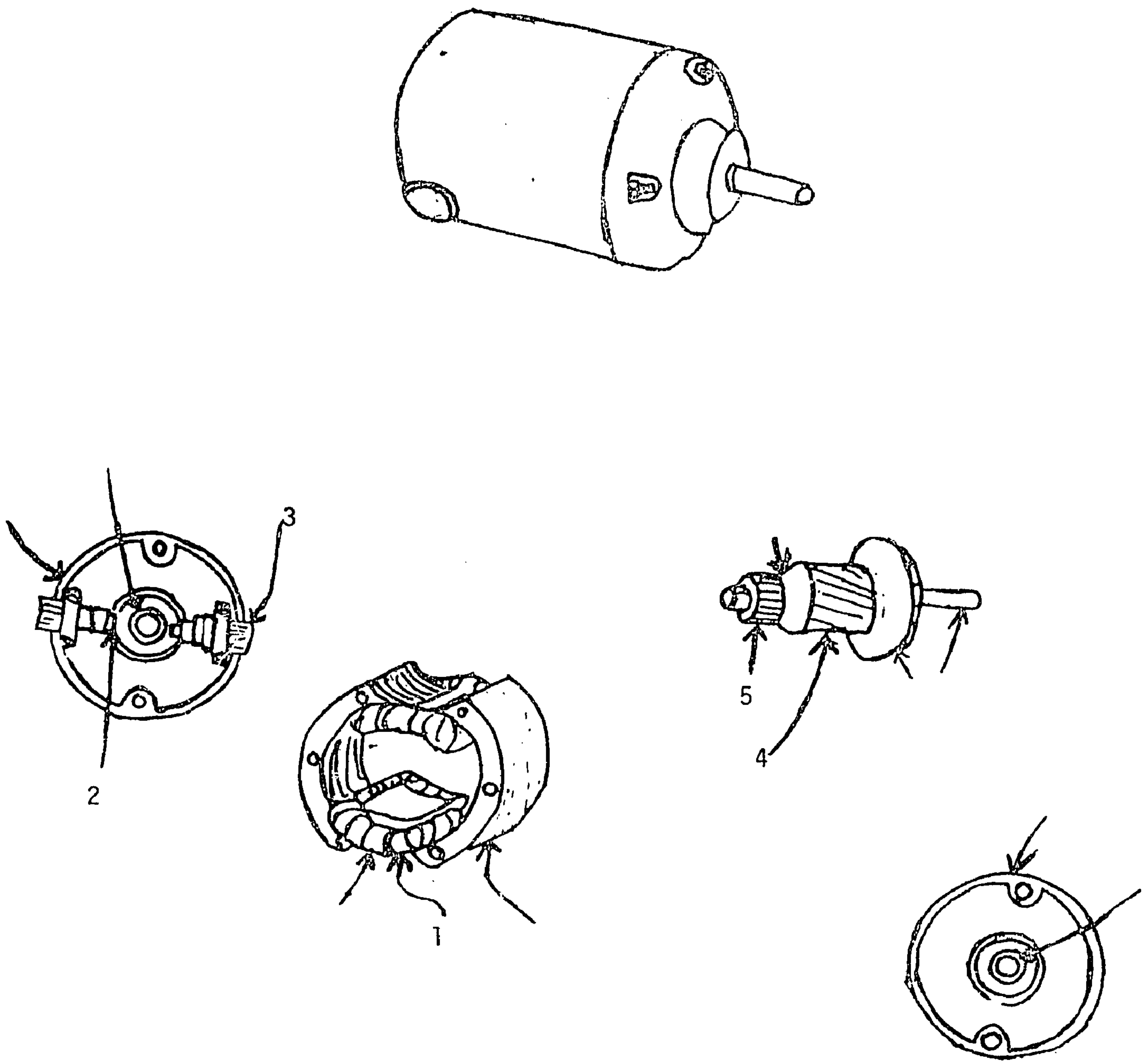
9. On the illustration of the DC motor and generator, which number would identify the laminated core?

   a. 2
   b. 1
   c. 3
   d. 4

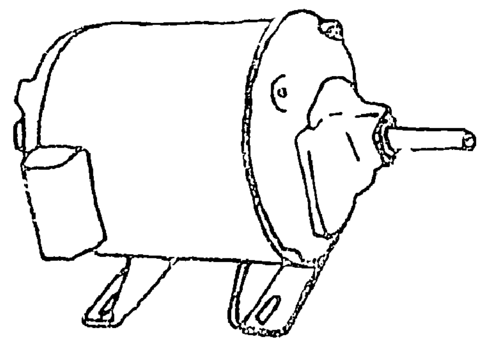
10. On the illustration of the DC motor and generator, which number would identify the brush and holder?

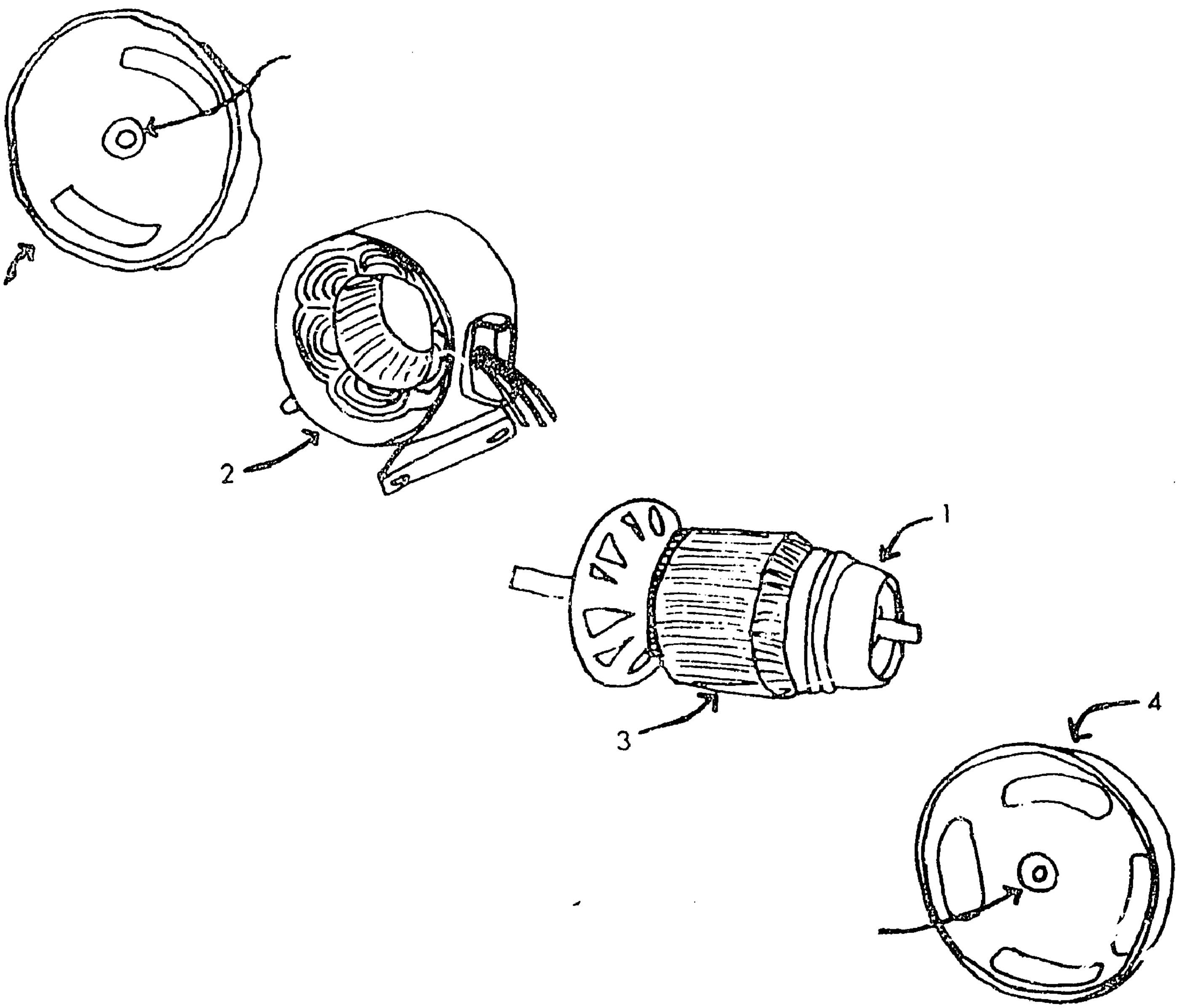
    a. 2
    b. 1
    c. 4
    d. 3

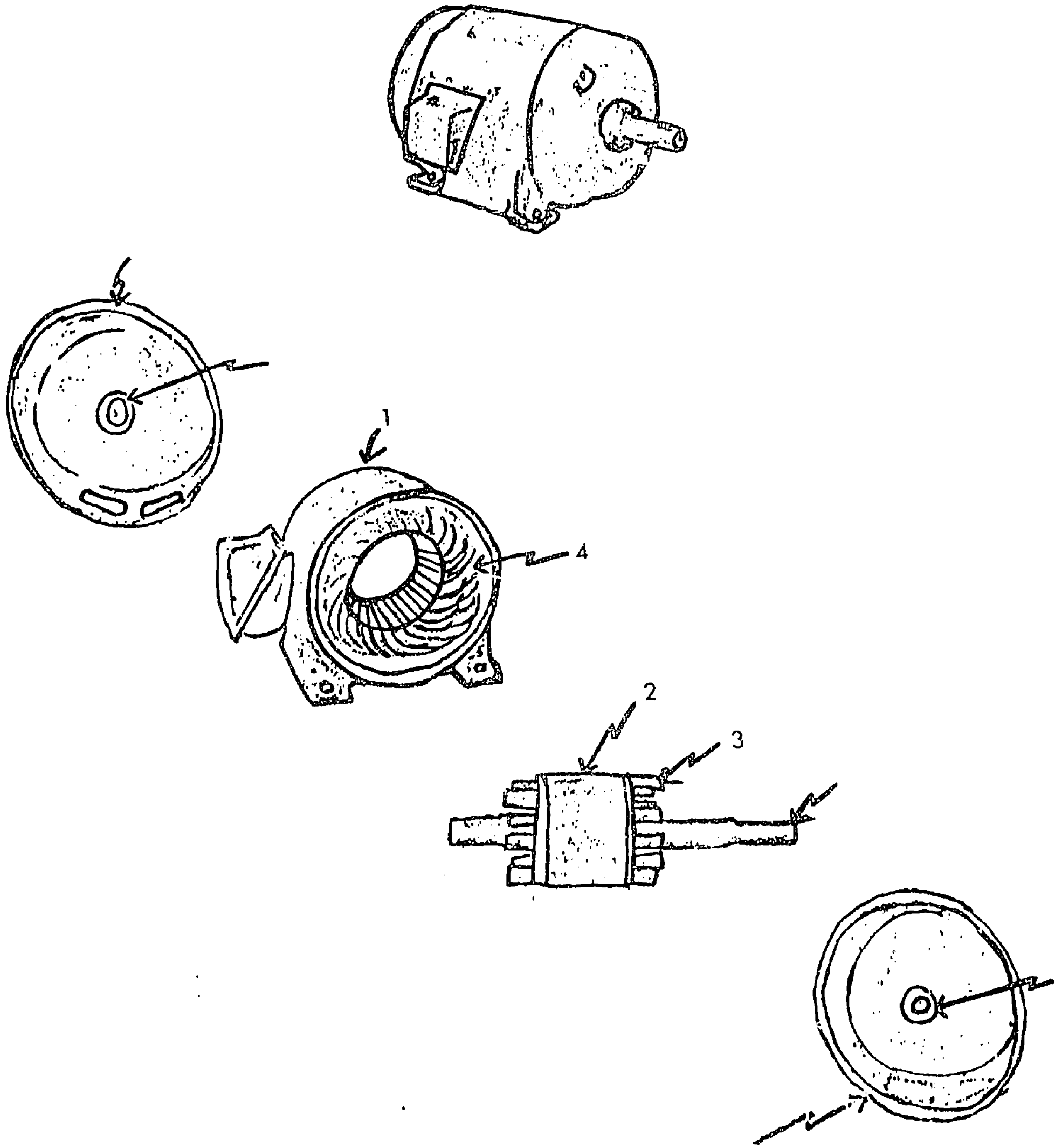
UNIVERSAL MOTOR



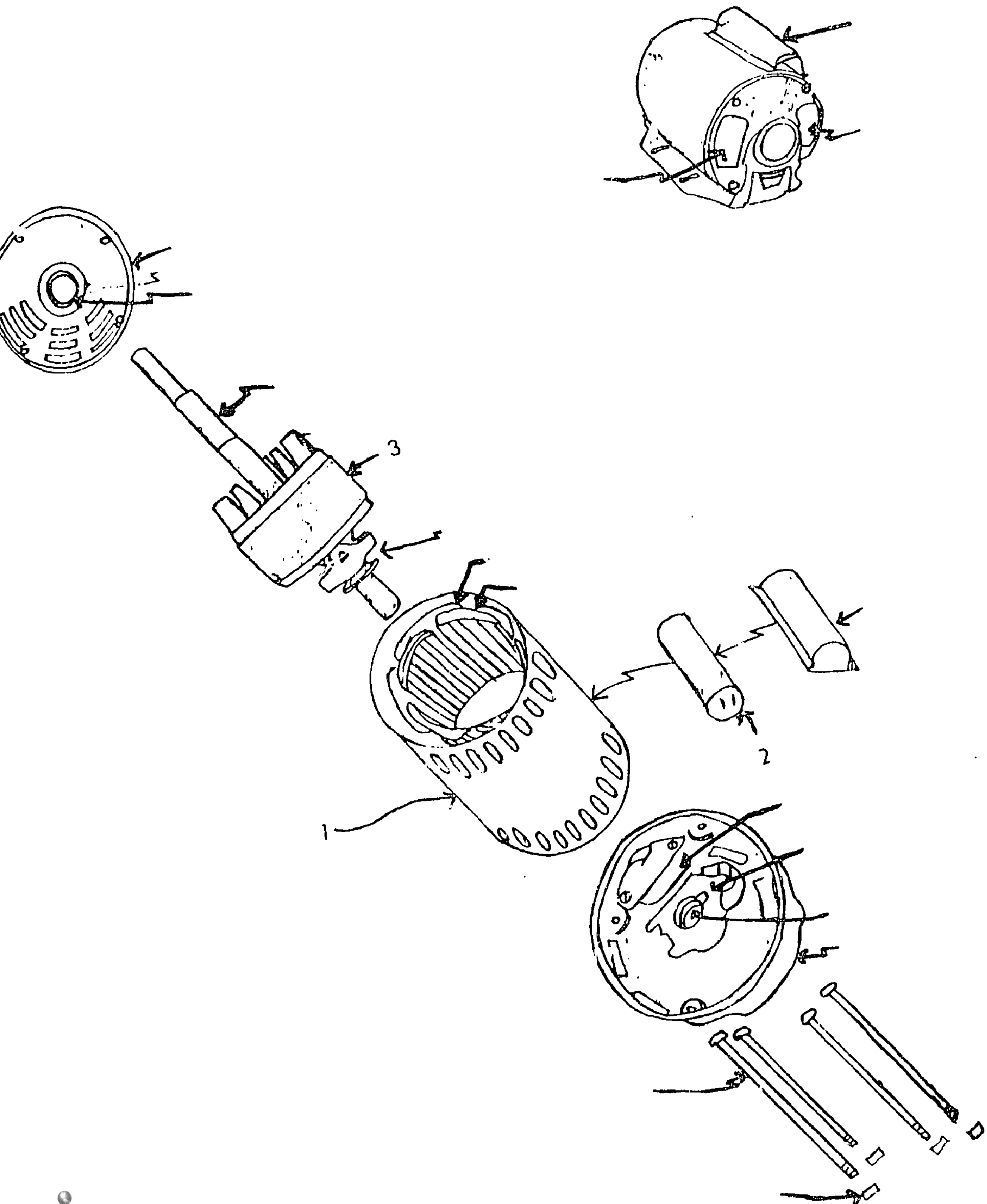
REPULSION-TYPE MOTOR



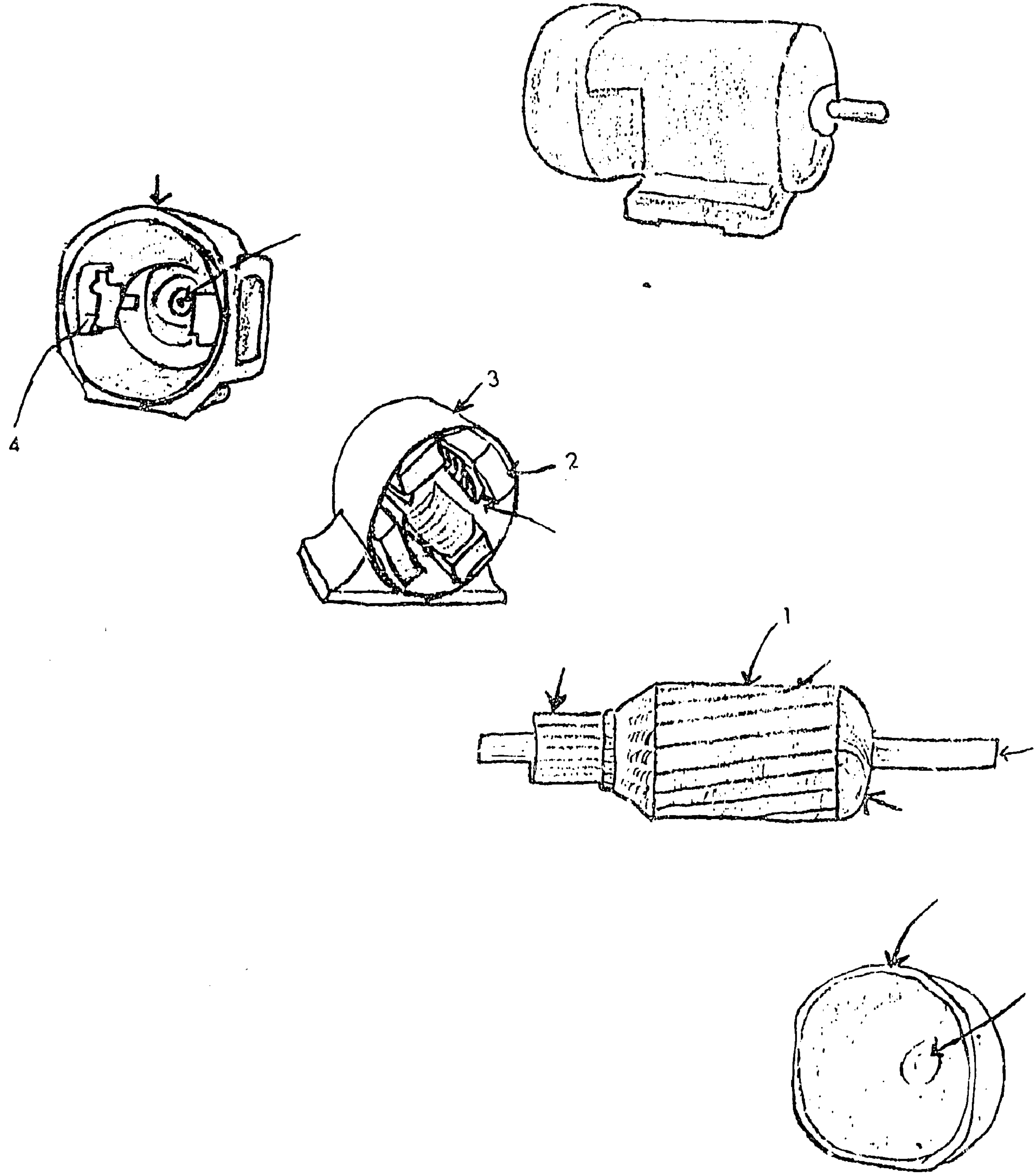



1
4
2
3
7

A SPLIT PHASE INDUCTION MOTOR



D. C. MOTOR AND GENERATOR



LAP TEST ANSWER KEY: 78.01.01.04.A2-2

MOTOR CONSTRUCTION

1. C
2. D
3. C
4. A
5. D
6. D
7. D
8. C
9. B
10. C

File Code: 78.01.01.05.A2-0

Date Published: 2-18-76

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Glasgow AFB, Montana 59231

Learning Activity Package

Student: ____________

Date: ____________

PERFORMANCE ACTIVITY: Types of Motors

OBJECTIVE:

Identify and describe the operational characteristics of various motor types.

EVALUATION PROCEDURE:

The descriptions of the motors include characteristics described in the resource.

RESOURCES:

Electric Motor Repair, Rosenberg R., 2nd Edition, Rinehart Press, 1970.

PROCEDURE:

1. Read about split-phase motors pages 1-4. Universal motors pages 254-257; shade-pole motors pages 265-268 and three-phase motors pages 106-107 in Electric Motor Repair.
2. Write a short description of each of the following motor types: Universal; Shade-pole; Split-phase, Three-phase.
3. Complete the multiple-choice test items for this LAP.
4. Check your answers with the test key. If your answers are all correct, record your time for completing this LAP on your SPR. If you have missed any questions, try to find out why you missed the test items. If you have any further problems, check with your instructor. When you have correctly completed all the test items, you may record your time on your SPR.

Principal Author(s): T. Ziller

Student: ______________ File Code: 78.01.01.05.A2-2

Date: ______________ Date Published: 12-18-74

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

LAP TEST: TYPES OF MOTORS

78.01.01.05

1. What rotates in a shaded-pole motor?

   a. field coil
   b. armature
   c. squirrel cage
   d. shade coil

2. On a shaded-pole motor rotor what is the heavy copper loop called?

   a. rotor loop
   b. shaded loop
   c. rotor ring
   d. shaded ring

3. What percent of the rotor speed in a capacitor start motor causes the switch to connect from the start to the run windings?

   a. 25%
   b. 100%
   c. 50%
   d. 75%

4. A machine that converts mechanical energy to electrical energy is called:

   a. an armature
   b. a generator
   c. a motor
   d. a capacitor

5. A DC motor has a device that reverses the connection to the revolving conductors in the generator. What is the device called?

   a. fields
   b. brushes
   c. a commutator
   d. coils

78.01.01.05 (continued)

6. A machine that converts electrical energy into mechanical energy is called:

   a. a generator
   b. a motor
   c. an alternator
   d. a capacitor

7. A resistance start motor is a form of which of the following?

   a. capacitor start
   b. repulsion
   c. series
   d. split-phase

8. If a resistor is wired in series with a start winding in a motor, what is the result?

   a. one phase is produced
   b. two phases are produced
   c. three phases are produced
   d. no result can be determined

9. A motor that is commonly used in washing machines is called which of the following?

   a. universal start motor
   b. capacitor start motor
   c. resistance start motor
   d. repulsion start motor

10. Which of the following motors requires a continuous duty capacitor?

   a. split capacitor
   b. split capacitor start
   c. split capacitor run
   d. variable capacitor start/run

LAP TEST ANSWER KEY: 78.01.01.05.A2-2

TYPES OF MOTORS

1. C
2. D
3. D
4. B
5. C
6. B
7. D
8. B
9. C
10. A

Student: ____________________ File Code: 78.01.01.00.B2-2

Date: ____________________ Date Published: 12/1/75

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UNIT POST TEST: ELECTRIC MOTOR FUNDAMENTALS

78.01.01.01

1. The flux lines that represent magnetic force:

   a. follow straight lines
   b. occur only at the magnetics
   c. are uniformly distributed in the area surrounding the magnet
   d. are concentrated at the ends, or poles, of the magnet

2. The lines of force that form a magnetic field around a magnet have polarity; this means that they:

   a. are triangular in shape
   b. radiate out in straight lines perpendicular to the surface of the magnet
   c. flow in a complete circuit around the magnet
   d. flow from one pole of the magnet to the other

3. When several loops are made in a conductor to form a coil, the polarity of the coil:

   a. depends on the direction in which the conductor is coiled around the core
   b. is the same as the polarity of the current flowing through the conductor
   c. is given by the left-hand rule for conductors
   d. is never north

4. An "induced current" can be produced by:

   a. vector quantities
   b. relative motion
   c. a conductor
   d. electromagnetic field

5. The left-hand rule for coils tells us the direction of:

   a. the flux lines circling
   b. the N pole of the coil
   c. current flow through the conductor
   d. flux density

78.01.01.02

6. According to Faraday's law, the voltage generated by the relative motion of a conductor and a magnetic field is:

   a. indirectly proportional to the cross sectional area of the field
   b. directly proportional to the cross section area of the field
   c. directly proportional to the rate at which the conductor cuts the lines of magnetic force
   d. always in the same direction, negative to positive

7. The flux density of a coil is inversely proportional to:

   a. the reluctance of the core
   b. the permeability of the core
   c. the diameter of the core
   d. the field of the core

8. The purpose of the commutator is:

   a. to oppose any change in current
   b. to convert D-C in the rotating armature to a pulsating A-C current
   c. to eliminate brushes
   d. to convert A-C in the rotating armature to a pulsating D-C current

9. How may output of generator be controlled when operating at constant speed?

   a. voltage regulator
   b. slow down the speed of the current flow
   c. reverse the rotation of the generator
   d. use a varispeed control device

10. Which of the following core materials would produce the strongest magnetic field for a given coil?

   a. air
   b. soft iron
   c. aluminum
   d. carbon rod

78.01.01.03

11. Why is the term "end play" important?

   a. because the end plates may press against the coils and cause a short
   b. only because of the run winding
   c. only because of the start winding
   d. because of insulation paper

78.01.01.03 (continued)

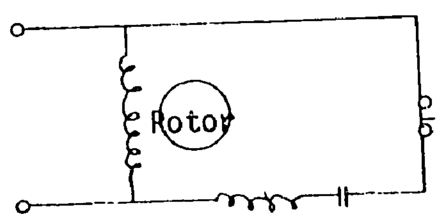
12. The generator action in a motor is:

    a. constant rotation of the armature in a motor
    b. conductors cutting through a magnetic field
    c. counter electro motive force generated
    d. not possible in a motor

13. Total current used by the motor is determined by:

    a. the power reduction ratio
    b. the field and armature currents
    c. the constant speed of the motor
    d. the percent of speed regulation

Fig. 6



14. Identify the schematic in Figure 6.

    a. series motor
    b. dyna-motor
    c. capacitor-start split-phase motor
    d. poly-phase motor

15. Motor starters are necessary on heavy duty motors:

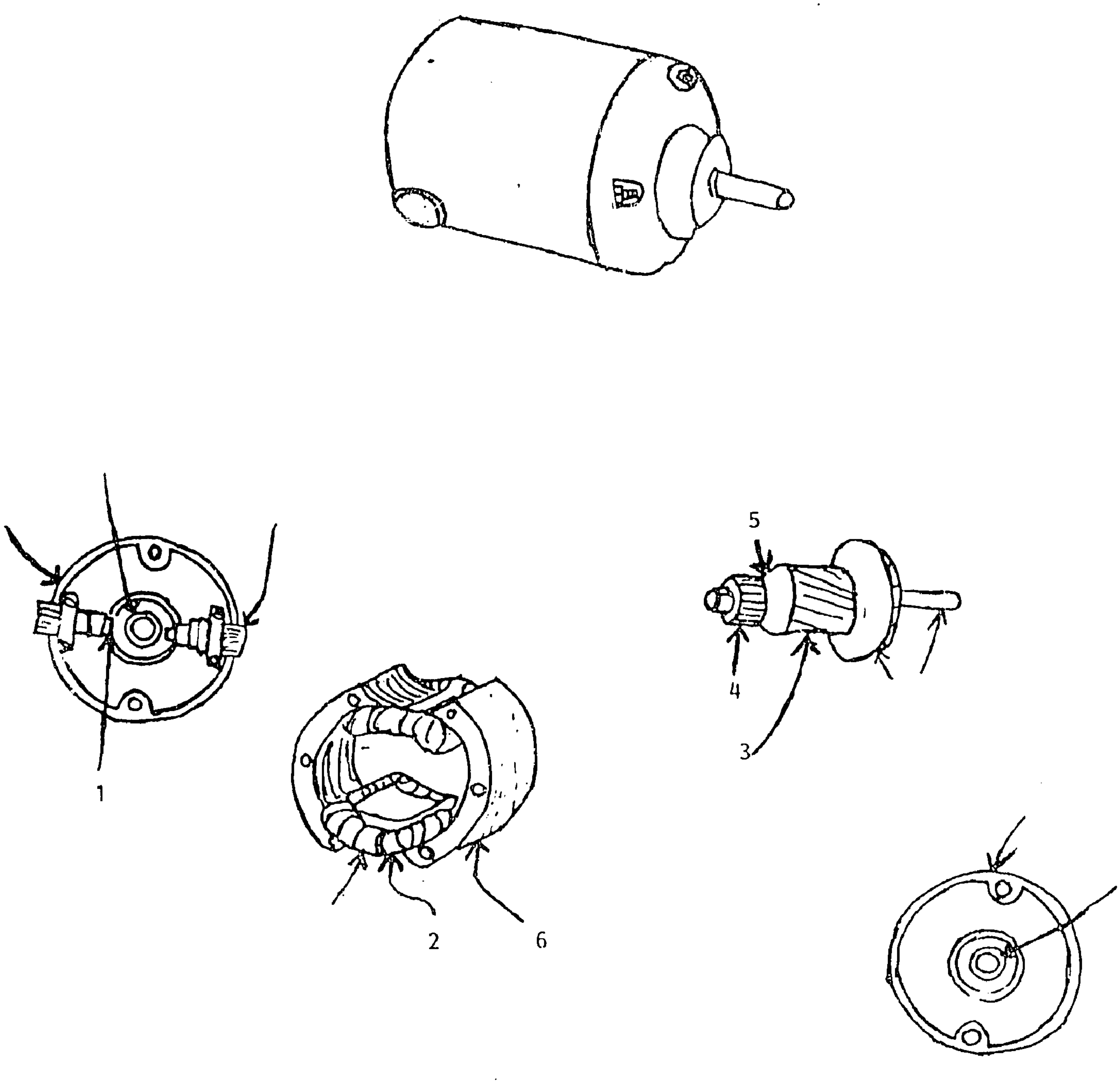
    a. to release high voltage feed back
    b. to increase starting torque
    c. to increase starting resistance
    d. to bypass the capacitor

78.01.01.04

16. On the illustration of the universal motor, which number would identify the carbon brush?

    a. 3
    b. 2
    c. 1
    d. 4

UNIVERSAL MOTOR



78.01.01.04 (continued)

17. On the illustration of the universal motor, which number would identify the commutator?

   a. 2
   b. 1
   c. 4
   d. 3

18. On the illustration of the universal motor, which number would identify the armature?

   a. 4
   b. 3
   c. 5
   d. 2

19. On the illustration of the polyphase motor, which number would identify the stator?

   a. 2
   b. 1
   c. 3
   d. 4

20. On the illustration of the DC motor and generator, which number would identify the field windings?

   a. 1
   b. 2
   c. 3
   d. 4

78.01.01.05

21. What are the two classes of polyphase induction motors?

   a. squirrel cage and wound rotor
   b. split phase and capacitor start
   c. wound rotor and syncronous
   d. squirrel cage and shaped pole

22. What device is used in a capacitor start motor to connect the AC voltage from the start to the run winding?

   a. resistor
   b. capacitor
   c. centrifugal switch
   d. inductor switch

78.01.01.05 (continued)

23. What percent of the rotor speed in a capacitor start motor causes the switch to connect from the start to the run windings?

    a. 25%
    b. 100%
    c. 50%
    d. 75%

24. What are the two principle classes of single phase induction motors?

    a. split-capacitor and capacitor start
    b. split-phase and commutator
    c. capacitor run and capacitor start
    d. repulsion and series

25. Which of the following motors requires a continuous duty capacitor?

    a. split capacitor
    b. split capacitor start
    c. split capacitor run
    d. variable capacitor start/run

UNIT TEST ANSWER SHEET

UNIT POST TEST: ELECTRIC MOTOR FUNDAMENTALS

Occupational Area: ____________________

File Code: 78.01.01.00.B2-2

Name: ____________________

ANSWERS

01.01.01	1.	D	78.01.01.05	21.	A	41.	
	2.	D		22.	C	42.	
	3.	A		23.	D	43.	
	4.	D		24.	B	44.	
	5	B		25.	A	45.	
01.01.02	6.	C		26.		46.	
	7.	A		27.		47.	
	8.	D		28.		48.	
	9.	A		29.		49.	
	10.	B		30.		50.	
01.01.03	11.	A		31.		51.	
	12.	B		32.		52.	
	13.	B		33.		53.	
	14.	C		34.		54.	
	15.	C		35.		55.	
.01.01.04	16.	C		36.		56.	
	17.	C		37.		57.	
	18.	B		38.		58.	
	19.	B		39.		59.	
	20.	B		40.		60.	

File Code: 78.01.02.00.A2-1

Date Published: 2-18-76

Mountain-Plains Education & Economic Development Program, Inc.

Glasgow AFB, Montana 59231

Learning Experience Guide

UNIT: REWINDING

RATIONALE:

All electric motors will some day need repair. There are several types of motors. The motor repair person will be asked to strip, insulate, wind and make internal connections. In order to do these tasks the repair person needs to know about the types of motor construction characteristics. Techniques and skills must be developed for rebuilding a motor.

PREREQUISITES:

Unit 78.01.01.: Electric Motor Fundamentals.

OBJECTIVES:

Remove, wind and install stator and armature windings that meet given motor specification.

RESOURCES:

Printed Materials

Electric Motor Repair. Second Edition, Rosenburg, Holt, Rinehart & Winston, 1970.

Audio/Visual

Display Boards:

1. Shaded-pole motor.
2. Split-phase motor.
3. Universal motor.

Equipment

Cutter, pipe
Equipment, special: chisel, coil stripping
coil shapers
insulation former
slotter-scraper
winder, armature
winder, coil

Principal Author(s): T. Ziller

Equipment, test: growler, internal and external
meter, volt-ohm
Motor, electric: three-phase
split-phase induction
capacitor start
repulsion
direct current
universal
shaded-pole
Oven, pegs, dowel (assortment)
Tools, basic: box, tool (18 x 8 x 9)
chisel, cold
crimpers, lug
cutters, diagonal
gauge, circular
hacksaw
hammer, ball peen
nut driver set
plier, arc joint
plier, coil tamping
plier, lineman's
plier, long chain-nose
plier, snap-ring (internal and external)
puller, pulley
punch, center
screwdriver, blade (set)
wire skinner/straightener
wrench, locking plier

GENERAL INSTRUCTIONS:

This unit consist of 6 Learning Activity Packages (LAPs). Each LAP will provide specific information for completion of a learning activity.

The general procedure for this unit is as follows:

(1) Read the first assigned Learning Activity Package (LAP).
(2) Begin and complete the first assigned LAP.
(3) Take and score the LAP test.
(4) Turn in the LAP test answer sheet.
(5) Determine the reason for any missed items on the LAP test.
(6) Proceed to and complete the next assigned LAP in the unit.
(7) Complete all required LAPs for the unit by following steps 3 through 6.
(8) In this Unit, there are some LAPs that have tests combined with other LAP tests. These combined tests are taken after completing the last LAP covered by the test.
(9) Take the unit tests as described in the Unit LEG "Evaluation Procedures".
(10) Proceed to the next assigned unit.

PERFORMANCE ACTIVITY:

.01 Taking Data about the Motor
.02 Stripping the Armature and Stator Windings
.03 Insulating the Stator and Armature
.04 Winding Stator Coils
.05 Winding Armature Coils
.06 Baking and Varnishing

EVALUATION PROCEDURE:

When pretesting:

1. The student takes the unit multiple-choice pretest.
2. Successful completion is 4 out of 5 items for each LAP part of the pretest.
3. The student then takes a unit performance test if the unit pretest was successfully completed.
4. Satisfactory completion of the performance test is meeting the criteria listed on the performance test.

When post testing:

1. The student takes a multiple-choice unit post test and a unit performance test.
2. Successful unit completion is meeting the listed criteria for the performance test.

FOLLOW-THROUGH:

You may now begin with the first LAP in this unit. Talk to your instructor if you need help.

Student: ______________________ File Code: 78.01.02.00.A2-2

Date: ______________________ Date Published: ~~12-12-74~~

Mountain-Plains Education &
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UNIT PRETEST: REWINDING

78.01.02.01

1. On a motor, the number of slots separating the sides of a coil, including the slots in which the winding lies, is called:

   a. turns
   b. pitch
   c. slots
   d. end room

2. How is the span of a coil in a motor recorded?

   a. a pencil or pen
   b. not necessary
   c. 1-4 or 2-6 or as the case may be
   d. 1-32 or 2-36 as the case may be

3. When working on a motor, how do you get information on the number of turns of wire?

   a. you guess at it
   b. it is stamped on the frame
   c. you count each coil
   d. it is stamped on data plate

4. When is the proper time to start recording data for three-phase motor?

   a. just when the instructor is watching
   b. after it is completed
   c. as soon as you put it on the work bench
   d. not necessary

5. In a three-phase motor, all the coils have the same:

   a. bearings
   b. pitch
   c. coils
   d. poles

78.01.02.02

6. While stripping the stator on a motor, why is it important to count the turns of wires and number of coils per pole?

   a. to check the manufacturer's specifications
   b. to get it on the data card, so when it is rewound, it will have the same number of turns per pole
   c. to guard against a change in polarity
   d. because when it is rewound, it should have 5 less coils per pole than are unwound

7. How much heat is needed to burn the stator on a motor?

   a. the stator is made to withstand any temperature
   b. approximately 200 degrees C.
   c. approximately 100 degrees C.
   d. approximately 400 degrees

8. If the burning method is used, why is it very important that the stator on a motor be allowed to cool gradually?

   a. it costs money to cool it rapidly
   b. it is not necessary
   c. it prevents warping
   d. so that the stator doesn't get burned

9. One method of stripping a stator is to:

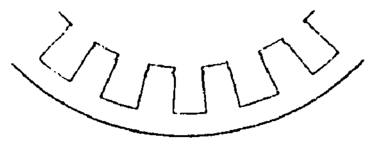
   a. cut both sides off
   b. cut each coil on one side and pull the coil out the other
   c. pull
   d. cut each coil on one side and pull

10. When stripping a motor, why should one coil be saved?

   a. to be reused when the motor is rebuilt
   b. to provide the dimensions for the new coils
   c. because the new coils must be wound in reverse of the old ones
   d. to provide a guide for installing the new coils

<u>78.01.02.03</u>

11. What type of slot does this drawing represent in a motor?



   a. semiclosed stator
   b. rotor
   c. open slot stator
   d. stator

12. If necessary, mylar combination could be used for what insulation type class on a motor?

   a. A
   b. B-H
   c. B-F
   d. B

13. When reinsulating a core on a motor, if the insulation paper is to be cuffed, how much longer than the slot will it have to be?

   a. 1/4 inch
   b. 1/8 inch
   c. 5/8 inch
   d. 1/2 inch

14. When rewinding a motor, the insulation paper is cut longer than the slot by:

   a. 1/8 inch
   b. 1/4 inch
   c. 1/2 inch
   d. 5/16 inch

15. When reinsulating a core on a motor, the cuff should be turned back:

   a. 1/4 inch
   b. 5/8 inch
   c. 1/2 inch
   d. 1/8 inch

78.01.02.04

16. What is the easiest way to rewind the stator on a motor, if it has been charred?

    a. cut off flush on one end of stator coils and pull
    b. unwind each wire at a time
    c. cut each end of the coils and pull
    d. cut only one end of each coil and pull

17. What is commonly used to determine which form should be used when rewinding the stator on a split phase motor?

    a. a form gauge
    b. a wire gauge
    c. a single strand of wire
    d. a flexible tube

18. When using wood forming blocks for shaping coils for the stator on a split-phase motor, approximately what depth should the wood blocks be in relation to the stator slots?

    a. 1/2 of the slot depth
    b. equal to the slot depth
    c. 3/4 of the slot depth
    d. 1/4 of the slot depth

19. What is one of the primary advantages of skein winding over other types of winding in a split-phase motor?

    a. less power will be used when operating the motor
    b. higher voltage is obtained
    c. lower voltage is obtained
    d. many conductors may be placed in the slot at one time

20. Skein coils, when installed in a split phase motor, must be placed in what way in the slots?

    a. from the smallest pitch to the largest
    b. from the largest pitch to the smallest
    c. from the center pitch to the smallest
    d. from the center pitch to the largest

78.01.02.05

21. What is the primary purpose of an interpole field coil on a DC motor?

    a. prevent arching of the brushes
    b. increase horsepower
    c. increase motor starting torque
    d. decrease friction in the motor

78.01.02.05 (continued)

22. Series field coils consist of which of the following in a DC motor?

 a. light wire with many turns
 b. heavy wire with many turns
 c. heavy wire with a few turns
 d. light wire with a few turns

23. Shunt fields in a DC motor consist of which of the following?

 a. heavy wire with a few turns
 b. light wire with a few turns
 c. light wire with many turns
 d. heavy wire with many turns

24. How are field coils connected in a DC motor?

 a. so all poles have the same polarity
 b. so alternate polarity exists
 c. so all poles have negative polarity
 d. so all poles have positive polarity

25. If the shunt field comes into contact directly or indirectly with the series field in a DC motor, which of the following will develop?

 a. direct short
 b. more horsepower
 c. less horsepower
 d. more starting torque

78.01.02.06

26. Before dipping, the stator from a motor should be placed in a baking oven for:

 a. 10 minutes
 b. 45 minutes
 c. 60 minutes
 d. 30 minutes

27. When varnishing a motor, many shops do not have a baking oven and they want a harder finish than air drying varnish. They would use:

 a. lead varnish
 b. synthetic AC 43
 c. solventless epoxy resin
 d. orange varnish

78.01.02.06 (continued)

28. Immediately after removing the stator of a motor from the varnish dip tank, the stator is placed in the oven:

    a. just before it stops dripping
    b. just after it stops dripping
    c. yes
    d. no

29. What will help decrease the moisture content in the windings of a stator on a motor?

    a. dripping
    b. baking
    c. varnishing
    d. baking and varnishing

30. Approximately how long must the winding of a motor soak in solvent?

    a. two hours
    b. one hour
    c. 30 minutes or until bubbling ceases
    d. 30 minutes

UNIT TEST ANSWER SHEET

UNIT PRETEST:
REWINDING

Occupational Area: ______________________
File Code: 78.01.02.00.A2-2
Name: ______________________

ANSWERS

78.01.02.01	1.	B	78.01.02.05	21.	A	41.	
	2.	C		22.	C	42.	
	3.	C		23.	C	43.	
	4.	C		24.	B	44.	
	5.	B		25.	A	45.	
78.01.02.02	6.	B	78.01.02.06	26.	C	46.	
	7.	D		27.	C	47.	
	8.	C		28.	B	48.	
	9.	B		29.	D	49.	
	10.	B		30.	C	50.	
78.01.02.03	11.	C		31.		51.	
	12.	A		32.		52.	
	13.	D		33.		53.	
	14.	B		34.		54.	
	15.	D		35.		55.	
78.01.02.04	16.	A		36.		56.	
	17.	C		37.		57.	
	18.	C		38.		58.	
	19.	D		39.		59.	
	20.	A		40.		60.	

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Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Learning Activity Package

Student: ______________________

Date: ______________________

PERFORMANCE ACTIVITY: Taking Data About the Motor

OBJECTIVE:

Identify and record pertinent data for rewinding various motor types.

EVALUATION PROCEDURE:

Score at least 80% on a written multiple-choice test.

RESOURCES:

Electric Motor Repair, Rosenburg, Robert; 2nd Edition, Rinehart Press, San Francisco, 1970.

Assortment of motor (polyphase, repulsion and split-phase) displays.

PROCEDURE:

1. Read pages 5-9 in Electric Motor Repair.
2. Record data about a split-phase motor using the attached data sheet for split-phase motor.
3. Record data about a polyphase motor using the attached data sheet for polyphase motor.
4. Record data about a repulsion motor using the data sheet for the repulsion motor.
5. Take the LAP test.

Principal Author(s): T. Ziller

DATA SHEET FOR POLYPHASE MOTOR

MAKE Morse - Fair banks

H.P. 10	R.P.M. 625	VOLTS 208/416	AMPS. 15
CYCLE 60	TYPE T-P	FRAME JA-11	STYLE cont.
TEMP. 60° C	MODEL DPA-16	SERIAL NO. 1820746	PHASE 3

NO. OF COILS 54	NO. OF SLOTS 36	CONNECTION 2 Y
SIZE WIRE 20	NO. OF TURNS 65	NO. OF GROUPS 18
COILS/GROUP 3	NO. OF POLES 6	PITCH OF COIL 1 & 8

DATA SHEET FOR POLYPHASE MOTOR

MAKE

H.P.	R.P.M.	VOLTS	AMPS.
CYCLE	TYPE	FRAME	STYLE
TEMP.	MODEL	SERIAL NO.	PHASE

NO. OF COILS	NO. OF SLOTS	CONNECTION
SIZE WIRE	NO. OF TURNS	NO. OF GROUPS
COILS/GROUP	NO. OF POLES	PITCH OF COIL

DATA SHEET FOR SPLIT-PHASE MOTOR

AKE Frankler Electric

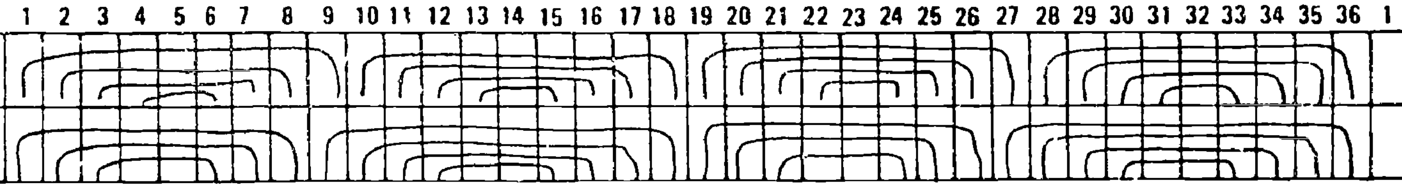
P. 1/2	R.P.M. 1725	VOLTS 117	AMPS. 4.65
CLE 60 Hz	TYPE A/B	FRAME 174036-2	S.F. 1.05
MP. RISE 50° C	MODEL 3181AX	SERIAL NO. 1411	PHASE 1 Ø
). OF POLES 4	CODE R-B 3	NO. OF SLOTS 36	TIME RATING cont.

NDING	SIZE WIRE	NO. OF CIRCUITS	PITCH	TURNS
JNNING	20	1	1-9	42-39-29-13
ARTING	24	1	1-8 / 1-10	31-23-19-13

OT NO. 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 1

JNNING

ARTING



ROTATION CLOCKWISE COUNTER CLOCKWISE

DATA SHEET FOR SPLIT-PHASE MOTOR

AKE

I.P.	R.P.M.	VOLTS	AMPS.
CYCLE	TYPE	FRAME	S.F.
TEMP. RISE	MODEL	SERIAL NO.	PHASE
NO. OF POLES	CODE	NO. OF SLOTS	TIME RATING

INDING	SIZE WIRE	NO. OF CIRCUITS	PITCH	TURNS
RUNNING				
STARTING				

SLOT NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	1
RUNNING																																					
STARTING																																					

ROTATION CLOCKWISE COUNTER CLOCKWISE

Student: ____________________ File Code: 78.01.02.01.A2-2

Date: ____________________ Date Published: 12-18-74

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

LAP TEST: TAKING DATA ABOUT THE MOTOR

78.01.02.01

1. Identify the information necessary in taking data for the rewinding of a motor.

   a. none of these
   b. obtain information on both the run and start windings
   c. note specific information concerning the old windings
   d. obtain as much data as possible

2. What information would you put on your data sheet if the start winding on a motor was shorted?

   a. don't put anything on the data sheet
   b. put just the start winding on the information sheet
   c. put just the run winding on the data sheet
   d. put both the run winding and start winding information

3. How should the absence of the odd-sized slot on a motor be marked?

   a. center punch mark in the center slot of each pole
   b. only when center slot is odd-sized
   c. don't worry about it
   d. only when start winding is to be changed

4. Why is taking the proper data when working on a motor important?

   a. it is just something we do in schools
   b. it is added paper work to increase the price it costs the consumer
   c. so that no difficulty will be encountered upon reassembly
   d. it is not needed

5. On a motor, the number of slots separating the sides of a coil, including the slots in which the winding lies, is called:

   a. turns
   b. pitch
   c. slots
   d. end room

6. How is the span of a coil in a motor recorded?

   a. a pencil or pen
   b. not necessary
   c. 1-4 or 2-6 or as the case may be
   d. 1-32 or 1-36 as the case may be

7. What is meant by the pitch of a coil on a motor?

   a. the number of slots separating the sides of a coil
   b. the number of groups of coils
   c. the number of degrees they are apart
   d. how far the coil protrudes from the slots

8. When working on a motor, how do you get information on the number of turns of wire?

   a. you guess at it
   b. it is stamped on the frame
   c. you count each coil
   d. it is stamped on data plate

9. In a three-phase motor, all the coils have the same:

   a. bearings
   b. pitch
   c. coils
   d. poles

10. Should the wire size be written on a data card, when repairing an inductor motor?

   a. no, it is not important
   b. yes, wire size determines total cost
   c. no, wire size has nothing to do with motors
   d. yes, the specifications call for it

LAP TEST ANSWER KEY: 78.01.02.01.A2-2

TAKING DATA ABOUT THE MOTOR

1. C
2. B
3. A
4. C
5. B
6. C
7. A
8. C
9. B
10. B

File Code: 78.01.02.02.A2-0

Date Published: 2-19-76

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Learning Activity Package

Student: ______________________

Date: ______________________

PERFORMANCE ACTIVITY: Stripping the Armature and Stator Windings

OBJECTIVE:

Given a motor, strip the stator windings following practices and procedures accepted in the industry. Identify stripping procedures and their purposes.

EVALUATION PROCEDURE:

Stator and armature stripping is evaluated by performance test at the end of this unit. Successfully complete at least 80% of the items on a combined multiple-choice test about this and one other LAP. The combined LAP test is taken after completing LAP "Insulating the Stator and Armature".

RESOURCES:

Electric Motor Repair, Rosenburg.

handtools

PROCEDURE:

1. Read pp. 9-12 and pp. 108 and 109 in Electric Motor Repair.
2. Obtain the tools required to strip the stator of its windings.
3. Strip the stator of the given motor.
   NOTE: If you have any difficulty or questions always check with your instructor.
   KEY POINT: Be sure you follow the procedure described in the text concerning the collection and recording of data motor information. If data information is inaccurate, you will not be able to repair the motor.
4. When you have stripped the stator, go to the instructor for evaluation.
5. Read pages 181 and 182 in Electric Motor Repair.
6. Obtain the tools required to strip the armature of its windings.
7. Strip the armature of a given motor.
8. Take the LAP test.

Principal Author(s): T. Ziller

DATA SHEET FOR SPLIT-PHASE MOTOR

MAKE

H.P.	R.P.M.	VOLTS	AMPS.
CYCLE	TYPE	FRAME	S.F.
TEMP. RISE	MODEL	SERIAL NO.	PHASE
NO. OF POLES	CODE	NO. OF SLOTS	TIME RATING

WINDING	SIZE WIRE	NO. OF CIRCUITS	PITCH	TURNS
RUNNING				
STARTING				

SLOT NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	1
RUNNING																																					
STARTING																																					

ROTATION	CLOCKWISE	COUNTER CLOCKWISE

DATA SHEET FOR POLYPHASE MOTOR

MAKE

H.P.	R.P.M.	VOLTS	AMPS.
CYCLE	TYPE	FRAME	STYLE
TEMP.	MODEL	SERIAL NO.	PHASE

NO. OF COILS	NO. OF SLOTS	CONNECTION
SIZE WIRE	NO. OF TURNS	NO. OF GROUPS
COILS/GROUP	NO. OF POLES	PITCH OF COIL

File Code: 78.01.02.03.A2-0

Date Published: 2-19-76

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Learning Activity Package

Student: ______________________

Date: ______________________

PERFORMANCE ACTIVITY: Insulating the Stator and Armature

OBJECTIVE:

Given the necessary tools, equipment, and supplies, correctly insulate the armature and stator of a motor to meet the standards of the manufacturer and follow procedures accepted in the industry. Identify procedures for insulating windings and characteristics of insulation.

EVALUATION PROCEDURE:

Insulation installation meets the criteria on the checklist. Score at least an 80% on a multiple-choice test.

RESOURCES:

Electric Motor Repair, Rosenburg.

Insulation former	assortment of dowel pegs
paper cutter	slotter/scraper

PROCEDURE:

1. Read pp. 12-13 and p. 109 in Electric Motor Repair.
2. Obtain the necessary tools and equipment required to insulate a given stator.
   NOTE: Be sure you follow the procedures described in the attached checklist: "Stator and Armature Insulation." (Caution: Follow data sheet information very carefully)
3. When you have completed all the steps necessary on the checklist to complete this job, go to the instructor for evaluation.
4. Insulate the given armature using the attached checklist for procedure.
5. Have the armature insulation installation evaluated by the instructor.
6. Take the LAP test.

Principal Author(s): T. Ziller

CHECKLIST: STATOR AND ARMATURE INSULATION

1.____ Clean the slots using a slotter-scraper.

2.____ If insulation is to be cuffed go to step 4. If not cuffed take step 3.

3.____ Cut insulation to length and width.
(Length is cut ½ inch larger than slot length; width is cut ½ inch wider than two times the depth plus the width of the slot.) Go to step 6.

4.____ Cut insulation length 1 inch larger than slot length. Cut insulation width ½ inch wider than two times the depth plus the width of the slot.

5.____ Use the insulation frames to put cuffs on the insulation strips.

6.____ Place insulation strips in the slots.

7.____ Form the strips to the slot walls with a dowel.

Student: ______________________ File Code: 78.01.02.02.A2-2 ~~78.01.02.03.A2-2~~

Date: ______________________ Date Published: 12-19-74

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

LAP TEST: STRIPPING THE ARMATURE AND STATOR WINDINGS/ INSULATING THE STATOR AND ARMATURE

78.01.02.02

1. While stripping the stator on a motor, why is it important to count the turns of wires and number of coils per pole?

   a. to check the manufacturer's specifications
   b. to get it on the data card, so when it is rewound, it will have the same number of turns per pole
   c. to guard against a change in polarity
   d. because when it is rewound, it should have 5 less coils per pole than are unwound

2. If only the start winding on a motor is to be changed, you should:

   a. cut one end of each coil and pull
   b. change both start and run windings
   c. lift out the start winding and remove the wedges with a hacksaw
   d. remove the wedges and lift out the start winding

3. How long should the stator on a motor be on the burning pit?

   a. 30 minutes
   b. several hours
   c. one hour
   d. 24 hours

4. If the burning method is used, why is it very important that the stator on a motor be allowed to cool gradually?

   a. it costs money to cool it rapidly
   b. it is not necessary
   c. it prevents warping
   d. so that the stator doesn't get burned

5. When stripping a motor, why should one coil be saved?

   a. to be reused when the motor is rebuilt
   b. to provide the dimensions for the new coils
   c. because the new coils must be wound in reverse of the old ones
   d. to provide a guide for installing the new coils

78.01.02.03

6. When insulating a motor stator, when would you use a paper cutter?

   a. to cut insulation only to be cuffed
   b. to cut insulation to proper width
   c. to cut the cuff only
   d. to cut only the wedges

7. If necessary, mylar combination could be used for what insulation type class on a motor?

   a. A
   b. B-H
   c. B-F
   d. B

8. Class A insulation is used when rewinding a motor and is made of:

   a. ragstock paper
   b. heavy paper
   c. dacron-mylar
   d. mylar

9. When rewinding a motor, the insulation paper is cut longer than the slot by:

   a. 1/8 inch
   b. 1/4 inch
   c. 1/2 inch
   d. 5/16 inch

10. What is the purpose of a feeder strip on a motor?

    a. it is never used
    b. it is used on the run winding
    c. it is used on the start winding
    d. it covers the edges of the slot

LAP TEST ANSWER KEY: 78.01.02.02.A2-2/78.01.02.03.A2-2

STRIPPING THE ARMATURE AND STATOR WINDINGS/INSULATING THE STATOR AND ARMATURE

LAP .02	1.	B
	2.	D
	3.	B
	4.	C
	5.	B
LAP .03	6.	B
	7.	A
	8.	A
	9.	B
	10.	D

File Code: 78.01.02.04.A2-0

Date Published: 2-19-76

Mountain-Plains Education &
Economic Development
Program, Inc.

Glasgow AFB, Montana 59231

Learning Activity Package

Student: ____________

Date: ____________

PERFORMANCE ACTIVITY: Winding Stator Coils

OBJECTIVE:

Given the necessary tools, equipment and supplies, wind the stator coils of a motor to the recommended specifications of the manufacturer, and follow procedures accepted in the industry. Identify procedures for winding stator coils.

EVALUATION PROCEDURE:

Winding skills are evaluated on a unit performance test. Successfully complete at least 80% of the items on a combined multiple-choice test about this and one other LAP. The combined LAP test is taken after completing LAP "Winding Field Coils".

RESOURCES:

Electric Motor Repair.
Checklist: Winding the Stator Coils

motor stator	coil shaper
coil winder	ohmmeter
	growler

PROCEDURE:

1. Read pages 13-16 and pages 109-111 in Electric Motor Repair.
2. Rewind a stator using the appropriate tools.
3. Check your stator coil following the attached "Checklist: Winding Stator Coils".
4. Have your instructor inspect the rewound motor's stator.
5. Take the LAP test.

Principal Author(s): T. Ziller

CHECKLIST: WINDING STATOR COILS

1. ____ Use coil winder hand, or skein for winding coils (size of stator coil obtained from original).
2. ____ Use correct size magnet wire (size of stator coil wire obtained from original).
3. ____ Wind stator coil using same number of turns as the original.
4. ____ Use shaping tool to form stator coil.
5. ____ Check manufacturer's specifications for proper connection.
6. ____ Check for shorts. (ohmmeter)
7. ____ Check for an open. (ohmmeter)
8. ____ Check for grounds. (ohmmeter)
9. ____ Connect coil to 6 volt battery; use a compass to check polarity.

File Code: 78.01.02.05.A2-0

Date Published: 2-19-76

Mountain-Plains Education &
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Glasgow AFB, Montana 59231

Learning Activity Package

Student: ____________________

Date: ____________________

PERFORMANCE ACTIVITY: Winding Armature Coils

OBJECTIVE:

Given necessary tools, equipment, and supplies wind the armature coils of a motor. Identify procedures for winding armature coils.

EVALUATION PROCEDURE:

Winding skills are evaluated on a unit performance test. Successfully complete at least 80% of the items on a multiple-choice test about this LAP.

RESOURCES:

Electric Motor Repair, Rosenburg, Robert; 2nd Edition.
Checklist: Winding Armature

motor armature	ohmmeter
armature winder	growler

PROCEDURE:

1. Read pages 86-91, 173-180 and 258-260 in Electric Motor Repair; refer to figures indicated in illustration section of the book when called for.
2. Rewind an armature coil using the attached "Checklist: Winding Armature Coils".
3. Have your instructor inspect the rewound armature.
4. Take the LAP test.

Principal Author(s): T. Ziller

CHECKLIST: WINDING ARMATURE COILS

1. ____ Use armature coil winder or hand wind (size armature coil obtained from original).

2. ____ Use correct size magnet wire (size of armature coil wire obtained from original).

3. ____ Wind armature coil using same number of turns as the original.

4. ____ Check manufacturer's specifications for proper connection.

5. ____ Check for shorts. (ohmmeter or growler)

6. ____ Check for an open. (ohmmeter or growler)

7. ____ Check for grounds. (ohmmeter or growler)

Student: ______________________ File Code: 78.01.02.05.A2-2

Date: ______________________ Date Published: 12-19-74

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LAP TEST: WINDING STATOR COILS/WINDING ARMATURE COILS

78.01.02.04

1. What is the easiest way to rewind the stator on a motor, if it has been charred?

   a. cut off flush on one end of stator coils and pull
   b. unwind each wire at a time
   c. cut each end of the coils and pull
   d. cut only one end of each coil and pull

2. Before winding a motor, which of the following should be completed first?

   a. remove end bells
   b. collect necessary data
   c. remove stator
   d. insulate slots

3. What is commonly used to determine which form should be used when rewinding the stator on a split phase motor?

   a. a form gauge
   b. a wire gauge
   c. a single strand of wire
   d. a flexible tube

4. When using wood forming blocks for shaping coils for the stator on a split phase motor, approximately what depth should the wood blocks be in relation to the stator slots?

   a. 1/2 of the slot depth
   b. equal to the slot depth
   c. 3/4 of the slot depth
   d. 1/4 of the slot depth

5. In a skein winding, which of the following is of prime importance, when winding the stator of a motor?

   a. radius must be exact
   b. circumference must be exact
   c. shape (round) must be exact
   d. shape (rectangular) must be exact

78.01.02.05

6. In a motor, all the coils are wound with the same size:

   a. start winding is different
   b. magnetic wire
   c. each set of coils is a different size
   d. leads

7. When rewinding the shunt field coils on an electric motor, how should the number of turns be determined?

   a. the turns should be estimated by using an ohmmeter
   b. the turns should be counted
   c. the turns should be estimated
   d. the coils should be weighted

8. Series field coils consist of which of the following in a DC motor?

   a. light wire with many turns
   b. heavy wire with many turns
   c. heavy wire with a few turns
   d. light wire with a few turns

9. Shunt fields in a DC motor consist of which of the following?

   a. heavy wire with a few turns
   b. light wire with a few turns
   c. light wire with many turns
   d. heavy wire with many turns

10. If the shunt field comes into contact directly or indirectly with the series field in a DC motor, which of the following will develop?

    a. direct short
    b. more horsepower
    c. less horsepower
    d. more starting torque

LAP TEST ANSWER KEY: 78.01.02.04.A2-2/78.01.02.05.A2-2

WINDING STATOR COILS/WINDING ARMATURE COILS

LAP .04

1. A
2. B
3. C
4. C
5. B

LAP .05

6. B
7. D
8. C
9. C
10. A

File Code: 78.01.02.06.A2-0

Date Published: 2-19-76

Mountain-Plains Education &
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Glasgow AFB, Montana 59231

Learning Activity Package

Student: ____________

Date: ____________

PERFORMANCE ACTIVITY: Baking and Varnishing

OBJECTIVE:

Given the necessary tools, equipment, and supplies, correctly varnish and bake the windings of a motor according to: (1) manufacturer's specifications and (2) following procedures and practices accepted in the industry. Identify the procedure for baking and varnishing windings and identify the characteristics of varnishes.

EVALUATION PROCEDURE:

Baking and varnishing skills are evaluated on the unit performance test. Successfully complete at least 80% of the items on a multiple-choice test about this LAP.

RESOURCES:

Motor stator/armature.
Electric Motor Repair, by Robert Rosenburg.

baking oven

PROCEDURE:

1. Read pages 20-21 and 185-186 in Electric Motor Repair.
2. Insulate stator following the procedures on the attached "Checklist: Baking and Varnishing." (Caution: Be sure of proper ventilation and observe fire precautions during the dipping and dying process).
3. Take the LAP test.

Principal Author(s): T. Ziller

CHECKLIST: BAKING AND VARNISHING

1. _____ Bake at 250° F the armature or stator to eliminate moisture for an hour.

2. _____ Spray, brush or dip windings in varnish until air bubbles disappear.

3. _____ Hang for air drying or bake at 250° F for about 3 hours.

4. _____ Remove excess varnish with lathe or scraper.

Student: ______________________ File Code: 78.01.02.06.A2-2

Date: ______________________ Date Published: 12-19-74

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LAP TEST: BAKING AND VARNISHING

78.01.02.06

1. Before dipping, the stator from a motor should be placed in a baking oven for:

   a. 10 minutes
   b. 45 minutes
   c. 60 minutes
   d. 30 minutes

2. At what approximate temperature should the stator on a motor be preheated?

   a. 200 degrees F.
   b. 112 degrees F
   c. 250 degrees F
   d. 250 degrees C

3. When varnishing a motor, the entire process of dipping or trickling the varnish should take no longer than:

   a. 5 to 10 minutes
   b. 20-30 minutes
   c. 15-20 minutes
   d. 10-15 minutes

4. When varnishing a motor, many shops do not have a baking oven and they want a harder finish than air drying varnish. They would use:

   a. lead varnish
   b. synthetic AC 43
   c. solventless epoxy resin
   d. orange varnish

5. When varnishing a motor, a type of varnish that does not require baking is:

   a. orange varnish
   b. resin varnish
   c. air drying varnish
   d. polyester varnish

78.01.02.06

6. Immediately after removing the stator of a motor from the varnish dip tank, the stator is placed in the oven:

   a. just before it stops dripping
   b. just after it stops dripping
   c. yes
   d. no

7. When do you varnish the new windings in a stator of a motor?

   a. after installing the windings in the stator and before installing flexible flexible leads
   b. after installing the windings, completing a test and installing flexible leads
   c. after installing the windings in the stator
   d. before installing the windings in the stator

8. What will help decrease the moisture content in the windings of a stator on a motor?

   a. dripping
   b. baking
   c. varnishing
   d. baking and varnishing

9. Approximately how long must the winding of a motor soak in solvent?

   a. two hours
   b. one hour
   c. 30 minutes or until bubbling ceases
   d. 30 minutes

10. What purpose does preheating the varnish for a motor serve?

   a. increases penetration of the varnish
   b. stops the varnish from running off the winding
   c. removes moisture
   d. removes moisture and increases penetration of the varnish

LAP TEST ANSWER KEY: 78.01.02.06.A2-2

BAKING AND VARNISHING

1. C
2. C
3. B
4. C
5. C
6. B
7. B
8. D
9. C
10. D

Student: ____________________ File Code: 78.01 02.00.B2-2

Date: ____________________ Date Published: 12-16-74

Mountain-Plains Education & Economic Development Program, Inc.
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UNIT POST TEST: REWINDING

78.01.02.01

1. What are the consequences of incorrect data, when working on a motor?

   a. the motor would run counter-clock wise
   b. if the windings are in the wrong location, a motor may not start properly
   c. you remember how it's done, so you don't need the data
   d. the motor would run too slowly

2. Why is the term "end room" important, when taking data on a motor?

   a. only because of the run winding
   b. only because of the start winding
   c. because the end plates may press against the coils and cause a short
   d. because of insulation paper

3. What information would you put on your data sheet if the start winding on a motor was shorted?

   a. don't put anything on the data sheet
   b. put just the start winding on the information sheet
   c. put just the run winding on the data sheet
   d. put both the run winding and start winding information

4. What is meant by the pitch of a coil on a motor?

   a. the number of slots separating the sides of a coil
   b. the number of groups of coils
   c. the number of degrees they are apart
   d. how far the coil protrudes from the slots

5. When is the proper time to start recording data for three-phase motor?

   a. just when the instructor is watching
   b. after it is completed
   c. as soon as you put it on the work bench
   d. not necessary

78.01.02.02

6. If only the start winding on a motor is to be changed, you should:

   a. cut one end of each coil and pull
   b. change both start and run windings
   c. lift out the start winding and remove the wedges with a hacksaw
   d. remove the wedges and lift out the start winding

7. How much heat is needed to burn the stator on a motor?

   a. the stator is made to withstand any temperature
   b. approximately 200 degrees c
   c. approximately 100 degrees c
   d. approximately 400 degrees c

8. While stripping the stator on a motor, should you check wire size?

   a. yes, you have to to determine new winding sizes
   b. no, anyone can guess the wire size
   c. sometimes you should just in case you lose the stator
   d. never, it's not that important

9. One method of stripping a stator is to:

   a. cut both sides off
   b. cut each coil on one side and pull the coil out the other
   c. pull
   d. cut each coil on one side and pull

10. When stripping a motor, why should one coil be saved?

   a. to be reused when the motor is rebuilt
   b. to provide the dimensions for the new coils
   c. because the new coils must be wound in reverse of the old ones
   d. to provide a guide for installing the new coils

78.01.02.03

11. What type of slot does this drawing represent in a motor?

   a. semiclosed stator
   b. rotor
   c. open slot stator
   d. stator

78.01.02.03 (continued)

12. The best procedure to follow when reinsulating a core on a motor is to:

    a. it isn't necessary to reinsulate the core
    b. replace it with thinner insulation than was originally used
    c. replace it with thicker insulation than was originally used
    d. replace it with the same type and thickness of insulation as used in the original winding

13. When reinsulating a core on a motor, if the insulation paper is to be cuffed, how much longer than the slot will it have to be?

    a. 1/4 inch
    b. 1/8 inch
    c. 5/8 inch
    d. 1/2 inch

14. What type of insulation is used when reinsulating a core on a motor because it is resistant to high temperature and has high tensile strength?

    a. rag-stock paper
    b. mylar combination
    c. nylon paper
    d. dacron-mylar

15. When reinsulating a core on a motor, the cuff should be turned back:

    a. 1/4 inch
    b. 5/8 inch
    c. 1/2 inch
    d. 1/8 inch

78.01.02.04

16. What two ways are usually used to measure wire for a motor?

    a. micrometer and depth gauge
    b. American screw gauge and depth gauge
    c. American wire gauge and feeler gauge
    d. micrometer and wire gauge

78.01.02.04 (continued)

17. Which of the following ways of winding will produce the tightest winding possible?

 a. skein
 b. form winding
 c. motor winding
 d. hand winding

18. What is one of the primary advantages of skein winding over other types of winding in a split phase motor?

 a. less power will be used when operating the motor
 b. higher voltage is obtained
 c. lower voltage is obtained
 d. many conductors may be placed in the slot at one time

19. Skein coils, when installed in a split phase motor, must be placed in what way in the slots?

 a. from the smallest pitch to the largest
 b. from the largest pitch to the smallest
 c. from the center pitch to the smallest
 d. from the center pitch to the largest

20. Which of the following types of windings should not be used, if the wire size is over 21 A.W.G.?

 a. hand
 b. firm
 c. skein
 d. machine

78.01.02.05

21. In a motor, all the coils are wound with the same size:

 a. start winding is different
 b. magnetic wire
 c. each set of coils is a different size
 d. leads

22. What is the primary purpose of an interpole field coil on a DC motor?

 a. prevent arching of the brushes
 b. increase horsepower
 c. increase motor starting torque
 d. decrease friction in the motor

78.01.02.05 (continued)

23. Interpole fields in a DC motor consist of which of the following?

a. heavy wire with a few turns
b. heavy wire with many turns
c. light wire with a few turns
d. light wire with many turns

24. How are the coils connected in a DC motor?

a. so all poles have the same polarity
b. so alternate polarity exists
c. so all poles have negative polarity
d. so all poles have positive polarity

25. Most generally, the poles in a DC motor are connected:

a. in a series
b. in a parallel
c. in a series parallel
d. alternately series than parallel

78.01.02.06

26. Before dipping, the stator from a motor should be placed in a baking oven for:

a. 10 minutes
b. 45 minutes
c. 60 minutes
d. 30 minutes

27. When varnishing a motor, a type of varnish that does not require baking is:

a. orange varnish
b. resin varnish
c. air drying varnish
d. polyester varnish

28. Immediately after removing the stator of a motor from the varnish dip tank, the stator is placed in the oven:

a. just before it stops dripping
b. just after it stops dripping
c. yes
d. no

78.01.02.06 (continued)

29. When do you varnish the new windings in a stator of a motor?

    a. after installing the windings in the stator and before installing flexible leads
    b. after installing the windings, completing a test and installing flexible leads
    c. after installing the windings in the stator
    d. before installing the windings in the stator

30. What will help decrease the moisture content in the windings of a stator on a motor?

    a. dripping
    b. baking
    c. varnishing
    d. baking and varnishing

UNIT TEST ANSWER SHEET

UNIT POST TEST:
REWINDING

Occupational Area: ______________________
File Code: 78.01.02.00.B2-2
Name: ______________________

ANSWERS

.02.01	1.	B	78.01.02.05	21.	B	41.	
	2.	C		22.	A	42.	
	3.	B		23.	A	43.	
	4.	A		24.	B	44.	
	5.	C		25.	A	45.	
1.02.02	6.	D	78.01.02.06	26.	C	46.	
	7.	D		27.	C	47.	
	8.	A		28.	B	48.	
	9.	B		29.	B	49.	
	10.	B		30.	D	50.	
01.02.03	11.	C		31.		51.	
	12.	D		32.		52.	
	13.	D		33.		53.	
	14.	C		34.		54.	
	15.	D		35.		55.	
01.02.04	16.	D		36.		56.	
	17.	D		37.		57.	
	18.	D		38.		58.	
	19.	A		39.		59.	
	20.	C		40.		60.	

Student: ____________ File Code: 78.01.02.00.A1-5

Date: ____________ Date Published: 11/15/74

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Family Pay Number: ____________ Sex: M F (Circle 1)

UNIT PERFORMANCE TEST: REWINDING

OBJECTIVE 1:

Given a malfunctioning stator and field coil, the student will rewind the stator and field coil so that it functions according to the manufacturer's specifications, following safe practices and procedures.

OBJECTIVE 2:

Using appropriate equipment, the student will rewind a faulty stator and field coil.

OBJECTIVE 3:

Using appropriate tools and test equipment the student will take shorts and open tests.

TASK:

The student will rewind a stator and field coil and, in the process, he will make shorts and open and grounding tests, using appropriate test equipment.

ASSIGNMENT:

CONDITIONS:

The student will be given a malfunctioning stator and field coil (it may be bugged by the instructor or it may be one brought in by a customer.) He will be required to rewind the stator and field coil in conditions similar to those in a typical motor repair shop. He will be allowed to use any and all tools, equipment, service manuals, text books, etc., commonly found in a repair shop. He must complete it in a reasonable length of time with no assistance from the instructor(s) or students.

RESOURCES:

Tools:
Internal-external snap ring pliers
7 Piece nut driver set
Tool box 18 x 8 x 9
Circular gauge
Hacksaws
Pulley puller
Arc joint pliers
Lineman's pliers
Diagonal cutting pliers
Long chain-nose pliers
Locking plier wrench
Coil tamping pliers
4-Piece standard set screwdrivers
Center punch
Cold chisel
Ball peen hammer
Lug crimpers
Wire skinner and straightener

Equipment:
Coil stripping chisel
Armature winder
Coil winder
External Growler
Insulation former
Coil shapers
Stator
Field Coil

Printed Material:
Electric Motor Repair, Rosenburg, Robert, 2nd Ed., Rinehart Press, San Francisco, 1970

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Student: ____________ File Code: 78.01.02.00.A1-5

Date: ____________ Date Published: 11/15/74

Family Pay Number: ____________ Sex: M F (Circle 1)

PERFORMANCE CHECKLIST:

OVERALL PERFORMANCE: Satisfactory_____ Unsatisfactory_____

	CRITERION Met	CRITERION Not Met
Objective 1:		
1. Follows safe practices and procedures.		
Criterion: No injury results to the student or the		
equipment and complies with OSHA requirements.		
2. Follows proper procedures for disassembly.		
Criterion: No damage results to the stator or field coil.		
3. Rewinds a stator and field coil.		
Criterion: When repaired, the stator or field coil functions		
according to the manufacturer's specifications.		
4. Reassembles the stator and field coil properly.		
Criterion: Functions according to the manufacturer's		
specifications and the procedures followed agree		
with those described in the service literature.		
5. The repaired stator and field coil is repaired in		
a neat, professional manner.		

	CRITERION Met	Not Met
Criterion: No damage results to the stator and field		
coil such as opens and shorts.		
6. All connections and fastenings are properly completed.		
Criterion: The stator and field coil connections complies		
with the manufacturer's specifications. The		
connections are mechanically fastened and		
structurally sound. The connection is		
electrically fastened and free of defects.		
7. Stator or field coil functions according to the		
manufacturer's specifications.		
Criterion: Manufacturer's specifications.		
8. Uses appropriate repair part and supplies.		
Criterion: They match exactly those listed in the		
manufacturer's specifications.		
Objective 2:		
9. Uses coil-stripping tool to remove coils.		
Criterion: Proper equipment application results in a		
defect-free operative motor.		
10. Uses armature winder, if appropriate, when winding		
the armature.		

(Checklist continued)

	CRITERION Met	Not Met
Criterion: Proper equipment application results in a		
defect-free operative motor.		
11. Uses coil winder, when winding field coil		
Criterion: Proper equipment application results in a		
defect-free operative motor.		
12. Uses insulation former, when insulating.		
Criterion: Proper equipment application results in a		
defect-free operative motor.		
13. Uses coil shaper,on the field coils.		
Criterion: Proper equipment application results in a		
defect-free operative motor.		
Objective 3:		
14. Test for grounds, using growler or ohmmeter.		
Criterion: Trouble-shooting techniques reveal the		
malfunction, as identified by Assignment Sheet.		
15. Test for shorts in the field coils, using a growler.		
16. Test for shorts in the stator coil, using a growler.		
17. Test for an open field coil or stator using an		
ohmmeter.		
Criterion: Trouble-shooting techniques reveal the		

	CRITERION Met	Not Met
malfunction, as identified by Assignment Sheet.		
18. Job is completed in a reasonable amount of time.		
Criterion: Not to exceed 4 hours.		
The student must successfully complete 16 out of 18 line items		
to achieve an overall score of satisfactory.		

File Code: 78.01.03.00.A2-1

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Mountain-Plains Education & Economic Development Program, Inc.

Glasgow AFB, Montana 59231

Learning Experience Guide

UNIT: SPLIT-PHASE INDUCTION MOTORS

RATIONALE:

The split-phase induction motor is used as a drive motor in many appliances on the market. Because these appliances are so commonly used, a motor repairman must know how to repair their mechanical devices and electrical systems.

PREREQUISITES:

Unit: 38.01.02. Rewinding

OBJECTIVE:

Troubleshoot, repair, and rewind split-phase induction motors using appropriate tools, equipment, and procedures. Identify parts, operational characteristics and procedures for diagnosis and repair of split-phase induction motors.

RESOURCES:

GENERAL INSTRUCTIONS:

This unit consist of 5 Learning Activity Packages (LAPs). Each LAP will provide specific information for completion of a learning activity.

The general procedure for this unit is as follows:

(1) Read the first assigned Learning Activity Package (LAP).
(2) Begin and complete the first assigned LAP.
(3) Take and score the LAP test.
(4) Turn in the LAP test.
(5) Determine the reason for any missed items on the LAP test.
(6) Proceed to and complete the next assigned LAP in the unit.
(7) Complete all required LAPs for the unit by following steps 3 through 6.
(8) Take the unit tests as described in the Unit LEG "Evaluation Procedures".
(9) Proceed to the next assigned unit.

Principal Author(s): T. Ziller

PERFORMANCE ACTIVITIES:

.01 Work Order.
.02 Operation of the Split-Phase Induction Motor.
.03 Split-Phase Induction Motor Construction.
.04 Troubleshooting Split-Phase Induction Motors.
.05 Repairing Split-Phase Induction Motors.

EVALUATION PROCEDURE:

When Pretesting:

1. The student takes the unit multiple-choice pretest.
2. Successful completion is 4 out of 5 items for each LAP part of the pretest.
3. The student then takes a unit performance test if the unit pretest was successfully completed.
4. Satisfactory completion of the performance test is meeting the criteria listed on the performance test.

When post testing:

1. The student takes a multiple-choice unit post test and a unit performance test.
2. Successful unit completion is meeting the listed criteria for the performance test.

FOLLOW-THROUGH:

After completing this guide, you are ready to begin the first LAP. Your instructor will help you with any questions you may have.

Student: ____________ File Code: 78.01.03.00.A2-2

Date: ____________ Date Published: 12-12-74

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

UNIT PRETEST: SPLIT-PHASE INDUCTION MOTORS

78.01.03.01

1. What is the purpose of the completion date on a work order for a split-phase induction motor?

   a. so the customer can't complain
   b. always leave blank
   c. only used if it's routine
   d. to inform customer the day the job was completed

2. The job description on a work order for a split-phase induction motor is:

   a. not required
   b. a description of the customer
   c. a description of the trouble
   d. a description of parts used

3. What purpose does a work order for a split-phase induction motor serve?

   a. it is a record for the instructor to know who did the work
   b. it is a record of what's been done, who did it, and who it belongs to
   c. it is added paper work
   d. it is so a more accurate inventory can be kept

4. What is meant by total cost on a work order for a split-phase induction motor?

   a. cost of two or more parts
   b. grand total
   c. cost of each
   d. cost of all parts used per unit cost

5. Should you always double check the customers description of the malfunction on a work order for a split-phase induction motor?

   a. only on certain occasions
   b. the customer is always right
   c. only if the customer requests it
   d. yes, to verify the malfunction

78.01.03.02

6. What is the function of the centrifugal switch on a split-phase induction motor?

   a. connects the start winding to run winding when it reaches approximately 75% of full speed
   b. to disconnect the start winding when it reaches approximately 75% of full speed
   c. to disconnect the run winding when it reaches approximately 75% of full speed
   d. to connect the run winding to start winding when it reaches approximately 75% of full speed

7. On a split-phase induction motor which end plate should be taken off first?

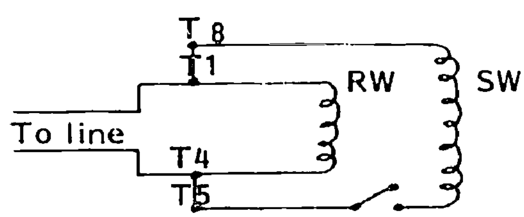
   a. bottom plate
   b. front end plate
   c. shaft end plate
   d. rear end plate

8. Which end of a split-phase induction motor has two punch marks on the stator housing?

   a. the rear endplate
   b. the shaft end
   c. both ends
   d. on the shaft

9. How would you change the rotation on this split-phase induction motor?

   a. T8 to T5, T1 to T4
   b. T8 to T4, T1 to T4
   c. T8 to T1, T4 to T5
   d. T8 to T4, T1 T5

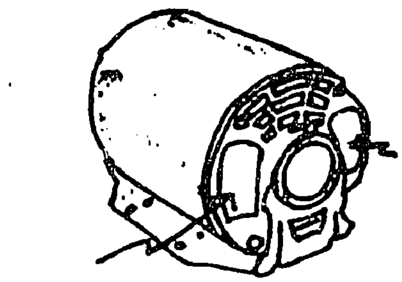


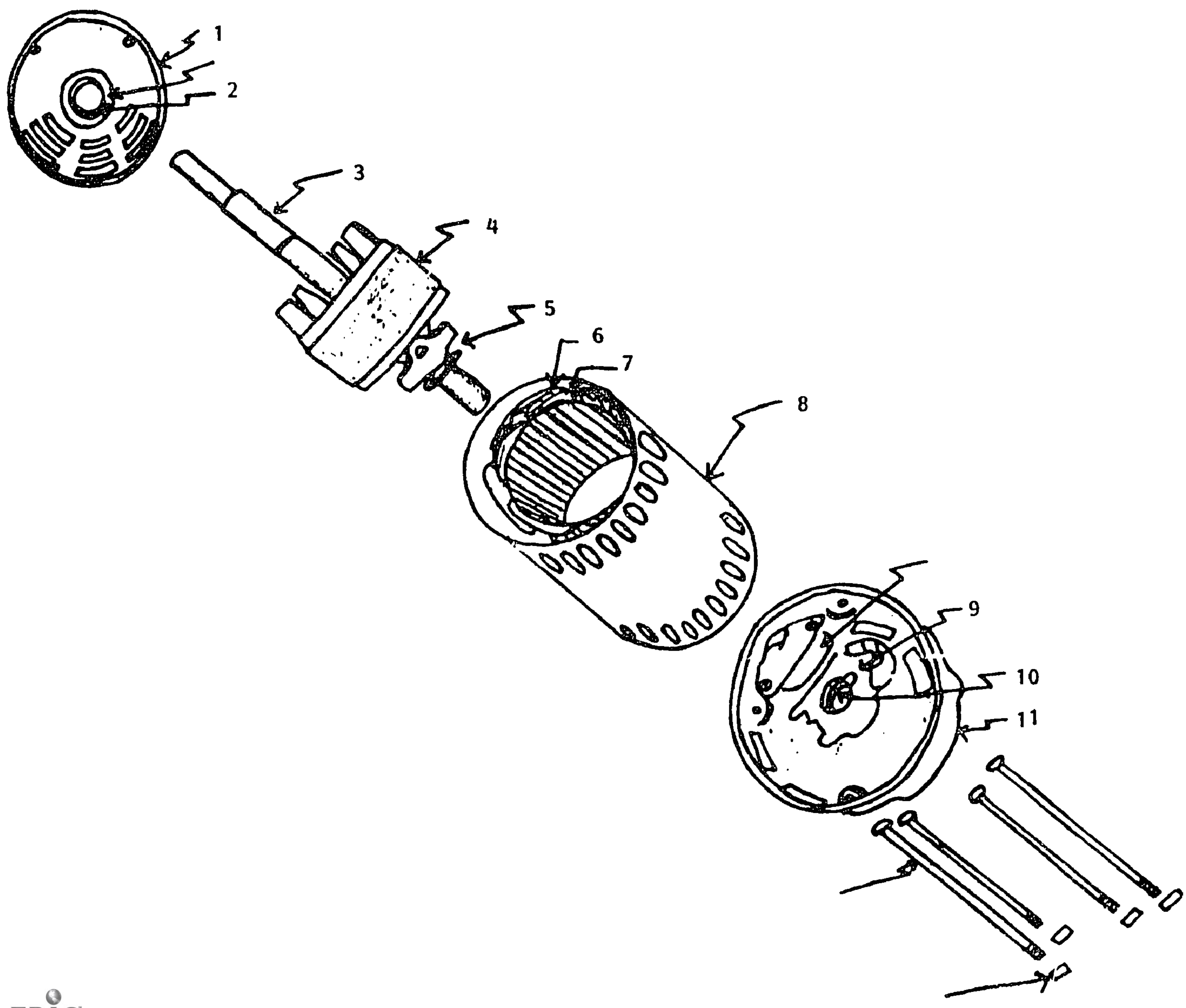
10. Where is the squirrel cage winding found on a split-phase induction motor? (see Figure #1)

   a. 1
   b. 3
   c. 4
   d. 7

SPLIT PHASE INDUCTION MOTOR

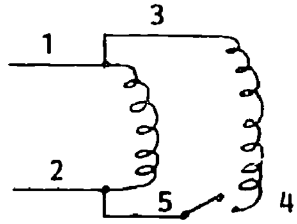
Diagram 1 for question 10





78.01.03.03

11. The start winding on a split-phase induction motor is located between:



a. 4-5
b. 3-4
c. 1-2
d. 1-4

12. How many sets of winding on a split-phase induction motor make one pole?

a. 3
b. 2
c. 4
d. 1

13. The centrifugal switch on a split-phase induction motor is represented between:

a. 1-4
b. 1-2
c. 4-5
d. 3-4

14. On a split-phase induction motor, why is there more current on the initial start than after it is running?

a. the windings are in parallel
b. the windings are in series
c. it has the same amount of windings in the start as run windings
d. it has more windings in the start winding than the run

15. The run winding on a split-phase induction motor is located between:

a. 3-4
b. 1-4
c. 4-5
d. 1-2

78.01.03.04

16. A broken centrifugal switch will cause the split-phase induction motor to:

a. not start
b. slow in starting
c. run faster than normal
d. run slower than normal

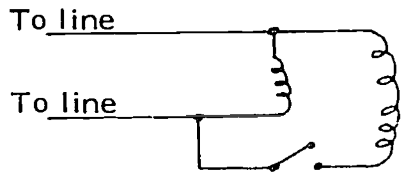
78.01.03.04 (continued)

17. If the split-phase induction motor won't start, it is probably a:

a. loose bearing
b. loose end bell
c. bad start winding
d. bad run winding

18. In the schematic below, the split-phase induction motor:

a. is in starting position
b. has reached 75% of normal speed
c. none of the above
d. reached 25% of normal speed

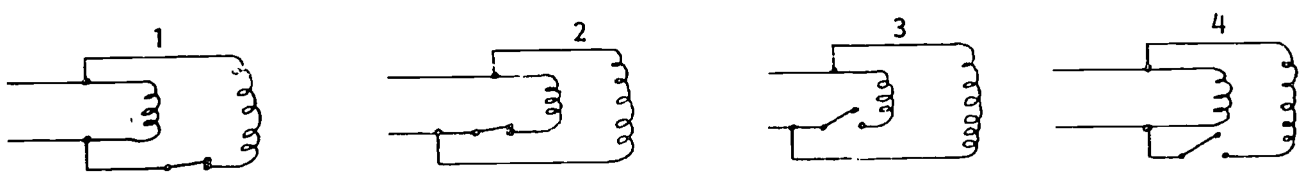


19. If a shaft on a split-phase induction motor does not rotate freely, this indicates:

a. rotor out of balance
b. too much end play
c. bad bearings
d. centrifugal switch closed

20. In which schematic below is the split-phase induction motor in the starting position?

a. 1
b. 3
c. 2
d. 4



78.01.03.05

21. How is a skein winding made on a split-phase induction motor?

a. the coils are formed on blocks than laid into the slots, one at a time
b. one wire is laid into each coil slot at a time
c. one long coil is formed on two pegs
d. one wire is laid into the slots, at a time

78.01.03.05 (continued)

22. Each pole of a split-phase induction motor covers:

    a. 160 electrical degrees
    b. 180 electrical degrees
    c. 120 electrical degrees
    d. 90 electrical degrees

23. Voltage changes by means of reconnections on a split-phase induction motor are:

    a. always possible
    b. not always possible
    c. on four pole series connected motor
    d. on six pole series connected motor

24. In rewinding a split-phase motor, the turns ratio depends on:

    a. span of the coil
    b. the number of turns per coil
    c. the pitch
    d. the cord factor

25. A skein winding on a split-phase induction motor is used mainly for:

    a. run windings
    b. start windings
    c. both run and start windings
    d. deceleration windings

UNIT TEST ANSWER SHEET

UNIT PRETEST: SPLIT-PHASE INDUCTION MOTORS

Occupational Area: ____________
File Code: 78.01.03.00.A2-2
Name: ____________

ANSWERS

78.01.03.01	1.	D	78.01.03.05	21.	C	41.	
	2.	C		22.	B	42.	
	3.	B		23.	B	43.	
	4.	D		24.	B	44.	
	5.	D		25.	B	45.	
78.01.03.02	6.	B		26.		46.	
	7.	B		27.		47.	
	8.	B		28.		48.	
	9.	D		29.		49.	
	10.	C		30.		50.	
78.01.03.03	11.	B		31.		51.	
	12.	D		32.		52.	
	13.	C		33.		53.	
	14.	A		34.		54.	
	15.	D		35.		55.	
78.01.03.04	16.	A		36.		56.	
	17.	C		37.		57.	
	18.	B		38.		58.	
	19.	C		39.		59.	
	20.	A		40.		60.	

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Glasgow AFB, Montana 59231

File Code: 78.01.03.01.A2-0

Date Published: 2-20-76

Learning Activity Package

Student: ____________

Date: ____________

PERFORMANCE ACTIVITY: Work Order

OBJECTIVE:

Properly fill out a work order.
Identify the types of work order entries and their purpose.

EVALUATION PROCEDURE:

Correctly answer at least 80% of the multiple-choice test items.
Completed work order must meet the criteria of the attached checklist.

RESOURCES:

Work order (example attached)
NOTE: Multi-copies
Checklist

PROCEDURE:

Steps

1. Obtain a copy of a work order card.
2. Using the checklist, fill out attached work order form.
3. Have the instructor evaluate the completed form.
4. Take the LAP test.

Principal Author(s): T. Ziller

Work Order Checklist

The following are steps to check when filling out a work order.

_____ 1. Fill in work order number.

_____ 2. Fill in date received (the day the motor comes into the shop).

_____ 3. Fill in date the job is completed (when completed).

_____ 4. Fill in customer's name and address.

_____ 5. Enter type of equipment, telephone number, model and name.

_____ 6. Briefly describe the malfunction.

_____ 7. Estimate cost of material and hours to complete job.

_____ 8. Enter the total hours it took you to complete the job.

_____ 9. Number of hours times labor per hour (enter this total in Block 11).

_____ 10. Enter all material used to repair motors (example: 2 ea. bearing EM249 Unit cost 83 cents. Total costs $1.66).

_____ 11. Name of person completing work.

_____ 12. Instructor's signature upon completion and final check out.

MOUNTAIN PLAINS Building Trades Department 90

1. Work Order ________ 3. Needed By ________ 5. Customer ________

2. Date Received ________ 4. Completed ________ 6. Address ________

9. Estimated Cost ________ 7. Telephone ________

8. Job Description ____

____

Labor per hour $8.00 ____________________

10. Number Hours ________ ____________________

11. Total ________ ____________________

12.

Number	Material Description	Unit Cost	Total Costs

13. Grand Total ________

14. Completed By ____________________
(Participant's Signature)

15. ____________________
(instructor's signature)

Student: ______________________ File Code: 78.01.03.01.A2-2

Date: ______________________ Date Published: 12-19-74

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LAP TEST: WORK ORDER

78.01.03.01

1. What is the purpose of the completion date on a work order?

   a. so the customer can't complain
   b. only used it its routine
   c. always leave blank
   d. to inform customer the day the job was completed

2. On a work order the job description is:

   a. a description of the trouble
   b. a description of the customer
   c. not required
   d. a description of parts used

3. Should you always double check the customers description of the malfunction on a work order?

   a. only if the customer requests it
   b. the customer is always right
   c. yes, to check for accuracy
   d. only on certain occasions

4. On a work order is it necessary to know the number of hours worked on a project?

   a. no, it is part of parts cost
   b. yes, for self satisfaction
   c. yes, for totaling labor costs on grand total
   d. only if you are trying to do it faster then someone else

5. What is meant by total cost on a work order?

   a. total cost
   b. cost of all parts used per unit cost
   c. cost of each
   d. grand total

78.01.03.01 (continued)

6. When do you fill out a work order card?

    a. after the motor is left in the shop and the customer is gone
    b. after it is tested
    c. while the customer is present
    d. never

7. Whose telephone number is used on the work order?

    a. your home number
    b. the shop's number where you are working
    c. not required
    d. customer's number

8. What is meant by unit cost on a work order?

    a. cost of two if two are used
    b. total cost
    c. cost of each item
    d. grand total

9. Why is the date received important on a work order?

    a. you work on the oldest routine order
    b. it is used only if it's routine
    c. it makes no difference
    d. you always leave blank

10. When would you put something in the "needed by" block on a work order?

    a. if it's needed immediately
    b. only if it is routine
    c. always fill it in
    d. you always leave blank

LAP TEST ANSWER KEY: 78.01.03.01.A2-2

WORK ORDER

1. D
2. A
3. C
4. C
5. B
6. C
7. D
8. C
9. A
10. A

File Code: 78.01.03.02.A2-0

Date Published: 2-20-76

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Learning Activity Package

Student: ______________________

Date: ______________________

PERFORMANCE ACTIVITY: Operation of the Split-Phase Induction Motor

OBJECTIVE:

Describe the operation of a split-phase induction motor.
Identify operational characteristics of the split-phase induction motor.

EVALUATION PROCEDURE:

Successfully complete at least 80% of the items on a multiple-choice test about this LAP.

RESOURCES:

Split-phase induction motor.
Electric Motor Repair, by Robert Rosenburg, pages 3-4.
Introduction to Power Technology: Principles of Electric Motors, Vega, pages 20-23.

motor test analyser

PROCEDURE:

Steps

1. Read pages 3-4 in Electric Motor Repair.
2. Complete experiment #1, "Split-Phase Induction Motors" in Introduction to Power Technology.
3. Write a description on the motor's operation using simple electrical schematics.
4. Take the LAP test.

Principal Author(s): T. Ziller

Student: ____________________ File Code: 78.01.03.02.A2-2

Date: ____________________ Date Published: 12-19-74

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LAP TEST: OPERATION OF THE SPLIT-PHASE INDUCTION MOTOR

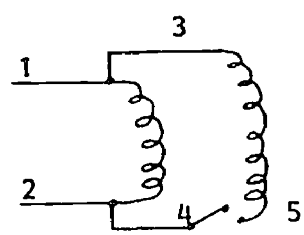
78.01.03.02

1. On a split-phase induction motor, why is there more current on initial start than after it is running?

   a. the windings are in parallel
   b. it has the same amount of windings in the start as in the run windings
   c. the windings are in series
   d. there are more windings in the start winding than in the run

2. On a split-phase induction motor the centrifugal switch is located between: (see diagram)

   a. 3-4
   b. 4-5
   c. 1-4
   d. 1-2



3. The squirrel cage winding on a split-phase induction motor consists of heavy copper bars located in the:

   a. laminating iron cores in the stator
   b. laminating iron cores in the rotor
   c. centrifugal switch
   d. shaft

4. At the start, the current flowing through both the run and start windings of a split-phase induction motor causes:

   a. centrifugal force
   b. the centrifugal switch to close
   c. a magnetic field
   d. the rotor to turn

5. The run winding on a split-phase induction motor is located between: (see diagram in question #2)

   a. 3-4
   b. 4-5
   c. 1-2
   d. 1-4

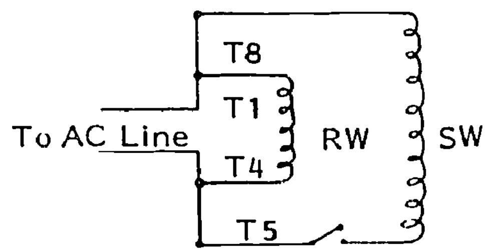
78.01.03.02 (continued)

6. The start winding in a split-phase induction motor is located between: (see diagram in question #2)

   a. 4-5
   b. 3-4
   c. 1-4
   d. 1-2

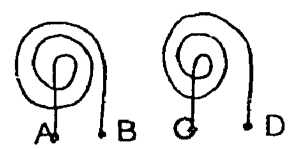
7. How would you change the rotation on this split-phase induction motor?

   a. T8 to T1, T4 to T5
   b. T8 to T4, T1 to T4
   c. T8 to T5, T1 to T4
   d. T8 to T4, T1 to T5



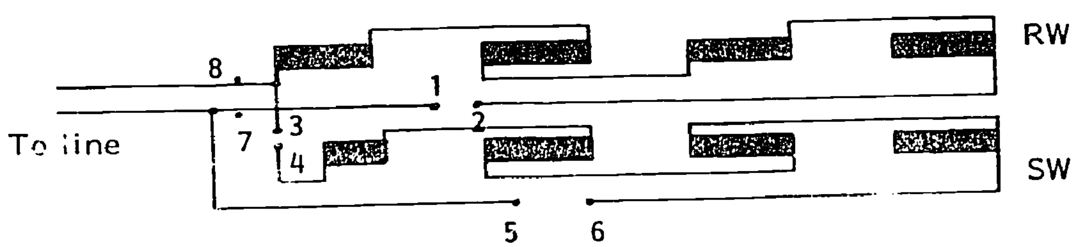
8. How are the coils connected in a two-pole motor run winding?

   a. B to D, A and C to power line
   b. A to C, B and D to power line
   c. B to C, A and D to power line
   d. A to D, B and C to power line



9. In the schematic of the run and start windings on a split-phase induction motor where would the centrifugal switch be placed?

   a. 1-2
   b. 3-4
   c. 7-8
   d. 5-6



10. Where is the connection diagram located on the split-phase induction motor?

   a. on inside of end bell
   b. on the stator
   c. data piate
   d. on centrifugal switch

LAP TEST ANSWER KEY: 78.01.03.02.A2-2

OPERATION OF THE SPLIT-PHASE INDUCTION MOTOR

1. A
2. B
3. B
4. C
5. C
6. B
7. D
8. A
9. D
10. C

File Code: 78.01.03.03.A2-0

Date Published: 2-20-76

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Learning Activity Package

Student: ____________________

Date: ____________________

PERFORMANCE ACTIVITY: Split-Phase Induction Motor Construction

OBJECTIVE:

Given the necessary tools, disassemble a split-phase induction motor according to: (1) manufacturer's specifications and (2) following procedures and practices accepted in the industry. Identify and label the main parts of a split-phase induction motor.

EVALUATION PROCEDURE:

Disassembly procedure meets criteria of attached checklist. Identification of main parts, matches the illustration. Successfully complete at least 80% of the items on a multiple-choice test about this LAP.

RESOURCES:

Split-phase induction motor.
Illustration of a split-phase induction motor. (attached)
Basic tools split-phase induction motor.
Electric Motor Repair, by Robert Rosenburg.

PROCEDURE:

Steps

1. Read pages 1-3 in Electric Motor Repair.
2. Follow the attached checklist for disassembly.
3. Take the LAP test.

Principal Author(s): T. Ziller

CHECKLIST FOR DISASSEMBLY: SPLIT-PHASE INDUCTION MOTOR

______ 1. Mark stator and end bell.
NOTE: Refer to the attached exploded view.

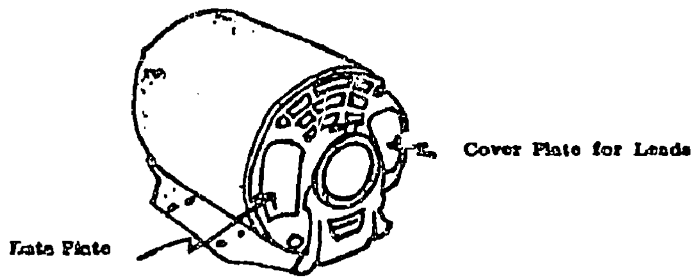
______ 2. Using proper hand tools, remove nuts and bolts (don't lose nuts and bolts).

______ 3. Remove end bells from stator.

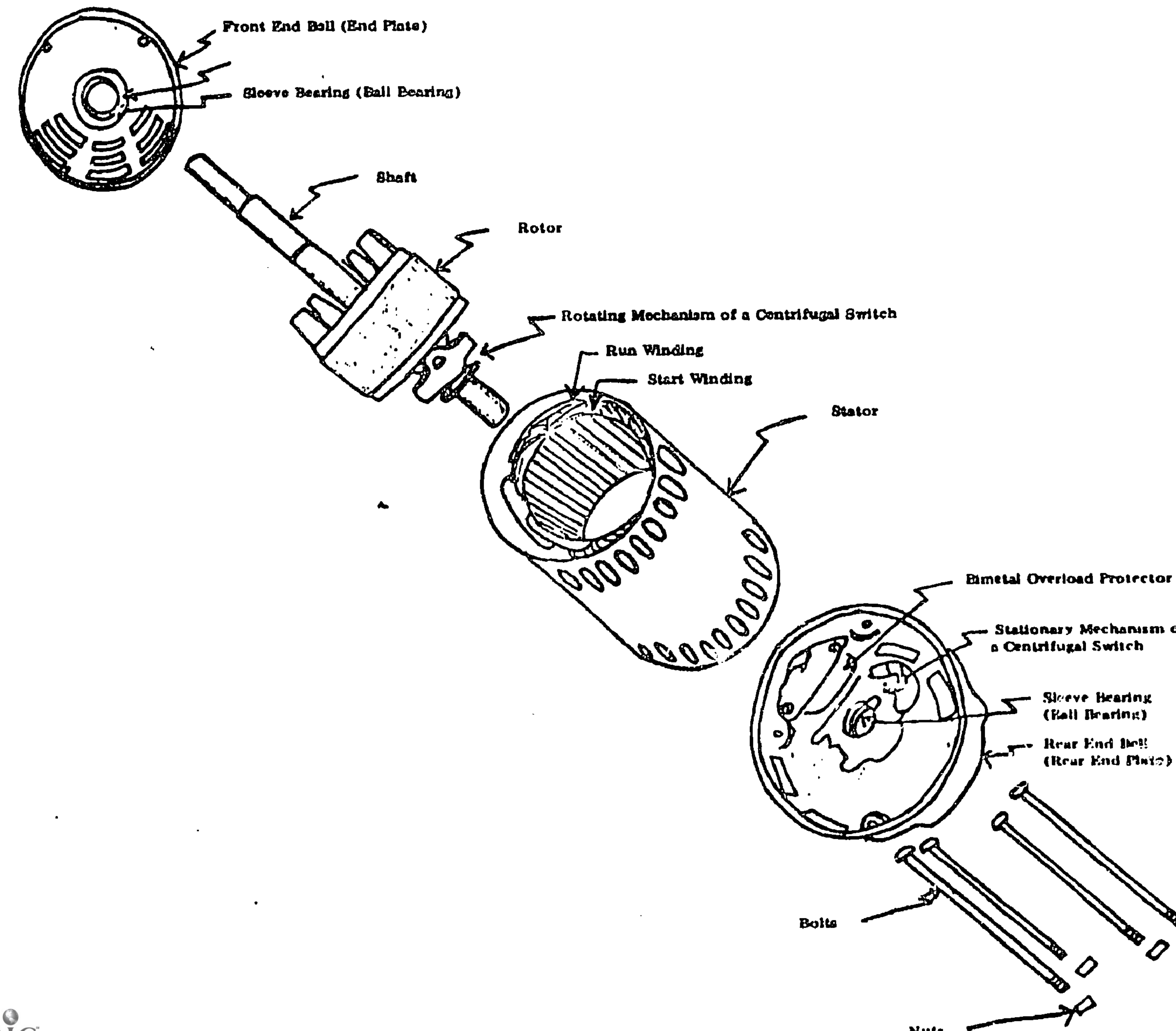
______ 4. Remove rotor from the stator.

______ 5. Identify each component part of the motor by labeling using masking tape.

SPLIT PHASE INDUCTION MOTOR



A SPLIT PHASE INDUCTION MOTOR



Student: ______________ File Code: 78.01.03.03.A2-2

Date: ______________ Date Published: 12-19-74

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LAP TEST: SPLIT-PHASE INDUCTION MOTOR CONSTRUCTION

78.01.03.03

1. Where is th quirrel-cage winding found on a split-phase induction motor?

   a. inside stator
   b. inside the rotor
   c. inside front end plate
   d. inside rear end plate

2. On a split-phase induction motor of the two windings inside the stator, which is the run winding?

   a. the thin flat bars on the rear endplate
   b. the smallest diameter wire
   c. the largest diameter wire
   d. heavy copper bars

3. What is the function of the centrifugal switch on a split-phase induction motor?

   a. to connect the run winding to start winding when it reaches approximately 75% of full speed
   b. to connect the start winding to run winding when it reaches approximately 75% of full speed
   c. to disconnect the start winding when it reaches approximately 75% of full speed
   d. to disconnect the run winding when it reaches approximately 75% of full speed

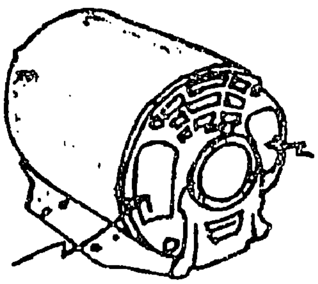
4. Where should the punch marks be on a split-phase induction motor?

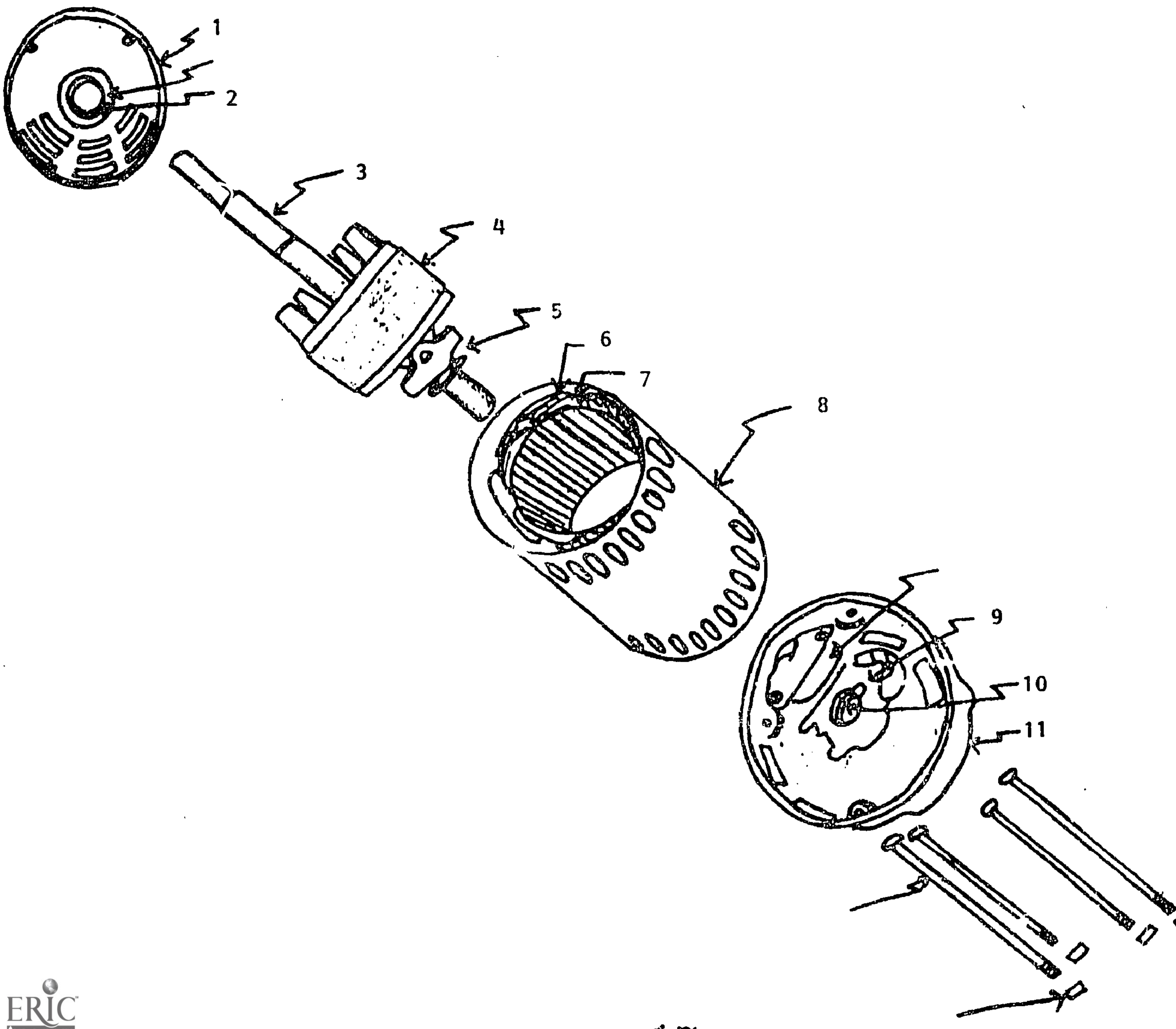
   a. on top
   b. in line with each other
   c. on bottom
   d. any place

5. Where is the stationary switch located on a split-phase induction motor? (see diagram)

   a. 11
   b. 10
   c. 3
   d. 2

SPLIT PHASE INDUCTION MOTOR





78.01.03.03 (continued)

6. What type of bearing is normally found in split-phase induction motor?

   a. sleeve bearing
   b. swivel bearings
   c. roller bearings
   d. ball bearings

7. What functions does the end plate serve on a split-phase induction motor?

   a. to hold the shaft
   b. to house the bearing and keep the motor in position
   c. to have some place to put oil
   d. to hold the bearing

8. What items make up the rotor assembly on a split-phase induction motor ? (see diagram)

   a. 3,4,7
   b. 3,4,5
   c. 2,4,7
   d. 2,3,4

9. On a split-phase induction motor which end plate should be taken off first?

   a. bottom plate
   b. shaft end plate
   c. rear end plate
   d. front end plate

10. Where are the bearings located on a split-phase induction motor? (see diagram)

   a. 1 and11
   b. 2 and 7
   c. 2 and 8
   d. 3 and 6

LAP TEST ANSWER KEY: 78.01.03.03.A2-2

SPLIT-PHASE INDUCTION MOTOR CONSTRUCTION

1. B
2. C
3. C
4. B
5. A
6. A
7. B
8. B
9. D
10. A

File Code: 78.01.03.04.A2-0

Date Published: 2-20-76

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Learning Activity Package

Student: ______________________

Date: ______________________

PERFORMANCE ACTIVITY: Troubleshooting Split-Phase Induction Motors

OBJECTIVE:

Correctly troubleshoot a split-phase induction motor following the recommended procedures for locating the troubled area as given in the attached checklist.

EVALUATION PROCEDURE:

Instructor will confer with student to acknowledge if correct diagnosis was made. Successfully complete at least 80% of the items on a multiple-choice test about this LAP.

RESOURCES:

Checklist for troubleshooting a split-phase induction motor.
Tools, test equipment, work order form and a split-phase induction motor.
Service Manuals for the Motor.
Electric Motor Repair, by Robert Rosenburg, pages 4-5.

PROCEDURE:

Steps

1. Review pages 4-5 in reference Electric Motor Repair.
2. Follow the checklist for troubleshooting an appliance. (Attached)
3. Complete the LAP test.

Principal Author(s): T. Ziller

CHECKLIST FOR TROUBLE-SHOOTING: SPLIT-PHASE MOTOR

1. Make a thorough visual inspection.
2. If the motor sparks badly, check for:
    a. Shorted field poles (Ohmmeter) (Growler).
    b. Wrong lead position on the commutator
    c. Open armature coils (Ohmmeter).
    d. Shorted armature coils (Growler).
    e. Reversed coil leads.
    f. Worn bearings
    g. High mica.
    h. Wrong direction of rotation.
3. If the motor runs hot, check for:
    a. Worn bearings.
    b. Dry bearings
    c. Shorted coils (Growler).
    d. Overload (Ammeter)
    e. Shorted fields (Growler)
    f. Brushes off-neutral
4. If the motor smokes, check for:
    a. Shorted armature (Growler)
    b. Shorted fields (Growler)
    c. Worn bearings
    d. Wrong voltage (Voltmeter)
    e. Overload
5. If the motor has poor torque, check for:
    a. Shorted coils (Growler)
    b. Shorted field (Growler)
    c. Wrong brush position
    d. Worn bearings
6. Take a resistance reading on the motor field windings. Take a resistance reading on the armature coils. (Record values).

7. Plug the motor into 115V AC power source.
8. Take a voltage reading on the motor terminals. (Record value). Compare with manufacturer's name plate.
9. Using an ammeter take a current reading on the motor. (Record value). Compare with manufacturer's name plate.
10. Disconnect from AC power.
11. Connect fields to a low D.C. voltage.
12. Use a compass and check for polarity.

Student: ____________ File Code: 78.01.03.04.A2-2

Date: ____________ Date Published: 12-19-74

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LAP TEST: TROUBLESHOOTING SPLIT-PHASE INDUCTION MOTORS

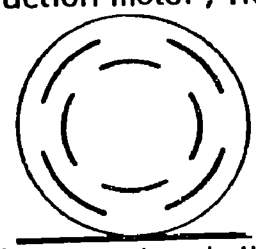
78.01.03.04

1. To determine whether a winding on a split-phase induction motor is grounded, you would connect a test lamp between:

   a. one test lead to the centrifugal switch and one to the power lead
   b. test lead in series with the run or start windings
   c. one test lead to the rotor and one to the power line
   d. one test lead to the power lead and other lead to the core

2. On a split-phase induction motor, how many poles does this schematic represent?

   a. two
   b. six
   c. eight
   d. four



3. If you get a shock when you touch the frame of the split-phase induction motor, it:

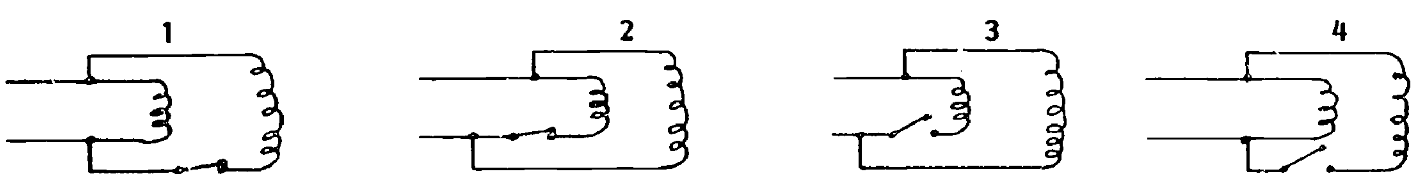
   a. will not operate
   b. has a short
   c. is grounded
   d. is open

4. When the split-phase induction motor hums, but does not run, the probable cause is:

   a. the end bells are improperly mounted
   b. badly worn bearings
   c. a defective autotransformer
   d. an opened start or run winding

5. In which schematic below is the split-phase induction motor in the start position?

   a. 3
   b. 1
   c. 2
   d. 4



78.01.02.04 (continued)

6. If a split-phase induction motor does not start, the possible cause is a:

   a. bad start winding
   b. loose bearing
   c. bad run winding
   d. loose end bell

7. A shaft on a split-phase induction motor that does not rotate freely indicates:

   a. the centrifugal switch is closed
   b. too much end play
   c. the rotor is out of balance
   d. bad bearings

8. A split-phase induction motor that runs slower than it's normal speed indicates:

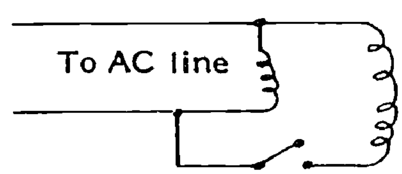
   a. bad start winding
   b. short run winding
   c. short squirrel cage winding
   d. bad centrifugal switch

9. What is used to test for grounds on a split-phase induction motor?

   a. growler
   b. ohmmeter
   c. amp probe
   d. voltmeter

10. In the schematic below, the split-phase induction motor:

   a. will not run
   b. none of the above
   c. is in starting position
   d. has reached 75% of normal speed



LAP TEST ANSWER KEY: 78.01.03.04.A2-2

TROUBLESHOOTING SPLIT-PHASE INDUCTION MOTORS

1. D
2. D
3. C
4. D
5. B
6. A
7. D
8. B
9. B
10. D

File Code: 78.01.03.05.A2-0

Date Published: 2-20-76

Mountain-Plains Education &
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Glasgow AFB, Montana 59231

Learning Activity Package

Student: ______________________

Date: ______________________

PERFORMANCE ACTIVITY: Repairing Split-Phase Induction Motors

OBJECTIVE:

Repair, service and reassemble a split-phase induction motor following the steps for repair, service and reassembly given in the attached checklist, and correctly fill out purchase requisition if necessary. Identify repair, service and reassembly techniques.

EVALUATION PROCEDURE:

The appliance must operate properly. The student must correctly fill out purchase requisition. Successfully complete at least 80% of the items on a multiple-choice test about this LAP.

RESOURCES:

Checklist for repair, service and reassembly of the motor.
Test equipment, tools, work order form and requisition form.
Split-phase induction motor.
Service Manuals for the Motor.
Electric Motor Repair, by Robert Rosenburg, pages 37-49.

PROCEDURE:

Steps

1. Follow the checklist for repair, service and reassembly of a motor. (Attached)
   NOTE: Refer to the attached exploded view of a split-phase induction motor.
2. Complete the multiple-choice test item test for this LAP.

Principal Author(s): T. Ziller

CHECK LIST

Ordering Replacement Parts

The following are steps to check when filling out an order form for a replacement part. If any steps listed do not apply to the order blank to be used, ignore them.

_____ 1. Fill out the number of replacements needed for that particular item in the quantity blank.

_____ 2. Write in the entire parts number from catalog.

_____ 3. Fill in the manufacturer's brand name in the appropriate space.

_____ 4. Write in a brief description or name of the item in the appropriate space.

_____ 5. List the price of each item on order form from catalog.

_____ 6. List the total price of all units combined. (multiply quantity by price of each).

_____ 7. List the page number in the catalog in which the part was found.

_____ 8. Write in the shipping weight of the total quantity desired of each item.

_____ 9. Write in appropriate blank the catalog number located usually on front cover.

_____ 10. Total the amount of all goods and fill in correct blank.

_____ 11. Determine total shipping weight of all items and fill in blank.

_____ 12. From charts, determine cost of shipping and insurance for total amount of parts and fill in.

_____ 13. Determine sales tax on the total amount of goods and fill in.

_____ 14. Add cost of insurance and shipping, sales tax, and total price of goods together and record on order form.

_____ 15. Write on order form person or firm to ship to.

_____ 16. Write address to be shipped to.

_____ 17. Write city to be shipped to.

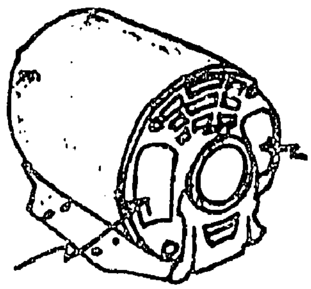
_____ 18. Write state to be shipped to.

_____ 19. Write ZIP code to be shipped to.

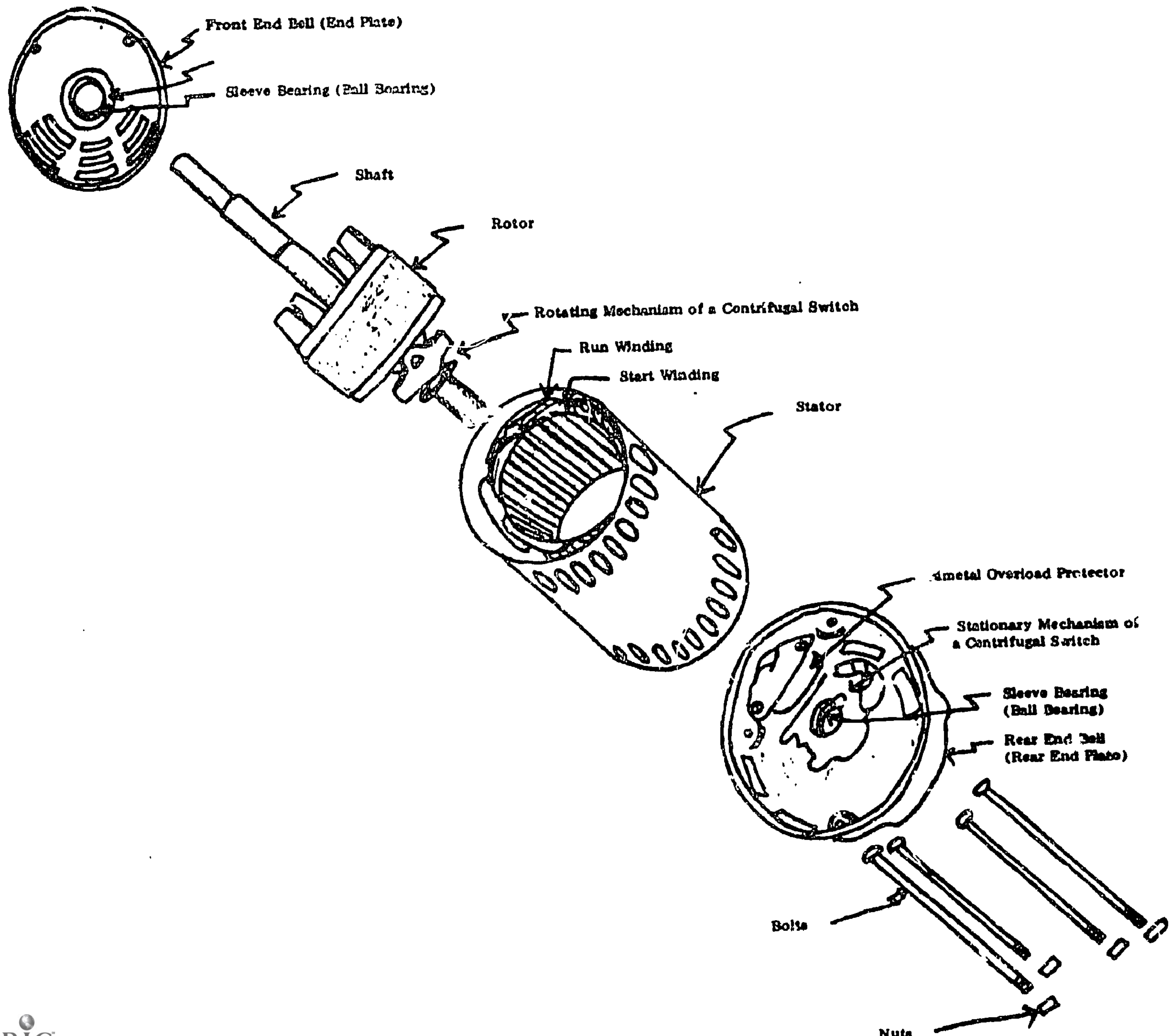
_____ 20. Fill in date form is completed.

_____ 21. Fill out blanks on methods or ways items are to be shipped.

SPLIT PHASE INDUCTION MOTOR



A SPLIT PHASE INDUCTION MOTOR



Service Checklist for Split-Phase Induction Motor

1. ___ Lubricate bearings (30W oil for sleeve bearings, general purpose lubricating grease for ball bearings).

2. ___ Insure that rotating mechanism of the centrifugal switch on the rotor is not binding.

3. ___ Check contact points on the stationary mechanism of the centrifugal switch for cleanliness.

4. ___ Insure that all leads to stationary centrifugal switch are tight.

Bearing Replacement Checklist for Split-Phase Induction Motor

1. ___ Using proper tools, remove bad bearing.

2. ___ Replace using proper tools. Ream to fit if necessary.

3. ___ Lubricate new bearing.

CENTRIFUGAL SWITCH REPLACEMENT FOR SPLIT-PHASE INDUCTION MOTOR

1. ___ Label all leads and remove from switch.

2. ___ Remove centrifugal switch.

3. ___ Install new switch, reconnect all leads.

Checklist for Reassembly of Split-Phase Induction Motor

1. ___ Gently set rotor inside stator.

2. ___ Align end bells with punch marks.

3. ___ Insert bolts and tighten.

4. ___ Connect motor to power source.

5. ___ Refer to exploded view.

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PURCHASE REQUISITION

78.01.03.05.A2-0

ORIGINATOR'S CONTROL NO.

REQUISITION NO.	REQUISITION DATE	TIME REQUIRED	PURCHASE ORDER NO.	PAGE of

[ ] RESEARCH DEVELOPMENT [ ] OPERATIONS
[ ] START UP

SUGGESTED SOURCE

ACCOUNTING DATA

USING ACTIVITY

USED FOR

DEPARTMENT
[ ] ADMINISTRATION
[ ] FAMILY LIFE
[ ] INSTRUCTION
[ ] MULTI-PURPOSE
[ ] STATE PROGRAMS
[ ] PLANNING & RESEARCH
[ ] OTHER

ITEM NO.	QUAN.	UNIT	DESCRIPTION OF SUPPLIES / SERVICES	EST. UNIT PRICE	EST. AMOUNT

REMARKS

EST. TOTAL AMOUNT

Title	Signature	Date	Title	Signature	Date
ORIGINATOR			PROPERTY CONTROLLER		
DEPT. HEAD			PROCUREMENT OFFICER		
DIR			ACCOUNTING OFFICE (To Procurement)		

MPEEDP Form PR-1 3805 REV.

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LAP TEST: REPAIRING SPLIT-PHASE INDUCTION MOTORS

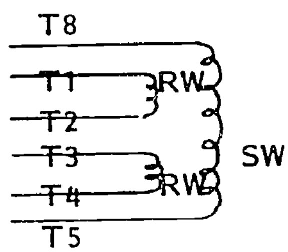
78.01.03.05

1. How is a skein winding made on a split-phase induction motor?

   a. one wire is laid into the slots at a time
   b. one long coil formed on two pegs
   c. one wire is laid into each coil slot at a time
   d. coils are formed on blocks then laid into the slots, one at a time

2. To connect the motor for 230 volt operation (see diagram) which leads must be connected?

   a. T8,T2,T4 together, T3,T5--one side, T1--other side of line
   b. T8,T2,T3 together. T4,T5--one side, T1--other side of line
   c. T8,T3,T2 together, T4,T1--one side, T5--other side
   d. T8,T3,T1 together, T4,T5,T2--one side, T1--other side of line



3. To connect the motor for 110 volt operation (see diagram) which leads must be connected?

   a. T8,T3,T4 together on one side of line, T4,T5,T1--other side
   b. T8,T3,T1 together on one side of line, T4,T5,T2--other side of line
   c. T8,T2,T3 together, T4,T5--one side, T1--other side of line
   d. T8,T2,T5 together to one side of line, T4,T5,T3--other side

4. Skein wind on a split-phase induction motor is used mainly for:

   a. start windings
   b. intermediate windings
   c. run windings
   d. it is used the same on all windings

78.01.03.05 (continued)

5. In making a form winding for a split-phase induction motor the first thing to do is:

   a. wind your coils on 2 pegs then lay into slots
   b. calculate the size of the forms
   c. count number turns per coil
   d. insulate the slots first

6. In rewinding on a split-phase induction motor for a change of voltage from 115 V to 230 V, the turns per coil would be:

   a. one half original turns
   b. doubled
   c. remain the same
   d. larger span

7. Rewinding for a change of voltage on a split-phase induction motor you change:

   a. connections
   b. wire size
   c. number of turns
   d. wire size and number of turns

8. In dual voltage motor 225V-236V the run winding is connected in for 230V.

   a. parallel
   b. series with start winding
   c. series
   d. parallel with start winding

9. When rewinding a split-phase induction motor, the size of copper wire is designated by:

   a. a micrometer
   b. a wire gauge
   c. its radius
   d. its diameter

10. When rewinding a split-phase induction motor, which number would indicate the largest size wire?

   a. 16
   b. 19
   c. 29
   d. 31

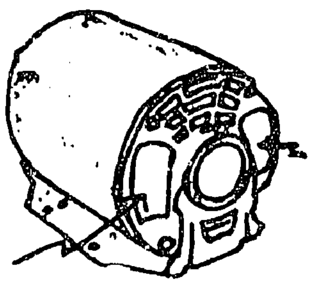
LAP TEST ANSWER KEY: 78.01.03.05.A2-2

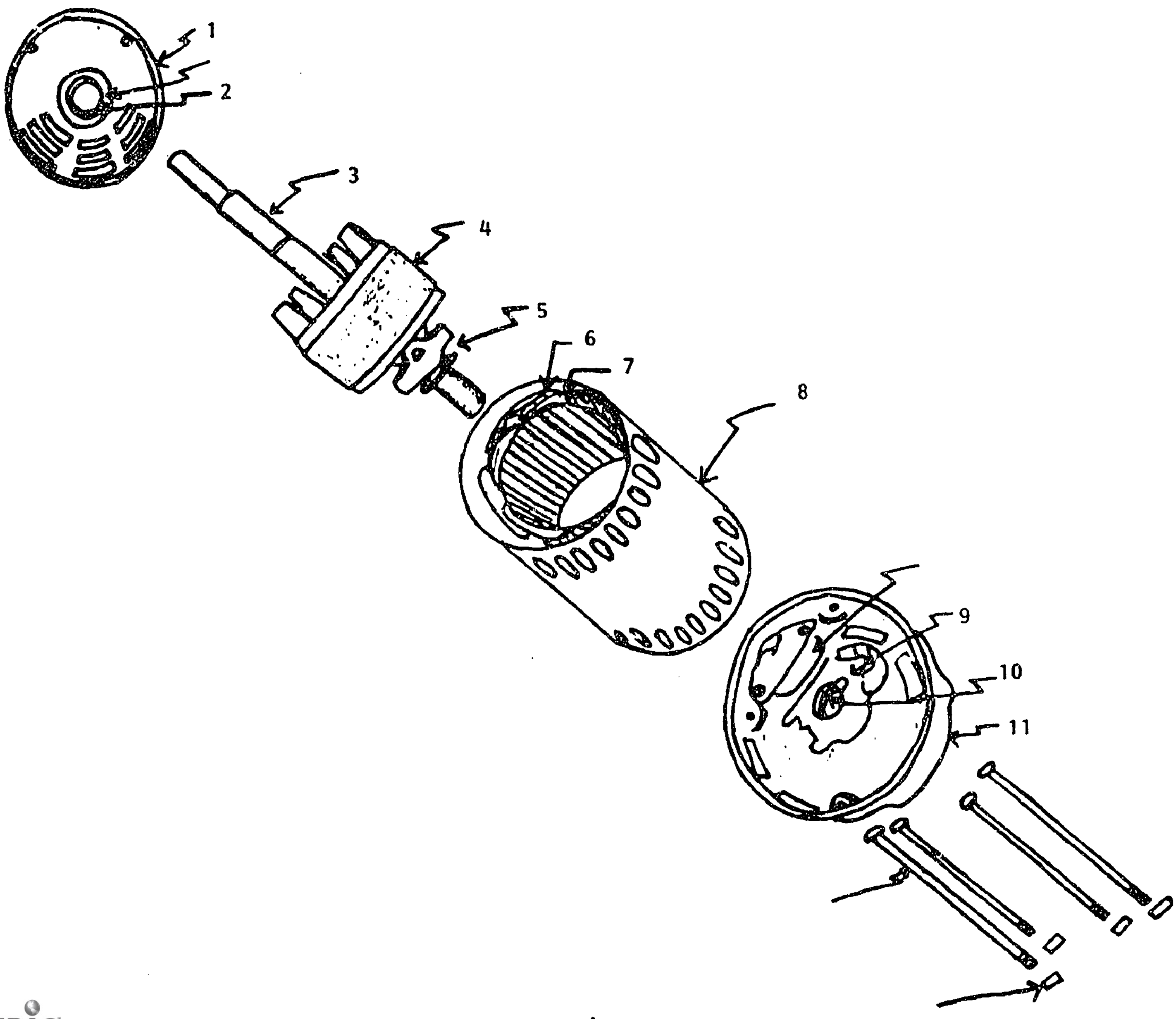
RFPAIRING SPLIT-PHASE INDUCTION MOTORS

1. B
2. B
3. B
4. A
5. B
6. B
7. D
8. C
9. B
10. A

SPLIT PHASE INDUCTION MOTOR

Diagram 1





Student: ____________________ File Code: 78.01.03.00.B2-2

Date: ____________________ Date Published: 1-27-76

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Glasgow AFB, Montana 59231

UNIT POST TEST: SPLIT-PHASE INDUCTION MOTORS

78.01.03.01

1. When do you fill out a work order card when repairing an electric motor?

    a. after the motor is left in the shop and the customer is gone
    b. after it is tested
    c. while the customer is present
    d. never

2. When would you put something in the "needed by" block of a work order when repairing an electric motor?

    a. always fill it in
    b. always leave blank
    c. only if it's needed immediately
    d. only if it is routine

3. What is meant by unit cost on a work order when repairing an electric motor?

    a. the grand total
    b. the cost of each item used
    c. the total cost
    d. the cost of two if two are used

4. Why is the date received important on a work order when repairing an electric motor?

    a. it makes no difference
    b. only if its routine is it important
    c. identifies the oldest routine order to work on
    d. always leave blank

5. When repairing an electric motor, why is it necessary to know the number of hours on a work order that you worked on a particular project?

    a. so the employer can make a profit
    b. so the customer is not overcharged for labor
    c. so the customer is not under charged
    d. so the secretary can keep the books straight

78.01.03.02

6. Where are the bearings located on a split-phase induction motor? (see diagram 1)

   a. 2 and 6
   b. 2 and 10
   c. 2 and 8
   d. 2 and 7

7. What functions does the end plate on a split-phase induction motor serve?

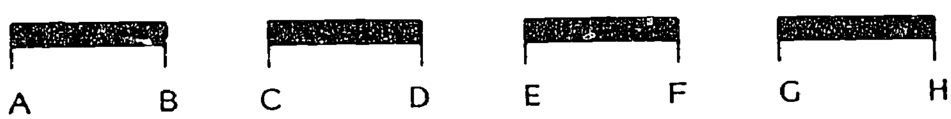
   a. to have some place to put oil
   b. to hold the shaft
   c. to house the bearing and keep the motor in position
   d. to hold the bearing

8. Where is the squirrel-cage winding on a split-phase induction motor found?

   a. inside the rotor
   b. inside the stator
   c. inside the front end plate
   d. inside the rear end plate

9. What is the proper connection of this 4 pole motor of the run winding?

   a. B to D, C to E, F to H, A and G to power line
   b. B to C, D to E, F to G, A and H to power line
   c. B to H, C to G, F to F, D and E to power line
   d. A to D, B to E, C to G, E and H to power line



10. Where is the stationary switch located on a split-phase induction motor? (see diagram)

   a. 3
   b. 2
   c. 10
   d. 9

78.01.03.03

11. The squirrel cage winding of a split-phase induction motor consists of heavy copper bars located in:

    a. laminating iron cores in the rotor
    b. the shaft
    c. laminating iron cores in the stator
    d. the centrifugal switch

12. At the start, the current flowing through both the run and start windings of a split-phase induction motor causes:

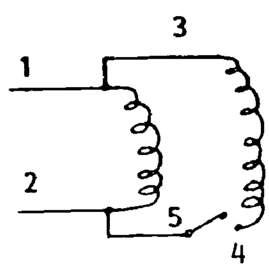
    a. centrifugal force
    b. magnetic fields
    c. the rotor to turn
    d. the centrifugal switch to close

13. What other name is used to refer to start winding on a split-phase induction motor?

    a. main winding
    b. auxiliary winding
    c. squirrel cage winding
    d. run winding

14. In the diagram, the centrifugal switch of a split-phase induction motor is located between:

    a. 3-4
    b. 4-5
    c. 1-4
    d. 1-2



15. In the run winding of a split-phase induction motor, how many poles are there?

    a. 1
    b. 4
    c. 3
    d. 2

78.01.03.04

16. If the start winding of a split-phase induction motor remains in the circuit, the:

    a. start winding is shorted
    b. centrifugal switch is not closing
    c. centrifugal switch is not opening
    d. contact points are burnt

17. When the internal wires are touching the iron cores of the rotor or stator on a split-phase induction motor, this is called:

    a. an open circuit
    b. a short
    c. a ground
    d. an internal short

18. To determine whether a winding on a split-phase induction motor is grounded while using a test lamp you would:

    a. connect one test lead to the rotor and one to the power line
    b. connect test lead in series with the run or start windings
    c. connect one test lead to centrifugal switch and one to power lead
    d. connect one test lead to power lead and other lead to core

19. What is used to test for grounds on a split-phase induction motor?

    a. ohmmeter
    b. growler
    c. amp probe
    d. voltmeter

20. If a split phase induction motor runs slower than it's normal speed, there is a:

    a. short in the squirrel cage winding
    b. bad centrifugal switch
    c. short in the run winding
    d. bad start winding

78.01.03.05

21. In rewinding a split-phase induction motor effective turns depend on the:

    a. spand of coil
    b. numbers of turns
    c. chord factor
    d. pitch

78.01.03.05 (continued)

22. The size of copper wire used in a split-phase induction motor is designated by:

   a. micrometer
   b. diameter
   c. wire gauge
   d. radius

23. In making a form winding for a split-phase induction motor the first thing to do is:

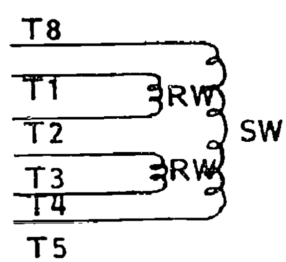
   a. insulate the slots first
   b. wind your coils on 2 pegs then lay into slots
   c. obtain the size for the forms
   d. count number turns per coil

24. Skein wind on a split-phase induction motor is used mainly for:

   a. start windings
   b. intermediate windings
   c. run windings
   d. it is used the same on all windings

25. To connect motor for 110 volt operation:

   a. T8,T3,T1 together on one side of line, T4,T5,T2 - other side of line
   b. T8,T3,T4, together on one side of line, T4,T5,T1 - other side
   c. T8,T2,T3 together, T4,T5 -- one side, T1 - other side of line
   d. T8,T2,T5 together to one side of line, T4,T5,T3 - other side



UNIT TEST ANSWER SHEET

UNIT POST TEST:

Occupational Area: SPLIT-PHASE INDUCTION MOTORS

File Code: 78.01.03.00.B2-2

Name: ______________________

ANSWERS

78.01.03.01	1.	C	78.01.03.05	21.	A	41.	
	2.	C		22.	C	42.	
	3.	B		23.	C	43.	
	4.	C		24.	A	44.	
	5.	B		25.	A	45.	
78.01.03.02	6.	B		26.		46.	
	7.	C		27.		47.	
	8.	A		28.		48.	
	9.	A		29.		49.	
	10.	D		30.		50.	
78.01.03.03	11.	A		31.		51.	
	12.	B		32.		52.	
	13.	B		33.		53.	
	14.	B		34.		54.	
	15.	B		35.		55.	
78.01.03.04	16.	C		36.		56.	
	17.	C		37.		57.	
	18.	D		38.		58.	
	19.	A		39.		59.	
	20.	C		40.		60.	

Student: ______________ File Code: 78.01.03.00.A1-5

Date: ______________ Date Published: 11/15/74

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Family Pay Number: ______________ Sex: M F (Circle 1)

UNIT PERFORMANCE TEST: SPLIT-PHASE INDUCTION MOTORS

OBJECTIVE 1:

Given a malfunctioning split-phase motor, the student will service and repair motor so that it functions according to the manufacturer's specifications, following safe practices and procedures.

OBJECTIVE 2:

Using appropriate tools and test equipment the student will take shorts and open tests.

OBJECTIVE 3:

Using appropriate equipment, the student will rewind a faulty split-phase motor.

OBJECTIVE 4:

Using appropriate tools and test equipment, the student will calculate and record amperage, voltage, resistance and wattage of a split-phase motor.

TASK:

The student will service and repair a split-phase motor and, in the process, he will make shorts and open and grounding tests, using appropriate test equipment.

ASSIGNMENT:

CONDITIONS:

The student will be given a malfunctioning split-phase motor (it may be bugged by the instructor or it may be one brought in by a customer). He will be required to service and repair the motor in conditions similar to those in a typical motor repair shop. He will be allowed to use any and all tools, equipment, service manuals, text books, etc., commonly found in a repair shop. He must complete it in a reasonable length of time with no assistance from the instructor(s) or students.

RESOURCES:

Tools:
- Internal-external snap ring pliers
- 7-Piece nut driver set
- Tool box 18 x 8 x 9
- Circular gauge
- Hacksaws
- Pulley puller
- Arc joint pliers
- Lineman's pliers
- Diagonal cutting pliers
- Long chain-nose pliers
- Coil tamping pliers
- Locking plier wrench
- 4-Piece standard set screwdriver
- Center punch
- Cold chisel
- Ball peen hammer
- Lug crimpers
- Wire skinner and straightener

Equipment:
- Coil stripping chisel
- Armature winder
- Coil winder
- External Growler
- Insulation former
- Coil shapers

Student: ______ File Code: 78.01.03.00.A1-3

Date: ______ Date Published: 11/15/74

Mountain-Plains Education & Economic Development Program, Inc. Glasgow AFB, Montana 59231

Family Pay Number: ______ Sex: M F (Circle 1)

PERFORMANCE CHECKLIST:

OVERALL PERFORMANCE: Satisfactory ______ Unsatisfactory ______

	CRITERION Met	CRITERION Not Met
Objective 1:		
1. Follows safe practices and procedures.		
Criterion: No injury results to the student or the equipment and complies with OSHA requirements.		
2. Follows proper procedures for disassembly.		
Criterion: No damage results to the motor.		
3. Diagnosis and troubleshoots malfunctions properly.		
Criterion: When repaired, the motor functions according to the manufacturer's specifications.		
4. Reassembles the motor properly.		
Criterion: Appliance functions according to the manufacturer's specifications and the procedures followed agree with those described in the service literature.		
5. The repaired motor is repaired in a neat, professional manner.		

(Checklist continued)

	CRITERION Met	CRITERION Not Met
Criterion: No damage results to the motor such as opens		
and shorts.		
6. All connections and fastenings are properly completed.		
Criterion: The motor connection complies with the		
manufacturer's specifications. The connections		
are mechanically fastened and structurally		
sound. The connection is electrically fastened		
and free of defects.		
7. Motor functions according to the manufacturer's		
specifications.		
Criterion: Manufacturer's specifications.		
8. Uses appropriate repair part and supplies.		
Criterion: They match exactly those listed in the		
manufacturer's specifications.		
Objective 2:		
9. Test for grounds, using growler or millivolt meter.		
10. Test for shorts in the field coils, using a growler.		
11. Test for an open field coil, using an ohmmeter.		
12. Test for reversed coils, using a compass or bar		
magnet test.		

	CRITERION Met	Not Met
Criterion: Trouble-shooting techniques reveal the malfunction,		
as identified by job sheet.		
Objective 3:		
13. Uses coil-stripping tool to remove coils.		
14. Uses coil winder, if appropriate, when winding		
field coil.		
15. Uses insulation former, if appropriate, when		
insulating.		
16. Uses coil shaper, if appropriate, on field coils.		
Criterion: Proper equipment application results in a		
defect-free operative motor.		
Objective 4:		
17. Uses test equipment properly.		
18. Wattage readings are accurate.		
19. Voltage readings are accurate.		
20. Amperage readings are accurate.		
21. Resistance readings are accurate.		
Criterion: Manufacturer's specifications.		
22. When applicable, mathematical calculations are correct.		
Criterion: AC/DC Circuit Manuals, Westinghouse		

(Checklist continued)

	CRITERION Met	Not Met
23. The motor is repaired in a reasonable time.		
Criterion: Not to exceed 4 hours.		
The student must successfully complete 20 out of 23 line items		
to achieve an overall score of satisfactory.		

File Code: 78.01.04.00.A2-0

Date Published: 2-20-76

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Learning Experience Guide

UNIT: CAPACITOR MOTORS

RATIONALE:

Capacitor motors are basically split-phase motors with some differences in internal and external circuit wiring. The motor repairman should be familiar with these differences.

The topic, Capacitor Motors, is a vital part of the preparation needed by an electric motor repairman.

PREREQUISITES:

Unit: Split-Phase Induction Motors

OBJECTIVE:

Troubleshoot, repair, and rewind capacitor motors using appropriate tools, equipment, and procedures. Identify parts, operational characteristics and procedures for diagnosis and repair of capacitor motors.

RESOURCES:

PERFORMANCE ACTIVITIES:

.01 Operation of Capacitor Motors.
.02 Capacitor Motor Construction.
.03 Troubleshooting Capacitor Motors.
.04 Repairing Capacitor Motors.

GENERAL INSTRUCTIONS:

This unit consists of 4 Learning Activity Packages (LAPs). Each LAP will provide specific information for completion of a learning activity.

The general procedure for this unit is as follows:

(1) Read the first assigned Learning Activity Package (LAP).
(2) Begin and complete the first assigned LAP.
(3) Take and score the LAP test.
(4) Turn in the LAP test answer sheet.
(5) Determine the reason for any missed items on the LAP test.

Principal Author(s): T. Ziller

Printed Material

Electric Motor Repair, second edition Robert Rosenburg (see more bibleo - data) Rinehart and Winston, 1970.

Introduction to Power Technology: Principles of Electric Motors, second edition, Vega Enterprises Inc., Decator, Illinois, 1973.

Service Manuals

Attached Lap reading material:
Checklist for Disassembly
Checklist for troubleshooting: Capacitor Motors
Checklist for Repair, Service and Reassembly: Split-Phase Capacitor Start Motor

Audio/Visual

Attached Illustration: capacitor motor
split-phase ________ motor

Equipment

capacitor motor
motor test analyzer
motor board for capacitor motor
tools

GENERAL INSTRUCTIONS: (continued)

(6) Proceed to and complete the next assigned LAP in the unit.
(7) Complete all required LAPs for the unit by following steps 3 through 6.
(8) Take the unit tests as described in the Unit LEG "Evaluation Procedures".
(9) Proceed to the next assigned unit.

EVALUATION PROCEDURE:

When pretesting:

1. The student takes the unit multiple-choice pretest. Successful completion is 4 out of 5 items for each LAP part of the pretest.
2. The student then takes a unit performance test if the unit pretest was successfully completed. Satisfactory completion of the performance test is meeting the criteria listed on the performance test.

When post testing:

The student takes a multiple-choice unit post test and a unit performance test. Successful unit completion is meeting the listed criteria for the performance test.

FOLLOW-THROUGH:

You may now begin with the first LAP in this unit. Talk to your instructor if you need help.

Student: ______________________ File Code: 78.01.04.00.A2-2

Date: ______________________ Date Published: 12-13-74

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UNIT PRETEST: CAPACITOR MOTORS

78.01.04.01

1. Where would a two-valve capacitor motor be used?

   a. heaters
   b. fans
   c. compressors
   d. blowers

2. The purpose of a capacitor-start motor is to provide:

   a. lower RPM
   b. higher RPM
   c. lower starting torque
   d. higher starting torque

3. What is different about a permanent-split capacitor motor?

   a. no centrifugal switch is necessary
   b. it has comparatively higher torque
   c. there is no need for a rotor
   d. it is two motors in one housing

4. What is another name for a permanent-split capacitor motor?

   a. three phase motor
   b. single-valve capacitor-run motor
   c. two phase motor
   d. split-phase induction motor

5. On a two-valve capacitor motor, what purpose does the centrifugal switch serve?

   a. takes the capacitor and run winding out of circuit
   b. to substitute a lower capacity
   c. takes the capacitor and start winding out of circuit
   d. takes the start winding out of the circuit

78.01.04.02

6. What is the purpose of the centrifugal switch in a capacitor-start motor?

   a. to remove the start winding from the run winding
   b. to remove the run winding from the capacitor
   c. to help to reduce eddy currents
   d. to remove the capacitor and start winding from the run winding at 75% FS

7. Where is the bearing located in a capacitor-start motor?

   a. between the rotor and centrifugal switch
   b. the center of the end plate
   c. on the end of the shaft only
   d. split-phase capacitor start motor does not require one

8. In a capacitor-start motor, what helps to prevent the motor from drawing too much current?

   a. the fuse
   b. the extra set contact points
   c. the centrifugal switch
   d. the overload device

9. Where is the centrifugal switch located in a capacitor-start motor?

   a. on the front end plate
   b. on the rear end plate
   c. on top of the stator
   d. inside the stator

10. In a capacitor-start motor the capacitor is in ________ with start wind.

    a. series
    b. series parallel
    c. parallel series
    d. parallel

78.01.04.03

11. How is a capacitor checked using an ohmmeter?

    a. the ohmmeter will show infinity reading
    b. the ohmmeter will give a different reading
    c. lead on + terminal = lead on = terminal ohmmeter on high
    d. the ohmmeter will show zero OHMS

78.01.04.03 (continued)

12. If the capacitor of a capacitor-start motor becomes open:

 a. the motor will burn up if connected to power line before starting
 b. it will start but will not reach full speed
 c. it will start but with less starting torque
 d. motor won't start, will run if started manually have FS before load

13. If a capacitor-start motor starts fine but when centrifugal switch kicks out it drops back to start winding, what is the problem?

 a. open run winding
 b. defective capacitor
 c. wrong connections
 d. defective centrifugal switch

14. In a capacitor-start motor, if the fuse burns out when current is applied to the motor, look for:

 a. shorted windings
 b. open run winding
 c. open start winding
 d. open capacitor

15. On a capacitor start--capacitor-run motor, what type of capacitor is used?

 a. paper capacitor
 b. oil capacitor
 c. two-valve oil capacitor
 d. two-valve paper capacitor

78.01.04.04

16. When a capacitor-start motor is first put on the work bench, which of the following should be done?

 a. refer to manufacturer's booklet
 b. plug it into a voltage source and see what doesn't work properly
 c. use a test lamp or ohmmeter and check for grounds, shorts, opens
 d. dismantle and look inside

17. Without a load on a capacitor-start motor, smoking while running may be caused by:

 a. failure of centrifugal switch to open starting winding circuit
 b. overloaded
 c. shorted winding
 d. defective capacitor

78.01.04.04 (continued)

18. If a capacitor-start motor (without a load) hums but does not run, suspect:

    a. grounded winding
    b. shorted winding
    c. overload
    d. defective capacitor

19. On a capacitor-start motor, if you get a shock when you touch the frame of the motor, the motor:

    a. is shorted
    b. is open
    c. is grounded
    d. will not operate

20. After rewinding a capacitor-start motor and it appears to be running fine, what test equipment would you use to check current drain?

    a. ammeter
    b. ohmmeter
    c. low resistance meter
    d. voltmeter

UNIT TEST ANSWER SHEET
UNIT PRETEST
CAPACITOR MOTORS

Occupational Area: ______
File Code: 78.01.04.00.A2-2
Name: ______

ANSWERS

78.01.04.01	1.	C	21.		41.	
	2.	D	22.		42.	
	3.	A	23.		43.	
	4.	B	24.		44.	
	5.	B	25.		45.	
78.01.04.02	6.	D	26.		46.	
	7.	B	27.		47.	
	8.	D	28.		48.	
	9.	B	29.		49.	
	10.	A	30.		50.	
78.01.04.03	11.	C	31.		51.	
	12.	D	32.		52.	
	13.	A	33.		53.	
	14.	A	34.		54.	
	15.	C	35.		55.	
78.01.04.04	16.	C	36.		56.	
	17.	A	37.		57.	
	18.	D	38.		58.	
	19.	C	39.		59.	
	20.	A	40.		60.	

File Code: 78.01.04.01.A2-0

Date Published: 2-23-76

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Learning Activity Package

Student: ____________

Date: ____________

PERFORMANCE ACTIVITY: Operation of the Capacitor Motor

OBJECTIVE:

Describe the operation of a capacitor motor.
Identify operational characteristics of a capacitor motor.

EVALUATION PROCEDURE:

Successfully complete at least 80% of the items on a multiple-choice test about this LAP.

RESOURCES:

Capacitor start motor.
Electric Motor Repair, by Robert Rosenberg, pages 52-53, 62-71.
Introduction to Power Technology Principles of Electric Motors, Vega, pages 24-27.

motor test analyzer

PROCEDURE:

Steps

1. Read pages 52-53 and 62-71 in Electric Motor Repair.
2. Complete experiment #2, "Capacitor Start Motors" in Introduction To Power Technology, pages 24-27.
3. Write a description of the motor's operation using simple electrical schematics.
4. Take the LAP test.

Principal Author(s): T. Ziller

Student: ______________ File Code: 78.01.04.01.A2-2

Date: ______________ Date Published: 12-19-74

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LAP TEST: OPERATION OF THE CAPACITOR MOTOR

78.01.04.01

1. Normally, when is an oil-filled capacitor used?

   a. only when low current is required
   b. only when using a two-valve capacitor
   c. only on start cycle
   d. when it is in the circuit on run cycle

2. The purpose of a capacitor-start motor is to provide:

   a. lower starting torque
   b. higher starting torque
   c. lower RPM
   d. higher RPM

3. What is taken off the line after the motor reaches approximately 75% full speed?

   a. start winding, centrifugal switch, and capacitor
   b. run winding and centrifugal switch
   c. capacitor and centrifugal switch
   d. start winding and rotor

4. Where would a two-valve capacitor motor be used?

   a. in fans
   b. in heaters
   c. in blowers
   d. in compressors

5. The capacitor and the centrifugal switch are connected in series with the:

   a. run winding
   b. only while centrifugal switch is closed
   c. start winding
   d. only while centrifugal switch is open

78.01.04.01 (continued)

6. The start winding is how many electrical degrees out of phase with the run winding?

   a. 90
   b. 180
   c. 75
   d. -190

7. How are the two valves of capacity obtained?

   a. only by using a transformer
   b. two capacitors in parallel
   c. dual capacitor in one can
   d. two capacitors in series

8. What is connected to the line after the motor reaches approximately 75% full speed?

   a. start winding
   b. run winding
   c. centrifugal switch
   d. capacitor

9. What is the major advantage of a two-valve capacitor motor?

   a. it reduces starting torque
   b. it produces slower speed
   c. it produces higher speed
   d. it creates high starting torque

10. The run winding is how many electrical degrees out of phase with the start winding?

    a. lagging by 75
    b. lagging by 0
    c. leading by 180
    d. leading by 190

LAP TEST ANSWER KEY: 78.01.04.01.A2-2

OPERATION OF THE CAPACITOR MOTOR

1. D
2. B
3. A
4. D
5. B
6. A
7. C
8. B
9. D
10. C

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File Code: 78.01.04.02.A2-0

Date Published: 2-23-76

Learning Activity Package

Student: ____________________

Date: ____________________

PERFORMANCE ACTIVITY: Capacitor Motor Construction

OBJECTIVE:

Disassemble and identify the component parts of a capacitor motor.

EVALUATION PROCEDURE:

Instructor will examine the disassembled motor for correct disassembly. Identification of main parts will be in compliance with attached identification list. Also score at least 80% on a multiple-choice test.

RESOURCES:

Capacitor motor.
Checklist on disassembly of the motor. (attached)
Illustration of a capacitor motor. (attached)
Hand tools.
Electric Motor Repair, by Robert Rosenburg.

PROCEDURE:

Steps

1. Follow the checklist for disassembly of a capacitor motor.
2. Complete the multiple-choice test items for this LAP.

Principal Author(s): T. Ziller

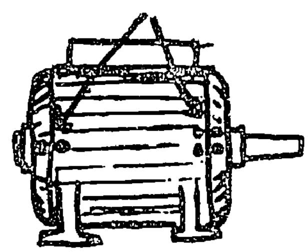
File Code: 78.01.04.02.A2-0

CHECKLIST FOR DISASSEMBLY:

CAPACITOR MOTOR

1. Using a ball peen hammer and center punch, put two (2) punch marks on the end bell and on the stator, on the end of the motor in line with each other and within ½" of each other.

2. Using the same tools, put one (1) punch mark on the stator and end bell in line with step 1 but on the other end of motor and within ½" of each other.



3. Using a nut driver of proper size, remove the four (4) nuts and remove the long bolts. (Caution: do not lose the nuts).

4. Using a ball peen hammer and cold chisel, gently tap the front end bell where it meets the stator on shaft end; when loose, slide the end bell off the end of shaft.

5. Firmly hold onto the shaft and pull straight out. Try not to let the rotor drag on the stator laminations.

6. Using the tools in step 4, gently tap the rear end bell loose; it will still be connected with 4 wires to the centrifugal switch. Do not force.

7. To remove capacitor, remove the screws folding the cover plate; capacitor will fall out (don't lose the screws).

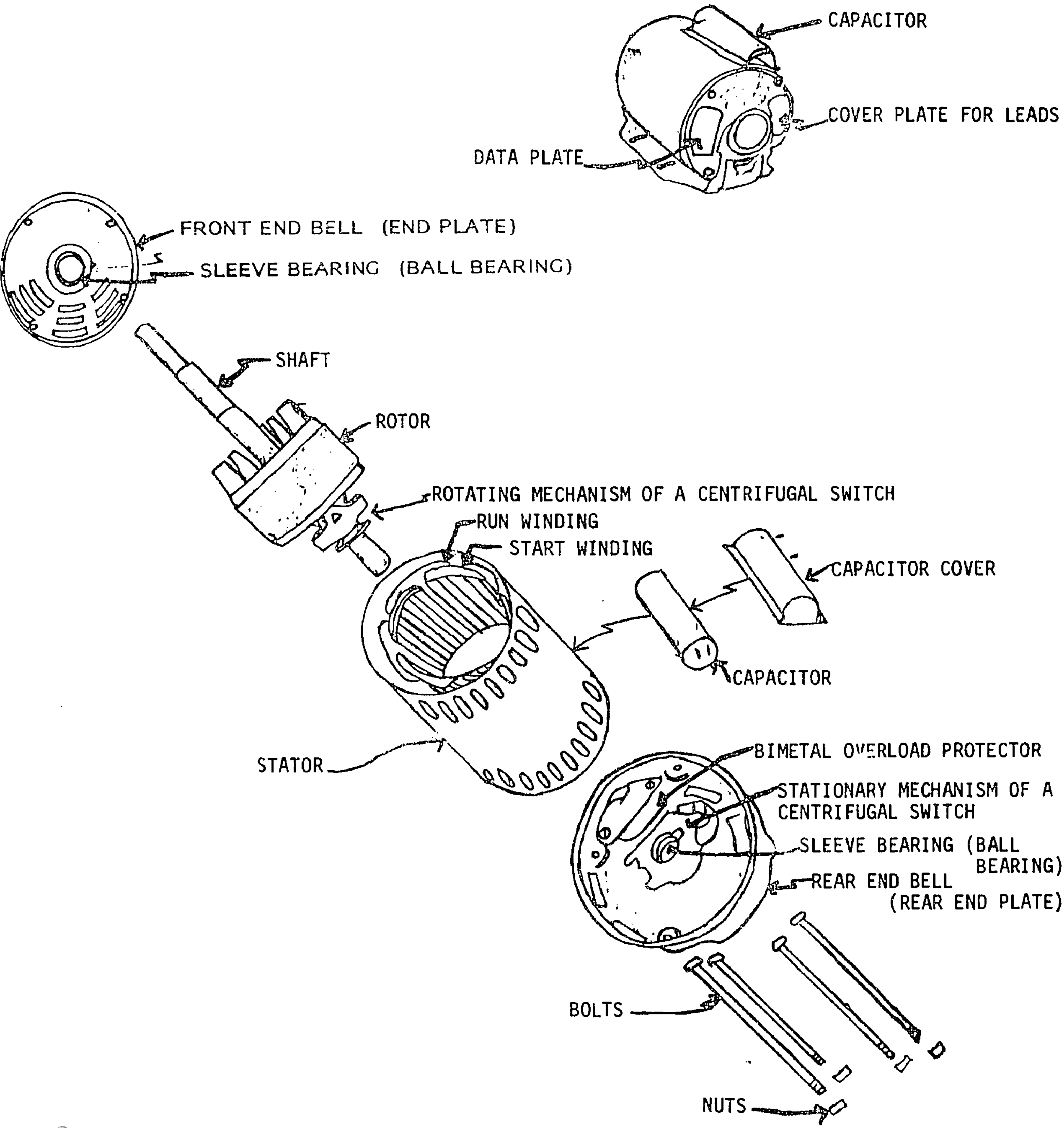
8. To remove the centrifugal switch, use a screwdriver and remove the screws. (Caution: do not lose the screws).

9. To remove proctector (thermal relay), remove the two screws with a screwdriver. (Caution: do not lose the screws).

10. Label each component part using masking tape.

11. Have the instructor examine the identified parts.

CAPACITOR MOTOR



Student: ______________________ File Code: 78.01.04.02.A2-2

Date: ______________________ Date Published: 12-20-74

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LAP TEST: CAPACITOR MOTOR CONSTRUCTION

78.01.04.02

1. What does the stator house in electric motors?

   a. Starting and run winding
   b. the capacitor
   c. front end plate
   d. the centrifugal switch

2. How is a bimetallic overload device connected in a capacitor-start motor?

   a. series parallel
   b. series
   c. parallel series
   d. parallel

3. What is the purpose of the end plate in a capacitor-start motor?

   a. to hold the capacitor
   b. to hold the rotor in center of the stator
   c. to hold the winding in place
   d. to keep stator from collapsing

4. What is the purpose of bearing packing in a capacitor-start motor?

   a. to house the bearing
   b. to hold oil for bearing lubrication
   c. so that the rotor will be held in the center of the stator
   d. to hold the bearing in place

5. How is the centrifugal switch mounted in a capacitor-start motor?

   a. with washers
   b. by welding
   c. with nuts
   d. with screws

78.01.04.02 (continued)

6. In a capacitor-start motor, what helps to prevent the motor from drawing too much current?

   a. the overload device
   b. the centrifugal switch
   c. the extra set contact points
   d. the fuse

7. Where is the bearing located in a capacitor-start motor?

   a. between the rotor and centrifugal switch
   b. split-phase capacitor-start motor does not require one
   c. on the end of the shaft only
   d. in the center of the end plate

8. Normally, where is the capacitor located on a capacitor-start motor?

   a. on top of the stator
   b. in the rotor
   c. in side the stator
   d. inside the rear end plate

9. In a capacitor-start motor the capacitor is in parallel with the:

   a. bearings
   b. centrifugal switch
   c. run winding
   d. start windng

10. What is the purpose of the centrifugal switch in a capacitor-start motor?

    a. to remove the capacitor and start winding from the run winding at 75% full speed
    b. to help to reduce eddy currents
    c. to remove the run winding from the capacitor
    d. to remove the start winding from the run winding

LAP TEST ANSWER KEY: 78.01.04.03.A2-2

CAPACITOR MOTOR CONSTRUCTION

1. A
2. B
3. B
4. B
5. D
6. A
7. D
8. A
9. C
10. A

File Code: 78.01.04.03.A2-0

Date Published: 2-23-76

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Learning Activity Package

Student: ____________

Date: ____________

PERFORMANCE ACTIVITY: Troubleshooting Capacitor Motors

OBJECTIVE:

Troubleshoot a capacitor motor following the steps given on the checklist.

EVALUATION PROCEDURE:

The student is to troubleshoot motors using a given checklist and score at least 80% on a multiple-choice test.

RESOURCES:

Checklist for troubleshooting, test equipment, tools, work order form and requisition form.
Capacitor Motor.
Service Manuals.
Electric Motor Repair, by Robert Rosenburg, pages 74-79.

PROCEDURE:

Steps

1. Follow the checklist for troubleshooting a motor (Attached)
2. Complete the multiple-choice test items for this LAP.

Principal Author(s): T. Ziller

CHECKLIST FOR TROUBLESHOOTING: CAPACITOR MOTORS.

1. Make a thorough visual inspection.

2. If the motor sparks badly, check for:

   a. Shorted field poles (Ohmmeter) (Growler).
   b. Wrong lead position on the commutator.
   c. Open armature coils (Ohmmeter).
   d. Shorted armature coils (Growler).
   e. Reversed coil leads.
   f. Worn bearings.
   g. High mica.
   h. Wrong direction of rotation.

3. If the motor runs hot, check for:

   a. Worn bearings.
   b. Dry bearings.
   c. Shorted coils (Growler).
   d. Overload (Ammeter).
   e. Shorted fields (Growler).
   f. Brushes off-neutral.

4. If the motor smokes, check for:

   a. Shorted armature (Growler).
   b. Shorted fields (Growler).
   c. Worn bearings.
   d. Wrong voltage (Voltmeter).
   e. Overload (Ammeter).

5. If the motor has poor torque, check for:

   a. Shorted coils (Growler).
   b. Shorted field (Growler).
   c. Wrong brush position.
   d. Worn bearings.

6. Take a resistance reading on the motor field windings.
   Take a resistance reading on the armature coils. (Record values).

7. Plug the motor into 115V AC power source.

8. Take a voltage reading on the motor terminals. (Record value) Compare with manufacturer's name plate.

9. Using an ammeter take a current reading on the motor. (Record value). Compare with manufacturer's name plate.

10. Disconnect from AC Power.

11. Connect fields to a low D.C. voltage.

12. Use a compass and check for polarity.

Student: ______________________ File Code: 78.01.04.03.A2-2

Date: ______________________ Date Published: 12-20-74

Mountain-Plains Education & Economic Development Program, Inc.
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LAP TEST: TROUBLE-SHOOTING CAPACITOR MOTORS

78.01.04.03

1. How is a capacitor checked using an ohmmeter?

   a. the ohmmeter shows infinity reading
   b. the ohmmeter will show zero OHMS
   c. +lead on + terminal: - lead on - terminal ohmmeter on high
   d. the ohmmeter will give a different reading

2. What will the ohmmeter show if the capacitor is shorted?

   a. the ohmmeter will give a different reading
   b. the ohmmeter will show zero OHMS
   c. the ohmmeter shows infinity reading
   d. + lead on + terminal: - lead on - terminal OM-high reverse

3. If a capacitor-start motor starts fine but when the centrifugal switch kicks out, it drops back to start winding, what is the problem?

   a. wrong connections
   b. defective capacitor
   c. open run winding
   d. defective centrifugal switch

4. In a capacitor-start motor, if the fuse burns out when current is applied to the motor, look for:

   a. open run winding
   b. open capacitor
   c. open start winding
   d. shorted windings

5. How are capacitors rated?

   a. by power factor - PF
   b. by working volts direct current- WVDC
   c. farads
   d. horsepower - HP

78.01.04.03 (continued)

6. If the capacitor of a capacitor-start motor becomes shorted:

   a. it will cause it to over speed
   b. the motor may start, but starting torque will be greatly reduced
   c. it will create a short circuit directly across the line
   d. the motor will not run

7. The capacitance of a capacitor-start motor should be within what % of the rated capacity?

   a. 20%
   b. 40%
   c. 10%
   d. 30%

8. If you receive an electrical shock from a capacitor-start motor when you put your hand on it, the trouble may be:

   a. a bad centrifugal switch
   b. badly worn bearings
   c. a grounded winding
   d. a defective capacitor

9. On a capacitor-start, capacitor-run motor, what type of capacitor is used?

   a. oil capacitor
   b. paper capacitor
   c. two-valve paper capacitor
   d. two-valve oil capacitor

10. If a capacitor-start motor has difficulty starting, the trouble may be (with no load applied):

   a. open windings
   b. bad centrifugal switch
   c. defective capacitor
   d. over load

LAP TEST ANSWER KEY: 78.01.04.02.A2-2

TROUBLE-SHOOTING CAPACITOR MOTORS

1. C
2. B
3. C
4. D
5. C
6. B
7. A
8. C
9. D
10. C

File Code: 78.01.04.04.A2-0

Date Published: 2-23-76

Mountain-Plains Education &
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Glasgow AFB, Montana 59231

Learning Activity Package

Student: ____________

Date: ____________

PERFORMANCE ACTIVITY: Repairing Capacitor Motors

OBJECTIVE:

Repair, service and reassemble a capacitor motor.
Identify procedures for the repair, service and reassembly of capacitor motors.

EVALUATION PROCEDURE:

The appliance must operate properly. The student is to repair, service and reassemble motors that are consistent with the given checklist. Also score 80% on a multiple-choice test.

RESOURCES:

Checklist for repair, service and reassembly, test equipment, tools, work order form and requisition form.
Capacitor Motor.
Service Manuals.
Electric Motor Repair, by Robert Rosenburg, pages 74-79.
Illustration of a Split-Phase capacitor motor.

PROCEDURE:

Steps

1. Follow the checklists for repair, service and reassembly.
2. Complete the multiple-choice test items for this LAP.

Principal Author(s): T. Ziller

CHECKLIST FOR REPAIR, SERVICE AND REASSEMBLY: SPLIT-PHASE CAPACITOR MOTOR

1. Lubricate bearings (30-w oil for sleeve bearings, general purpose lubricating grease for ball bearings).

2. Insure that rotating mechanism of the centrifugal switch on the rotor is not binding.

3. Check contact points on the stationary mechanism of the centrifugal switch for cleanliness.

4. Insure that all leads to stationary centrifugal switch are tight.

Bearing Replacement Checklist for Split-Phase Capacitor Motor

1. Using proper tools, remove bad bearings.
2. Replace, using proper tools. Ream to fit as necessary.
3. Relubricate new bearings.

Centrifugal Switch Replacement for Split-Phase Capacitor Motor

1. Label all leads and remove from centrifugal switch.
2. Remove centrifugal switch.
3. Install new switch, reconnect all leads.

Capacitor Check and Replacement

1. Remove screws holding capacitor (don't lose screws).
2. Remove capacitor from holder (don't lose holder).
3. Using soldering iron, unsolder the leads.
4. Using proper test equipment, test capacitor.
5. Order a new capacitor using a requisition form.
6. Resolder leads onto new capacitor, insert in holder, install onto stator.

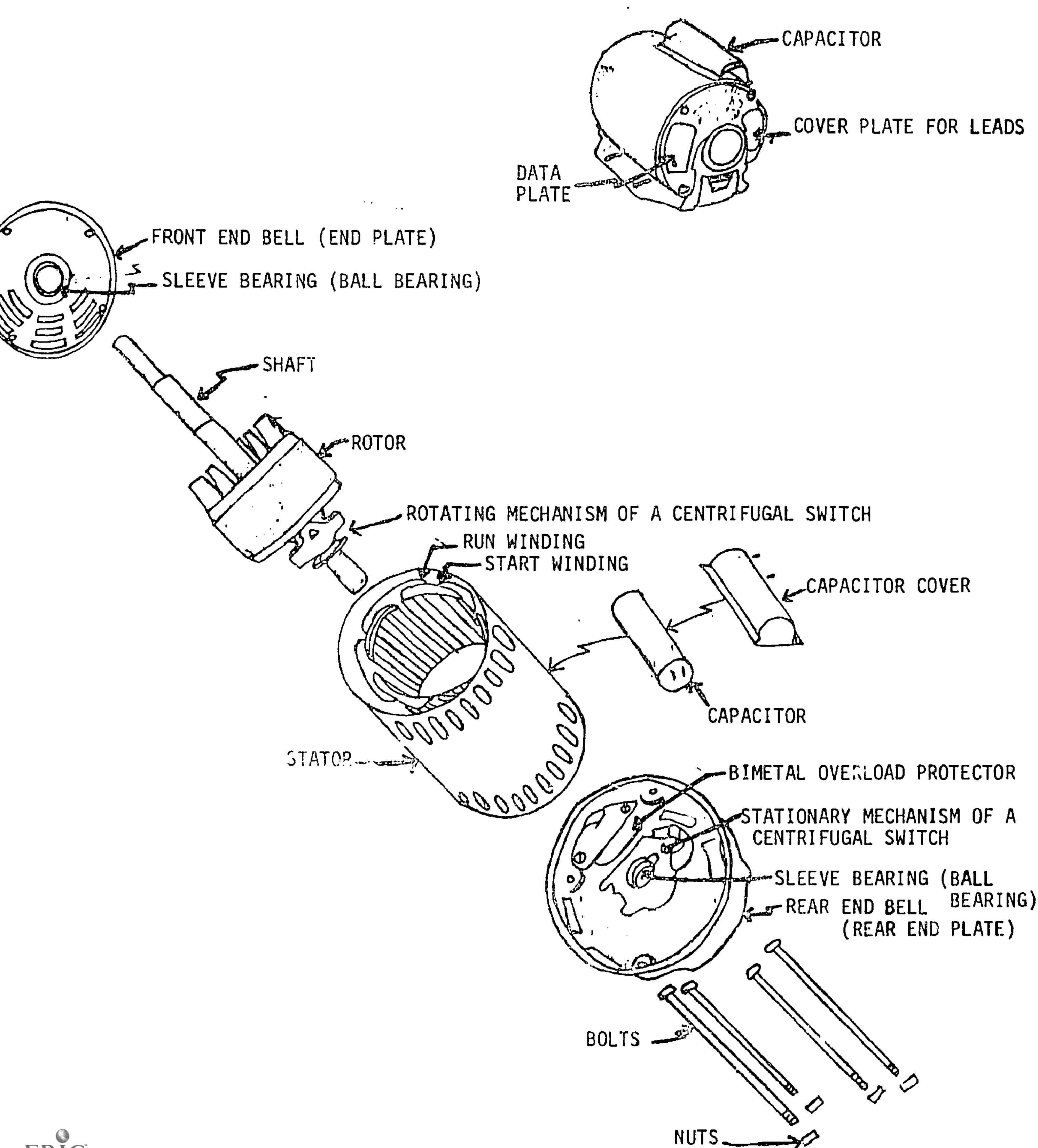
Checklist: Rewinding Split-Phase Capacitor Motor

1. Take data from data plate on motor and enter on data sheet for split-phase motor. (Page 7-9) See instructor when completed.
2. Strip the stator. (Page 9-10).
3. Check for correct size of magnetic wire. (Page 10-12).
4. Form fit the paper insulation to fit the stator slots. See instructor when completed.
5. Rewind motor using the form winding method. (Page 13-16).
6. Splice and connect all ends and beginning wires of each pole correctly. (Page 53-71). See instructor when completed.
7. Test new winding with proper test equipment. (Page 20).
8. Dip stator winding into varnish. (Page 20 and 21).
9. Reassemble the motor.
10. Connect motor to power source and test under load.

Checklist: Reassembly of Split-Phase Capacitor Motor

1. Gently set rotor inside stator
2. Align end bells with punch marks
3. Insert bolts and tighten
4. Install capacitor cover on the capacitor
5. Connect motor to power source
6. Refer to exploded view

A SPLIT-PHASE CAPACITOR MOTOR



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LAP TEST: REPAIRING CAPACITOR MOTORS

78.01.04.04

1. If the shaft of a capacitor-start motor will not turn by hand, you should suspect:

   a. wrong connections
   b. a bad centrifugal swtich
   c. a defective capacitor
   d. bad bearings

2. When a capacitor-start motor is first put on the work bench, which of the following should be done?

   a. check the manufacturer's booklet
   b. use a test lamp or ohmmeter and check for grounds, shorts, opens
   c. dismantle it and look inside
   d. plug it into a voltage source and see what doesn't work properly

3. How does a capacitor-start motor differ from a split-phase motor?

   a. the capacitor is added in parallel with centrifugal switch
   b. the capacitor is connected in series parallel with start winding
   c. the capacitor is added in series with centrifugal switch
   d. the capacitor is connected in parallel with the start winding

4. After rewinding a capacitor-start motor and it appears to be running fine, what test equipment would you use to check current drain?

   a. ammeter
   b. low resistance meter
   c. ohmmeter
   d. voltmeter

5. In a capacitor-start motor, if the varnish is scrapped or nicked in one spot, should it be installed in the starter?

   a. always
   b. never
   c. sometimes
   d. occasionally

78.01.04.04 (continued)

6. When you apply current to a capacitor-start motor and the fuse burns open, look for:

   a. wrong connections
   b. a shorted winding
   c. too small a fuse
   d. an open capacitor

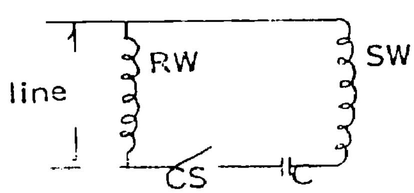
7. On testing a capacitor-start motor, you find the shaft free but the motor hums and doesn't run suspect:

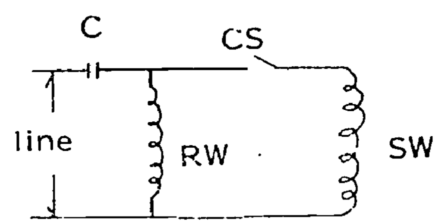
   a. an overload
   b. badly worn bearings
   c. an open start or run winding
   d. a shorted start or run winding

8. After rewinding the start winding of a capacitor-start motor, and while test running, smoke appears from the motor, trouble may be due to:

   a. a defective capacitor
   b. a shorted winding
   c. an open winding
   d. wrong connections

9. Which is the proper schematic for a capacitor-start motor?

A)


C)


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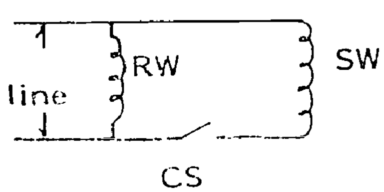
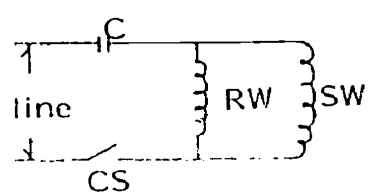


D)


10. On a capacitor-start motor, if you get a shock when you touch the frame of the motor, the motor:

   a. will not operate
   b. is open
   c. is shorted
   d. is grounded

LAP TEST ANSWER KEY: 78.01.04.04.A2-2

REPAIRING CAPACITOR MOTORS

1. D
2. B
3. C
4. A
5. B
6. B
7. C
8. B
9. A
10. D

Student: ____________________ File Code: 78.01.04.00.B2-2

Date: ____________________ Date Published: 12-17-74

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UNIT POST TEST: CAPACITOR MOTORS

78.01.04.01

1. What is the major advantage of a two-valve capacitor motor?

   a. it creates high starting torque
   b. it produces slower speed
   c. it produces higher speed
   d. it reduces starting torque

2. The capacitor and the centrifugal switch are connected in series:

   a. with the start winding
   b. only while centrifugal switch is open
   c. only while centrifugal switch is closed
   d. with the run winding

3. Normally, when is an oil-filled capacitor used?

   a. only on start cycle
   b. only when using a two-valve capacitor
   c. when it is in the circuit on run cycle
   d. only when low current is required

4. What is connected to line after motor reaches approximately 75% full speed?

   a. run winding
   b. capacitor
   c. start winding
   d. centrifugal switch

5. What is taken off the line after motor reaches approximately 75% full speed?

   a. run winding and centrifugal switch
   b. start winding, centrifugal switch, and capacitor
   c. capacitor and centrifugal switch
   d. start winding and rotor

78.01.04.02

6. What is the purpose of the end plate in a capacitor-start motor?

   a. to keep stator from collapsing
   b. to hold the rotor in center of the stator
   c. to hold the capacitor
   d. to hold the winding in place

7. What is the purpose of bearing packing in a capacitor-start motor?

   a. house the bearing
   b. to hold oil for bearing lubrication
   c. to hold the bearing in place
   d. so that the rotor will be held in the center of the stator

8. In a capacitor-start motor the capacitor is in parallel with the:

   a. start winding
   b. centrifugal switch
   c. bearings
   d. run winding

9. Normally, where is the capacitor located on a capacitor-start motor?

   a. inside the rear end plate
   b. in the rotor
   c. on top of the stator
   d. inside the stator

10. Where is the oil wick located in a capacitor-start motor?

   a. between the rotor and centrifugal switch
   b. split-phase capacitor-start motor does not require one
   c. between bearing and shaft
   d. inside the endplate and bearings

78.01.04.03

11. What will the ohmmeter show if the capacitor is shorted?

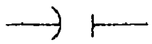
   a. + lead on + terminal: - lead on - terminal om-high reverse
   b. the ohmmeter will show infinity reading
   c the ohmmeter will give a different reading
   d. the ohmmeter will show zero OHMS

78.01.04.03 (continued)

12. If you receive an electrical shock from a capacitor-start motor when you put your hand on it, the trouble may be:

    a. grounded winding
    b. badly worn bearings
    c. bad centrifugal switch
    d. defective capacitor

13. What is the schematic symbol for a capacitor?

    a. 
    b. 
    c. 
    d. 

14. If a capacitor-start motor smokes while running, the trouble may be:

    a. wrong connections
    b. grounded winding
    c. defective capacitor
    d. shorted windings

15. How are capacitors rated?

    a. power factor - PF
    b. working volts direct current - WVDC
    c. Farads
    d. horsepower - HP

78.01.04.04

16. How does a capacitor-start motor differ from a split-phase motor?

    a. capacitor is connected in series parallel with start winding
    b. capacitor is added in series with centrifugal switch
    c. capacitor is connected in parallel with the start winding
    d. capacitor is added in parallel with centrifugal switch

17. After a capacitor-start motor has been rewound and it has poor starting torque, the trouble may be:

    a. open fuse
    b. wrong connections
    c. over loaded
    d. open overload device

78.01.04.04 (continued)

18. In a capacitor-start motor, a winding is said to be shorted when there is:

    a. normal resistance in the coil
    b. high resistance in the coil
    c. no resistance is in the coil
    d. minimum current

19. After rewinding the start winding of a capacitor-start motor and while test running, smoke appears from the motor, trouble may be due to:

    a. shorted winding
    b. open winding
    c. wrong connections
    d. defective capacitor

20. On testing a capacitor-start motor, you find the shaft free but the motor hums and doesn't run, suspect:

    a. shorted start or run winding
    b. badly worn bearings
    c. open start or run winding
    d. overload

UNIT TEST ANSWER SHEET
UNIT POST TEST: CAPACITOR MOTORS

Occupational Area:
File Code: 78.01.04.00.B2-2
Name:

ANSWERS

01.04.01	1. A	21.	41.
	2. C	22.	42.
	3. C	23.	43.
	4. A	24.	44.
	5. B	25.	45.
01.04.02	6. B	26.	46.
	7. B	27.	47.
	8. D	28.	48.
	9. C	29.	49.
	10. D	30.	50.
01.04.03	11. D	31.	51.
	12. A	32.	52.
	13. B	33.	53.
	14. D	34.	54.
	15. C	35.	55.
01.04.04	16. B	36.	56.
	17. B	37.	57.
	18. C	38.	58.
	19. A	39.	59.
	20. C	40.	60.

Student: ____________ File Code: 78.01.04.00.A1-5

Date: ____________ Date Published: 11/15/74

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Family Pay Number: ____________ Sex: M F (Circle 1)

UNIT PERFORMANCE TEST: CAPACITOR MOTORS

OBJECTIVE 1:

Given a malfunctioning capacitor motor, the student will service and repair the motor so that it functions according to the manufacturer's specifications, following safe practices and procedures.

OBJECTIVE 2:

Using appropriate tools and test equipment the student will take shorts and open tests.

OBJECTIVE 3:

Using appropriate equipment, the student will rewind a faulty capacitor motor.

OBJECTIVE 4:

Using appropriate tools and test equipment, the student will calculate and record amperage, voltage, resistance and wattage of a capacitor motor.

TASK:

The student will service and repair a capacitor motor and, in the process, he will make shorts and open and grounding tests, using appropriate test equipment.

ASSIGNMENT:

CONDITIONS:

The student will be given a malfunctioning capacitor motor (it may be bugged by the instructor or it may be one brought in by a customer). He will be required to service and repair the motor in conditions similar to those in a typical motor repair shop. He will be allowed to use any and all tools, equipment, service manuals, text books, etc., commonly found in a repair shop. He must complete it in a reasonable length of time with no assistance from the instructor(s) or students.

RESOURCES:

Tools:
- Internal-external snap ring pliers
- 7-Piece nut dri[illegible]
- Tool box 18 x 8 [illegible]
- Circular gauge
- Hacksaws
- Pulley puller
- Arc joint pliers
- Lineman's pliers
- Diagonal cutting pliers
- Long chain-nose pliers
- Locking plier wrench
- Coil tamping pliers
- 4-piece standard set screwdrivers
- Center punch
- Cold chisel
- Ball peen hammer
- Lug crimpers
- Wire skinner and straightener

Equipment:
- Coil stripping chisel
- Armature winder
- Coil winder
- External gr[illegible]
- Insulation former
- Coil shapers

Mountain-Plains Education & Economic Development Program, Inc.
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Student: ________ File Code: 78.01.04.00.A1-5

Date: ________ Date Published: 11/15/74

Family Pay Number: ________ Sex: M F (Circle 1)

PERFORMANCE CHECKLIST:

OVERALL PERFORMANCE: Satisfactory ______ Unsatisfactory ______

	CRITERION Met	Not Met
Objective 1:		
1. Follows safe practices and procedures.		
Criterion: No injury results to the student or the equipment		
and complies with OSHA requirements.		
2. Follows proper procedures for disassembly.		
Criterion: No damage results to the motor.		
3. Diagnosis and troubleshoots malfunctions properly.		
Criterion: When repaired, the motor functions according		
to the manufacturer's specifications.		
4. Reassembles the motor properly.		
Criterion: Appliance functions according to the		
manufacturer's specifications and the		
procedures followed agree with those		
described in the service literature.		
5. The repaired motor is repaired in a neat,		

	CRITERION Met	Not Met
professional manner.		
Criterion: No damage results to the motor such as opens		
and shorts.		
6. All connections and fastenings are properly completed.		
Criterion: The motor connection complies with the		
manufacturer's specifications. The connections		
are mechanically fastened and structurally		
sound. The connection is electrically fastened		
and free of defects.		
7. Motor functions according to the manufacturer's		
specifications.		
Criterion: Manufacturer's specifications.		
8. Uses appropriate repair part and supplies.		
Criterion: They match exactly those listed in the		
manufacturer's specifications.		
Objective 2·		
9. Test for grounds, using growler of millivolt meter.		
10. Test for shorts in the field coils, using a growler.		
11. Test for an open field coil, using an ohmmeter		
12. Test for reversed coils, using a compass or bar		

	CRITERION Met	CRITERION Not Met
magnet test.		
13. Use capacitor checker to check for opened or shorted		
capacitor.		
Criterion: Troubleshooting techniques reveal the malfunction,		
as identified by job sheet.		
Objective 3:		
14. Uses coil-stripping tool to remove coils.		
15. Uses coil winder, if appropriate, when winding		
field coil.		
16. Uses insulation former, if appropriate, when		
insulating.		
17. Uses coil shaper, if appropriate, on the field coils.		
Criterion: Proper equipment application results in a		
defect-free operative motor.		
Objective 4:		
18. Uses test equipment properly.		
19. Wattage readings are accurate.		
20. Voltage readings are accurate.		
21. Amperage readings are accurate.		
22. Resistance readings are accurate.		

	CRITERION Met	Not Met
Criterion: Manufacturer's specifications.		
23. When applicable, mathematical calculations are correct.		
Criterion: AC/DC Circuit Manuals, Westinghouse.		
24. The motor is repaired in a reasonable time.		
Criterion: Not to exceed 4 hours.		
The student must successfully complete 21 out of 24 line items		
correctly to achieve an overall score of satisfactory.		

File Code: 78.01.05.00.A2-1

Date Published: 2-23-76

Mountain-Plains Education & Economic Development Program, Inc.
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Learning Experience Guide

UNIT: REPULSION MOTORS

RATIONALE:

An understanding of theory and applications related to repulsion motors is necessary for an electric motor repairman because they are widely used in industrial and commercial applications.

PREREQUISITES:

Unit: Capacitor Motors

OBJECTIVE:

Troubleshoot, and repair repulsion motors using appropriate tools, equipment and procedures. Identify parts, operational characteristics and procedures for troubleshooting and repair of repulsion motors.

RESOURCES:

Electric Motor Repair, 2nd Ed.; Robert Rosenberg, Holt, Rinehart, and Winston, 1970.
Introduction to Power Technology Principles of Electric Motors, 2nd Ed., Vega Enterprises Inc., Decatur, Illinois, 1973.

GENERAL INSTRUCTIONS:

This unit consists of 4 Learning Activity Packages (LAPs). Each LAP will provide specific information for completion of a learning activity.

The general procedure for this unit is as follows:

(1) Read the first assigned Learning Activity Package (LAP).
(2) Begin and complete the first assigned LAP.
(3) Take and score the LAP test.
(4) Turn in the LAP test answer sheet.
(5) Determine the reason for any missed items on the LAP test.
(6) Proceed to and complete the next assigned LAP in the unit.
(7) Complete all required LAPs for the unit by following steps 3 through 6.
(8) Take the unit tests as described in the Unit LEG "Evaluation Procedures".
(9) Proceed to the next assigned unit.

Principal Author(s): T. Ziller

Resource List:

Printed Material

1. Electric Motors, second edition, Anderson, Theodore, Audel and Company, 1971.

2. Introduction to Power Technology: Principles of Electric Motors, second edition, Vega Enterprises Inc., Decator, Illinois, 1973.

A set of manufacturer's motor specifications and data sheets.
Service manuals.
Checklist attached to LAPs:
Checklist for Disassembly: Repulsion Motors
Checklist for Troubleshooting: Repulsion Motors
Checklist for Repair Service and Assembly: Repulsion Motors

Ausio/Visual

Illustration attached to LAP: (1) Repulsion - type Motors (2) Exploded view of Repulsion Armature.

Equipment

Repulsion motor
motor to test analyzer
tools

PERFORMANCE ACTIVITIES:

.01 Operation of the Repulsion Motor.
.02 Repulsion Motor Construction.
.03 Troubleshooting Repulsion Motors.
.04 Repairing Repulsion Motors.

EVALUATION PROCEDURE:

When pretesting:

1. The student takes the unit multiple-choice pretest. Successful completion is 4 out 5 items for each LAP part of the pretest.
2. The student then takes a unit performance test if the unit pretest was successfully completed. Satisfactory completion of the performance test is meeting the criteria listed on the performance test.

When post testing:

The student takes a multiple-choice unit post test and a unit performance test. Successful unit completion is meeting the listed criteria for the performance test.

FOLLOW-THROUGH:

You are now ready to begin the first LAP in this unit. Your instructor will be available to assist you when needed.

Student: ____________________ File Code: 78.01.05.00.A2-2

Date: ____________________ Date Published: 12-13-74

Mountain-Plains Education & Economic Development Program, Inc.
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UNIT PRETEST: REPULSION MOTORS

78.01.05.01

1. How are repulsion-type motors classified by the NEMA?

   a. as single-phase motors
   b. as single-phase wound-rotor motors
   c. as single-phase repulsion-type motors
   d. as split-phase repulsion motors

2. On a repulsion motor, how can the speed be decreased?

   a. only by changing the brushes
   b. only by changing the winding in the armature
   c. only by changing the commutator
   d. by moving the brush holder further away from neutral

3. Which of the types of repulsion motors has either a constant speed or varying speed characteristic?

   a. repulsion motor
   b. repulsion-induction motor
   c. universal motor
   d. repulsion-start motor

4. The one advantage of a repulsion-induction motor is:

   a. no commutator
   b. no centrifugal switch mechanism used
   c. that it can be called an inductive series motor
   d. no compensating winding

5. Which of the types of repulsion motors has a varying speed characteristic?

   a. universal motor
   b. repulsion-induction motor
   c. repulsion-start induction motor
   d. repulsion motor

78.01.05.02

6. What four items are on the shaft of a repulsion induction motor?

   a. windings, commutator, endplay spacer and brushes
   b. laminated core, winding, commutator and brushes
   c. fan, laminated core, winding, and commutator
   d. brushes, commutator, rotor coils, and sleeve bearings

7. On repulsion-type motors, at approximately what speed do the governor weights move?

   a. 3650 RPM
   b. 50%
   c. 1875 RPM
   d. 75%

8. The centrifugal mechanism of repulsion-type motors comes out of several parts that are located in:

   a. the end bell
   b. on the stator
   c. the armature
   d. the stator

9. What is the purpose of the stator of a repulsion-type motor?

   a. to hold the core
   b. to hold the brushes
   c. to hold the armature winding
   d. to hold the laminated core and field winding

10. Why is it necessary to record data on repulsion-start induction motors?

   a. it is added paper work to increase the price to the consumer
   b. it is not required
   c. it is just something we do in school
   d. it is so it can be reassembled the same as it came apart

78.01.05.03

11. How is the neutral point located if it is not marked on the case of repulsion-start induction motors?

   a. motor will run in counterclockwise direction only
   b. motor will run in clockwise direction only
   c. motor will not run in either direction
   d. motor will over speed

78.01.05.03 (continued)

12. How many neutral points are there in a repulsion-start motor?

  a. 4
  b. 2
  c. 1
  d. 3

13. If the brushes are shifted in a counterclockwise direction on a repulsion-type motor, the armature will rotate in a:

  a. counterclockwise direction
  b. clockwise direction
  c. no change
  d. the motor will stop

14. In repulsion type motors if the brushes are moved clockwise, the armature will rotate in a :

  a. the motor will stop
  b. counterclockwise direction
  c. the direction will not be changed
  d. clockwise direction

15. To reverse a repulsion-type motor that has two off-center brush holders which are individually moved:

  a. move either holder 90 mechanical degrees
  b. each brush holder is moved 180 electrical degrees
  c. move either holder 90 electrical degrees
  d. each brush holder is moved 180 mechanical degrees

78.01.05.04

16. How is the stator tested for a short?

  a. by using a growler
  b. by feeling for hottest coil
  c. by using a test light
  d. by using a millivoltmeter

17. If the repulsion motor fails to start when the switch is closed, the trouble may be:

  a. overload
  b. wrong brush holder position
  c. grounded field
  d. improper tension in the spring

78.01.05.04 (continued)

18. If the repulsion motor does not come up to speed, the trouble may be:

    a. incorrect brushes setting
    b. brushes not contacting commutator
    c. grounded armature
    d. dirty or burnt necklace

19. If the repulsion motor sparks internally, the trouble may be:

    a. wrong bad connection
    b. dirty necklace
    c. shorted armature
    d. high mica

20. Open armature coils will cause the repulsion motor to:

    a. burn out fuses
    b. spark internally
    c. hum but not run
    d. become excessively hot

UNIT TEST ANSWER SHEET

Occupational Area: UNIT PRETEST REPULSION MOTORS

File Code: 78.01.05.00.A2-2

Name: ______

ANSWERS

1.05.01	1. B ____	21. ____	41. ____
	2. D ____	22. ____	42. ____
	3. B ____	23. ____	43. ____
	4. B ____	24. ____	44. ____
	5. D ____	25. ____	45. ____
1.05.02	6. C ____	26. ____	46. ____
	7. D ____	27. ____	47. ____
	8. C ____	28. ____	48. ____
	9. D ____	29. ____	49. ____
	10. D ____	30. ____	50. ____
1.05.03	11. C ____	31. ____	51. ____
	12. B ____	32. ____	52. ____
	13. A ____	33. ____	53. ____
	14. D ____	34. ____	54. ____
	15. D ____	35. ____	55. ____
1.05.04	16. B ____	36. ____	56. ____
	17. B ____	37. ____	57. ____
	18. D ____	38. ____	58. ____
	19. D ____	39. ____	59. ____
	20. B ____	40. ____	60. ____

File Code: 78.01.05.01.A2-0

Date Published: 2-23-76

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Learning Activity Package

Student: ____________________

Date: ____________________

PERFORMANCE ACTIVITY: Operation of the Repulsion Motor

OBJECTIVE:

Describe the operation of a repulsion motor. Identify operational characteristics of a repulsion type motor.

EVALUATION PROCEDURE:

Successfully complete at least 80% of the items on a multiple-choice test about this LAP.

RESOURCES:

Electric Motor Repair, Robert Rosenburg, pages 81-84, 94-96.
Repulsion motor.
Introduction to Power Technology Principles of Electric Motors, Vega, pages 32-35.

motor test analyzer

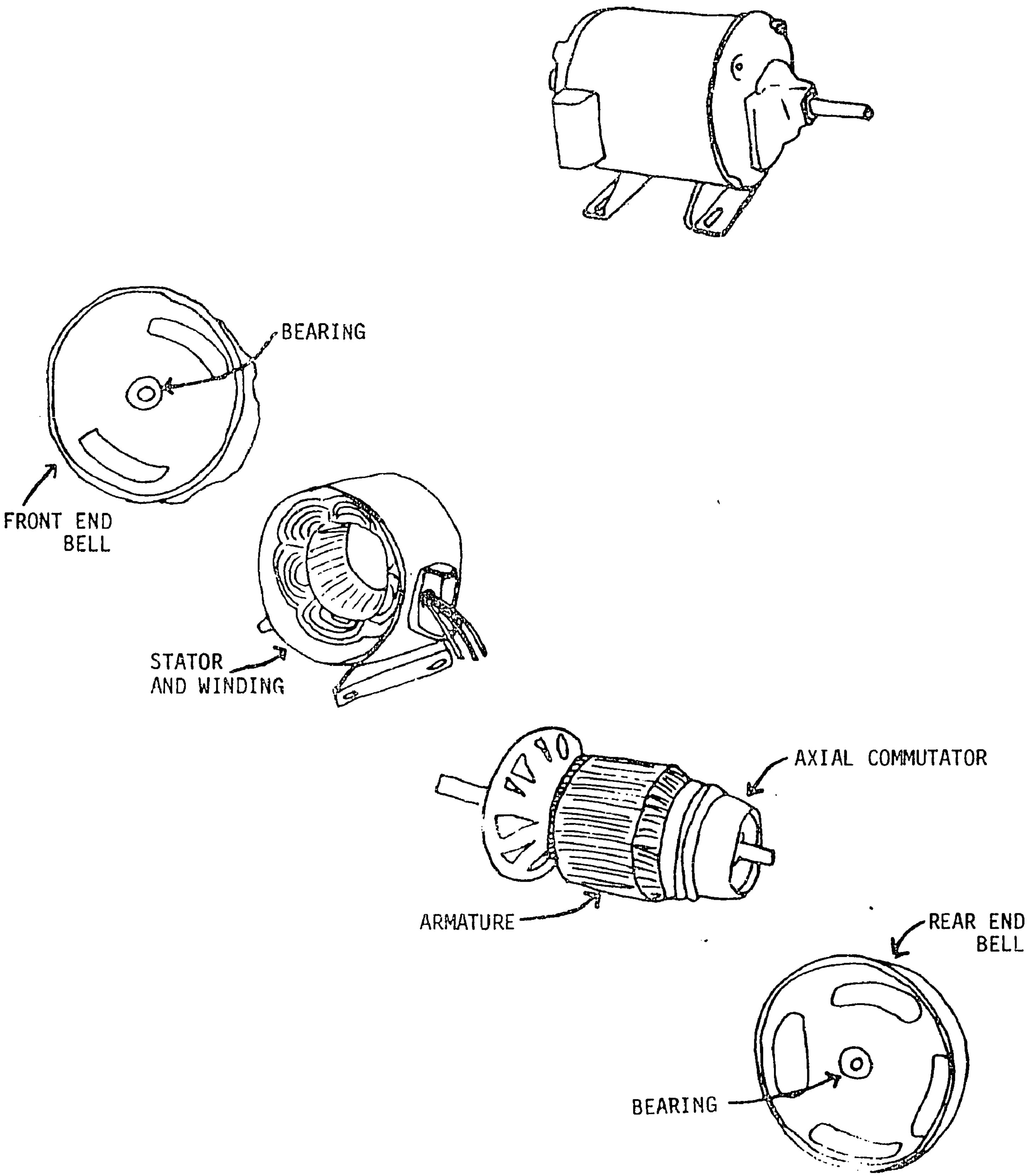
PROCEDURE:

Steps

1. Read pages 81-84, 94-96 in Electric Motor Repair, by Robert Rosenburg.
2. Complete experiment #4, "Repulsion Induction Motors", in Introduction to Power Technology, pages 32-35.
3. Write a description of the motor's operation using simple electrical schematics.
4. Take the LAP test.

Principal Author(s): T. Ziller

REPULSION-TYPE MOTOR



FOR OPERATION:

~~OPERATIONAL~~ CHECK LIST A REPULSION ~~TYPE~~ MOTORS

1.______ Connect motor to power source and observe.

2.______ Stator usually has one (1) winding similar to the running winding of a capacitor motor.

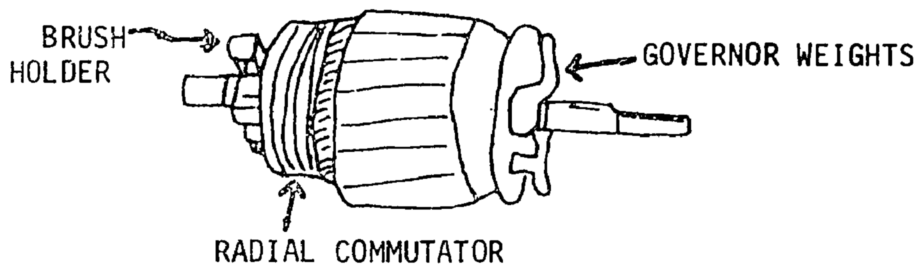
3.______ The armature has winding and is connected to copper bars called a commutator.

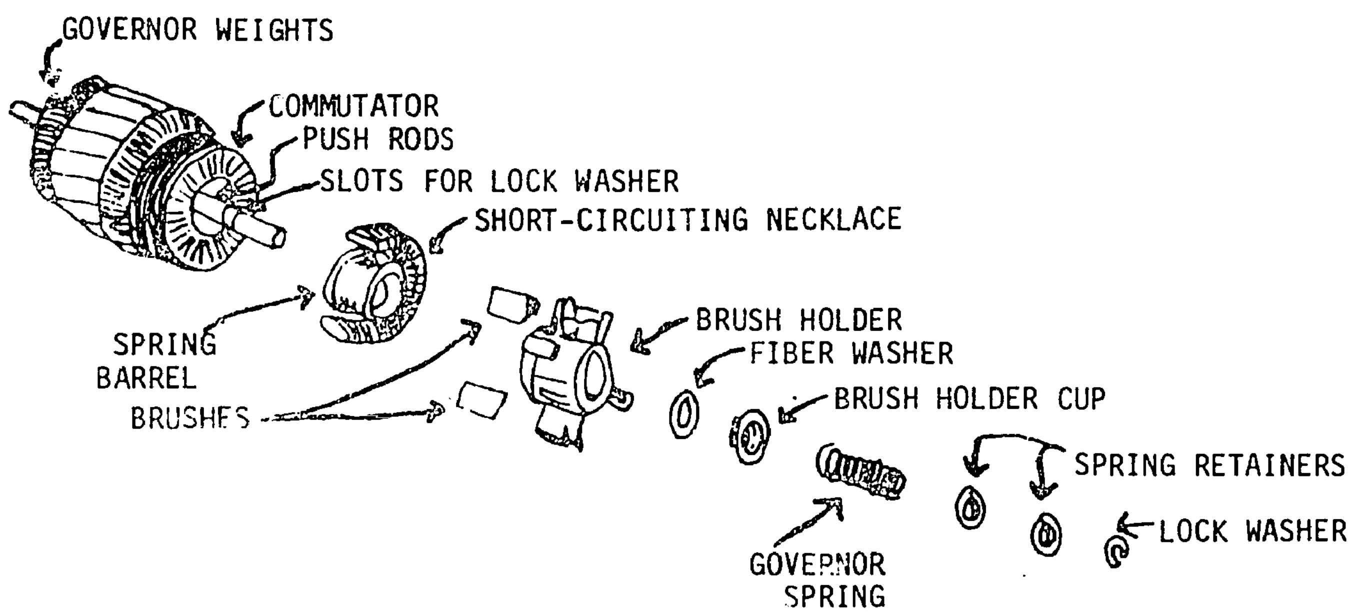
4.______ Two (2) end bells to support the bearings for the shaft of the armature most turn.

5.______ Brushes made of carbon which fit into brush holders that ride against the commutator, used to conduct current through the armature winding.

6.______ Disconnect motor from power source.

EXPLODED VIEW OF REPULSION ARMATURE





Student: ______________________ File Code: 78.01.05.01.A2-2

Date: ______________________ Date Published: 12-23-74

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LAP TEST: OPERATION OF THE REPULSION MOTOR

78.01.05.01

1. A test for telling the difference between a repulsion and repulsion induction motor is to connect to line voltage, reach full speed, and raise brushes - if speed drops, it is a:

   a. universal motor
   b. repulsion-start induction motor
   c. repulsion induction motor
   d. repulsion motor

2. Of the three types of repulsion motors, which has the higher starting torque?

   a. repulsion-start induction motor
   b. universal motor
   c. repulsion motor
   d. repulsion induction motor

3. On a repulsion-start induction motor using an axial commutator, the brushes:

   a. ride
   b. remain the same
   c. lift
   d. can do both ride and lift

4. There are two types of repulsion-start induction motors, and they are:

   a. centrifugal devices and commutator
   b. brush riding and commutator
   c. brush-lifting and brush-riding
   d. brush-lifting and centrifugal device

5. On a repulsion-start induction motor, what determines the number of brushes that ride on the commutator?

   a. the manufacturer
   b. the number of poles
   c. how they are connected to the stator
   d. how they are connected to the voltage

78.01.05.01 (continued)

6. How are repulsion-type motors classified by the NEMA?

    a. single phase wound rotor motors
    b. split-phase repulsion motors
    c. single phase motors
    d. single phase repulsion-type motors

7. One feature common in all tyes of repulsion motors is that:

    a. each has slip rings
    b. each has a centrifugal switch
    c. each uses a capacitor
    d. each has a rotor containing a winding connected to a commutator

8. Which of the types of repulsion motors has the constant speed characteristics?

    a. repulsion-induction motor
    b. repulsion-start induction motor
    c. repulsion motor
    d. universal motor

9. Which repulsion-type motor starts on a repulsion motor but operates as an induction motor?

    a. repulsion induction motor
    b. repulsion-start induction motor
    c. universal motor
    d. repulsion motor

10. Which of the types of repulsion motors has a varying speed characteristic?

    a. universal motor
    b. repulsion-start induction motor
    c. repulsion-induction motor
    d. repulsion motor

LAP TEST ANSWER KEY: 78.01.05.01.A2-2

OPERATION OF THE REPULSION MOTOR

1. D
2. A
3. A
4. C
5. B
6. A
7. D
8. B
9. B
10. D

File Code: 78.01.05.02.A2-0

Date Published: 2-23-76

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Learning Activity Package

Student: ____________

Date: ____________

PERFORMANCE ACTIVITY: Repulsion Motor Construction

OBJECTIVE:

Disassemble a repulsion motor following the recommended steps for disassembly as given in the attached checklist. Also, identify the main parts of a repulsion motor by labeling each component.

EVALUATION PROCEDURE:

Instructor will examine the disassembled motor for correct disassembly in accordance with the attached checklist. Also score at least 80% on a multiple-choice test.

RESOURCES:

Checklist for disassembly: Repulsion Motor.
Electric Motor Repair, Robert Rosenburg, pages 80-81.
Illustration of a repulsion motor.
Service Manuals.
Tools and repulsion motor.

PROCEDURE:

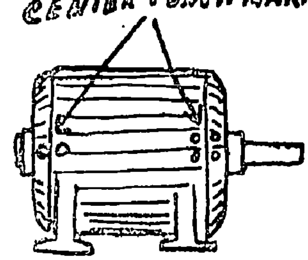
Steps

1. Follow the checklist for disassembly of the motor. (Attached)
2. Complete the multiple-choice test items for this LAP.

Principal Author(s): T. Ziller

CHECKLIST FOR DISASSEMBLY: REPULSION MOTORS

_______ 1. Put punch marks on end bell and stator (same as split phase motors), 1 mark on rear end bell and stator; 2 marks on front bell and stator.



_______ 2. Using proper tools, remove the four (4) housing bolts.

_______ 3. Remove end bells from the stator and gently remove armature.

Disassembly of armature for repulsion type motors.

Caution: DO NOT LOSE THE PARTS.

_______ 1. Pushing on the spring retainers, remove snap ring (lock washer).

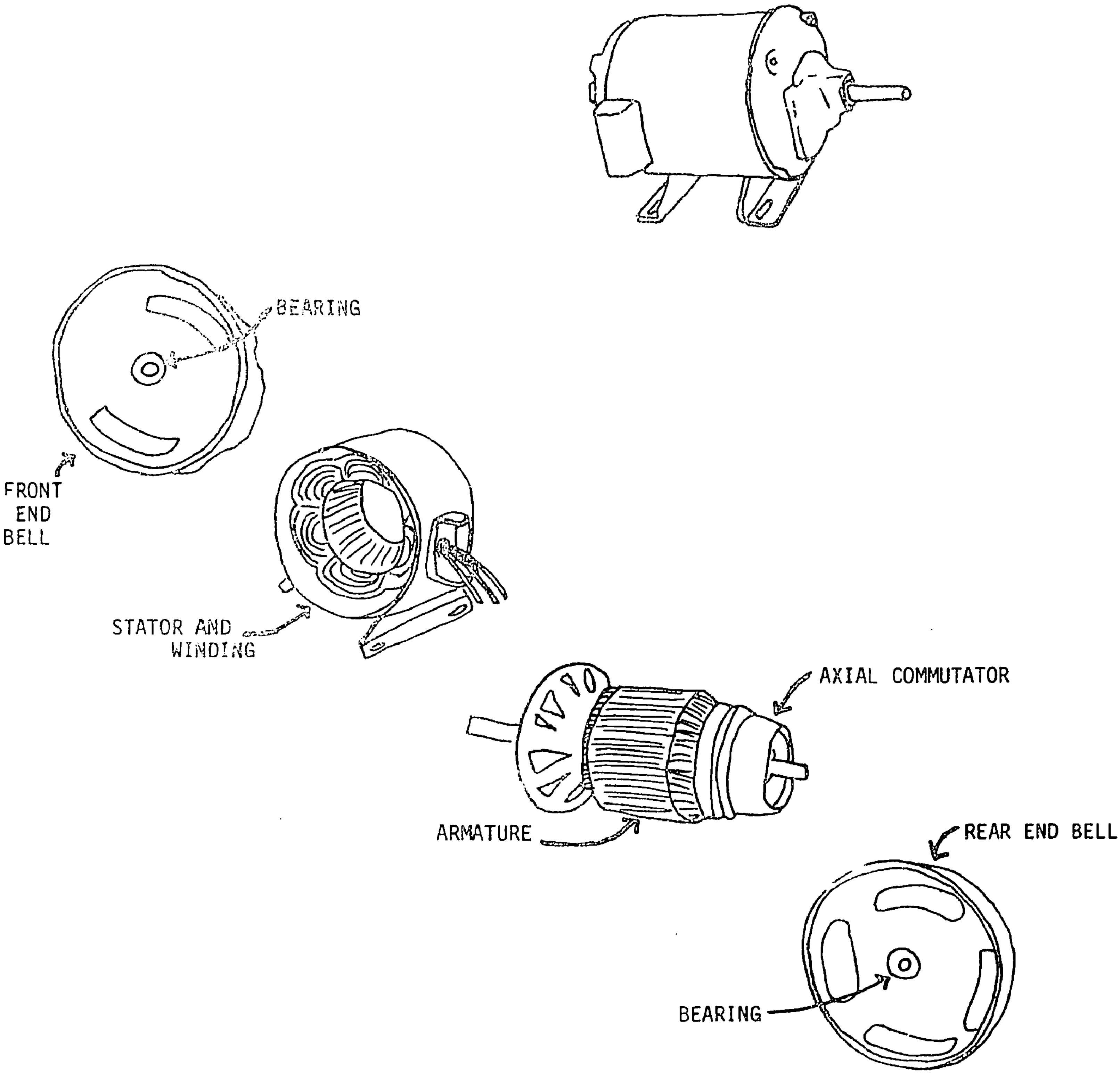
_______ 2. Slowly release the pressure on spring retainers.

_______ 3. Remove from the shaft the spring retainers, governor spring, brush holder cap, fiber washer, and brush holder.

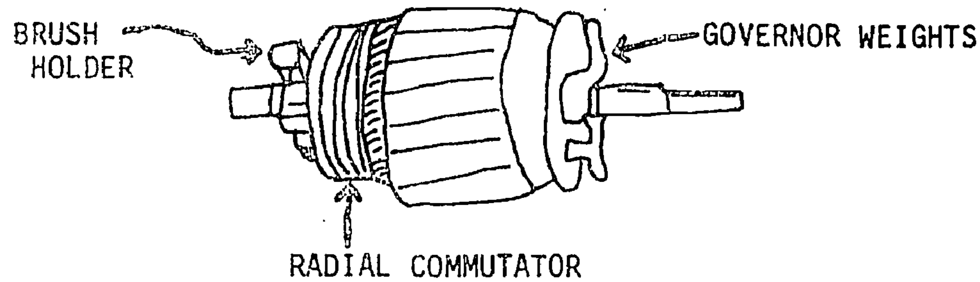
_______ 4. Stand armature on commutator and gently thump the shaft on a wood surface; the short circuiting necklace, spring barrel and push rods should slip out.

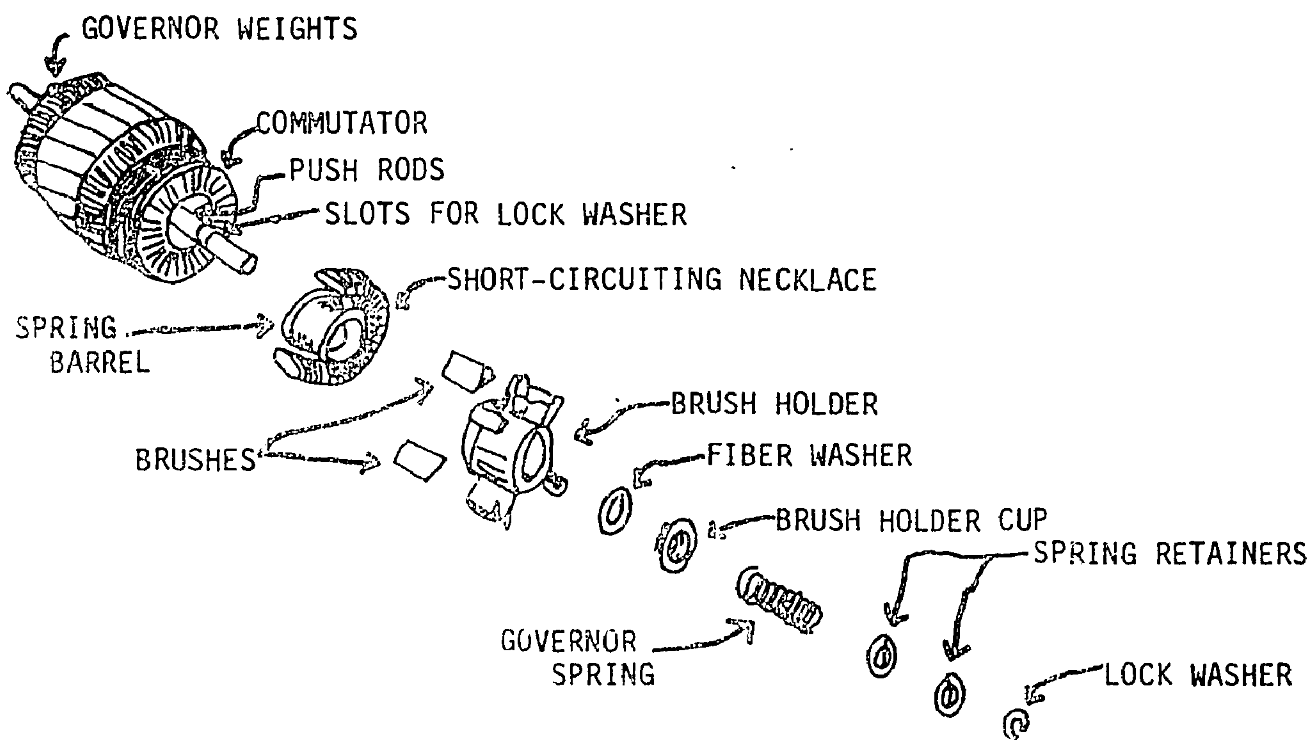
_______ 5. Identify each component of the motor by labeling with masking tape.

REPULSION-TYPE MOTOR



EXPLODED VIEW OF REPULSION ARMATURE





Student: ______________________ File Code: 78.01.05.02.A2-2

Date: ______________________ Date Published: 12-23-74

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

LAP TEST: REPULSION MOTOR CONSTRUCTION

78.01.05.02

1. The centrifugal mechanism of repulsion-type motors comes out of several parts that are located in:

   a. the end bell
   b. on the stator
   c. the stator
   d. the armature

2. What is the purpose of end bells on a repulsion motor?

   a. to house the bearings
   b. to house the bearing and center the rotor in the stator
   c. to keep dirt out of the stator
   d. to keep the rotor in the center of the stator

3. What four items are on the shaft of a repulsion-induction motor?

   a. fan, laminated core, winding, and commutator
   b. windings, commutator, endplay spacer and brushes
   c. brushes, commutator, rotor coils, and sleeve bearings
   d. laminated core, winding, commutator, and brushes

4. Before you start to disassemble a repulsion-type motor, how should it be marked?

   a. with a piece of chalk, draw a line around the motor
   b. not necessary, just remember the way you disassembled it
   c. with center punch, one mark on stator and end bell
   d. one mark on both end bells and stator

5. On repulsion-type motors, what is the purpose of the governor weights?

   a. to push the brushes away from the commutator
   b. to control the speed of the rotor
   c. to move only the push rods
   d. to cause the short circuiting necklace to short out the commutator

78.01.05.02 (continued)

6. What should be done while disassembling a repulsion-type motor?

   a. you should read all the information in the book
   b. you should fill out a data card
   c. you should ask your instructor
   d. you should mark the end bells

7. On a repulsion-induction motor, the copper bar parallel to the shaft is called the:

   a. axial commutator
   b. radial commutator
   c. commutator threads
   d. spring barrel commutator

8. What is the purpose of short circuiting necklace in repulsion-type motors?

   a. to move the governor weights
   b to hold the push rods in center position
   c. to short out the commutator windings
   d. to hold the spring barrel

9. What is the purpose of the stator of a repulsion-type motor?

   a. to hold the core
   b. to hold the armature winding
   c. to hold the brushes
   d. to hold the laminated core and field winding

10. On repulsion-type motors at approximately what speed do the governor weights move?

   a. 3650 RPM
   b. 50%
   c. 75%
   d. 1875 RPM

LAP TEST ANSWER KEY: 78.01.05.02.A2-2

REPULSION MOTOR CONSTRUCTION

1. D
2. B
3. A
4. C
5. D
6. B
7. A
8. C
9. D
10. C

File Code: 78.01.05.03.A2-0

Date Published: 2-23-76

Mountain-Plains Education &
Economic Development
Program, Inc.
Glasgow AFB, Montana 59231

Learning Activity Package

Student: ______________________

Date: ______________________

PERFORMANCE ACTIVITY: Troubleshooting Repulsion Motors

OBJECTIVE:

Troubleshoot a repulsion motor following the steps for troubleshooting as given in the attached checklist.

EVALUATION PROCEDURE:

Correctly troubleshoot a repulsion motor using a checklist. Also score at least 80% on a written multiple-choice test.

RESOURCES:

Checklist for troubleshooting a motor.
Electric Motor Repair, Robert Rosenburg, pages 97-105.
Repulsion motor.
Service Manuals.
Test equipment, tools.

PROCEDURE:

Steps

1. Follow the checklist for troubleshooting a motor. (Attached)
2. Complete the multiple-choice test items for this LAP.

Principal Author(s): T. Ziller

CHECKLIST FOR TROUBLESHOOTING: REPULSION MOTORS

1. If motor fails to start when the switch is closed, the trouble could be:

   a. burned out fuse.
   b. worn bearings.
   c. sticking brushes in holder.
   d. badly worn brushes.
   e. opens in stator or armature.
   f. wrong brush holder position.
   g. shorted armature.
   h. dirty commutator.
   i. wrong lead position.
   j. necklace shorting armature.

2. If motor does not start properly, the trouble may be:

   a. worn bearings.
   b. dirty necklace or diry commutator.
   c. brushes moving from commutator too soon, or brush spring tension too weak.
   d. centrifugal mechanism not assembled properly.
   e. brush holder set in wrong position.
   f. short-circuited mechanism worn, broken or improperly assembled.
   g. governor weights jammed.
   h. improper tension in the spring.
   i. shorted armature.
   j. excessive end play.
   k. overload.
   l. shorted stator.
   m. worn lip on brush holder.

3. If motor becomes excessively hot, the trouble may be:

   a. motor connected for 115 volt operation but being run on 230 volt.
   b. shorted armature or stator.
   c. overload.
   d. worn bearings.
   e. broken or bent necklace.
   f. brush holder out of position.

4. If motor is noisy:

   a. worn bearings or shaft.
   b. lose centrifugal device.
   c. shorted stator coil.
   d. excessive end play.
   e. dirty short-circuiting device.

5. If motor burns out fuse:

   a. grounded field.
   b. incorrect connections.
   c. brushes not making contact with commutator.
   d. shorted armature.
   e. incorrect setting of brushes.
   f. frozen bearings.

6. If motor hums but does not run:

   a. wrong lead connections.
   b. worn bearings.
   c. incorrect brush setting.
   d. shorted armature or shorted stator.
   e. grounded stator.
   f. brushes sticking or not making contact.
   g. dirty commutator.

7. If motor does not come up to full speed:

   a. wrong spring tension on brushes.
   b. dirty or burned necklace.
   c. dirty commutator.
   d. shorted armature or shorted stator coil.
   e. worn bearings.
   f. push rods too long.

8. If motor sparks internally:

   a. open armature coils.
   b. dirty commutator.
   c. high mica.
   d. short or sticking brushes.

9. Take a resistance reading on the motor field windings.
   Take a resistance reading on the armature coils. (Record values).

10. Plug the motor into 115V AC power source.

11. Take a voltage reading on the motor terminals. (Record value). Compare with manufacturer's name plate.

12. Using an ammeter take a current reading on the motor. (Record value). Compare with manufacturer's name plate.

13. Disconnect from AC power.

14. Connect fields to a low D.C. voltage.

15. Use a compass and check for polarity.

Student: ____________________ File Code: 78.01.05.03.A2-2

Date: ____________________ Date Published: 12-23-74

Mountain-Plains Education & Economic Development Program, Inc.
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LAP TEST: TROUBLESHOOTING REPULSION MOTORS

78.01.05.03

1. If the repulsion motor does not start properly, the trouble may be:

   a. the push rod is too long
   b. an open circuit in the stator
   c. brushes moving from commutator too soon
   d. wrong, bad connections

2. If the repulsion motor keeps burning out fuses, the trouble may be:

   a. a worn brush holder
   b. a shorted field
   c. a shorted armature
   d. worn bearings

3. If the repulsion motor becomes excessively hot, the trouble may be:

   a. a dirty short-circuiting device
   b. worn brushes
   c. a grounded running winding
   d. a broken or burnt necklace

4. A millivoltmeter is used to test armature for:

   a. opens
   b. reverses
   c. gro[illegible]
   d. shorts

5. A growler is used to test the:

   a. stator for shorts
   b. armature for opens
   c. stator for grounds
   d. armature for shorts

78.01.05.03 (continued)

6. What is used in testing for grounds?

   a. voltmeter
   b. a DC battery and compass
   c. an internal growler
   d. a test lamp

7. How is the stator tested for a short?

   a. with a millivoltmeter
   b. with a test light
   c. by feeling for hottest coil
   d. with a growler

8. If the repulsion motor hums but does not run, the trouble may be a (n):

   a. shorted stator
   b. open armature coil
   c. open in start winding
   d. grounded stator

9. If the repulsion motor fails to start when the switch is closed, the trouble may be:

   a. a wrong brush holder position
   b. an overload
   c. improper tension in the spring
   d. a grounded field

10. If the repulsion motor sparks internally, the trouble may be:

   a. high mica
   b. wrong/bad connection
   c. a shorted armature
   d. a dirty necklace

LAP TEST ANSWER KEY: 78.01.05.03.A2-2

TROUBLESHOOTING REPULSION MOTORS

1. C
2. C
3. D
4. D
5. D
6. D
7. C
8. A
9. [illegible]
10. [illegible]

File Code: 78.01.05.04.A2-0

Date Published: 2-23-76

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Learning Activity Package

Student: ______________________

Date: ______________________

PERFORMANCE ACTIVITY: Repairing Repulsion Motors

OBJECTIVE:

Repair, service and reassemble a repulsion motor following the steps for repair, service and reassembly on a given checklist. Identify procedures for the repair, service and reassembly of repulsion motors.

EVALUATION PROCEDURE:

The motor must operate properly. The student follows a checklist on repair, service and reassembly of the motor. Also score at least 80% on a multiple-choice test.

RESOURCES:

Checklist for repair, service and reassembly: Repulsion motors. (Attached)
Electric Motor Repair, Robert Rosenburg, pages 97-105.
Repulsion motor.
Service Manuals.
Test equipment, tools.

Illustration: Repulsion motors
Test equipment: vom, growler

PROCEDURE.

Steps

1. Follow the checklist for repair, service, and reassembly of a motor. (Attached)
2. Complete the multiple-choice test items for this LAP.

Principal Author(s): T. Miller

CHECKLIST FOR REPAIR, SERVICE AND REASSEMBLY: REPULSION MOTORS

SERVICING REPULSION MOTORS

_____ 1. Check armature commutator for proper brush tension.

_____ 2. Check commutator for smoothness and no build up between bars.

_____ 3. Check for proper brush seating on commutator.

_____ 4. Check for cleanliness and proper movement of short-circuiting device.

_____ 5. Check push rods for freedom of movement and cleanliness.

_____ 6. Check for over all cleanliness inside and out.

_____ 7. Lubricate bearings (30 w. oil).

REPAIR OF REPULSION MOTORS

_____ 1. If bearings are bad, using proper tools replace bearings.

_____ 2. If commutator is grooved, use lathe and cut down, smooth and undercut between bars.

_____ 3. Check brushes for proper wear and length.

_____ 4. Check brush spring tension.

_____ 5. Using proper test equipment, test field coils and armature windings for shorts, opens and grounds.

REASSEMBLY OF REPULSION MOTORS

_____ 1. Refer to the attached exploded view of armature:

a. Insert push rods into holes of armature.
b. Lay necklace around spring barrel and slide over shaft.
c. Slide brush holder over the shaft, insert fiber washer into brush holder, insert brush holder cup, governor spring, spring retainers and snap ring.

_____ 2. Insert proper brushes into brush holder.

_____ 3. Align front end bell with marks.

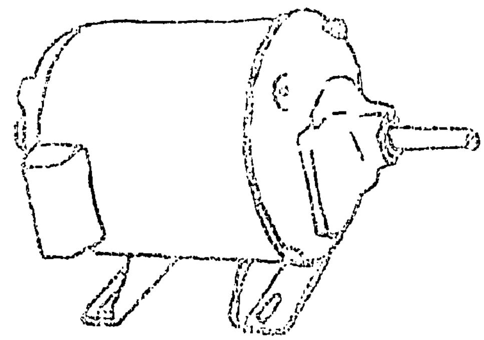
_____ 4. Gently slip armature into stator and front end bell.

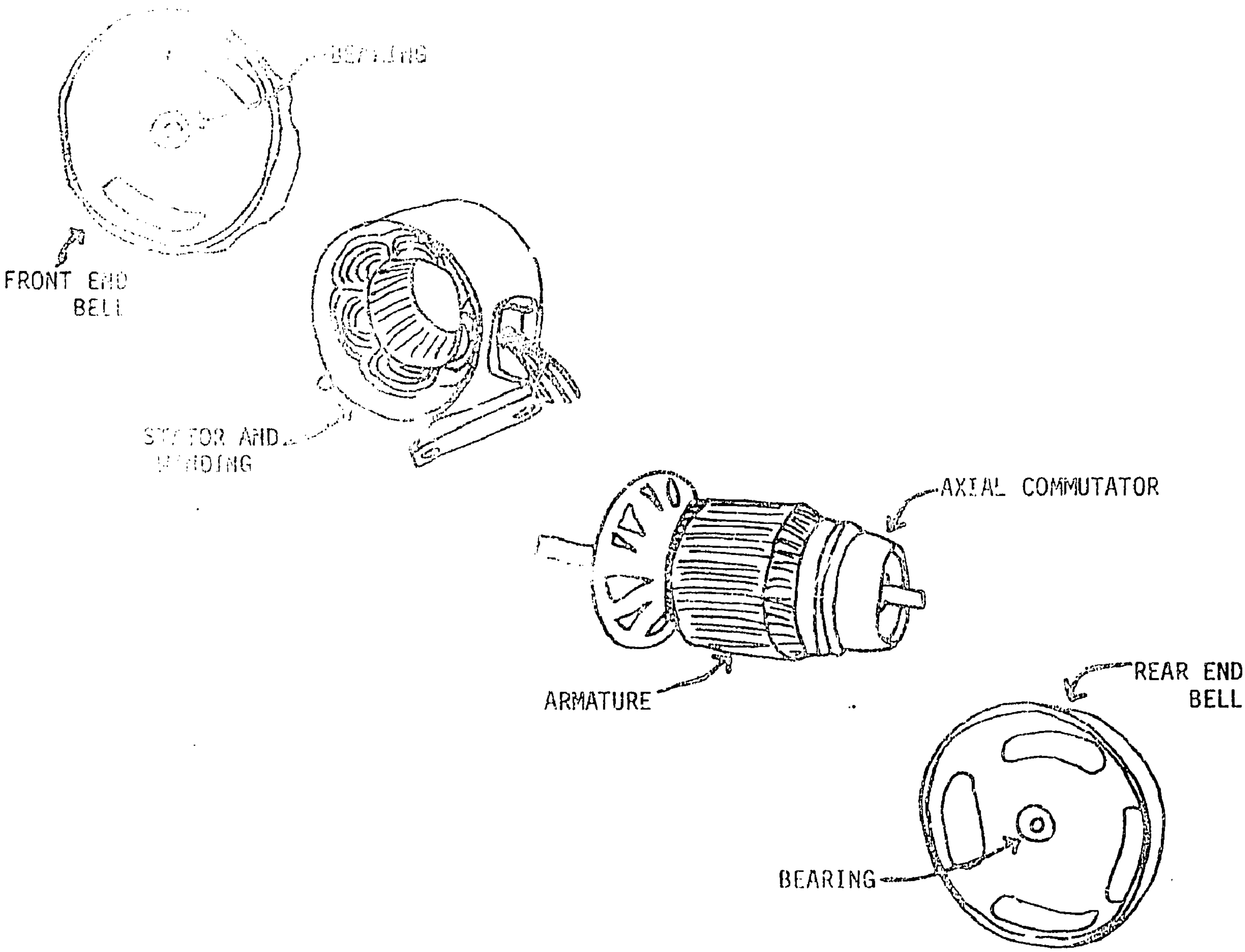
_____ 5. Align rear end bell with marks (bring leads out).

_____ 6. Insert bolts and tighten.

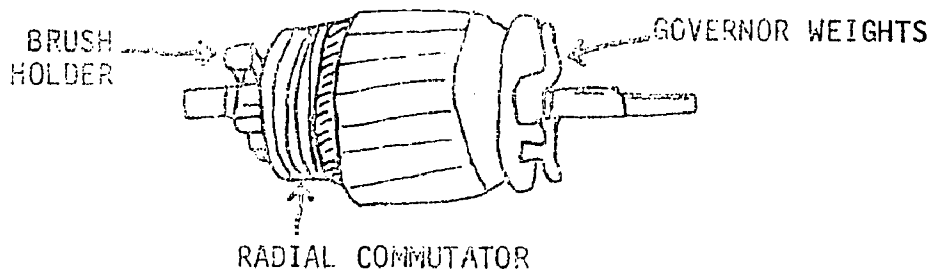
_____ 7. Connect to power source and check operation.

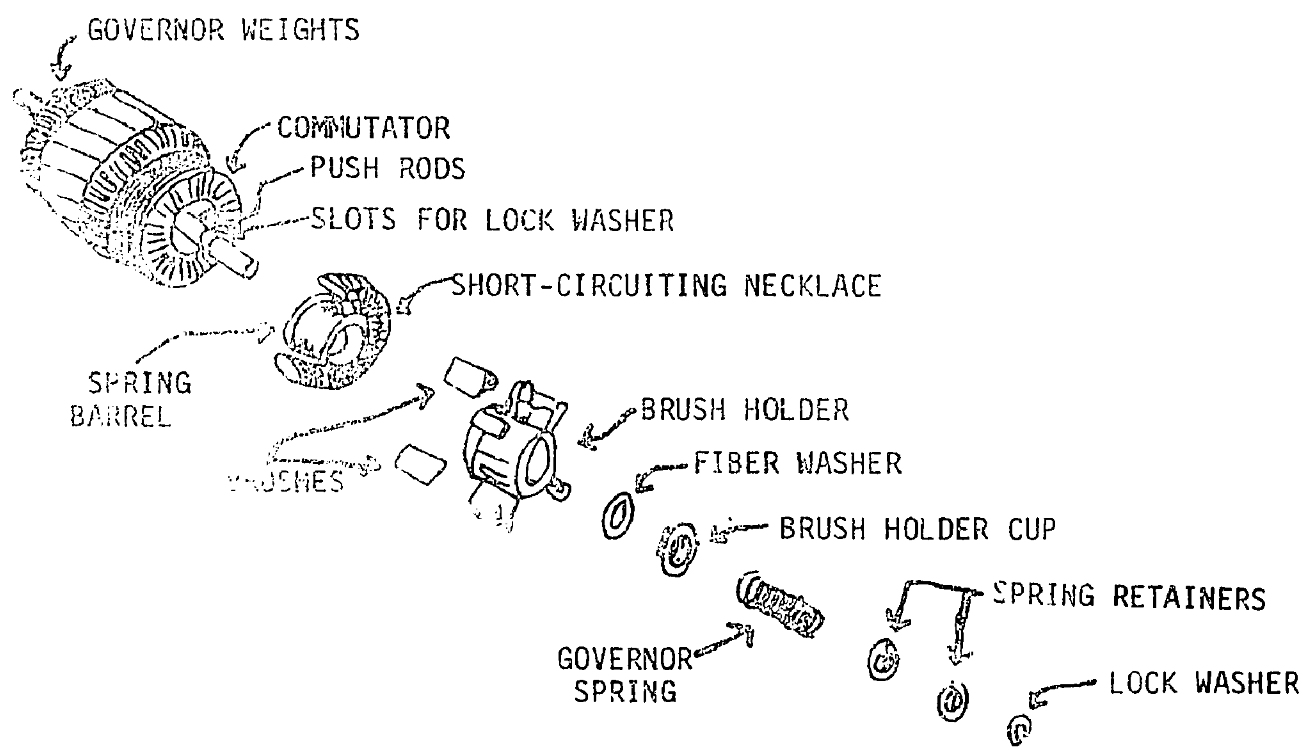
REPULSION MOTORS





EXPLODED VIEW OF REPULSION ARMATURE





Student: ______________________ File Code: 78.01.05.04.A2-2

Date: ______________________ Date Published: 12-23-74

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LAP TEST: REPAIRING REPULSION MOTORS

78.01.05.04

1. How many neutral points are there in a repulsion-start motor?

   a. 2
   b. 3
   c. 1
   d. 4

2. How is the neutral point located if it is not marked on the case of repulsion-start induction motors?

   a. motor will over speed
   b. motor will run in counterclockwise direction only
   c. motor will not run in either direction
   d. motor will run in clockwise direction only

3. What type of material are brushes made of for repulsion-type motors?

   a. carbon or graphite
   b. copper or lead
   c. graphite post
   d. carbon post

4. In repulsion-type motors the stator winding is usually known as the?

   a. equalizer winding
   b. armature or rotor
   c. centrifugal short-circuiting device
   d. inducing winding

5. To reverse a repulsion-type motor that has two off-center brush holders which are individually moved:

   a. each brush holder is moved 180 electrical degrees
   b. each brush holder is moved 180 mechanical degrees
   c. move either holder 90 electrical degrees
   d. move either holder 90 mechanical degrees

78.01.05.04 (continued)

6. On a brush-riding repulsion motor, if the brushes are shifted to the left, the armature will rotate:

   a. varying the speed
   b. clockwise
   c. 90 degrees
   d. counterclockwise

7. In repulsion-type motors if the brushes are moved clockwise, the armature will rotate in a:

   a. clockwise direction
   b. counterclockwise direction
   c. the motor will stop
   d. the direction will not change

8. What is commonly referred to as a "pigtail" on brushes for a repulsion-type motor?

   a. type of connection in stator
   b. type of connection in armature
   c. copper wire on one end of the brush
   d. type of connection in the commutator

9. If the brushes are shifted in a counterclockwise direction on a repulsion-type motor, the armature will rotate in a:

   a. no change
   b. clockwise direction
   c. the motor will stop
   d. counterclockwise direction

10. If a repulsion-start induction motor is set on the soft neutral position, how can this be checked?

    a. with an ohmmeter
    b. with an ammeter
    c. with a voltmeter
    d. by moving brushes so motor will not run, then to the right slightly

LAB TEST ANSWER KEY: 78.01.05.04.A2-7

REPAIRING REPULSION MOTORS

1. [illegible]
2. [illegible]
3. [illegible]
4. [illegible]
5. [illegible]
6. [illegible]
7. [illegible]
8. [illegible]
9. [illegible]
10. [illegible]

Student: ______________________ File Code: 78.01.05.00.B2-2

Date: ______________________ Date Published: 12-17-74

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Glasgow AFB, Montana 59231

UNIT POST TEST: REPULSION MOTORS

78.01.05.01

1. A test for telling the difference between a repulsion and repulsion-induction motor is connect to line voltage, reach full speed, and raise brushes - if speed drops, it is a:

    a. repulsion induction motor
    b. universal motor
    c. repulsion motor
    d. repulsion-start induction motor

2. Of the three types of repulsion motors, which has the higher starting torque?

    a. universal motor
    b. repulsion-start induction motor
    c. repulsion induction motor
    d. repulsion motor

3. What is the purpose of a compensating winding in a repulsion motor?

    a. to raise the power factor and provide better speed regulation
    b. to lower the power factor
    c. to lower the power factor and get more speed
    d. to get more RPM

4. Which of the types of repulsion motors has the constant speed characteristics?

    a. repulsion induction motor
    b. repulsion-start induction motor
    c. universal motor
    d. repulsion motor

5. Which repulsion type motor starts on a repulsion motor but operates as an induction motor?

    a. repulsion-start induction motor
    b. repulsion motor
    c. repulsion induction motor
    d. universal motor

78.01.05.02

6. Before you start to disassemble a repulsion-type motor, how should it be marked?

   a. not necessary, just remember the way you disassembled it
   b. with a piece of chalk, draw a line around the motor
   c. with center punch, 1 mark on starter and end bell
   d. one mark on both end bells and starter

7. On a repulsion start induction run motor, the copper bars that are perpendicular to the shaft are called:

   a. spring barrel commutator
   b. redial commutator
   c. commutator threads
   d. axial commutator

8. On repulsion-type motors, what is the purpose of the governor weights?

   a. to move only the push rods
   b. to control the speed of the rotor
   c. to push the brushes away from the commutator
   d. to cause the short circuiting necklace to short out the commutator

9. What is the purpose of the spring barrel on a repulsion motor?

   a. it helps to remove the governor springs
   b. it moves the governor weights
   c. it has no real purpose
   d. it holds the short-circuiting necklace in place

10. On a repulsion-induction motor, the copper bar parallel to the shaft is called the:

   a. commutator thread
   b. axial commutator
   c. radial commutator
   d. spring barrel commutator

78.01.05.03

11. If a repulsion-start induction motor is set on the soft neutral position, this can be checked by

   a. an ammeter
   b. an ohmmeter
   c. a voltmeter
   d. moving brushes so motor will not run, then to right slightly

78.01.05.03 (continued)

12. What is commonly referred to as a "pigtail" on brushes for a repulsion-type motor?

    a. the type of connection in the commutator
    b. the type of connection in stator
    c. the type of connection in armature
    d. copper wire on one end of the brush

13. On a brush-riding repulsion motor, if the brushes are shifted to the left, the armature will rotate:

    a. counterclockwise
    b. the motor will stop
    c. and will only vary the speed
    d. counterclockwise

14. Repulsion-type motors with stationary brush holders can be reversed:

    a. by rewinding the armature
    b. by reversing end for end the stator
    c. cannot be reversed
    d. by rewinding the stator for opposite polarity

15. On a brush-lifting repulsion motor, the brushes are shifted to the right and the armature will rotate.

    a clockwise
    b. and will only vary the speed
    c. the motor will stop
    d. cou[illegible]wise

78.01.05.04

16. If motor is noisy in operation, it may be caused by:

    a. a shorted armature
    b. frozen bearings
    c worn brushes
    d a shorted stator coil

17. The proper way to repair high MICA is to:

    a. clean commutator with emery cloth
    b. turn down the armature in a lathe and then undercut the MICA
    c. file down the commutator and use a hack saw blade to undercut
    d. replace with new commutator

78.01.05.04 (continued)

18. A growler is used to test the:

    a. armature for opens
    b. stator for grounds
    c. stator for shorts
    d. armature for shorts

19. If the motor keeps burning out fuses, the trouble may be:

    a. a worn brush holder
    b. worn bearings
    c. a shorted armature
    d. a shorted field

20. If the motor becomes excessively hot, the trouble may be:

    a. a broken or burnt necklace
    b. worn brushes
    c. a dirty short-circuiting device
    d. a grounded running windings

UNIT TEST ANSWER SHEET
UNIT POST TEST:
REPULSION MOTORS

Occupational Area: ______________________

File Code: 78.01.05.00.B2-2

Name: ______________________

ANSWERS

78.01.05.01	1.	C	21.		41.	
	2.	B	22.		42.	
	3.	A	23.		43.	
	4.	B	24.		44.	
	5.	A	25.		45.	
78.01.05.02	6.	C	26.		46.	
	7.	B	27.		47.	
	8.	D	28.		48.	
	9.	D	29.		49.	
	10.	B	30.		50.	
78.01.05.03	11.	D	31.		51.	
	12.	D	32.		52.	
	13.	A	33.		53.	
	14.	B	34.		54.	
	15.	A	35.		55.	
78.01.05.04	16.	D	36.		56.	
	17.	B	37.		57.	
	18.	D	38.		58.	
	19.	C	39.		59.	
	20.	A	40.		60.	

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Student: ________ File Code: 78.01.05.00.A1-5

Date: ________ Date Published: 11/15/74

Family Pay No.: ________ Sex: M F (Circle 1)

REPULSION MOTORS

OBJECTIVE 1:

Given a malfunctioning repulsion motor, the student will service and repair the motor so that it functions according to the manufacturer's specifications, following safe practices and procedures.

OBJECTIVE 2:

Using appropriate tools and test [illegible] will make shorts and open tests.

OBJECTIVE 3:

Using appropriate equipment, the student will rewind a faulty repulsion motor.

OBJECTIVE 4:

Using appropriate tools and test equipment, the student will calculate and record amperage, voltage, resistance and wattage of a repulsion motor.

TASK:

The student will service and repair a repulsion motor and, in the process, he will make shorts and open and grounding tests, using appropriate test equipment.

ASSIGNMENT:

CONDITIONS:

The student will be given a malfunctioning repulsion motor (it may be bugged by the instructor or it maybe one brought in by a customer). He will be required to service and repair the motor in conditions similar to those in a typical motor repair shop. He will be allowed to use any and all tools, equipment, service manuals, text books, etc., commonly found in a repair shop. He must complete it in a reasonable length of time with no assistance from the instructor(s) or students.

RESOURCES:

Tools:

- Internal-external snap ring pliers
- 7-Piece nut driver set
- Tool box 18 x 8 x 9
- Circular gauge
- Hacksaws
- Pulley puller
- Arc joint pliers
- Lineman's pliers
- Diagonal cutting pliers
- Long chain-nose pliers
- Locking plier wrench
- Coil tamping pliers
- 4-piece standard set screwdrivers
- Center punch
- Cold chisel
- Ball peen hammer
- Lug crimpers
- Wire stripper and soldering [illegible]

Equipment:

- Coil stripping chisel
- Armature winder
- Coil winder
- [illegible]
- Insulation former
- Coil shapers

[illegible] FRC Code: 78.01.05.00.A1-5

[illegible] Date Published: 11/15/74

[illegible] Sex: M F (Circle 1)

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

[illegible]

OVERALL PERFORMANCE: [illegible] Unsatisfactory [illegible]

	CRITERION Met	CRITERION Not Met
Objective [illegible]:		
1. Follows safe practices and procedures.		
Criterion: No injury results to the student or the equipment and complies with OSHA requirements		
2. Follows proper procedures for disassembly.		
Criterion: No damage results to the motor.		
3. Diagnosis and troubleshoots malfunctions properly.		
Criterion: [illegible] repaired, the motor functions according to the manufacturer's specifications.		
4. Reassembles the motor properly		
Criterion: Appliance [illegible] according to the manufacturer's specifications and the procedures followed agree with those [illegible] in the service literature.		
5. [illegible] in a neat, professional manner.		

	CRITERION Met	Not Met
Criterion: No damage results to the motor such as opens		
[illegible] shorts		
[illegible] connections and fastening are properly completed		
[illegible] The motor connection complies with the		
manufacturer's specifications. The connections		
are mechanically fastened and structurally		
sound. The connection is electrically fastened		
[illegible] of defects		
[illegible] motor functions according to the manufacturer's		
specifications.		
Criterion: manufacturer's specifications.		
[illegible] parts and supplies.		
Criterion: They match exactly those listed in the		
manufacturer's specifications.		
[illegible]ive [illegible]		
[illegible] commutator, using test lamp.		
[illegible] shorted [illegible] using test lamp.		
[illegible] growler or millivolt meter.		
[illegible]		
13. [illegible] armature coil using a growler.		

	CRITERION Met	Not Met
[illegible] open field coil, using an ohmmeter.		
[illegible] armature coil, using an ohmmeter.		
[illegible] coils, using a compass or [illegible]		
[illegible]		
[illegible] Troubleshooting techniques reveal the [illegible]		
[illegible] fied by [illegible]		
[illegible]		
[illegible] tool to remove coils.		
[illegible] winder, if appropriate, when winding		
the armature.		
10. Use [illegible] coil winder, if appropriate, when winding a field		
[illegible]		
[illegible] insulation former, if appropriate, when		
[illegible]		
[illegible] coil [illegible], if appropriate, on the field coils.		
[illegible] equipment application results in a		
defect-free operative motor.		
Objective [illegible]		
[illegible]		
22. [illegible] readings are accurate.		

Not Met

... are accurate

... spe...

... mathematic... ...

... complete 25 out of ...

... all ... satisfactory.

Printed Materials

1. Electric Motors, (2nd Ed.) Anderson, Theodore Audel and Company.
2. Electric Motor Repair, (2nd Ed.) Rosenberg, Holt, Rinehart, and Winston, 1970. A set of manufacturer's motor specifications and data sheets.
3. Introduction to Power Technology Principles of Electric Motors, (2nd Ed.), Vega Enterprises Inc., Decator, Illinois, 1973.

Service Manuals

Checklist: Checklist for troubleshooting Polyphase Motors
Three-Phase Motor disassembly.

Audio/Visual

Service and repair checklist: Polyphase Motors requisition form
Illustration: Polyphase Motors

Equipment

motor test analyzer
three-phase motor
ball peen hammer
center punch
nut driver
cold chisel
screwdriver
amprobe or ammeter
ohmmeter
voltmeter
growler

EVALUATION PROCEDURE:

When pretesting:

1. The student takes the unit multiple-choice pretest. Successful completion is 4 out of 5 items for each LAP part of the pretest.
2. The student then takes a unit performance test if the unit pretest was successfully completed. Satisfactory completion of the performance test is meeting the criteria listed on the performance test.

When post testing:

The student takes a multiple-choice unit post test and a unit performance test. Successful unit completion is meeting the listed criteria for the performance test.

FOLLOW-THROUGH:

At this time you are ready to begin the first LAP in this unit.

Student: ______________________ File Code: 78.01.06.00.A2-2

Date: ______________________ Date Published: 12-13-74

Mountain-Plains Education &
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Glasgow AFB, Montana 59231

UNIT PRETEST: POLYPHASE MOTORS

78.01.06.01

1. Three-phase motors have one fairly constant characteristic which is:

   a. torque
   b. speed
   c. size
   d. all have ball bearings

2. Three-phase motors vary from fractional/horsepower size to:

   a. several hundred HP
   b. a few HP
   c. several thousand HP
   d. several HP

3. Polyphase motors are:

   a. D-C Motors
   b. A-C Motors
   c. A-C/D-C Motors
   d. Universal motors

4. The construction of a three-phase motor is similar to that of a:

   a. shaded-pole motor
   b. repulsion-type motor
   c. split-phase motor
   d. direct-current motor

5. The 3 main parts of a three phase motor are end-plates, stator, and:

   a. [illegible]
   b. [illegible]
   c. field coil
   d. [illegible]

78.01.06.02

6. An A-C motor that is designed for either three-phase or two-phase operation is called a:

   a. polyphase motor
   b. split-phase capacitor-start motor
   c. repulsion-type motor
   d. split-phase motor

7. What is the difference between a squirrel-cage and a wound rotor on a three-phase motor?

   a. there is no difference
   b. same but uses ball bearings
   c. wound rotor has slip rings
   d. same but uses sleeve bearings

8. What is the purpose of the stator of a three-phase motor?

   a. to center the rotor
   b. to enable the shaft to turn
   c. to hold the bearings
   d. to house the laminated core and windings

9. Where is the squirrel-cage winding found in a polyphase motor?

   a. inside the rotor
   b. inside the front end plate
   c. inside the rear end plate
   d. on the stator

10. What is the difference between a squirrel-cage and a wound rotor on a three-phase motor?

   a. there is no difference
   b. wound rotor has slip rings
   c. same but uses ball bearings
   d. same but uses sleeve bearings

78.01.06.03

11. Reverses in a polyphase motor may occur in:

   a. coils
   b. phases
   c. groups
   d. all answers are correct

78.01.06.03 (continued)

12. In a polyphase delta-connected motor using a test lamp how would you determine which phase is open?

    a. place one lead at delta point and other on each phase lead
    b. you can not test delta connected motors for opens
    c. disconnect the phases and test each phases separately
    d. disconnect at delta point and test each phase separately

13. In a polyphase star-connected motor using a test lamp how would you determine which phase is open?

    a. disconnect the phases and test each phase separately
    b. place one test lead at star point and the other on each other phase head
    c. connect one test lead to star point and the other to both sections of phase
    d. disconnect at the star point and test each phase separately

14. How would you locate a grounded phase in a polyphase star-connected motor, using a test lamp?

    a. place one test lead to motor frame and one test lead to one power lead
    b. place one test lead at star point and the other test lead to each lead
    c. disconnect phase at leads and test each phase separately
    d. disconnect at star point and test each phase separately

15. In what way is an internal growler used to test a polyphase motor, parallel-connected for shorts?

    a. parallels disconnected, growler in position-bad coils become hot
    b. parallels disconnected, note vibrations of hacksaw blade
    c. hold the growler in position, defective coils will become hot
    d. by [illegible] the vibration of a hacksaw blade

78.01.06.04

16. Polyphase motors that require taping but have semiclosed slots are taped where?

    a. only [illegible]
    b. only [illegible]
    c. each [illegible] is taped completely
    d. [illegible]

17. Polyphase [illegible] coils are always wound on:

    a. forms or coil winding heads
    b. coil winding heads only
    c. free handed
    d. blocks of wood

78.01.06.04 (continued)

18. The practice of winding coils in groups for three phase motors is called:

    a. skein winding
    b. diamond winding
    c. lap winding
    d. group or gang winding

19. The coil winding head for three phase motors having six sides is called a:

    a. mush type
    b. a diamond
    c. gang
    d. group

20. What will happen if you scratch the insulation in one spot on a coil of a three-phase motor?

    a. it will short out one coil
    b. the motor will not run
    c. it will ground out the entire motor
    d. the motor will operate normally

UNIT TEST ANSWER SHEET

UNIT PRETEST

POLYPHASE MOTORS

Occupational Area: ____________

File Code: ____.01.06.00.A2-2____

Name: ____________

ANSWERS

01.06.01	1. B	21.	41.		
	2. C	22.	42.		
	3. B	23.	43.		
	4. C	24.	44.		
	5. B	25.	45.		
.01.06.02	6. A	26.	46.		
	7. C	27.	47.		
	8. D	28.	48.		
	9. A	29.	49.		
	10. B	30.	50.		
.01.06.[illegible]	11. D	31.	51.		
	12. C	32.	52.		
	13. [illegible]	33.	53.		
	14. D	34.	54.		
	15. [illegible]	35.	55.		
01.06.[illegible]	16. [illegible]	36.	56.		
	17. A	37.	57.		
	18. D	38.	58.		
	19. [illegible]	39.	59.		
	20. [illegible]	40.	60.		

File Code: 78.01.06.01.A2-0

Date Published: 2-23-76

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Learning Activity Package

Student: ____________________

Date: ____________________

PERFORMANCE ACTIVITY: Operation of the Polyphase Motor

OBJECTIVE:

Describe the operation of a three-phase motor. Draw a schematic of the motor circuits. [illegible] characteristics of the three-phase motor.

EVALUATION PROCEDURE:

Successfully complete at least 80% of the items on a multiple-choice test about this LAP.

RESOURCES:

Electric Motors, Anderson, pp. 20-28.
Electric Motor Repair, Rosenberg, pp. 106-107.
Introduction to Power Technology, [illegible] of Electric Motors, Experiment #6, pp. 40-42.

motor test analyzer
three-phase motor

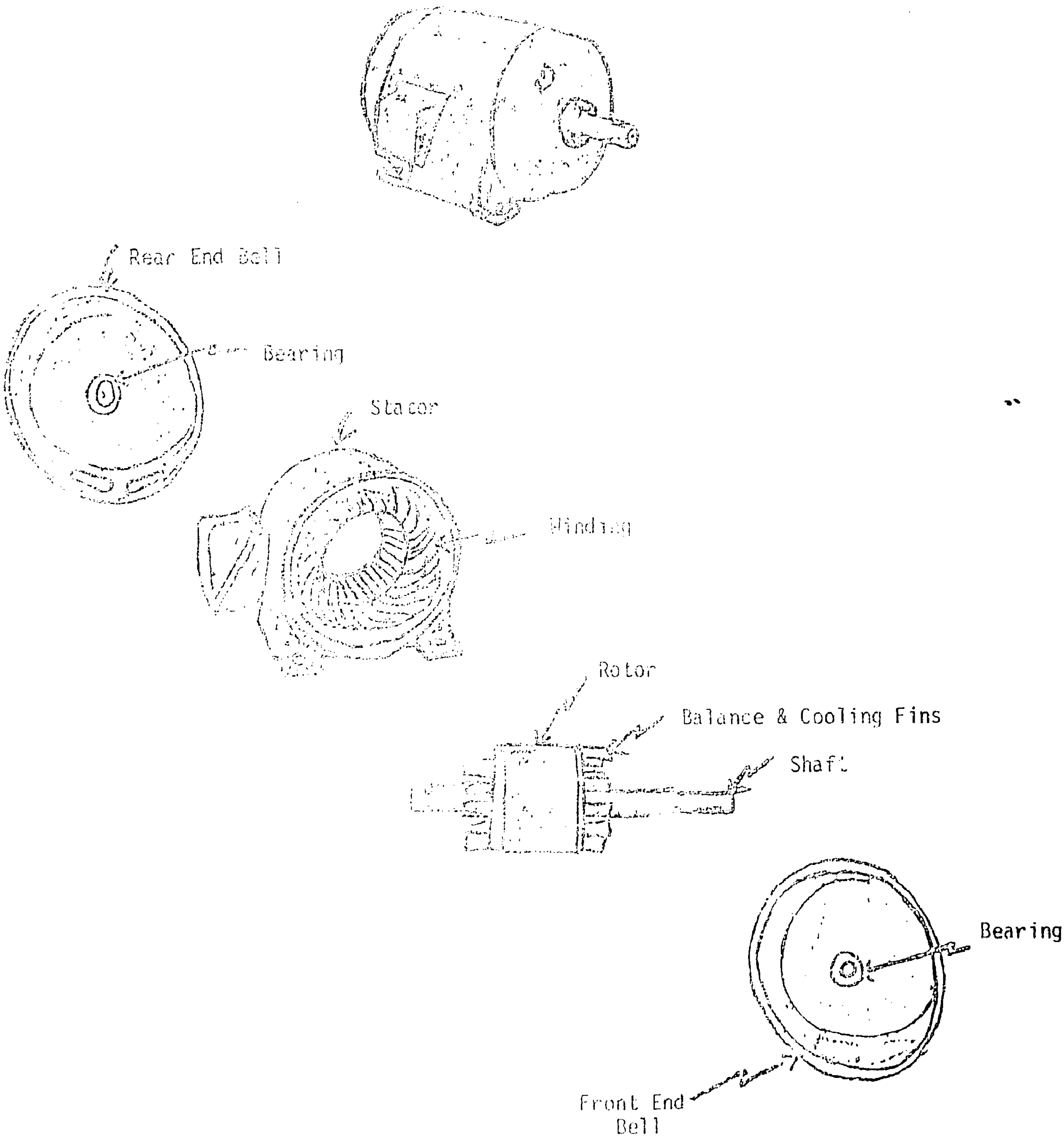
PROCEDURE:

Steps

1. Read and study carefully the information found on pages 20-28 in the Electric Motors and pages 106-107 in Electric Motor Repair.
2. Operate the motor and observe the characteristics of the motor according to the steps listed in experiment #6, pp. 40-42 in Introduction to Power [illegible].
3. Write a description of the operation of a three-phase motor using simple schematics.
4. Take the LAP test.

Principal Author(s): T. Miller

Polyphase Motors



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File Code: 78.01.06.02.A2-0

Date Published: 2-23-76

Learning Activity Package

Student: ____________________

Date: ____________________

PERFORMANCE ACTIVITY: Polyphase Motor Construction

OBJECTIVE:

Disassemble a three-phase motor following the recommended steps for disassembly; identify the main parts by function and inter-relationship by labeling with masking tape.

EVALUATION PROCEDURE:

Accurate listing of the steps correlated to the steps attached. Proper disassembly procedures followed as described in the checklist.

RESOURCES:

Checklist: Three-Phase Motor Disassembly
Illustration: Polyphase Motors
Electric Motor Repair, Rosenberg, pp. 106-107.
Three-phase motor

Ball peen hammer
Center punch
Nut driver
Cold chisel
Screwdriver

PROCEDURE:

Steps

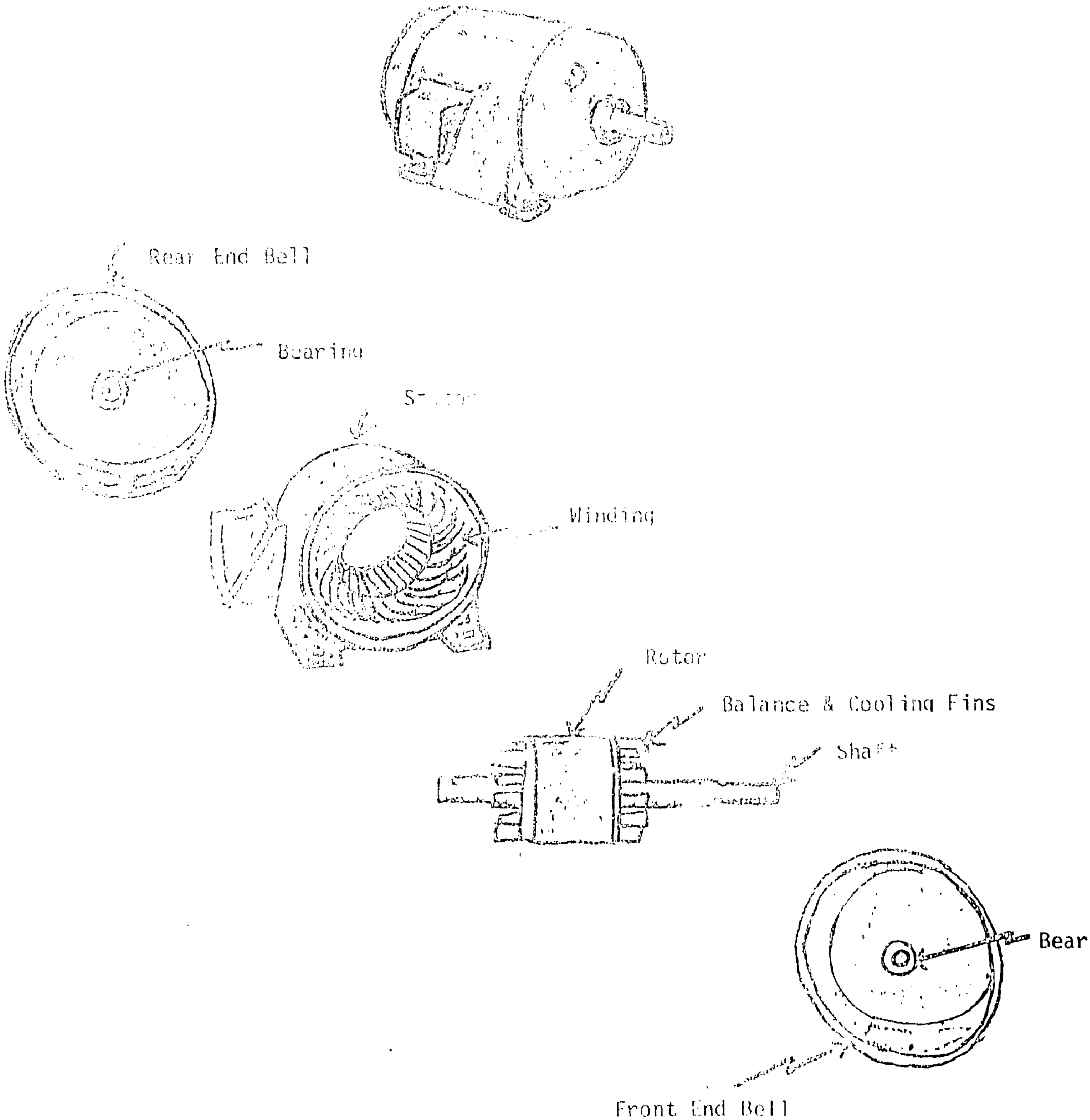
1. Using the resources as reference and the attached disassembly checklist as a guide, disassemble a three-phase motor.
2. Apply all safety practices and procedures.
3. Complete the multiple-choice test items for this LAP.

Principal Author(s): T. Ziller

THREE-PHASE MOTOR DISASSEMBLY

1. Using a ball peen hammer and center punch, put two (2) punch marks on the end ball and on the stator, on the end of the motor in line with each other and within ½" of each other.
2. Using the same tools, put one (1) punch mark on the stator and end bell in line with step 1 but on the other end of motor and within ½" of each other.
3. Using a nut driver of proper size, remove the four (4) nuts and remove the long bolts. (Caution: do not lose the nuts)
4. Using a ball peen hammer and cold chisel, gently tap the front end bell where it meets the stator on shaft end; when loose, slide the end bell off the end of shaft.
5. Firmly hold onto the shaft and pull straight out. Try not to let the rotor drag on the stator laminations.
6. Using the tools in step 4, gently tap the rear end bell loose. Do not force.
7. To remove motor protection (thermal relay), remove the two screws with a screwdriver. (Caution: do not lose the screws)
8. Turn in the disassembly checklist, identification list, and LAP to the instructor and ask any questions you may have over any phase of the disassembly of the motor.
9. Label all parts of the motor using the names shown on the attached motor's exploded view diagram.

POLYPHASE MOTORS



78.01.06.01.A2-2
78.01.06.02.A2-2

Student: File Code:

Date Published: 12-23-74

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

[illegible] TEST: OPERATION OF THE POLYPHASE MOTOR/ POLYPHASE MOTOR CONSTRUCTION

78.01.06.01

1. The end plates of a three-phase motor are mounted to the side of the stator frame with:

   a. rivets
   b. pins
   c. screws
   d. bolts

2. The rotor of a three-phase motor is of what type?

   a. slip-ring
   b. wound
   c. concentric
   d. squirrel-cage

3. Three-phase motors have one fairly constant characteristic which is:

   a. torque
   b. speed
   c. all have ball bearings
   d. size

4. [illegible] fairly constant characteristic of:

   a. torque
   b. frequency
   c. voltage
   d. speed

5. [illegible]

   a. [illegible] ally
   b. [illegible] nt
   c. [illegible] an D.C.
   d. [illegible] d motor

found in a polyphase motor?

have that a split-phase has?

, the coils in the slots of the stator are connected to
winding and are called:

winding

difference between a squirrel-cage and a wound rotor
?

but uses ball bearings
but has sleeve bearings
or has slip rings
difference

motor that is designed for either three-phase or two-phase operation is

phase motor
type motor
capacitor start motor
motor

LAP TEST ANSWER KEY: 78.01.06.01.A2-2/78.01.06.02.A2-2

OPERATION OF THE POLYPHASE MOTOR/POLYPHASE MOTOR CONSTRUCTION

LAP .01
1. D
2. D
3. B
4. D
5. A

LAP .02
6. D
7. A
8. D
9. C
10. A

File Code: 78.01.06.03.A2-0

Date Published: 2-23-76

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Learning Activity Package

Student: ____________

Date: ____________

PERFORMANCE ACTIVITY: Troubleshooting Polyphase Motors

OBJECTIVE:

Diagnose a three-phase induction motor following the steps for trouble-shooting as given in the attached checklist.

EVALUATION PROCEDURE:

The motor must be diagnosed properly. The student is to follow a checklist for troubleshooting a motor.

RESOURCES:

Checklist for troubleshooting polyphase motors.
Test equipment, tools and work order form.
Three-phase motor.
Service Manuals for the motor.
Electric Motor Repair, Robert Rosenberg, pp. 138-145.

PROCEDURE:

Steps

1. Follow the checklist for troubleshooting polyphase motors.
   NOTE: Refer to the exploded view of a three-phase motor.
2. Complete the multiple-choice test items for this LAP.

Principal Author(s): T. Ziller

CHECKLIST FOR TROUBLING POLYPHASE MOTORS

1. Inspect the motor to detect mechanical troubles.
    A. Broken, cracked or warped end plates (or bells).
    B. Badly bent shaft.
    C. Broken or burned leads.
    D. Broken centrifugal switch.
    E. Check shaft for free rotation.
    F. Check shaft end play by pushing and pulling shaft - if it slips over ¼", it may not engage with the centrifugal switch.
    G. Laying motor in normal position, check for up and down movement, a rough check for possible bad bearings.
    H. Check for grounds and opens (with testlight, bell, ohmmeter).

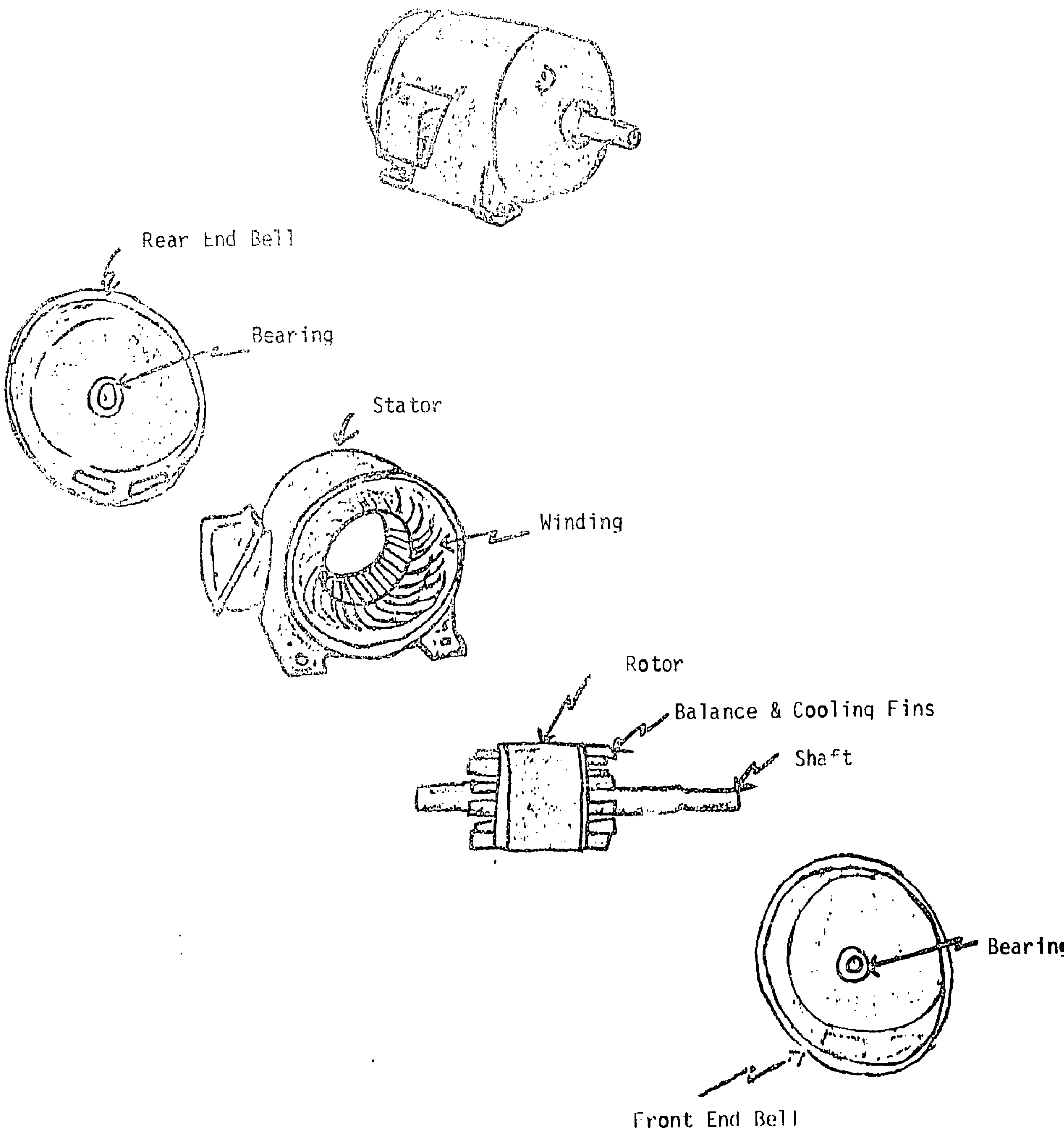
2. Inspect motor for continuity.
    A. Short test on fields (ohmmeter).
       Record valve ____________.
    B. Opens test on fields (ohmmeter).
       Record valve ____________.
    C. Grounds test on fields (growler or ohmmeter).
       Record valve ____________.

3. Connect motor to power source.
    A. Does shaft rotate?
    B. Does motor have a loud hum and rotate slowly? (If yes, start winding is shorted or bearings are bad; centrifugal switch is on)
    C. Does motor have a grinding noise? (bad bearings)
    D. Does motor smell or feel hot? (winding are shorted)
    E. Check voltage source (voltmeter).
       Record valve ____________.
    F. Check current (amprobe or ammeter).
       Record valve ____________.

4. Disconnect motor from power source.

5. Compare figures with manufacturer's specifications.

POLYPHASE MOTORS



Student: ______________________ File Code: 78.01.06.03.A2-2

Date: ______________________ Date Published: 12-23-74

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

LAP TEST: TROUBLESHOOTING POLYPHASE MOTORS

78.01.06.03

1. Reverses in a polyphase motor may occur in:

   a. phases
   b. groups
   c. coils
   d. all answers are correct

2. In a polyphase delta-connected motor, using a test lamp, how would you locate a grounded phase?

   a. disconnect at delta point and test each phase separately
   b. place one test lead at delta point and the other test lead to power leads
   c. place one test lead to the motor frame and one test lead to one of the power leads
   d. disconnect phases at leads and test each phase separately

3. If a polyphase motor produces a noisy hum and prevents the motor from pulling full load, the trouble is:

   a. a reversed phase
   b. an open parallel connection
   c. a defective controller
   d. frozen bearings

4. How would you locate a grounded phase in a polyphase star-connected motor, using a test lamp?

   a. disconnect phase at leads and test each phase separately
   b. place one test lead to the motor frame and one test lead to one power lead
   c. disconnect at start point and test each phase separately
   d. place one test lead at star point and other test lead to each lead

5. In a polyphase motor, if there is a reversed phase, the motor will:

   a. become excessively hot
   b. not run properly
   c. run properly
   d. fail to start

78.01.06.03 (continued)

6. A balance test on a polyphase motor would indicate:

   a. grounded coils
   b. shorts
   c. open circuit
   d. reversed coils

7. If a polyphase motor fails to start, the trouble may be:

   a. reversed coils or group
   b. a reversed phase
   c. incorrect voltage or frequency
   d. an open phase

8. In a polyphase star-connected motor using a test lamp, how would you determine which phase is open?

   a. disconnect the phases and test each phase separately
   b. place one test lead at star point and the other on each other phase heads
   c. connect one test lead to star point and other to both sections of phase
   d. disconnect at the star point and test each phase separately

9. In a polyphase delta-connected motor using a test lamp, how would you determine which phase is open?

   a. disconnect the phases and test each phase separately
   b. disconnect at delta point and test each phase separately
   c. place one lead at delta point and the other on each phase lead
   d. you can not test delta connected motors for opens

10. In what way is an internal growler used to test a polyphase motor, parallel-connected for shorts?

   a. by noting the vibrations of a hacksaw blade
   b. parallels disconnected, note vibrations of hacksaw blade
   c. hold the growler in position, defective coils will become not
   d. parallels disconnected growler in position-bad coils become hot

LAP TEST ANSWER KEY: 78.01.06.03.A2-2

TROUBLESHOOTING POLYPHASE MOTORS

1. D
2. D
3. B
4. C
5. B
6. B
7. D
8. B
9. A
10. D

File Code: 78.01.06.04.A2-0

Date Published: 2-23-76

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Learning Activity Package

Student: ______

Date: ______

PERFORMANCE ACTIVITY: Repairing Polyphase Motors

OBJECTIVE:

Repair, service and reassemble a three-phase induction motor following the steps for repair, service and reassembly as given in the attached checklist; and correctly complete requisition, if required.

EVALUATION PROCEDURE:

The motor must operate properly. The student is to follow a checklist on repair, service and reassembly of the motor. The requisition must be accurately completed. Also score at least 80% on a written test.

RESOURCES:

Illustration of polyphase motor.
Checklist on repair, service and reassembly of the motor.
Test equipment, tools.
Three-phase motor.
Service manuals for the motor.
Electric Motor Repair, by Robert Rosenberg, pp. 138-145.

requisition form
30-w oil
lubricating grease

PROCEDURE:

Steps

1. Follow the checklist for repair, service and reassembly polyphase motors.
   NOTE: Refer to the exploded view of a three-phase motor.
2. Complete the multiple-choice test items for this LAP.

Principal Author(s): T. Ziller

SERVICE AND REPAIR CHECKLIST: POLYPHASE MOTORS

1. Order a centrifugal switch for the motor using attached requisition form.

2. Lubricate bearings (30-w oil for sleeve bearings, general purpose lubricating grease for ball bearings).

3. Insure that rotating mechanism of the centrifugal switch on the rotor is not binding.

4. Check contact points on the stationary mechanism of the centrifugal switch for cleanliness.

5. Insure that all leads to stationary centrifugal switch are tight.

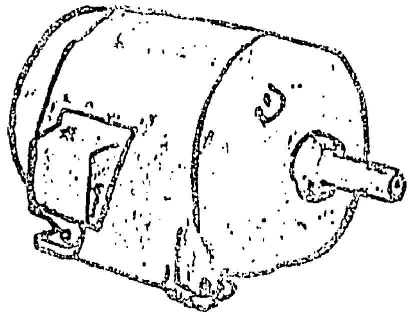
Bearing Replacement Checklist for Polyphase Motor:

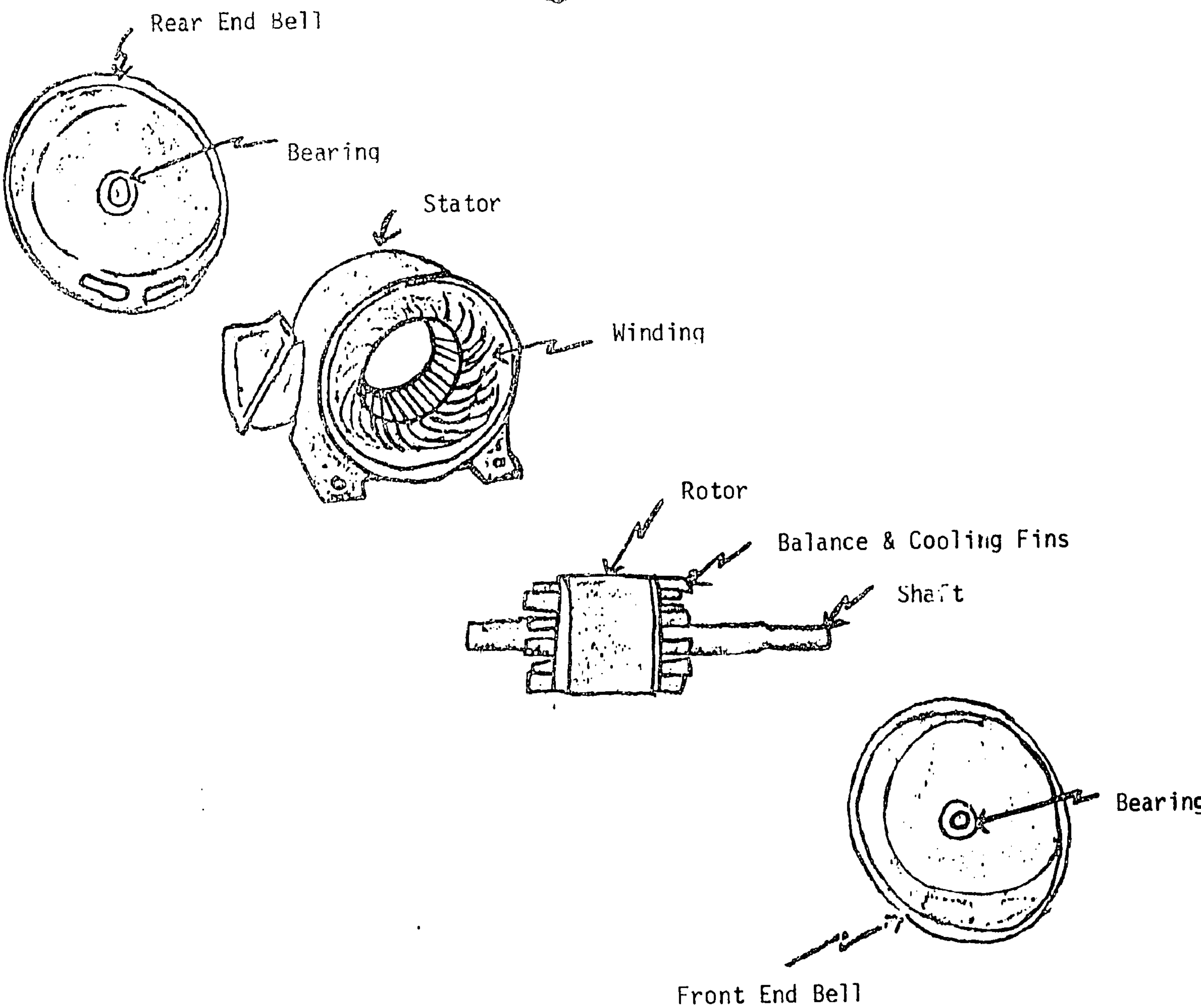
1. Using proper tools, remove bad bearings.
2. Replace using proper tools. Ream to fit as necessary.
3. Relubricate new bearings.

Centrifugal Switch Replacement for Polyphase Motor:

1. Label all leads and remove from centrifugal switch.
2. Remove centrifugal switch.
3. Install new switch, reconnect all leads.

POLYPHASE MOTORS





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Glasgow AFB, Montana 59231

PURCHASE REQUISITION

78.01.06.04.A2-0

ORIGINATOR'S CONTROL NO.

REQUISITION NO.	REQUISITION DATE	TIME REQUIRED	PURCHASE ORDER NO.	PAGE of

[ ] RESEARCH DEVELOPMENT [ ] OPERATIONS
[ ] START UP

SUGGESTED SOURCE

ACCOUNTING DATA

USING ACTIVITY

USED FOR

DEPARTMENT
[ ] ADMINISTRATION
[ ] FAMILY LIFE
[ ] INSTRUCTION
[ ] MULTI-PURPOSE
[ ] STATE PROGRAMS
[ ] PLANNING & RESEARCH
[ ] OTHER

ITEM NO.	QUAN.	UNIT	DESCRIPTION OF SUPPLIES / SERVICES	EST. UNIT PRICE	EST. AMOUNT

REMARKS

EST. TOTAL AMOUNT

Title	Signature	Date	Title	Signature	Date
ORIGINATOR			PROPERTY CONTROLLER		
DEPT. HEAD			PROCUREMENT OFFICER		
[illegible]OR			ACCOUNTING OFFICE (To Procurement)		

MPEEDP Form PR-1 3805 REV

Student: ______________________ File Code: 78.01.06.04.A2-2

Date: ______________________ Date Published: 12-23-74

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

LAP TEST: REPAIRING POLYPHASE MOTORS

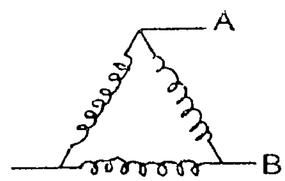
78.01.06.04

1. If there are 36 coils in a three phase motor, how many coils per phase are there?

   a. 3
   b. 12
   c. 36
   d. 4

2. This schematic symbol is for what type of three-phase connection?

   a. wye
   b. star
   c. pigtail
   d. delta



3. If you have only a rectangular form for a three-phase motor coil, how can you make it into a diamond?

   a. by pulling at the center of opposite sides
   b. can't be done
   c. only by using a diamond-shaped head
   d. can only make a diamond if using a rounded form

4. How are wye-connected coils of a three-phase motor connected?

   a. the ends of each coil together, the beginning of each to a phase
   b. beginning of each coil connected together
   c. the ends of each phase connected together
   d. the beginning of each phase connected together

5. What type of tape is preferred on a coil in a three phase motor?

   a. black electrical tape
   b. varnished cambric or fiberglass tape
   c. rubber tape
   d. cotton tape

78.01.06.04 (continued)

6. What type of tape is often used to tape the coils of a three-phase motor?

   a. cotton
   b. electrical
   c. paper
   d. rubber

7. With a semiclosed stator of a three-phase motor, what is the best procedure for inserting the coil into the slots?

   a. straight method
   b. fan method
   c. group method
   d. tube method

8. How are coils placed in the slots of a semiclosed stator of a polyphase motor?

   a. by taping edge of the slots
   b. by inserting the complete coil at one time
   c. can't be done
   d. the turns of the coils are inserted one by one

9. Insulation placed between each group of coils in a three-phase motor is called:

   a. varnished insulation
   b. glass insulation
   c. cambric insulation
   d. phase insulation

10. Why can't the coils be taped on a semiclosed stator of a three-phase motor?

   a. because to do so would damage the stator beyond repair
   b. it can be done but too much time is involved
   c. this type motor is not made to be rewound
   d. the opening will only allow one wire at a time

LAP TEST ANSWER KEY: 78.01.06.04.A2-2

REPAIRING POLYPHASE MOTORS

1. B
2. D
3. A
4. C
5. B
6. A
7. B
8. D
9. D
10. D

Student: ______________ File Code: 78.01.06.00.B2-2

Date: ______________ Date Published: 2/6/76

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

UNIT POST TEST: POLYPHASE MOTORS

78.01.06.01

1. The rotor of a three-phase motor is of what type?

   a. wound
   b. squirrel-cage
   c. concentric
   d. slip-ring

2. Polyphase motors are:

   a. universal motors
   b. A-C/D-C motors
   c. A-C motors
   d. D-C motors

3. The end plates of a three-phase motor are mounted to the side of the stator frame with:

   a. pins
   b. bolts
   c. screws
   d. rivets

4. In a three-phase motor, each phase is:

   a. [illegible] to the other phases
   b. related to the other phases
   c. dependent on the other phases
   d. independant of the other phases

5. The operation of practically all polyphase motors depends on a:

   a. stationary solenoid
   b revolving magnetic field
   c. stationary magnetic field
   d. revolving solenoid

78.01.06.02

6. What is the difference internally in two types of polyphase motors?

   a. both the coils and internal connections are changed
   b. the coils are wound differently but the connections are the same
   c. the coils are the same but the internal connections are different
   d. the coils and internal connections are the same

7. What is the purpose of the end bells of a polyphase motor?

   a. to house the bearings and to hold the rotor in center
   b. to enable the shaft to turn
   c. to house the winding
   d. to house the slip-ring

8. Three-phase motors have one fairly constant characteristic which is:

   a. size
   b. torque
   c. speed
   d. all have ball bearings

9. What doesn't a three-phase motor have that a split-phase motor has?

   a. centrifugal switch
   b. bearings
   c. end bells
   d. rotor

10. Where is the squirrel-cage winding found in a polyphase motor?

   a. on the stator
   b. inside the front end plate
   c. inside the rear end plate
   d. inside the rotor

78.01.06.03

11. In a polyphase delta-connected motor, using a test lamp, how would you locate a grounded phase?

   a. place one test lead at delta point and the other test lead to power leads
   b. place one test lead to the motor frame and one test lead to one of power leads
   c. disconnect phases at leads and test each phase separately
   d. disconnect at delta point and test each phase separately

78.01.06.03 (continued)

12. A balance test on a polyphase motor would indicate:

    a. shorts
    b. open circuit
    c. reversed coils
    d. grounded coils

13. If a polyphase motor fails to start, the trouble may be:

    a. reversed coils or group
    b. an open phase
    c. a reversed phase
    d. an incorrect voltage or frequency

14. If the polyphase motor runs slowly, the trouble may be:

    a. an open phase
    b. the motor is running on single phase
    c. a wrong connection
    d. a defective controller

15. In a polyphase motor, if there is a reversed phase, the motor will:

    a. fail to start
    b. run properly
    c. not run properly
    d. become excessively hot

78.01.06.04

16. There is one mistake that is often made when inserting the coil in to the slot of a polyphase motor and that is:

    a. the turns often slip between the insulation and core
    b. it won't fit in the stator
    c. it slips in the rotor
    d. it slips in the insulation

17. In a three-phase motor with a 1 to 6 pitch, how many coils must be put in before the whole coil can be put in to the slot?

    a. 6
    b. 3
    c. 4
    d. 1

78.01.06.04 (continued)

18. On polyphase motors if a wire gets between the insulation and the core, the coil will:

    a. short out
    b. start a fire
    c. will not run
    d. ground out

19. What is the symbol for a delta connection on a polyphase motor?

    a. △
    b. Y
    c. 
    d. V

20. How many groups of coils on a polyphase motor are there in each pole from one phase?

    a. 9
    b. 36
    c. 1
    d. 3

UNIT TEST ANSWER SHEET

Occupational Area: UNIT POST TEST: POLYPHASE MOTORS

File Code: 78.01.06.00.B2-2

Name:

ANSWERS

78.01.06.01	1.	B	21.		41.	
	2.	C	22.		42.	
	3.	B	23.		43.	
	4.	D	24.		44.	
	5.	B	25.		45.	
78.01.06.02	6.	C	26.		46.	
	7.	A	27.		47.	
	8.	C	28.		48.	
	9.	A	29.		49.	
	10.	D	30.		50.	
78.01.06.03	11.	C	31.		51.	
	12.	A	32.		52.	
	13.	B	33.		53.	
	14.	C	34.		54.	
	15.	C	35.		55.	
78.01.06.04	16.	A	36.		56.	
	17.	A	37.		57.	
	18.	D	38.		58.	
	19.	A	39.		59.	
	20.	D	40.		60.	

Student: ____________ File Code: 78.01.06.00.A1-5

Date: ____________ Date Published: 11/15/74

Mountain-Plains Education &
Economic Development
Program, Inc.
Glasgow AFB, Montana 59231

Family Pay Number: ____________ Sex: M F (Circle 1)

UNIT PERFORMANCE TEST: POLYPHASE MOTORS

OBJECTIVE 1:

Given a malfunctioning 3 phase motor, the student will service and repair the motor so that it functions according to the manufacturer's specifications, following safe practices and procedures.

OBJECTIVE 2:

Using appropriate tools and test equipment the student will take shorts and open tests.

OBJECTIVE 3:

Using appropriate equipment, the student will rewind a faulty 3 phase motor.

OBJECTIVE 4:

Using appropriate tools and test equipment, the student will calculate and record amperage, voltage, resistance and wattage of the motors field windings.

TASK:

The student will service and repair a 3 phase motor and, in the process, he will make shorts and open grounding tests, using appropriate test equipment.

ASSIGNMENT:

CONDITIONS:

The student will be given a malfunctioning 3 phase motor (it may be bugged by the instructor or it may be one brought in by a customer). He will be required to service and repair the motor in conditions similar to those in a typical motor repair shop. He will be allowed to use any and all tools, equipment, service manuals, text books, etc., commonly found in a repair shop. He must complete it in a reasonable length of time with no assistance from the instructor(s) or students.

RESOURCES:

Tools:
- Internal-external snap ring pliers
- 7-Piece nut driver set
- Tool box 18 x 8 x 9
- Circular gauge
- Hacksaws
- Pulley puller
- Arc joint pliers
- Lineman's pliers
- Diagonal cutting pliers
- Long chain-nose pliers
- Locking plier wrench
- Coil tamping pliers
- 4-piece standard set screwdrivers
- Center punch
- Cold chisel
- Ball peen hammer
- Lug crimpers
- Wire skinner and straightener

Equipment:
- Coil stripping chisel
- Armature winder
- Coil winder
- External growler
- Insulation former
- Coil shapers
- 3-Phase motor

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Student: ______________ File Code: 78.01.06.00.A1-5

Date: ______________ Date Published: 11/15/74

Family Pay Number: ______ Sex: M F (Circle 1)

PERFORMANCE CHECKLIST:

OVERALL PERFORMANCE: Satisfactory_____ Unsatisfactory_____

	CRITERION Met	Not Met
Objective 1:		
1. Follows safe practices and procedures.		
Criterion: No injury results to the student or the equipment and complies with OSHA requirements.		
2. Follows proper procedures for disassembly.		
Criterion: No damage results to the motor.		
3. Diagnosis and troubleshoots malfunctions properly.		
Criterion: When repaired, the motor functions according to the manufacturer's specifications.		
4. Reassembles the motor properly.		
Criterion: Appliance functions according to the manufacturer's specifications and the procedures followed agree with those described in the service literature.		
5. The repaired motor is repaired in a neat, professional manner.		

	CRITERION Met	CRITERION Not Met
Criterion: No damage results to the motor such as opens		
and shorts.		
6. All connections and fastenings are properly completed.		
Criterion: The motor connection complies with the manufacturer's		
specifications. The connections are mechanically		
fastened and structurally sound. The connection		
is electrically fastened and free of defects.		
7. Motor functions according to the manufacturer's		
specifications.		
Criterion: Manufacturer's specifications.		
8. Uses appropriate repair part and supplies.		
Criterion: They match exactly those listed in the		
manufacturer's specifications.		
Objective 2:		
9. Test for grounded commentator, using test lamp.		
10. Test for shorted communtator, using test lamp.		
11. Test for grounds, using growler or millivolt meter.		
12. Test for shorts in the field coils, using a growler.		
13. Test for shorts in the armature coil, using a growler.		
14. Test for an open field coil, using an ohmmeter.		

	CRITERION Met	Not Met
15. Test for an open armature coil, using an ohmmeter.		
16. Test for reversed coils, using a compass or bar		
magnet test.		
Criterion: Troubleshooting techniques reveal the		
malfunction, as identified by job sheet.		
Objective 3:		
17. Uses coil-stripping tool to remove coils.		
18. Uses armature winder, if appropriate, when winding		
the armature.		
19. Uses coil winder, if appropriate, when winding field		
coil.		
20. Uses insulation former, if appropriate, when		
insulating.		
21. Uses coil shaper, if appropriate, on the field coils.		
Criterion: Proper equipment application results in a		
defect-free operative motor.		
Objective 4:		
22. Uses test equipment properly.		
23. Wattage readings are accurate.		
24. Voltage readings are accurate.		

(Checklist continued)

	CRITERION Met	Not Met
25. Amperage readings are accurate.		
26. Resistance readings are accurate.		
Criterion: Manufacturer's specifications.		
27. When applicable, mathematical calculations are correct.		
Criterion: AC/DC Circuit Manuals, Westinghouse		
28. The motor is repaired in a reasonable time.		
Criterion: Not to exceed 8 hours.		
The student must successfully complete 25 out of 28 line items		
to achieve an overall score of satisfactory.		

File Code: 78.01.07.00.A2-0

Date Published: 2-23-76

Mountain-Plains Education & Economic Development Program, Inc.

Glasgow AFB, Montana 59231

Learning Experience Guide

UNIT: DIRECT CURRENT MOTORS AND GENERATORS

RATIONALE:

Small Direct Current Motors are used in Portable battery operated appliances, tape recorders, and motors with AC/DC adaptors. Most DC generators can be changed to a DC motor and vice versa.

PREREQUISITES:

None

OBJECTIVE:

Given text and illustrations, tools, equipment and materials; identify, disassemble, identify connection methods, troubleshoot and repair DC motors and DC generators.

RESOURCES:

GENERAL INSTRUCTIONS:

This unit consists of 8 Learning Activity Packages (LAPs). Each LAP will provide specific information for completion of a learning activity.

The general procedure for this unit is as follows:

(1) Read the first assigned Learning Activity Package (LAP).
(2) Begin and complete the first assigned LAP.
(3) Take and score the LAP test.
(4) Turn in the LAP test answer sheet.
(5) Determine the reason for any missed items on the LAP test.
(6) Proceed to and complete the next assigned LAP in the unit.
(7) Complete all required LAPs for the unit by following steps 3 through 6.
(8) Take the unit tests as described in the Unit LEG "Evaluation Procedures".
(9) Proceed to the next assigned unit.

Principal Author(s): T. Ziller

Printed Materials

1. Electric Motor Repair, 2nd Ed., Robert Rosenberg, Holt, Rinehart, and Winston, 1970.
2. A set of manufacturer's motor specifications and data sheets.
3. Introduction to Power Technology Principles of Electric Motors, 2nd Ed., Vega Enterprises Inc., Decator, Illinois, 1973.

Checklist:

Checklist for Disassembly: D-C Motors (attached)
Checklist for Troubleshooting: D-C Motors (attached)
Operational checklist for Generators
Checklist for Disassembly: Generators
Checklist for Troubleshooting: Generators
Checklist for Repair: Generators

Illustration:

D-C Motor (attached)

D-C generators (functional)
D-C motor
pin punch
growler
ohmmeter
compass
voltmeter
amprobe or ammeter

PERFORMANCE ACTIVITIES:

.01 Operation of the Direct-Current Motor.
.02 Direct-Current Motor Construction.
.03 Troubleshooting Direct-Current Motors.
.04 Repairing Direct-Currect Motors.
.05 Operation of the Generator.
.06 Generator Construction.
.07 Troubleshooting Generators.
.08 Repairing Generators.

EVALUATION PROCEDURE:

When pretesting:

1. The student takes the unit multiple-choice pretest. Successful completion is 4 out of 5 items for each LAP part of the pretest.
2. The student then takes a unit performance test if the unit pretest was successfully completed. Satisfactory completion of the performance test is meeting the criteria listed on the performance test.

When post testing:

The student takes a multiple-choice unit post test and a unit performance test. Successful unit completion is meeting the listed criteria for the performance test.

FOLLOW-THROUGH:

You may begin with the first LAP. Your instructor will be available to help you if needed.

Student: ______________________ File Code: 78.01.07.00.A2-2

Date: ______________________ Date Published: 12-13-74

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UNIT PRETEST: DIRECT-CURRENT MOTORS AND GENERATORS

78.01.07.01

1. In a D-C Motor, the field poles hold the:

   a. run winding
   b. armature
   c. run and start windings
   d. field coils

2. On all D-C motors, current must be conducted to the armature winding through the:

   a. brushes
   b. brush holders
   c. bearing
   d. end bells

3. In a D-C motor, the brushes are held stationary by the:

   a. end plates
   b. brush holders
   c. brush rigging
   d. commutator

4. What bears the weight of a D-C motors' armature and keeps it equidistant from the pole pieces?

   a. the ball bearing
   b. the end plates
   c. the end plates
   d. the sleeve bearing

5. What is the physical difference between a D-C motor and a D-C generator?

   a. none
   b. different fields
   c. weight
   d. different armatures

78.01.07.02

6. Which of the following characteristics is the D-C series motor known for?

   a. high maintenance cost
   b. low cost
   c. high starting torque
   d. continuous duty

7. In a D-C series motor, how are the field coils connected to the armature?

   a. no connection
   b. shunt
   c. series
   d. parallel

8. Which D-C motor has high starting torque and constant speed?

   a. shunt motor
   b. series motor
   c. compound motor
   d. universal motor

9. A D-C series motor contains:

   a. solenoid
   b. rotors
   c. field coils
   d. stators

10. Which of the following D-C motors has a variable-speed characteristic?

   a. compound
   b. alternator
   c. series
   d. shunt

78.01.07.03

11. Nearly all shunt and compound D-C motors of one-half horsepower or more have commutating poles known as:

   a. interpoles
   b. series-poles
   c. anterpoles
   d. shunt-poles

78.01.07.03 (continued)

12. In a long-shunt cumulative motor, the current flows through the series field and shunt-field coils of a pole in the:

    a. shunt direction
    b. opposite direction
    c. series direction
    d. same direction

13. If a shunt field is connected to armature so current flows through in opposite direction to series current, the D-C compound motor is known as:

    a. short-shunt differential motor
    b. long-shunt cumulative motor
    c. short-shunt cumulative motor
    d. long-shunt differential motor

14. In a two-pole D-C series motor the fields are connected in:

    a. tandem
    b. unison
    c. parallel
    d. series

15. When the shunt field of a D-C compound motor is connected to the armature terminals instead of across the line, the motor is known as a:

    a. short-shunt motor
    b. long-shunt motor
    c. short-series motor
    d. long-series motor

78.01.07.04

16. When a D-C motor is equipped with 4 poles, how many brushes does it have?

    a. 4
    b. 8
    c. 6
    d. 2

17. If a ground has been discovered in the shunt field of a D-C motor, the repairman should:

    a. check for the correct position of the brush holder
    b. remove the armature
    c. remove the field from the frame and rewind the coils
    d. remove the field from the frame and reinsulate

78.01.07.04 (continued)

18. If a ground has been discovered in the series fields of a D-C motor, the repairman should:

   a. remove the fields from the frame and rewind the coils
   b. remove the armature
   c. check for the correct position of the brush holders
   d. remove the fields from the frame and reinsulate

19. Which of the following can one use to check for correct interpole polarity without using a compass or removing the armature?

   a. if armature and brushes rotate in opposite direction--polarity ok
   b. armature-counterclockwise, brushes/center--interpole polarity ok
   c. armature-clockwise, brushes-center; interpole polarity ok
   d. if armature and brushes rotate in same direction--polarity is ok

20. The circuits which make up a shunt motor are:

   a. the armature, shunt field, and brushes
   b. shunt field, series field, and brushes
   c. series field and armature
   d. the shunt field and the armature

78.01.07.05

21. When a conductor is moved across the lines of force in a magnetic field, a voltage will be induced in the:

   a. conductor
   b. flux
   c. magnetic field
   d. force

22. What is the characteristic of a shunt generator?

   a. a large drop in voltage occurs as the load is decreased
   b. a slight drop in voltage occurs as the load is decreased
   c. a large drop in voltage occurs as the load is increased
   d. a slight drop in voltage occurs as the load is increased

23. If there is no load on a series generator, what will the voltage be?

   a. 220 V
   b. 110 V
   c. 0 V
   d. 440 V

78.01.07.05 (continued)

24. A wire moved to cut lines of magnetic force will produce:

a. mechanical energy
b. electromotive force
c. heat energy
d. static pressure

25. A moving coil in a generator is called:

a. a starting winding
b. a field winding
c. a magnetic force
d. an armature

78.01.07.06

26. D-C generators are rated in terms of:

a. horsepower
b. volts
c. kilowatts
d. amps

27. To discover the current output of a generator, the ammeter should be connected in:

a. series with the generator
b. series with the load
c. parallel with the load
d. parallel with the generator

28. If turns on series field are increased over the number necessary to give same voltage output at all load levels, the generator is said to be:

a. undercompounded
b. a shunt generator
c. flat-compounded
d. overcompounded

29. Direct current from a battery is used to:

a. energize the commutator
b. run the generator
c. keep the current flowing in the same direction
d. excite the field coil of a generator

78.01.07.06 (continued)

30. Generator voltage can be varied by using a resistor across the series field to vary the current through it. This is called a:

a. inverter
b. exciter
c. commutator
d. shunt

78.01.07.07

31. Solder in the inside of a D-C generator is caused by:

a. worn bearings
b. open field coils
c. armature over-heat
d. flat-compounded

32. If a generator has too much resistance in the field circuit, the generator will:

a. not generate
b. rotate
c. operate only slightly
d. operate normally

33. If a generator has too much resistance in its field circuit, the trouble may be:

a. shorted field coils
b. loose connections
c. bad bearings
d. grounded field coils

34. If a generator does not generate power, the trouble may be:

a. a loss of residual magnetism
b. an overload
c. a differential connection
d. too slow a speed

35. What would be the probable cause of a smoking D-C generator?

a. the wrong field connector
b. a completely shorted armature
c. a loss of residual magnetism
d. a bad bearing

78.01.07.08

36. If new brushes have been installed in a D-C generator, but they spark badly, the trouble may be:

    a. worn bearing
    b. the high and low bars on the commutator
    c. too much end play
    d. loose pole pieces

37. What could prevent sufficient current from flowing in the field coils of a generator?

    a. loss of residual magnetism
    b. wrong field connection
    c. faulty field rheostat
    d. wrong rotation

38. Why is it important to replace a D-C generators' brushes with replacements of the same type and size?

    a. severe sparking may result if brushes are different
    b. the generator will not operate at all
    c. the bearing will freeze up
    d. it is not necessary, any size and type can be used

39. If the voltage drops considerably as the load is placed on a generator, the trouble may be:

    a. loss of residual magnetism
    b. shorted armature
    c. too slow a speed
    d. wrong rotation

40. Which of the following should be used to determine the output in voltage that a generator puts out after it is repaired?

    a. berometer
    b. watt meter
    c. micrometer
    d. VOM

UNIT TEST ANSWER SHEET

UNIT PRETEST:
DIRECT-CURRENT MOTORS AND GENERATORS

Occupational Area: ____________
File Code: 78.01.07.00.A2-2
Name: ____________

ANSWERS

8.01.07.01	1.	D	78.01.07.05	21.	A	41.	
	2.	A		22.	D	42.	
	3.	B		23.	C	43.	
	4.	C		24.	B	44.	
	5.	A		25.	D	45.	
8.01.07.02	6.	C	78.01.07.06	26.	C	46.	
	7.	C		27.	B	47.	
	8.	C		28.	D	48.	
	9.	C		29.	D	49.	
	10.	C		30.	A	50.	
78.01.07.03	11.	A	78.01.07.07	31.	C	51.	
	12.	D		32.	A	52.	
	13.	A		33.	B	53.	
	14.	D		34.	A	54.	
	15.	A		35.	B	55.	
8.01.07.04	16.	A	78.01.07.08	36.	B	56.	
	17.	D		37.	C	57.	
	18.	D		38.	A	58.	
	19.	D		39.	B	59.	
	20.	D		40.	D	60.	

File Code: 78.01.07.01.A2-0

Date Published: 2-23-76

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Learning Activity Package

Student: ____________

Date: ____________

PERFORMANCE ACTIVITY: Operation of the Direct Current Motor

OBJECTIVE:

Describe the operation of D-C Motors.
Identify operational characteristics of D-C motors.

EVALUATION PROCEDURE:

Successful complete at least 80% of the items on a multiple-choice test about this LAP.

RESOURCES:

Electric Motor Repair, Robert Rosenberg, pages 203-204.
Introduction to Power Technology Principles of Electric Motors, Vega, pages 36-39.

PROCEDURE:

Steps

1. Carefully read pages 203-204 in Electric Motor Repair.
2. Study the illustration 7-1 - 7-14A.
3. Preview experiment #5 Universal Motors in Introduction to Power Technology, pages 36-39.
4. Write a description of the D-C motor operation using simple schematic diagrams.
5. Take the LAP test.

Principal Author(s): T. Ziller

Student: ______________ File Code: 78.01.07.01.A2-2

Date: ______________ Date Published: 12-23-74

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Glasgow AFB, Montana 59231

LAP TEST: OPERATION OF THE DIRECT-CURRENT MOTOR

78.01.07.01

1. Which of the following characteristics is the D-C series motor known for?

   a. continuous duty
   b. high maintenance cost
   c. high starting torque
   d. low cost

2. Which of the following D-C motors has a variable-speed characteristic?

   a. compound motor
   b. alternator motor
   c. shunt motor
   d. series motor

3. A series-shunt field and armature connection is characteristic of what type of motor?

   a. series motor
   b. compound motor
   c. shunt motor
   d. universal motor

4. In a D-C series motor, how are the field coils connected to the armature?

   a. no connection
   b. series
   c. parallel
   d. shunt

5. Which of the following components in a D-C shunt motor prevents a rise in speed?

   a. carbon brushes
   b. heavy shunt field
   c. light series field
   d. centrifugal switch

78.01.07.01 (continued)

6. Which of the following is characteristic of a D-C shunt motor?

   a. constant speed
   b. low speed
   c. variable speed
   d. high speed

7. Which D-C motor has high starting torque and constant speed?

   a. shunt motor
   b. series motor
   c. universal motor
   d. compound motor

8. Which of the following characteristics does a D-C series motor have?

   a. lighter load, lower speed
   b. low starting torque
   c. heavier load, higher speed
   d. variable speed

9. A stabilized shunt motor contains which of the following?

   a. a light series field
   b. variable field
   c. a heavy series field
   d. a rotor

10. A D-C series motor contains:

   a. stators
   b. solenoid
   c. rotors
   d. field coils

LAP TEST ANSWER KEY: 78.01.07.01.A2-2

OPERATION OF THE DIRECT-CURRENT MOTOR

1. C
2. D
3. B
4. B
5. B
6. A
7. D
8. D
9. A
10. D

File Code: 78.01.07.02.A2-0

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Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Learning Activity Package

Student: ____________________

Date: ____________________

PERFORMANCE ACTIVITY: Direct Current Motor Construction

OBJECTIVE:

Given the necessary tools, equipment, and supplies, correctly identify the main parts and disassemble a D-C motor according to: (1) manufacturer's specifications (2) following procedures and practices accepted in the industry, and (3) those procedures outlined in the reference text.

EVALUATION PROCEDURE:

Motor must be correctly disassembled; parts indentification must be 100% correctly labeled. Successfully complete at least 80% of the items on a multiple-choice test about this LAP.

pin punch
DC motor

RESOURCES:

D-C motor.
Electric Motor Repair, Robert Rosenberg, pages 202-203.
Checklist for Disassembly: D-C motors (attached).
Illustration: DC motor (attached).

PROCEDURE:

Steps

1. Review text reference, pages 202-203.
2. Have the instructor assign a work station where you will identify the main parts and complete the list of the main parts.
3. Follow the checklist for disassembly (attached).
4. Complete the multiple-choice test items for this LAP.

Principal Author(s): T. Ziller

CHECKLIST FOR DISASSEMBLY: D-C MOTORS

_________ 1. Mark end-bells and frame with pin-punch (re-assembly identification).

_________ 2. Remove retaining bolts (2).

_________ 3. Remove end-bells.

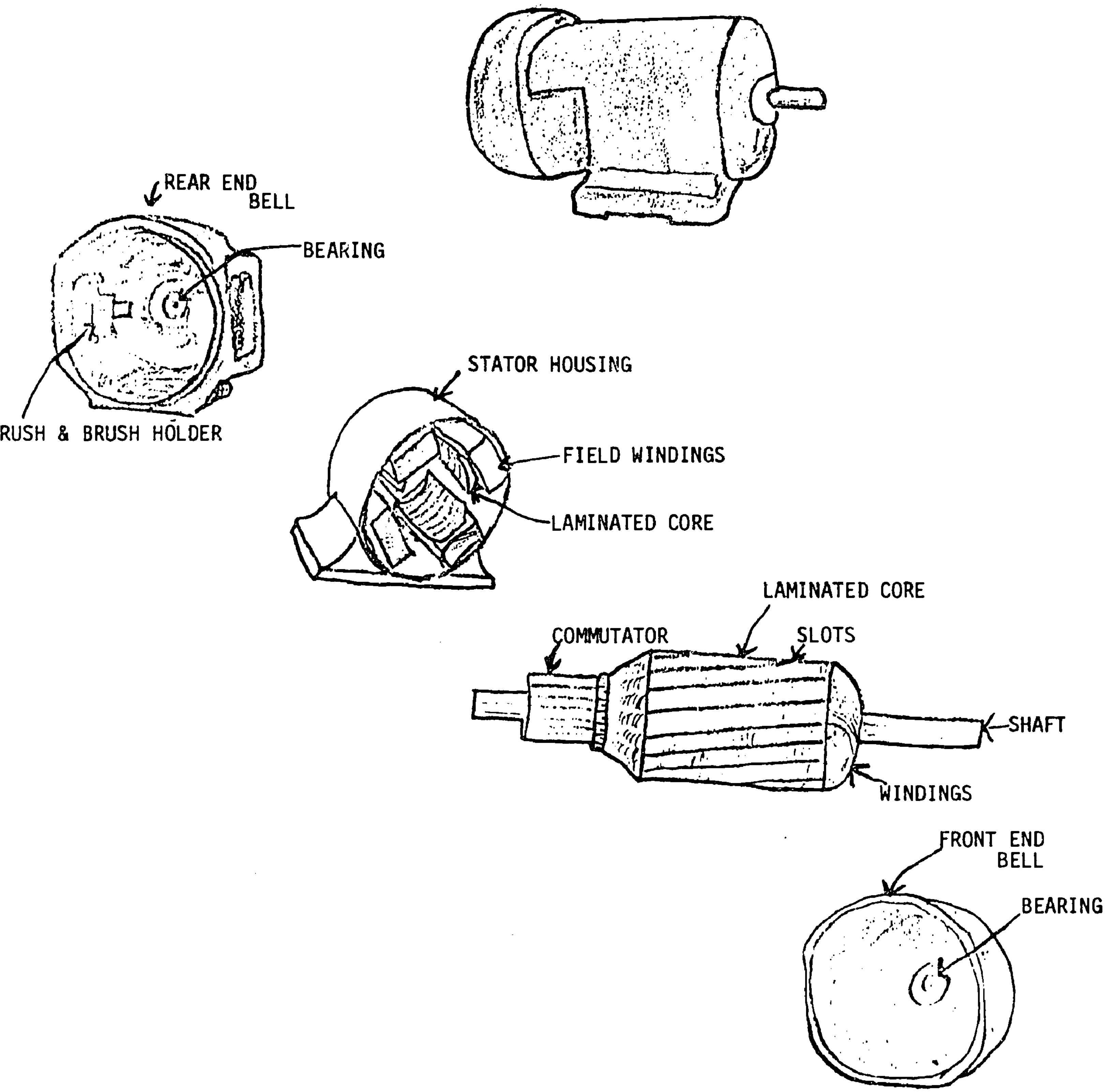
_________ 4. Lift brushes out of their holders.

_________ 5. Remove armature.

_________ 6. Unscrew pigtail connections and remove brushes.

_________ 7. Refer to attached exploded view.

D. C. MOTOR


REAR END BELL
BEARING
RUSH & BRUSH HOLDER
STATOR HOUSING
FIELD WINDINGS
LAMINATED CORE
LAMINATED CORE
COMMUTATOR
SLOTS
SHAFT
WINDINGS
FRONT END BELL
BEARING

Student: ____________________ File Code: 78.01.07.02.A2-2

Date: ____________________ Date Published: 12-23-74

Mountain-Plains Education & Economic Development Program, Inc.
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LAP TEST: DIRECT-CURRENT MOTOR CONSTRUCTION

78.01.07.02

1. What is the physical difference between a D-C motor and a D-C generator?

   a. different armatures
   b. weight
   c. none
   d. different fields

2. What type of slots are all armatures in a D-C construction motors equipped with?

   a. skewed only
   b. laminated
   c. straight only
   d. skewed or straight

3. What bears the weight of a D-C motors' armature and keeps it equidistant from the pole pieces?

   a. ball bearing
   b. end plates
   c. sleeve bearing
   d. end plates

4. In a D-C motor, the commutator is supplied with current:

   a. by allowing the brushes to ride on commutator up to certain speed
   b. by allowing the brushes to ride on the commutator while it's turning
   c. from the appropriate power source
   d. through the field coils

5. On a D-C motor, the end plates are secured to the frame with:

   a. screws
   b. clamps
   c. wire
   d. bolts

78.01.07.02 (continued)

6. In a D-C motor, the brushes are held stationary by the:

   a. brush holders
   b. brush rigging
   c. commutator
   d. end plates

7. On all D-C motors, current must be conducted to the armature winding through the:

   a. bearing
   b. end bells
   c. brush holders
   d. brushes

8. What is normally mounted inside the frame of a D-C motor?

   a. brush holder
   b. field poles
   c. end plates
   d. armature

9. On which part of a D-C motors' armature do the brushes ride?

   a. field coil
   b. armature coils
   c. brush holder
   d. commutator

10. On which portion of a D-C motor is the brush rigging usually mounted?

   a. front end plate
   b. back end plate
   c. armature shaft
   d. frame

LAP TEST ANSWER KEY: 78.01.07.02.A2-2

DIRECT-CURRENT MOTOR CONSTRUCTION

1. C
2. D
3. B
4. B
5. D
6. A
7. D
8. B
9. D
10. A

File Code: 78.01.07.03.A2-0

Date Published: 2-23-76

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Learning Activity Package

Student: ____________

Date: ____________

PERFORMANCE ACTIVITY: Troubleshooting Direct Current Motors

OBJECTIVE:

Given the necessary tools, equipment, and supplies, correctly troubleshoot DC motors according to: (1) manufacturer's specifications; (2) following procedures and practices accepted in the industry; and (3) those outlined in the reference text.

EVALUATION PROCEDURE:

Correct troubleshooting of a motor as determined by criteria on attached checklist. Successfully complete at least 80% of the items on a multiple-choice test about this LAP.

RESOURCES:

Electric Motor Repair, Robert Rosenberg, pages 210-226.
Checklist for troubleshooting: D-C Motor (attached).
D-C Motor.

PROCEDURE:

Steps

1. Review the reference text.
2. Go to the instructor and have him assign a work station and a D-C motor which you will troubleshoot.
3. Following the checklist described in the text, troubleshoot a D-C motor.
   NOTE: Follow safe practices and procedures at all times. Electricity is potentially dangerous.
4. Use the checklist as a general guide.
5. Take and score the LAP test.

Principal Author(s): T. Ziller

CHECKLIST FOR TROUBLESHOOTING: D.C. MOTORS

1. Make a thorough visual inspection.
2. Take a short test (Growler).
3. Take an open test (Ohmmeter) (Record value).
4. Connect fields to a low D.C. voltage.
5. Using a compass, check polarity.
6. Take a D.C. voltage reading (Voltmeter) (Record value).
7. Take a current reading (Amprobe or Ammeter) (Record value).
8. Disconnect power.
9. Compare values with manufacturer's specifications or name plate.

Student: ______________ File Code: 78.01.07.03.A2-2

Date: ______________ Date Published: 12-26-74

Mountain-Plains Education &
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Glasgow AFB, Montana 59231

LAP TEST: TROUBLESHOOTING DIRECT-CURRENT MOTORS

78.01.07.03

1. In a two-pole D-C shunt motor the shunt fields are connected in:

   a. series
   b. tandem
   c. unison
   d. parallel

2. In a D-C compound motor, if the current flows through the series-field and shunt-field coils of a pole in the same direction, and the shunt field is connected across the line, is known as a:

   a. long-shunt cumulative motor
   b. short-shunt cumulative motor
   c. long-shunt differential motor
   d. short-shunt differential motor

3. If the shunt field is connected to armature so current flows through in opposite direction to series current, the D-C compound motor is known as a:

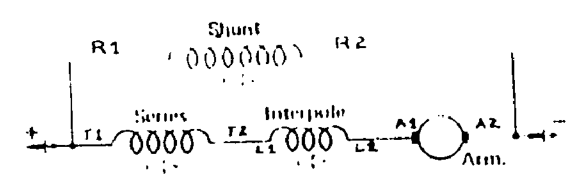
   a. short-shunt differential motor
   b. long-shunt differential motor
   c. long-shunt cumulative motor
   d. short-shunt cumulative motor

4. In a long shunt cumulative motor, the current flows through the series field and shunt-field coils of a pole in the:

   a. shunt direction
   b. opposite direction
   c. series direction
   d. same direction

5. To reverse the rotation of a D-C two-pole compound-interpole motor, reverse wires:

   a. R1 and R2
   b. T1 and T2
   c. A1 and A2
   d. L1 and L2



78.01.07.03 (continued)

6. On a four-pole, compound-interpole motor, if the leads on the brushholder are reversed, it will cause:

   a. the motor to stop
   b. the motor to operate correctly
   c. the interpoles to overload
   d. the brushes to spark

7. Nearly all shunt and compound D-C motors of one-half horsepower or more have commutating poles known as:

   a. shunt-poles
   b. interpoles
   c. anterpoles
   d. series-poles

8. In a D-C compound motor, the shunt fields are connected in:

   a. unison
   b. tandem
   c. series
   d. parallel

9. If the shunt field is connected across the armature so that the current flows through it in same direction as the series field, the D-C motor is known as a:

   a. long-shunt cumulative motor
   b. short-shunt differential motor
   c. long-shunt differential motor
   d. short-shunt cumulative motor

10. When the shunt field of a D-C compound motor is connected to the armature terminals instead of across the line, the motor is known as a:

    a. short-series motor
    b. long-shunt motor
    c. long-series motor
    d. short-shunt motor

LAP TEST ANSWER KEY: 78.01.07.03.A2-2

TROUBLESHOOTING DIRECT-CURRENT MOTORS

1. A
2. A
3. A
4. D
5. C
6. D
7. B
8. C
9. D
10. D

File Code: 78.01.07.04.A2-0

Date Published: 2-23-76

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Learning Activity Package

Student: ____________________

Date: ____________________

PERFORMANCE ACTIVITY: Repairing Direct Current Motors

OBJECTIVE:

Given the necessary tools, equipment, and supplies, correctly repair D-C motors according to: (1) manufacturer's specifications; (2) following procedures and practices accepted in the industry; and (3) those outlined in the reference text.

EVALUATION PROCEDURE:

Correctly reapir a motor as determined by criteria on attached checklist. Successfully complete at least 80% on the items on a multiple-choice test about this LAP.

RESOURCES:

Electric Motor Repair, Robert Rosenberg, pages 210-226.
Checklist for Repair: D-C Motors.
D-C Motor.

light machine oil
varnish

PROCEDURE:

Steps

1. Review the reference text.
2. Go to the instructor and have him assign a work station and a D-C motor which you will repair.
3. Following the procedure described in the text, repair a D-C motor.
   NOTE: Follow safe practices and procedures at all times. Electricity is potentially dangerous.
4. Use the attached checklist as a general guide.
5. Complete the multiple-choice test items for this LAP.

Principal Author(s): T. Ziller

CHECKLIST FOR REPAIR: D-C MOTOR

Service

1. Lubricate bearings. (light machine oil)
2. Insure that motor is not filled with lint or dirt.
3. Check for free rotation of shaft.

Repair

1. Using proper tools, remove bad bearings.
2. Replace bearing.
3. Lubricate new bearing.

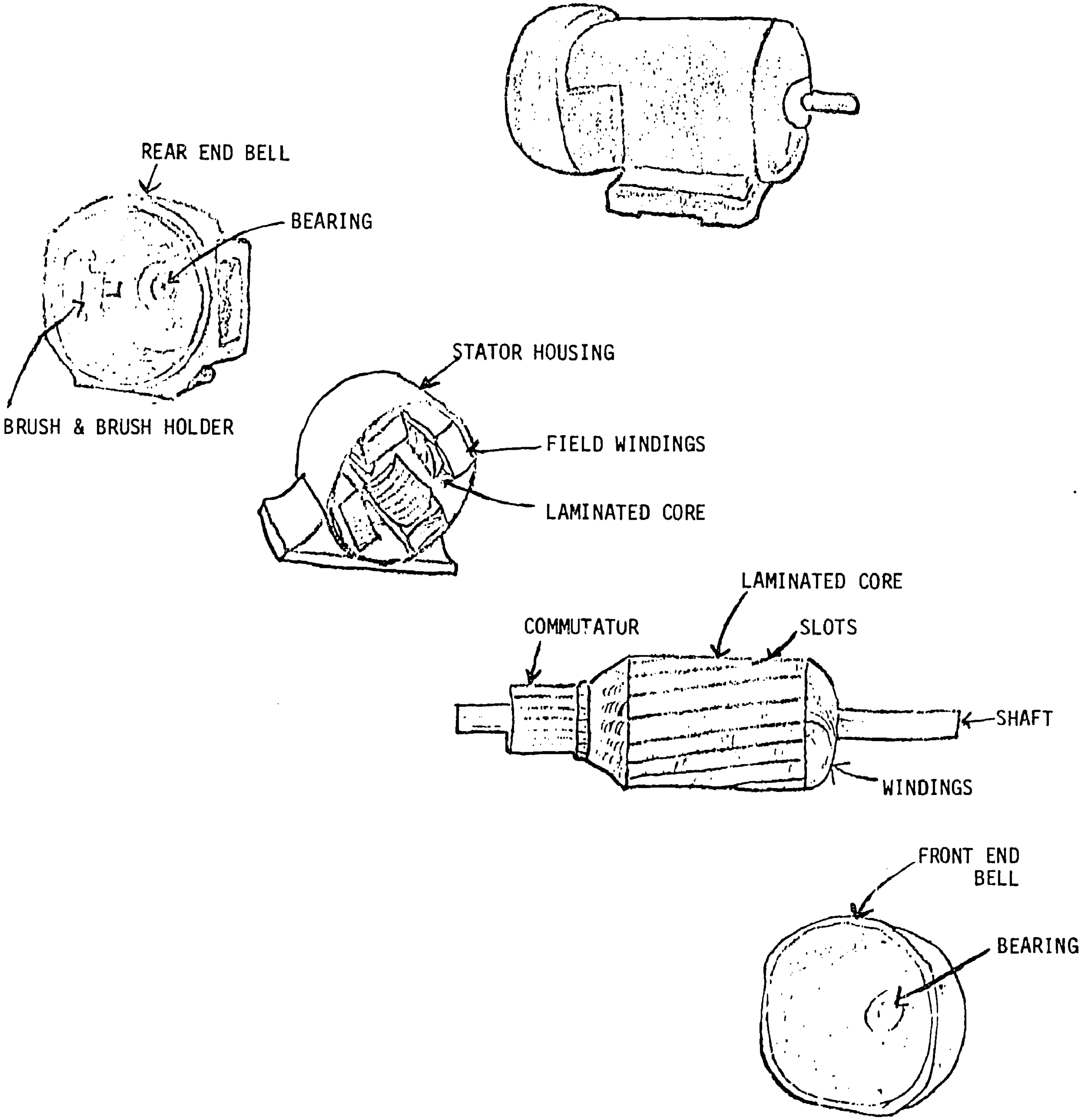
Rewinding

1. Strip the stator.
2. Check for correct size of magnetic wire.
3. Fit paper insulation in stator. (see instructor when completed)
4. Rewind motor using the form winding method.
5. Splice and connect leads. (see instructor when completed)
6. Test new winding with proper test equipment.
7. Dip stator in varnish.
8. Reassemble the motor.
9. Connect motor to power source.

Reassembly

1. Gently set rotor inside stator.
2. Align end bells.
3. Insert bolts and tighten.
4. Connect motor to power source.
5. Refer to exploded view.

D. C. MOTOR


REAR END BELL
BEARING
BRUSH & BRUSH HOLDER
STATOR HOUSING
FIELD WINDINGS
LAMINATED CORE
LAMINATED CORE
COMMUTATUR
SLOTS
SHAFT
WINDINGS
FRONT END BELL
BEARING

Student: ____________ File Code: 78.01.07.04.A2-2

Date: ____________ Date Published: 12-26-74

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

LAP TEST: REPAIRING DIRECT-CURRENT MOTORS

78.01.07.04

1. If a D-C motor fails to run when the switch is turned on, the trouble may be:

   a. the wrong voltage applied
   b. an open armature circuit
   c. a dirty commutator
   d. off-set brushes

2. If a ground has been discovered in the shunt field of a D-C motor, the repairman should:

   a. check for the correct position of the brush holder
   b. remove the field from the frame and rewind the coils
   c. remove the armature
   d. remove the field from the frame and reinsulate

3. How many circuits are in a shunt motor?

   a. 4
   b. 1
   c. 3
   d. 2

4. Why does the NECR require that all permanently installed D-C motors be grounded to a pipeline which is connected to the earth?

   a. it has nothing to do with motor operation
   b. it adds cost to the overall installation
   c. it causes the motor to burn open
   d. if not properly grounded, the operator may be severely shocked

5. The circuits which make up a shunt motor are:

   a. the shunt field and the armature
   b. series field and armature
   c. the armature, shunt field, and brushes
   d. shunt field, series field, and brushes

78.01.07.04 (continued)

6. If a D-C motor runs slowly, the trouble might be:

   a. shorted coils
   b. wrong interpole polarity
   c. worn bearings
   d. grounded coils

7. If a ground has been discovered in the series fields of a D-C motor, the repairman should:

   a. remove the armature
   b. check for the correct position of the brush holders
   c. remove the fields from the frame and reinsulate
   d. remove the fields from the frame and rewind the coils

8. What must be done before a test lamp is used on a D-C motor to check for a ground in the field winding?

   a. remove the brushes
   b. remove the armature from the stator
   c. disconnect the field coils
   d. disconnect all external leads

9. If a D-C motor sparks badly, the trouble may be:

   a. poor brush contact on the commutator
   b. tight bearings
   c. an overload
   d. shorted field coils

10. Which of the following can one use to check for correct interpole polarity without using a compass or removing the armature?

   a. if armature and brushes rotate in same direction-polarity is ok
   b. if armature and brushes rotate in oppostie direction-polarity ok
   c. armature-counterclockwise, brushes/center--interpole polarity ok
   d. armature-clockwise, brushes-center; interpole polarity ok

LAP TEST ANSWER KEY: 78.01.07.04.A2-2

REPAIRING DIRECT-CURRENT MOTORS

1. B
2. D
3. D
4. D
5. A
6. C
7. C
8. D
9. A
10. A

File Code: 78.01.07.05.A2-0

Date Published: 2-23-76

Mountain-Plains Education &
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Glasgow AFB, Montana 59231

Learning Activity Package

Student: ______________

Date: ______________

PERFORMANCE ACTIVITY: Operation of the Generator

OBJECTIVE:

Describe the operation of D-C generators.
Identify the operational characteristics of a D-C generator.

EVALUATION PROCEDURE:

Successfully complete at least 80% of the items on a multiple-choice test about this LAP.

RESOURCES:

Electric Motor Repair, Robert Rosenberg, pages 273-279.
D-C Generator (functional).
Introduction to Power Technology Principles of Electric Motors, Vega, pages 36-39.

PROCEDURE:

Steps

1. Read pages 273-279 in Electric Motor Repair.
2. Go to the assigned work station and observe the actual operation of a D-C generator.
3. Complete operational checklist and write a description on the operation of a D-C generator.
4. Review experiment #5 , Universal Motors in Introduction to Power Technology, pages 36-39.
5. Take the LAP test.

Principal Author(s): T. Miller

OPERATIONAL CHECKLIST FOR GENERATORS

_______ 1. Drive by mechanical means. Smaller generators are usually belt-driven.

_______ 2. D-C generator armature and field poles are identical to D-C motor armature and field poles.

_______ 3. In a D-C generator as the armature is rotated, the conductors (armature coils) cut through magnetic lines of force (caused by applying voltage to the field poles). As the armature coils continue to cut the lines of force, current flows in the armature coils. This process is known as electro-magnetic induction and always occurs under these conditions.

_______ 4. The induced current in the armature coils is called alternating current (A-C), because it flows back and forth through the coils as the armature rotates through the north and south magnetic poles of the field.

_______ 5. Direct current (D-C) is obtained from the brushes riding on the commutator.

_______ 6. The commutator is a series of metal wedges directly connected to the armature coils. The commutator rotates with the armature.

_______ 7. The two brushes are positioned on the commutator in such a way that the current flows through them alternately (one at a time) and so flows in one direction only. (D-C). The brushes are electrically connected only on every other commutator wedge.

Student: ______________________ File Code: 78.01.07.05.A2-2

Date: ______________________ Date Published: 12/23/74

Mountain-Plains Education & Economic Development Program, Inc.
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LAP TEST: OPERATION OF THE GENERATOR

1. When is a generator said to be separately excited?

   a. when the field coils are connected to an outside source of electricity
   b. 110 v.
   c. when the commutator is connected to an outside source of electricity
   d. when the armature is connected to a battery

2. How many types of self-excited generators are there?

   a. 4
   b. 1
   c. 2
   d. 3

3. When a conductor is moved across the lines of force in a magnetic field, a voltage will be induced in the:

   a. conductor.
   b. flux.
   c. magnetic field.
   d. force.

4. What is the characteristic of a shunt generator?

   a. A large drop in voltage occurs as the load is decreased.
   b. A slight drop in voltage occurs as the load is decreased.
   c. A large drop in voltage occurs as the load is increased.
   d. A slight drop in voltage occurs as the load is increased.

5. If there is no load on a series generator, what will the voltage be?

   a. 220 v.
   b. 110 v.
   c. 0 v.
   d. 440 v.

6. What are the three factors needed to generate electricity?

   a. electricity, mechanical power, and a conductor
   b. mechanical power, movement, and a generator
   c. magnetic lines of force, a conductor, and movement
   d. a motor, generator, and movement

7. A diverter in a compound generator varies the:

   a. voltage drop.
   b. current.
   c. resistance.
   d. capacitance.

8. A machine converting mechanical energy into electrical energy is called a(n):

   a. starter.
   b. motor.
   c. generator.
   d. engine.

9. A wire moved to cut lines of magnetic force will produce:

   a. heat energy.
   b. mechanical energy.
   c. electromotive force.
   d. static pressure.

10. A moving coil in a generator is called a(n):

   a. armature.
   b. field winding.
   c. magnetic force.
   d. starting winding.

LAP TEST ANSWER KEY: OPERATION OF THE GENERATOR

1. A
2. D
3. A
4. D
5. C
6. C
7. B
8. C
9. C
10. A

File Code: 78.01.07.06.A2-0

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Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Learning Activity Package

Student: ______________________

Date: ______________________

PERFORMANCE ACTIVITY: Generator Construction

OBJECTIVE:

Identify the component parts of generator.

EVALUATION PROCEDURE:

The student is to identify by labeling the component parts that is consistent with the attached checklist. Also score at least 80% on a multiple-choice test.

RESOURCES:

Electric Motor Repair, Robert Rosenberg, pages 273-279.
Checklist for Disassembly: Generators. (attached)

PROCEDURE:

Steps

1. Review reference text, pages 273-279.
2. Follow the checklist for disassembly. (Attached)
3. Complete the multiple-choice test items for this LAP.

Principal Author(s): T. Ziller

CHECKLIST FOR DISASSEMBLY: GENERATORS

_______ 1. Remove brushes with proper hand tools.

_______ 2. Mark stator and end bell.

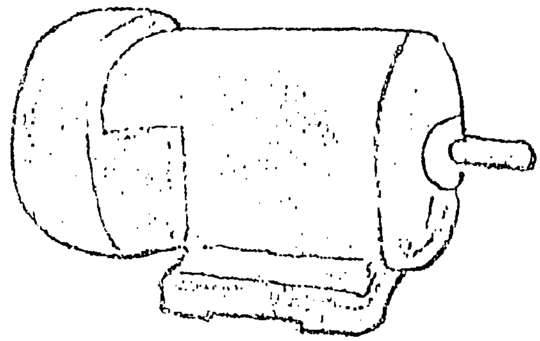
_______ 3. Using proper hand tools, remove nuts and bolts (Don't lose nuts and bolts).

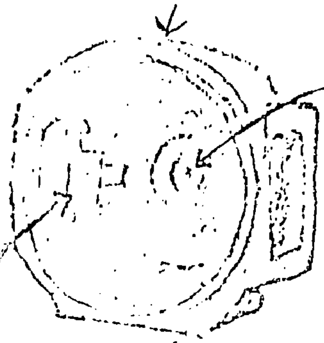
_______ 4. Remove end bells from stator.

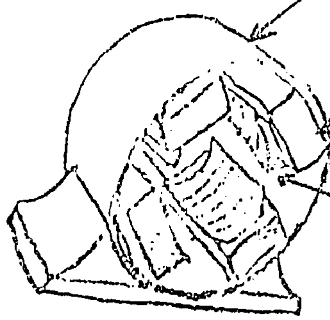
_______ 5. Gently slip armature from laminated core.

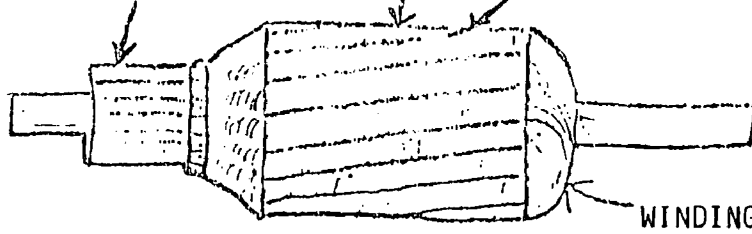
_______ 6. Refer to the attached exploded view.

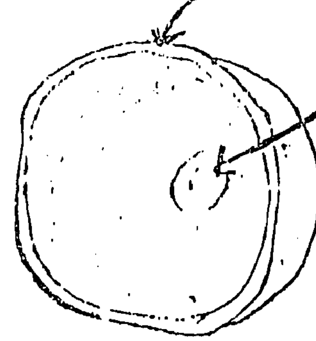
D. C. MOTOR AND GENERATOR











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LAP TEST: GENERATOR CONSTRUCTION

1. D-C generators are rated in terms of:

   a. horsepower.
   b. volts.
   c. kilowatts.
   d. amps.

2. To discover the current output of a generator, the ammeter should be connected in:

   a. a series with the generator.
   b. series with the load.
   c. parallel with the load.
   d. parallel with the generator.

3. If turns on series field are increased over the number necessary to give same voltage output at all load levels, the generator is said to be:

   a. undercompounded.
   b. a shunt generator.
   c. flat-compounded.
   d. overcompounded.

4. Three types of compound generators can be obtained by:

   a. adding more batteries to the exciter field.
   b. changing the number of turns in the series field.
   c. adding more interpoles.
   d. using bigger brushes.

5. Generator voltage can be varied by using a resistor across the series field to vary the current through it. This is called a:

   a. exciter.
   b. diverter.
   c. commutator.
   d. shunt.

6. The direct current generator is constructed similar to the:

   a. D-C motor.
   b. split phase motor.
   c. three phase motor.
   d. shaded pole motor.

7. Permanent gnets are used in generators to:

   a. produce lines of force necessary to generate electricity.
   b. produce voltage in electricity.
   c. hold the commutator.
   d. demagnetize the brushes.

8. Direct current from a battery is used to:

   a. keep the current flowing in the same direction.
   b. run the generator.
   c. excite the field coils of a generator.
   d. energize the commutator.

9. The generator wired so the armature fields and load are connected together is:

   a. permanent magnet generator.
   b. battery excited generator.
   c. separately excited generator.
   d. the series generator.

10. A coil of wire wound around a steel core and rotated in a magnetic field is called:

    a. the starter.
    b. the commutator.
    c. the conductor.
    d. the armature.

LAP TEST ANSWER KEY: GENERATOR CONSTRUCTION

1. C
2. B
3. D
4. B
5. B
6. A
7. A
8. C
9. D
10. D

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Date Published: 2-23-76

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Learning Activity Package

Student: ____________________

Date: ____________________

PERFORMANCE ACTIVITY: Troubleshooting Generators

OBJECTIVE:

Given the necessary tools, equipment, and supplies, correctly troubleshoot a generator according to: (1) manufacturer's specifications; (2) following procedures and practices accepted in the industry; and (3) those outlined in the reference text.

EVALUATION PROCEDURE:

Correct troubleshooting of a generator as determined by criteria on attached checklist. Successfully complete at least 80% of the items on a multiple-choice test about this LAP.

RESOURCES:

Electric Motor Repair, Robert Rosenberg, pages 279-280.
Checklist for Troubleshooting: Generators
D-C Generator.

Compass
Growler
Ohmmeter
Amprobe or Ammeter

PROCEDURE:

Steps

1. Review the reference text.
2. Go to the instructor and have him assign a work station and a D-C generator which you will troubleshoot.
3. Following the procedure described in the text, troubleshoot a D-C generator.
   NOTE: Follow safe practices and procedures at all times. Electricity is potentially dangerous.
4. Use the attached checklist as a general guideline.
5. Complete the multiple-choice test items for this LAP.

Principal Author(s): T. Ziller

CHECKLIST FOR TROUBLESHOOTING: GENERATORS

1. Make a thorough visual inspection.
2. Take a shorts test (Growler).
3. Take an open test (Ohmmeter) (Record values).
4. Connect fields to a low D.C. voltage.
5. Using a compass, check polarity.
6. Take an AC voltage reading (Voltmeter) (Record value).
7. Take a currect reading (Amprobe or Ammeter) (Record values).
8. Disconnect power.
9. Compare values with manufacturer's specifications or name plate.

Student: ____________ File Code: 78.01.07.07.A2-2

Date: ____________ Date Published: 12/23/74

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

LAP TEST: TROUBLESHOOTING GENERATORS

1. Solder in the inside of a D-C generator is caused by:

   a. worn bearings.
   b. open field coils.
   c. armature over-heat.
   d. flat-compounded.

2. If a generator has too much resistance in the field circuit, the generator will:

   a. not generate.
   b. rotate.
   c. operate only slightly.
   d. operate normally.

3. If a generator has too much resistance in its field circuit, the trouble may be:

   a. shorted field coils.
   b. loose connections.
   c. bad bearings.
   d. grounded field coils.

4. If a generator does not generate power, the trouble may be:

   a. a loss of residual magnetism.
   b. an overload.
   c. a differential connection.
   d. too slow a speed.

5. What would be the probable cause of a smoking D-C generator?

   a. the wrong field connection
   b. a completely shorted armature
   c. a loss of residual magnetism
   d. a bad bearing

6. Why would a wrong field connection result in a non-operational generator?

   a. The lines of force would be produced opposite of the residual lines.
   b. The armature would short and burn.
   c. A high resistance force would be created.
   d. The lines of force would be produced in the direction of the flux.

7. How is continuity of a field checked in a generator?

   a. use an ohmmeter
   b. use a manometer
   c. use a velocity meter
   d. use a ampmeter

8. If a generator does not produce current flow, what is a possible cause?

   a. field winding are not producing parallel lines of magnetic force
   b. arching brushes
   c. shorted armature
   d. flux lines are being broken

9. If a generator does not generate, what is the possible cause?

   a. loss of residual magnetism
   b. arching brushes
   c. partially shorted armature
   d. partially shorted field windings

10. Which of the following should you troubleshoot like a D-C generator?

   a. A-C shaded pole motor
   b. D-C motor
   c. A-C split phase motor
   d. A-C repulsion motor

LAP TEST ANSWER KEY: TROUBLESHOOTING GENERATORS

1. C
2. A
3. B
4. A
5. B
6. A
7. A
8. C
9. A
10. B

File Code: 78.01.07.08.A2-0

Date Published: 2-23-76

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Learning Activity Package

Student: ______________________

Date: ______________________

PERFORMANCE ACTIVITY: Repairing Generators

OBJECTIVE:

Given the necessary tools, equipment, and supplies, correctly repair a generator according to: (1) manufacturer's specifications; (2) following procedures and practices accepted in the industry; and (3) those outlined in the reference text.

EVALUATION PROCEDURE:

Correctly repair a generator as determined by criteria on attached checklist. Successfully complete at least 80% of the items on a multiple-choice test about this LAP.

RESOURCES:

Electric Motor Repair, Robert Rosenberg, pages 279-280.
Checklist for Repair: Generators

light machine oil
varnish

PROCEDURE:

Steps

1. Review the reference text.
2. Go to the instructor and have him assign a work station and a generator which you will repair.
3. Following the procedure described in the text, repair a generator.
   NOTE: Follow safe practices and procedures at all times. Electricity is potentially dangerous.
4. Use the attached checklist as a general guideline in repairing generators.
5. Complete the multiple-choice test items for this LAP.

Principal Author(s): T. Ziller

CHECKLIST FOR REPAIR: GENERATORS.

Service

1. Lubricate bearings. (light machine oil).
2. Insure that motor is not filled with lint or dirt.
3. Check for free rotation of shaft.

Repair

1. Using proper tools, remove bad bearings.
2. Replace bearing.
3. Lubricate new bearing.

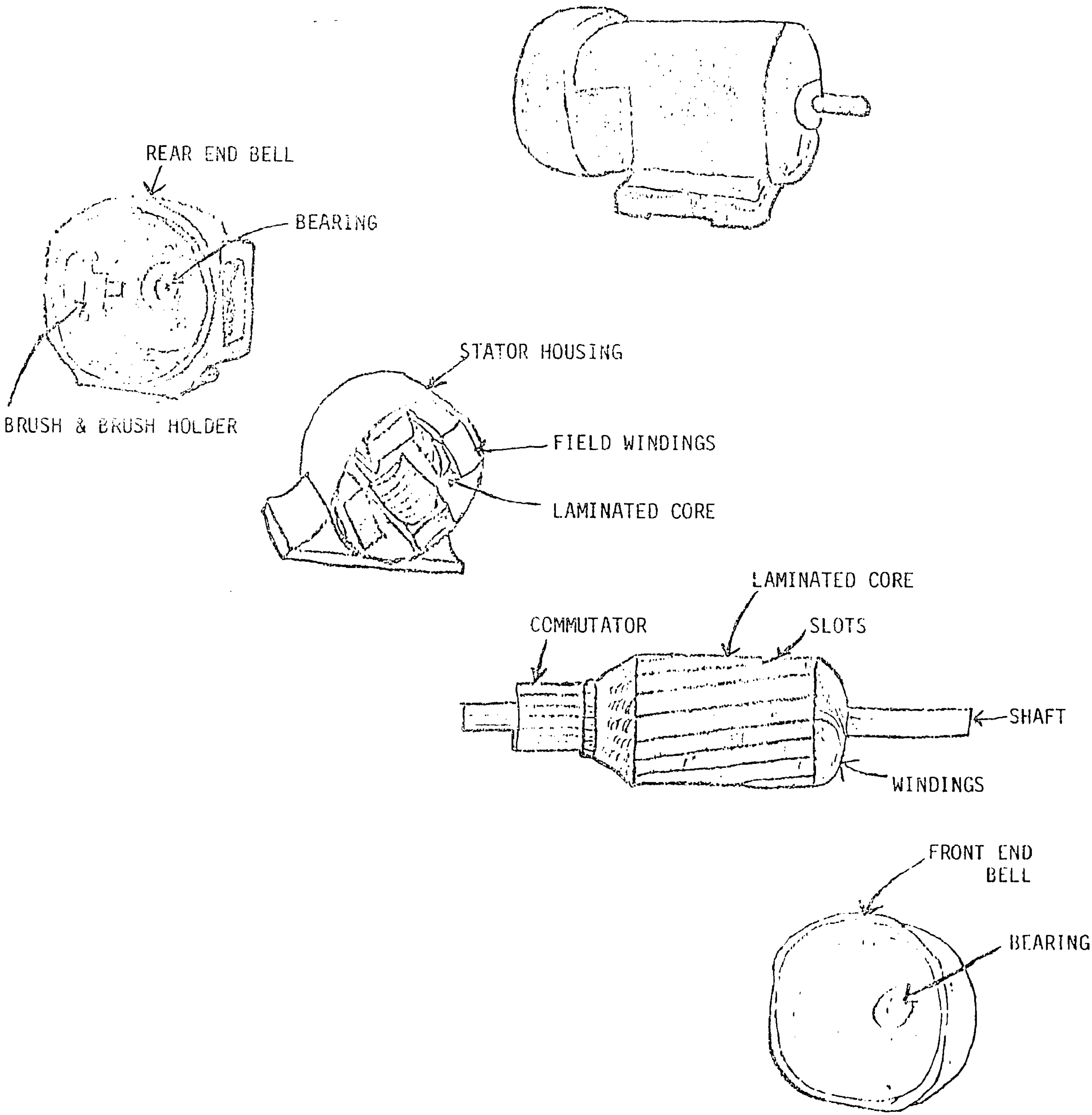
Rewinding

1. Strip the stator.
2. Check for correct size of magnetic wire.
3. Fit paper insulation in stator. (See instructor when completed).
4. Rewind motor using the form winding method.
5. Splice and connect leads. (See instructor when completed).
6. Test new winding with proper test equipment.
7. Dip stator in varnish.
8. Reassemble the motor.
9. Connect motor to power source.

Reassembly

1. Gently [illegible] rotor inside stator.
2. Align end bells.
3. Insert bolts and tighten.
4. Connect motor to power source.
5. Refer to exploded view.

GENERATOR


REAR END BELL
BEARING
BRUSH & BRUSH HOLDER
STATOR HOUSING
FIELD WINDINGS
LAMINATED CORE
LAMINATED CORE
COMMUTATOR
SLOTS
SHAFT
WINDINGS
FRONT END BELL
BEARING

Student: ____________________ File Code: 78.01.07.08.A2-2

Date: ____________________ Date Published: 12/23/74

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

LAP TEST: REPAIRING GENERATORS

1. If new brushes have been installed in a D-C generator, but they spark badly, the trouble may be:

   a. worn bearings.
   b. the high and low bars on the commutator.
   c. too much end play.
   d. loose pole pieces.

2. What could prevent sufficient current from flowing in the field coils of a generator?

   a. loss of residual magnetism
   b. wrong field connection
   c. faulty field rheostat
   d. wrong rotation

3. If the voltage drops considerably as the load is placed on a generator, the trouble may be:

   a. loss of residual magnetism.
   b. shorted armature.
   c. too slow a speed.
   d. wrong rotation.

4. Which of the following should be used to determine the output in voltage that a generator puts out after it is repaired?

   a. barometer
   b. watt meter
   c. micrometer
   d. VOM

5. If a field winding does not seem to be functioning properly, which of the following instruments should be used to determine the flow of current?

   a. ampmeter
   b. velocity meter
   c. barometer
   d. pryrometer

6. If after repairing a generator you find it turns the wrong direction, what should you do?

   a. rewind the generator
   b. change shunt field leads
   c. check the generator with a VOM
   d. turn the armature around

7. Where is the neutral point in an interpole generator found?

   a. at the center of the interpole winding
   b. directly under the center of the interpole
   c. at the center of armature shaft
   d. at the center of the commutator

8. If after repairing a generator the voltage does not build up, what is a possible cause?

   a. the case is shorted out
   b. bad bearings
   c. brushes are the wrong type
   d. resistance in the field circuit

9. If after repairing a generator you find only a low voltage will develop, which of the following may be the cause?

   a. bad brushes
   b. shorted armature
   c. bad bearings
   d. field windings connected improperly

10. If after repairing a generator you discover that no voltage is produced, what has happened to the magnetic lines of flux in the generator?

   a. they are not the cause of the problem
   b. they are running opposite to the residual lines of flux
   c. they are not being broken
   d. they are intersecting the residual lines at 45^{o}

LAP TEST ANSWER KEY: REPAIRING GENERATORS

1. B
2. C
3. B
4. D
5. A
6. B
7. B
8. D
9. B
10. C

Student: ____________ File Code: 78.01.07.00.B2-2

Date: ____________ Date Published: 1/27/76

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

UNIT POST TEST: DIRECT CURRENT MOTORS AND GENERATORS

78.01.07.01

1. What is the first step in disassembling a D-C motor?

   a. remove the retaining bolts
   b. mark the end bells and frame with a pin punch
   c. lift the brushes out of their holders
   d. unscrew the pigtail connections and remove the brushes

2. On which portion of a D-C motor is the brush rigging usually mounted?

   a. on the frame
   b. on the armature shaft
   c. on the back end plate
   d. on the front end plate

3. The sizes of D-C motors vary from:

   a. 1 Hp to 5 HP
   b. 1/20 HP to 10 HP
   c. 1/10 HP to 1/100 HP
   d. 1/100 HP to thousands of horse power

4. In a D-C motor, the commutator is supplied with current:

   a. by allowing the brushes to ride on the commutator while it's turning
   b. through the field coils
   c. from the appropriate power source
   d. by allowing the brushes to ride on commutator up to certain speed

5. On which part of a D-C motors' armature do the brushes ride?

   a. on the field coil
   b. on the armature coils
   c. on the brush holder
   d. on the commutator

78.01.07.02

6. A stabilized shunt motor contains which of the following?

   a. a rotor
   b. a light series field
   c. variable field
   d. a heavy series field

7. Which of the following characteristics does a D-C series motor have?

   a. lighter load, lower speed
   b. variable speed
   c. low starting torque
   d. heavier load, higher speed

8. Which of the following is characteristic of a D-C shunt motor?

   a. constant speed
   b. low speed
   c. variable speed
   d. high speed

9. Which of the following components in a D-C shunt motor prevents a rise in speed?

   a. light series field
   b. carbon brushes
   c. heavy shunt field
   d. centrifugal switch

10. A series-shunt field and armature connection is characteristic of what type of motor?

   a. shunt motor
   b. series motor
   c. universal motor
   d. compound motor

78.01.07.03

11. In a D-C compound motor: if the current flows through the series-field and shunt-field coils of a pole in the same direction, and the shunt-field is connected across the line, this is known as a:

   a. long-shunt cumulative motor
   b. short-shunt cumulative motor
   c. long-shunt differential motor
   d. short-shunt differential motor

78.01.07.03 (continued)

12. In a two-pole D-C shunt motor the shunt fields are connected in:

    a. parallel
    b. series
    c. tandem
    d. unison

13. If a shunt field is connected across the line so that the series and shunt fields have opposite polarity in same pole, the D-C compound motor is known as a:

    a. short-shunt differential motor
    b. lone-shunt differential motor
    c. long-shunt cumulative motor
    d. short-shunt cumulative motor

14. To reverse the rotation of a D-C series motor, all that is necessary is to interchange the leads on the:

    a. brushes
    b. stator
    c. armature
    d. terminal block

15. In a cumulative D-C motor, when the shunt field is connected across the line, it is given the name of:

    a. short series
    b. long series
    c. short shunt
    d. long shunt

78.01.07.04

16. If a D-C motor runs slowly, the trouble might be:

    a. shorted coils
    b. grounded coils
    c. wrong interpole polarity
    d. worn bearings

17. How many circuits are in a shunt motor?

    a. 2
    b. 3
    c. 4
    d. 1

78.01.07.04 (continued)

18. What must be done before a test lamp is used on a D-C motor to check for a ground in the field winding?

    a. remove the armature from the stator
    b. remove the brushes
    c. disconnect the field coils
    d. disconnect all external leads

19. In a D-C motor, if a bare wire touches the laminated pole, the motor is said to be:

    a. shorted
    b. interpoled
    c. open
    d. grounded

20. Why does the NECR require that all permanently installed D-C motors be grounded to a pipeline which is connected to the earth?

    a. it has nothing to do with motor operation
    b. it adds cost to the overall installation
    c. if not properly grounded, the operator may be severely shocked
    d. it causes the motor to burn open

78.01.07.05

21. A machine converting mechanical energy into electrical energy is called a (n):

    a. starter
    b. motor
    c. generator
    d. engine

22. A wire moved to cut lines of magnetic force will produce:

    a. heat energy
    b. mechanical energy
    c. electromotive force
    d. static pressure

23. A moving coil in a generator is called a (n):

    a. field winding
    b. armature
    c. magnetic force
    d. starting winding

78.01.07.05 (continued)

24. The mechanical device used to reverse the connections to the revolving conductors is called a (n):

    a. brushes
    b. field winding
    c. armature
    d. commutator

25. What are the three factors needed to generate electricity?

    a. electricity, mechanical power and a conductor
    b. mechanical power, movement, and a generator
    c. magnetic lines of force, a conductor, and movement
    d. a motor, generator, and movement

78.01.07.06

26. Three types of compound generators can be obtained by:

    a. changing the number of turns in the series field
    b. adding more batteries to the exciter field
    c. adding more interpoles
    d. using bigger brushes

27. Generator voltage can be varied by using a resistor across the series field to vary the current through it. This is called a:

    a. exciter
    b. diverter
    c. commutator
    d. shunt

28. The direct current generator is constructed similar to the:

    a. split-phase motor
    b. D-C motor
    c. three-phase motor
    d. shaded pole motor

29. Permanent magnets are used in generators to:

    a. demagnatize the brushes
    b. produce voltage in electricity
    c. hold the commutator
    d. produce lines of force necessary to generate electricity

78.01.07.06 (continued)

30. Direct current from a battery is used to:

  a. excite the field coils of a generator
  b. run the generator
  c. keep the current flowing in the same direction
  d. energize the commutator

78.01.07.07

31. How is continuity of a field checked in a generator?

  a. use a ampmeter
  b. use a manometer
  c. use a velocity meter
  d. use an ohmmeter

32. If a generator does not produce current flow, what is a possible cause?

  a. flux lines are being broken
  b. arching brushes
  c. field winding are not producing parallel lines of magnetic force
  d. shorted armature

33. If a generator does not generate, what is the possible cause?

  a. arching brushes
  b. loss of residual magnatism
  c. partially shorted armature
  d. partially shorted field windings

34. Which of the following should you trouble shoot like a D-C generator?

  a. A-C shaded pole motor
  b. D-C motor
  c. A-C split phase motor
  d. A-C repulsion motor

35. Why would a wrong field connection result in a non-operational generator?

  a. a high resistance force would be created
  b. the armature would short and burn
  c. the lines of force would be produced opposite of the residual lines
  d. the lines of force would be produced in the direction of the flux

78.01.07.08

36. If after repairing a generator the voltage does not build up, what is a possible cause?

    a. the case is shorted out
    b. bad bearings
    c. brushes are the wrong type
    d. resistance in the field circuit

37. If after repairing a generator you find only a low voltage will develop, which of the following may be the cause?

    a. bad bearings
    b. bad brushes
    c. shorted armature
    d. field windings connected imporperly

38. If after repairing a generator you discover that no voltage is produced, what has happened to the magnetic lines of flux in the generator?

    a. they are not being broken
    b. they are running opposite to the residual lines of flux
    c. they are not the cause of the problem
    d. they are intersecting the residual lines at 45 degrees

39. If the field winding does not seem to be functioning properly, which of the following instruments should be used to determine the flow of current?

    a. ampmeter
    b. velocity meter
    c. berometer
    d. pyrometer

40. If after repairing a generator you find it turns the wrong direction, what should you do?

    a. turn the armature around
    b. rewind the generator
    c. check the generator with a VOM
    d. change shunt field leads

UNIT TEST ANSWER SHEET

UNIT POST TEST:

DIRECT CURRENT MOTORS AND GENERATORS

Occupational Area: ______________________

File Code: 78.01.07.00.B2-2

Name: ______________________

ANSWERS

78.01.07.01	1.	B	78.01.07.05	21.	C	41.	
	2.	D		22.	C	42.	
	3.	D		23.	B	43.	
	4.	A		24.	D	44.	
	5.	D		25.	C	45.	
78.01.07.02	6.	B	78.01.07.06	26.	A	46.	
	7.	B		27.	B	47.	
	8.	A		28.	B	48.	
	9.	C		29.	D	49.	
	10.	D		30.	A	50.	
78.01.07.03	11.	A	78.01.07.07	31.	D	51.	
	12.	B		32.	D	52.	
	13.	B		33.	B	53.	
	14.	A		34.	B	54.	
	15.	D		35.	C	55.	
78.01.07.04	16.	D	78.01.07.08	36.	D	56.	
	17.	A		37.	C	57.	
	18.	D		38.	A	58.	
	19.	D		39.	A	59.	
	20.	C		40.	D	60.	

Student: ______________________ File Code: 78.01.07.00.A1-5

Date: ______________________ Date Published: 11/18/74

Mountain-Plains Education & Economic Development Program, Inc. Glasgow AFB, Montana 59231

Family Pay Number: __________ Sex: M F (Circle 1)

UNIT PERFORMANCE TEST: DIRECT CURRENT MOTORS AND GENERATORS

OBJECTIVE 1:

Given a malfunctioning direct current motor or generator, the student will service and repair the motor so that it functions according to the manufacturer's specifications, following safe practices and procedures.

OBJECTIVE 2:

Using appropriate tools and test equipment the student will take shorts and open tests.

OBJECTIVE 3:

Using appropriate equipment, the student will rewind a faulty direct current motor or generator.

OBJECTIVE 4:

Using appropriate tools and test equipment, the student will calculate and record amperage, voltage, resistance and wattage of the direct current motor or generator.

TASK:

The student will service and repair a direct current motor or generator and, in the process, he will make shorts and open and grounding tests, using appropriate test equipment.

ASSIGNMENT:

CONDITIONS:

The student will be given a malfunctioning direct current motor or generator (it may be bugged by the instructor or it may be one brought in by a customer). He will be required to service and repair the motor or generator in conditions similar to those in a typical motor repair shop. He will be allowed to use any and all tools, equipment, service manuals, test books, etc., commonly found in a repair shop. He must complete it in a reasonable length of time with no assistance from the instructor(s) or students.

RESOURCES:

Tools:
- Internal-external snap ring pliers
- 7-Piece nut driver set
- Tool box 18 x 8 x 9
- Circular gauge
- Hacksaws
- Pulley puller
- Arc joint pliers
- Lineman's pliers
- Diagonal cutting pliers
- Long chain-nose pliers
- Locking plier wrench
- Coil tamping pliers
- 4-piece standard set screwdriver
- Center punch
- Cold chisel
- Ball peen hammer
- Lug crimpers
- Wire skinner and straightener

Equipment:
- Coil stripping chisel
- Armature winder
- Coil winder
- External growler
- Insulation former
- Coil shapers

Student: ______________ File Code: 78.01.07.00.A1-5

Date: ______________ Date Published: 11/18/74

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Family Pay Number: ________ Sex: M F (Circle 1)

PERFORMANCE CHECKLIST:

OVERALL PERFORMANCE: Satisfactory_____ Unsatisfactory_____

	CRITERION Met	Not Met
Objective 1:		
1. Follows safe practices and procedures.		
Criterion: No injury results to the student or the equipment and complies with OSHA requirements.		
2. Follows proper procedures for disassembly.		
Criterion: No damage results to the motor.		
3. Diagnosis and troubleshoots malfunctions properly.		
Criterion: When repaired, the motor functions according to the manufacturer's specifications.		
4. Reassembles the motor or generator properly.		
Criterion: Appliance functions according to the manufacturer's specifications and the procedures followed agree with those described in the service literature.		

	CRITERION Met	CRITERION Not Met
5. The repaired motor or generator is repaired in a neat, professional manner.		
Criterion: No damage results to the motor such as opens and shorts.		
6. All connections and fastenings are properly completed.		
Criterion: The motor or generator connection complies with the manufacturer's specifications. The connections are mechanically fastened and structurally sound. The connection is electrically fastened and free of defects.		
7. Motor functions according to the manufacturer's specifications.		
Criterion: Manufacturer's specifications.		
8. Uses appropriate repair part and supplies.		
Criterion: They match exactly those listed in the manufacturer's specifications.		
Objective 2:		
9. Test for grounded commentator, using test lamp.		
10. Test for shorted communtator, using test lamp.		
11. Test for grounds, using growler or millivolt meter.		

	CRITERION Met	Not Met
12. Test for shorts in the field coils, using a growler.		
13. Test for shorts in the armature coil, using a growler.		
14. Test for an open field coil, using an ohmmeter.		
15. Test for an open armature coil, using an ohmmeter.		
16. Test for reversed coils, using a compass or bar		
magnet test.		
Criterion: Troubleshooting techniques reveal the malfunction,		
as identified by job sheet.		
Objective 3:		
17. Uses coil-stripping tool to remove coils.		
18. Uses armature winder, if appropriate, when winding		
the armature.		
19. Uses coil winder, if appropriate, when winding field		
coil.		
20. Uses insulation former, if appropriate, when		
insulating.		
21. Uses coil shaper, if appropriate, on the field coils.		
Criterion: Proper equipment application results in a		
defect-free operative motor.		

	CRITERION Met	Not Met
Objective 4:		
22. Uses test equipment properly.		
23. Wattage readings are accurate.		
24. Voltage readings are accurate.		
25. Amperage readings are accurate.		
26. Resistance readings are accurate.		
Criterion: Manufacturer's specifications.		
27. When applicable, mathematical calculations are correct.		
Criterion: AC/DC Circuit Manuals, Westinghouse.		
28. The motor or generator is repaired in a reasonable		
time.		
Criterion: Not to exceed 4 hours.		
The student must successfully complete 25 out of 28 line items		
to achieve an overall score of satisfactory.		

File Code: 78.01.08.00.A2-0

Date Published: 2-23-76

Mountain-Plains Education & Economic Development Program, Inc.

Glasgow AFB, Montana 59231

Learning Experience Guide

UNIT: UNIVERSAL AND SHADED POLE MOTORS

RATIONALE:

Universal and Shaded Pole Motors are fractional horse power motors. Almost all hand held and some fixed appliance motors are universal. Almost all timer motors used as a clocking device are Shaded Pole Motors.

PREREQUISITES:

Unit: D.C. Current Motors and Generators

OBJECTIVE:

Given a text and illustration, tools, equipment and materials; describe, troubleshoot, service, repair, and reassemble universal and shaded pole motors.

RESOURCES:

GENERAL INSTRUCTIONS:

This unit consists of 8 Learning Activity Packages (LAPs). Each LAP will provide specific information for completion of a learning activity.

The general procedure for this unit is as follows:

(1) Read the first assigned Learning Activity Package (LAP).
(2) Begin and complete the first assigned LAP.
(3) Take and score the LAP test.
(4) Turn in the LAP test answer sheet.
(5) Determine the reason for any missed items on the LAP test.
(6) Proceed to and complete the next assigned LAP in the unit.
(7) Complete all required LAPs for the unit by following steps 3 through 6.
(8) Take the unit tests as described in the Unit LEG "Evaluation Procedures".
(9) Proceed to the next assigned unit.

Principal Author(s): T. Ziller

Printed Materials

Electric Motor Repair, 2nd Ed. Robert Rosenberg, Rinehart, and Winston, 1970. A set of manufacturer's motor specifications and data sheets. Introduction to Power Technology Principles of Electric Motors, 2nd Ed., Vega Enterprises Inc., Decatur, Illinois, 1973.

Service Manuals

Attached Checklists:

Checklist: Operation of a Universal Motor
Checklist for Disassembly: Universal Motor
Checklist for Troubleshooting: Universal Motor
Checklist for Repairing a Universal Motor
Operational Checklist for Shaded Pole Motor
Checklist for Disassembly: Shaded Pole Motor
Checklist for Troubleshooting: Shaded Pole Motor
Checklist for Repairing Shaded Pole Motors

Illustration:

Universal Motor
Shaded Pole Motor

Equipment

Shaded Pole Motor
Universal Motor
Ohmmeter
Growler
Ammeter
Voltmeter
Light machine oil
hand tools

PERFORMANCE ACTIVITIES:

.01 Operation of the Universal Motor.
.02 Ur ersal Motor Construction.
.03 Troubleshooting Universal Motors.
.04 Repairing Universal Motors.
.05 Operation of the Shaded-Pole Motors.
.06 Shaded-Pole Motor Construction.
.07 Troubleshooting Shaded-Pole Motors.
.08 Repairing Shaded-Pole Motors.

EVALUATION PROCEDURE:

When pretesting:

1. The student takes the unit multiple-choice pretest. Successful completion is 4 out of 5 items for each LAP part of the pretest.
2. The student then takes a unit performance test if the unit pretest was successfully completed. Satisfactory completion of the performance test is meeting the criteria listed on the performance test.

When post testing:

The student takes a multiple-choice unit post test and a unit performance test.
Successful unit completion is meeting the listed criteria for the performance test.

FOLLOW-THROUGH:

After completing this guide, you may begin with the first LAP. This is the last unit in the course.

Student: ______________________ File Code: 78.01.08.00.A2-2

Date: ______________________ Date Published: 12-16-74

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

UNIT PRETEST: UNIVERSAL AND SHADED-POLE MOTORS

78.01.08.01

1. What type of motor is very similar to the D-C series motor?

   a. shaded pole
   b. universal
   c. compound
   d. split phase

2. What causes rotation in a universal motor when the armature and field coils are connected in series and current is applied?

   a. a current is induced to cause electromagnetic induction
   b. field coils change polarity, causing armature to turn under load
   c. brushes lift and rotation is maintained by field coils under load
   d. lines created by field react with lines created by armature

3. What are the two types of universal motors?

   a. split-commutator and slip ring
   b. split-phase and shaded pole
   c. concentrated-field and field winding
   d. A-C and D-C

4. How small in size are universal motors?

   a. 1/10 HP
   b. 1/100 HP
   c. 1/200 HP
   d. 1/3 HP

5. How are the armature and field coils connected?

   a. parallel-series
   b. parallel
   c. series-parallel
   d. series

78.01.08.02

6. How is the commutator of a universal motor connected to the shaft?

   a. it is glued on
   b. it is set-screwed on
   c. it is pressed on
   d. it is welded on

7. With what is the field core constructed on a universal motor?

   a. with heavy flat copper wire
   b. with tightly pressed and riveted laminations
   c. with small round copper wire
   d. with bronze wire

8. Identify #6 on the exploded view of a universal motor (attached).

   a. bell housing
   b. metal clamps
   c. field coils
   d. laminated core

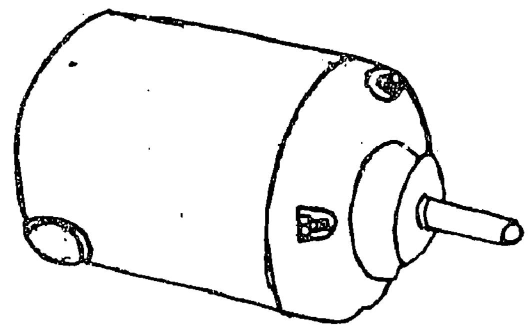
9. Identify #4 on the attached figure.

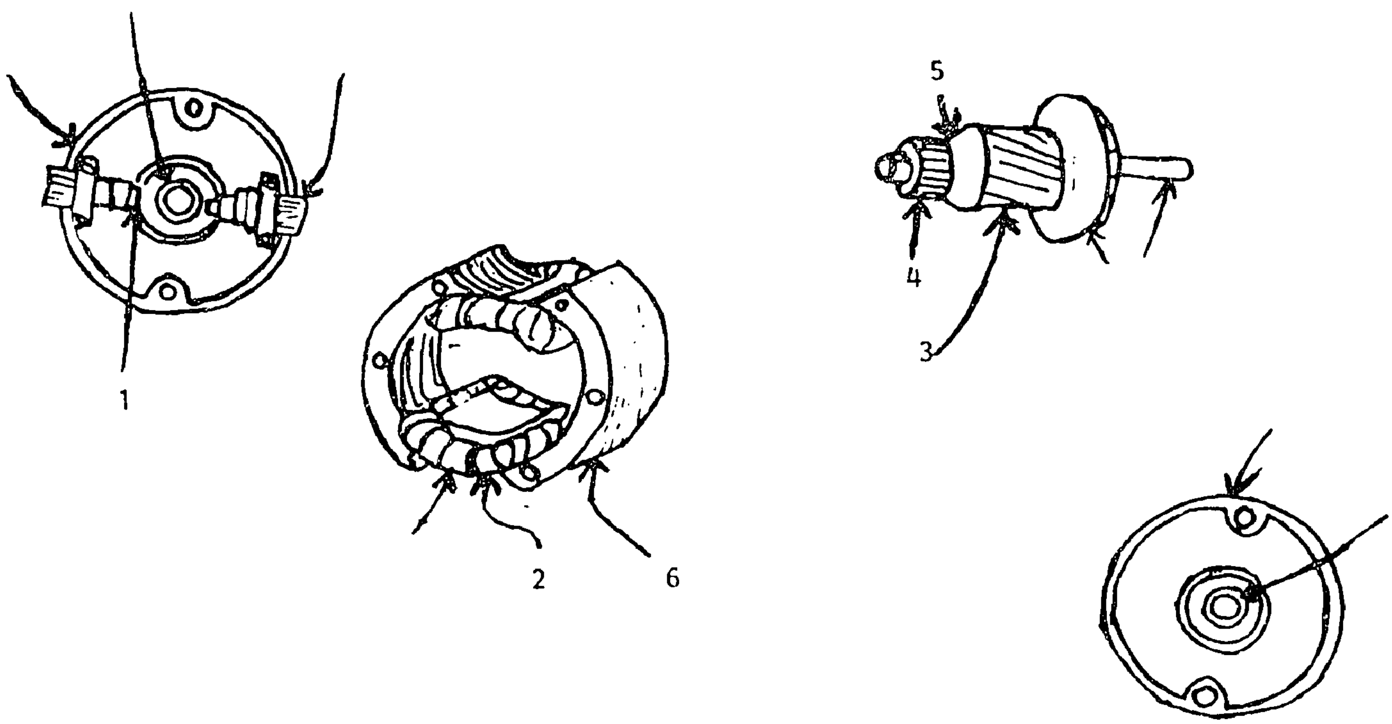
   a. fan
   b. commutator
   c. laminated core
   d. armature

10. Identify #3 on the attached figure.

   a. laminated core
   b. armature
   c. commutator
   d. fan

UNIVERSAL MOTOR





78.01.08.03

11. Shorted coils will cause a universal motor to:

    a. have poor torque
    b. smoke
    c. run hot
    d. spark badly

12. What would the wrong brush position cause a universal motor to do?

    a. run hot
    b. smoke
    c. spark badly
    d. have poor torque

13. What is the problem in a universal motor that causes it to rotate CCW?

    a. short in the armature
    b. short in the switch
    c. open field coil
    d. reversed motor leads

14. If the armature and field coils were connected in series, what problems could arise?

    a. the field coils would open
    b. it would short out the armature
    c. it is a normal connection
    d. the motor would hum

15. When testing for shorts, what test instrument is used?

    a. amprobe
    b. voltmeter
    c. browler
    d. ammeter

78.01.08.04

16. How many start windings are required by a shaded-pole motor?

    a. three
    b. four
    c. two
    d. one

78.01.08.04 (continued)

17. Reversed coil leads in a universal motor will cause:

    a. hot motor
    b. bad sparking
    c. smoke
    d. poor torque

18. If a universal motor has poor torque, the trouble may be:

    a. brushes off neutral
    b. shorted armature
    c. overload
    d. shorted field

19. If a universal motor smokes, the trouble may be:

    a. reversed coil leads
    b. high mica
    c. worn bearings
    d. wrong brush position

20. When installing new insulation in a universal motor armature, how far should the insulation extend above the end of the slots?

    a. 1/4 in.
    b. 1/16 in.
    c. 3/8 in.
    d. 1/2 in.

78.01.08.05

21. What is the phase difference between the shaded windings and the field windings?

    a. 45 degrees
    b. 180 degrees
    c. 90 degrees
    d. 270 degrees

22. How are the shade-poles connected?

    a. series opposing
    b. parallel alternately
    c. series alternately
    d. parallel supporting

78.01.08.05 (continued)

23. As current drops, what is induced in the shaded coil?

a. very little current
b. no current
c. a great amount of current
d. reverse current

24. During the part of the sine curve where the current drops near maximum to 0, current in the shaded coil will agin be:

a. lagging
b. opposed
c. dropped
d. induced

25. A characteristic of a shaded-pole motor is:

a. poor starting torque
b. maximum torque on starting
c. low torque at high speeds
d. low RPM

78.01.08.06

26. How can a shaded-pole motor be reversed?

a. by switching the position of the end bells
b. by changing the windings
c. by reversing the stator
d. by reversing the rotor

27. Identify figure number 4 on the attached illustration:

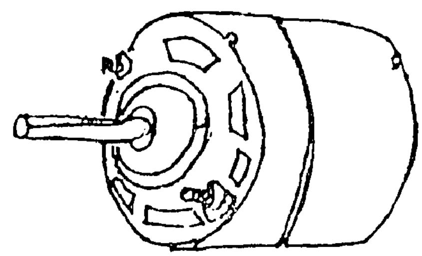
a. end bell
b. bearing
c. stator
d. winding

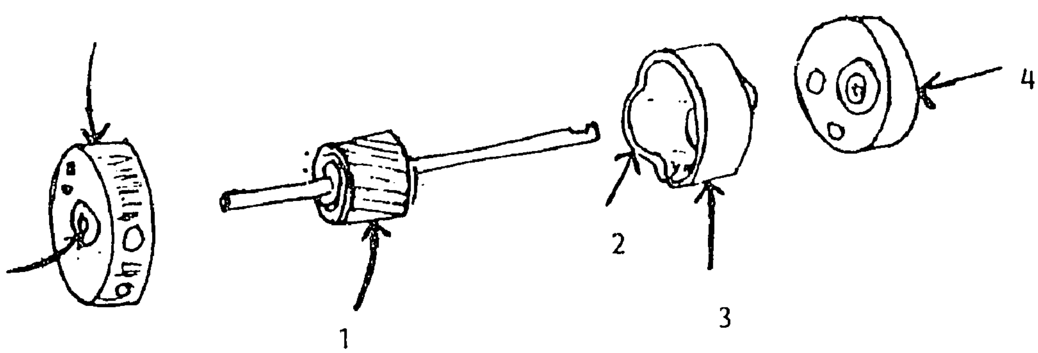
28. Identify item number 3 on the attached illustration.

a. rotor
b. end bell
c. winding
d. stator

SHADED POLE MOTOR

78.01.08.06





78.01.08.06 (continued)

29. Identify item number I on the attached illustration:

 a. rotor
 b. bearing
 c. stator
 d. winding

30. All shaded-pole motors have rotors of what type?

 a. squirrel-cage
 b. slotted
 c. split-phase
 d. fast starting torque

78.01.08.07

31. If a shaded-pole motor is noisy, the trouble may be:

 a. bad brushes
 b. the wrong brush setting
 c. worn bearing
 d. a shorted field

32. When using a test lamp on an open field coil of a shaded-pole motor, the light would:

 a. stay cut
 b. glow brightly
 c. glow normally
 d. glow dimly

33. When using a test lamp on a shorted field-coil of a shaded-pole motor, the light would:

 a. glow dimly
 b. glow brightly
 c. glow normally
 d. stay out

34. How many phase does a shaded-pole motor have?

 a. 2
 b. 1
 c. 3
 d. 4

78.01.08.07 (continued)

35. What meter would you use to troubleshoot a shaded pole motor?

   a. velocity meter
   b. ampmeter
   c. VOM
   d. micrometer

78.01.08.08

36. What method should be used to rewind a shaded-pole motor?

   a. set winding
   b. skein winding
   c. hang winding
   d. form winding

37. If after repairing a shaded-pole motor you find that the motor does not run, what may be the cause?

   a. magnetic flux lines are intersecting a 45 degrees
   b. loose bearings
   c. magnetic flux lines are parallel
   d. shorted field windings

38. When are shaded-pole motors used?

   a. where extremely long life is desired
   b. where high starting torque is needed
   c. where very high horsepower is needed
   d. where high starting torque is not needed

39. When repairing a field winding, how many turns should be in each field winding?

   a. as many as specifications call for
   b. it depends on the horsepower of the motor
   c. it depends on if the motor is A-C or D-C
   d. all shaded-pole motors require 1237 field windings

40. When repairing most shaded-pole motors, what should be done with the shaft bushings or bearings?

   a. lubricated with graphite
   b. greased with multi-purpose grease
   c. oiled with bearing oil
   d. oiled with light machine oil

UNIT TEST ANSWER SHEET

UNIT PRETEST:

UNIVERSAL AND SHADED-POLE MOTORS

Occupational Area: ______________

File Code: 78.01.08.00.A2-2

Name: ______________

ANSWERS

.01.08.01	1.	B	78.01.08.05	21.	C	41.	
	2.	D		22.	C	42.	
	3.	C		23.	A	43.	
	4.	C		24.	D	44.	
	5.	D		25.	A	45.	
.01.08.02	6.	C	78.01.08.06	26.	C	46.	
	7.	B		27.	A	47.	
	8.	D		28.	D	48.	
	9.	D		29.	A	49.	
	10.	C		30.	A	50.	
8.01.08.03	11.	A	78.01.08.07	31.	C	51.	
	12.	D		32.	A	52.	
	13.	D		33.	C	53.	
	14.	C		34.	B	54.	
	15.	C		35.	C	55.	
8.01.08.04	16.	D	78.01.08.08	36.	D	56.	
	17.	B		37.	D	57.	
	18.	D		38.	D	58.	
	19.	C		39.	A	59.	
	20.	B		40.	D	60.	

File Code: 78.01.08.01.A2-0

Date Published: 2-24-76

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Learning Activity Package

Student: ____________

Date: ____________

PERFORMANCE ACTIVITY: Operation of the Universal Motor

OBJECTIVE:

Write a description about the operation of a Universal Motor.

EVALUATION PROCEDURE:

Student is to write a description about the operation of a universal motor that is consistent with the attached checklist. Also score at least 80% on the multiple-choice test.

RESOURCES:

Checklist on operation of a universal motor. (attached)
Electric Motor Repair, Robert Rosenberg, pages 254-255.
Universal Motor.
Introduction to Power Technology Principles of Electric Motors, Vega, pages 36-39.

PROCEDURE:

Steps

1. Read pages 254-255 in Electric Motor Repair.
2. Follow the checklist for operation of motors. (Attached)
3. Complete experiment #5, Universal Motors in Introduction to Power Technology pages 36-39.
4. Operate the motor and observe the characteristics of the motor according to the items listed on the operational checklist attached.
5. Complete the multiple-choice test items for this LAP.

Principal Author(s): T. Ziller

CHECKLIST: OPERATION OF A UNIVERSAL MOTOR

1. ____________ Connect motor to power source.

2. ____________ A universal motor is constructed with an armature and field coils; they are connected in series.

3. ____________ Current applied to the field coils will set up magnetic lines of force, which will react with the force created by the armature and cause rotation.

4. ____________ Disconnect motor from power source.

Student: ____________________ File Code: 78.01.08.01.A2-2

Date: ____________________ Date Published: 12-23-74

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LAP TEST: OPERATION OF THE UNIVERSAL MOTOR

1. What are the two major characteristics of a universal motor?

   a. high starting torque and variable speed.
   b. low starting torque and variable speed.
   c. low starting torque and lots of power.
   d. high starting torque and constant speed.

2. Why is the universal motor the most popular type in the fractional horsepower size?

   a. it is inexpensive.
   b. it is used on most household appliances.
   c. it doesn't have field coils.
   d. it can be used as a generator.

3. What is the purpose of the field core in a universal motor?

   a. it houses the bearings.
   b. it supports the outer housing.
   c. it holds the armature.
   d. it holds the coil.

4. What type of motor is very similar to the DC series motor?

   a. shaded pole.
   b. universal.
   c. compound.
   d. split phase.

5. The type of motor that can be used on either AC or DC voltage is:

   a. a shaded pole motor.
   b. a split phase motor.
   c. a universal motor.
   d. a repulsion motor.

6. What causes rotation in a universal motor when the armature and field coils are connected in series and current is applied?

   a. a current is induced to cause electromatic induction.
   b. field coils change polarity, causing armature to turn under load.
   c. brushes lift and rotation is maintained by field coils under load.
   d. lines created by field react with lines created by armature.

7. Universal motors run on what currents?

   a. 115 volts.
   b. AC only.
   c. DC only.
   d. single phase AC or DC.

8. What are the two types of universal motors?

   a. split commutator and slipring.
   b. split phase and shaded pole.
   c. concentrated field and field winding.
   d. AC and DC.

9. How small in size are universal motors?

   a. 1/10 HP.
   b. 1/100 HP.
   c. 1/200 HP.
   d. 1/3 HP.

10. How are the armature and field coils connected?

   a. parallel series.
   b. parallel.
   c. series parallel.
   d. series.

LAP TEST ANSWER KEY: OPERATION OF THE UNIVERSAL MOTOR

1. A
2. B
3. D
4. B
5. C
6. D
7. D
8. C
9. C
10. D

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File Code: 78.01.08.02.A2-0

Date Published: 2-24-76

Learning Activity Package

Student: ____________

Date: ____________

PERFORMANCE ACTIVITY: Universal Motor Construction

OBJECTIVE:

Identify the component parts of a universal motor.

EVALUATION PROCEDURE:

Student is to identify by labeling the component parts of a universal motor that is consistent with attached checklist. Also score at least 80% on the multiple-choice test.

RESOURCES:

Illustration of a Universal Motor. (Attached)
Checklist on disassembly of a Universal Motor. (Attached)
Electric Motor Repair, Robert Rosenberg, pages 254-255.
Universal Motor.
Hand tools
Universal Motor display board

PROCEDURE:

Steps

1. Review pages 254-255 in Electric Motor Repair.
2. Follow the checklist for disassembly of motors. (Attached)
3. Complete the multiple-choice test items for this LAP.

Principal Author(s): T. Ziller

CHECKLIST FOR DISASSEMBLY: UNIVERSAL MOTOR

_______ 1. Remove brushes with proper hand tools.

_______ 2. Mark stator and end bell.

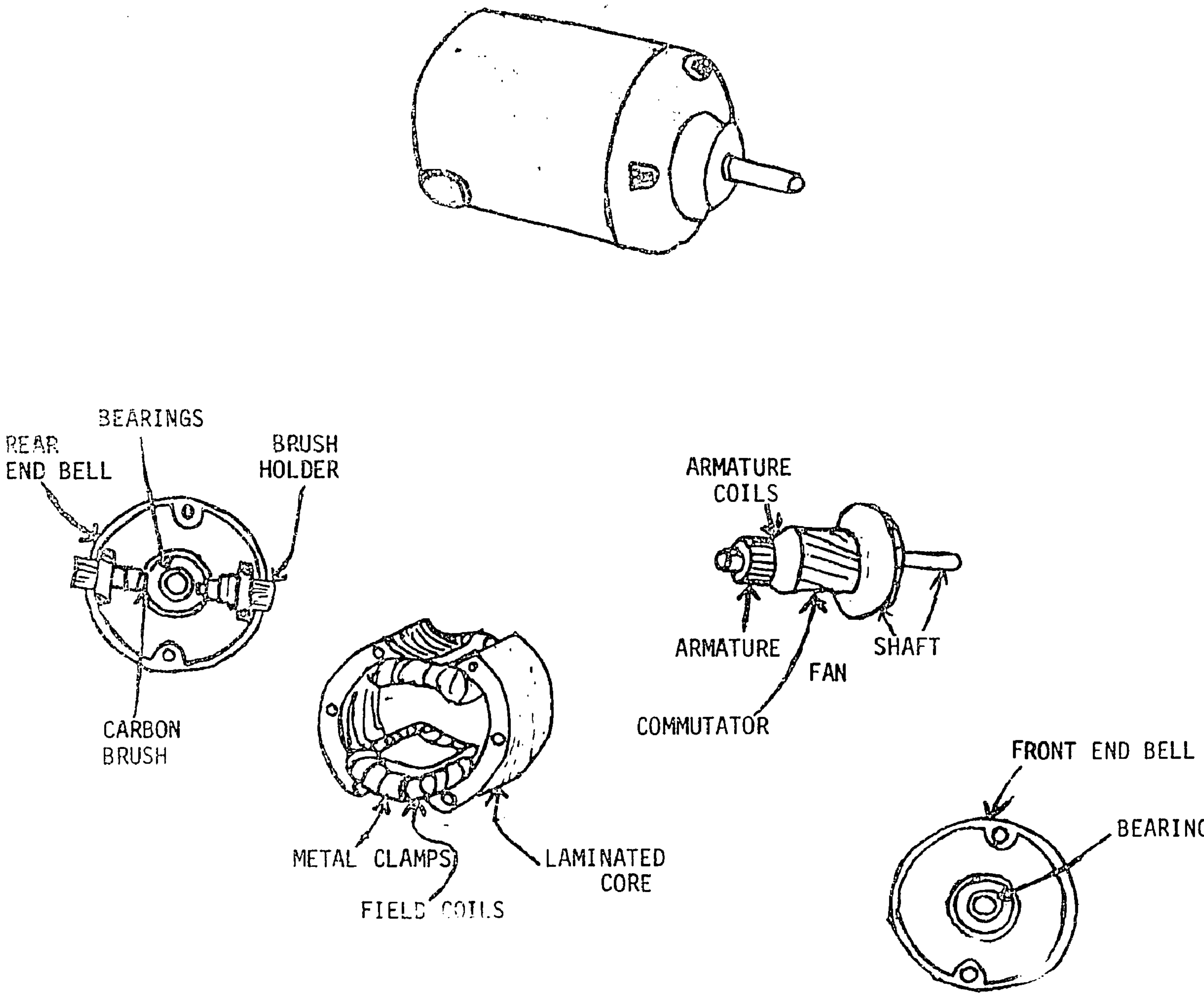
_______ 3. Using proper hand tools, remove nuts and bolts (Don't lose nuts and bolts).

_______ 4. Remove end bells from stator.

_______ 5. Gently slip armature from laminated core.

_______ 6. Refer to the attached exploded view.

UNIVERSAL MOTOR



Student: ____________________ File Code: 78.01.08.02.A2-2

Date: ____________________ Date Published: 1/6/76

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Glasgow AFB, Montana 59231

LAP TEST: UNIVERSAL MOTOR CONSTRUCTION

1. How is the commutator of a universal motor connected to the shaft?

   a. it is oiled on.
   b. it is set screwed on.
   c. pressed on.
   d. welded on.

2. Where is the frame located on a universal motor?

   a. end plates.
   b. outer housing.
   c. coil bracket.
   d. field core.

3. Why are universal motors usually built into the device they drive?

   a. they run at very low speed and cause vibration.
   b. they don't have any moving parts.
   c. they run at dangerously high speed without load.
   d. the bearings don't have to be lubricated.

4. With what is the field core constructed on a universal motor?

   a. with heavy flat copper wire.
   b. with tightly pressed and riveted laminations.
   c. with small round copper wire.
   d. with bronze wire.

5. Identify #6 on the exploded view of a universal motor (attached).

   a. bell housing.
   b. metal clamps.
   c. field coils.
   d. laminated core.

6. Identify #2 on the exploded view of a universal motor.

   a. oil seal.
   b. carbon brush holder.
   c. bearings.
   d. carbon brushes.

7. Identify #4 on the attached figure.

   a. fan.
   b. commutator.
   c. laminated core.
   d. armature.

8. Identify #1 on the attached figure.

   a. armature coils.
   b. field coils.
   c. commutator.
   d. metal clamps.

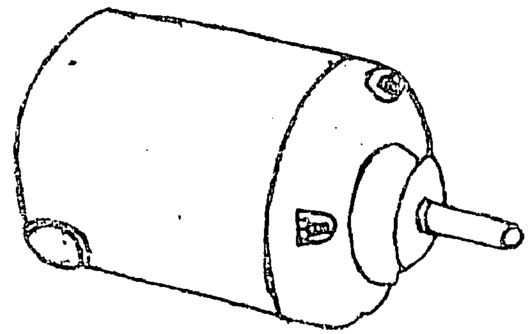
9. Identify #3 on the attached figure.

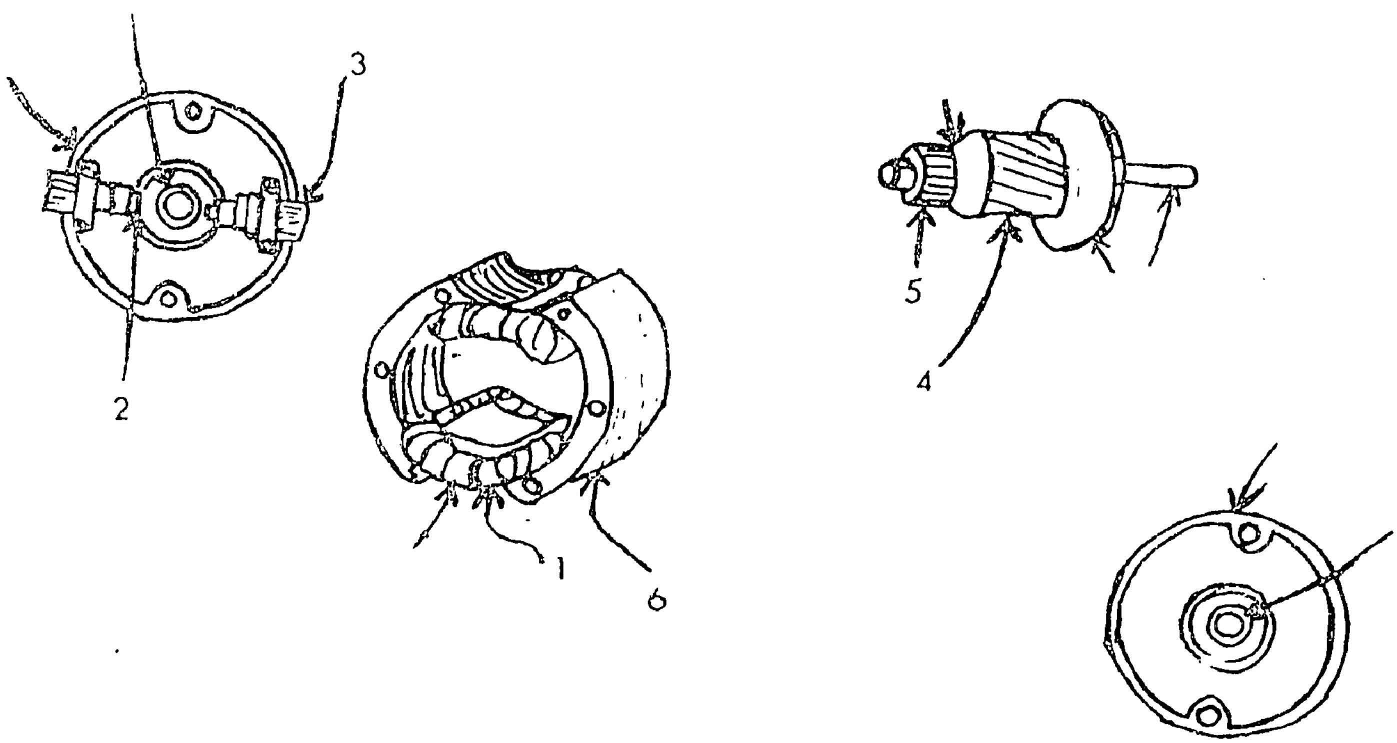
   a. laminated core.
   b. armature.
   c. brush holder.
   d. fan.

10. Identify #5 on the attached figure.

   a. commutator.
   b. armature coils.
   c. fan.
   d. laminated core.

UNIVERSAL MOTOR





LAP TEST ANSWER KEY: UNIVERSAL MOTOR CONSTRUCTION

1. C
2. B
3. C
4. B
5. D
6. D
7. D
8. B
9. C
10. B

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Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Learning Activity Package

Student: ____________________

Date: ____________________

PERFORMANCE ACTIVITY: Troubleshooting Universal Motors

OBJECTIVE:

Troubleshoot a universal motor following the steps given on the attached checklist.

EVALUATION PROCEDURE:

The appliance must operate properly and the student is to make a check-list on troubleshooting of the motor that is consistent with the given checklist. Successfully complete at least 80% of the items on a multiple-choice test about this LAP.

Universal motor
Ohmmeter
Growler
Ammeter
Voltmeter

RESOURCES:

Checklist on troubleshooting a motor. (Attached)
Universal Motor.
Service Manuals.
Electric Motor Repair, by Robert Rosenberg, pages 264-265.

PROCEDURE:

Steps

1. Follow the checklists for troubleshooting a motor.
2. Complete the multiple-choice test items for this LAP.

Principal Author(s): T. Ziller

CHECKLIST FOR TROUBLESHOOTING: UNIVERSAL MOTOR.

1. Make a thorough visual inspection.

2. If the motor sparks badly, check for:

   a. Shorted field poles (Ohmmeter) (Growler).
   b. Wrong lead position on the commutator.
   c. Open armature coils (Ohmmeter).
   d. Shorted armature coils (Growler).
   e. Reversed coil leads.
   f. Worn bearings.
   g. High mica.
   h. Wrong direction of rotation.

3 If the motor runs hot, check for:

   a. Worn bearings.
   b. Dry bearings.
   c. Shorted coils (Growler).
   d. Overload (Ammeter).
   e. Shorted fields (Growler).
   f. Brushes off-neutral.

4. If the motor smokes, check for:

   a. Shorted armature (Growler).
   b. Shorted fields (Growler).
   c. Worn bearings.
   d. Wrong voltage (Voltmeter).
   e. Overload (Ammeter).

5. If the motor has poor torque, check for:

   a. Shorted coils (Growler).
   b. Shorted field (Growler).
   c. Wrong brush position.
   d. Worn bearings.

6 Take a resistance reading on the motor field windings.
Take a resistance reading on the armature coils. (Record values).

7. Plug the motor into 115V AC power source.

8. Take a voltage reading on the motor terminals. (Record value) Compare with manufacturer's name plate.

9. Using an ammeter take a current reading on the motor. (Record value). Compare with manufacturer's name plate

10. Disconnect from AC Power.

11 Connect fields to a low D.C. voltage.

12. Use a compass and check for polarity.

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LAP TEST: TROUBLESHOOTING UNIVERSAL MOTORS

1. Shorted coils will cause a universal motor to.

   a. have poor torque.
   b. smoke.
   c. run hot.
   d. spark badly.

2. If the bearing housing was hot in a universal motor, the problem might be:

   a. the wrong voltage being applied.
   b. a shorted armature.
   c. a bad or dry bearing.
   d. an open field coil.

3. What piece of test equipment should be used to test for an open field coil winding in a universal motor?

   a. voltmeter.
   b. a wattmeter.
   c. an ohmmeter.
   d. an ammeter.

4. When using a test lamp on an open field coil of a universal motor, the light would:

   a. stay out.
   b. glow normally.
   c. glow dimly.
   d. glow brightly.

5. What would the wrong brush position cause a universal motor to do?

   a. run hot.
   b. smoke.
   c. spark badly.
   d. have poor torque.

6. What is the problem in a universal motor that causes it to rotate slow?

   a. short in the armature.
   b. short in the switch.
   c. open field coil.
   d. reversed motor leads.

7. When metering a universal field coil, the meter is connected?

   a. in parallel with the commutator.
   b. in parallel with the field coil.
   c. in series with the stator windings.
   d. in series with the field coil.

8. If the armature and field coil were connected in series, what problems could arise?

   a. the field coils would open.
   b. it would short out the armature.
   c. it is a normal connection.
   d. the motor would hum.

9. If the insulation is burnt on the field coils

   a. revarnish.
   b. rewind the coils.
   c. it is a normal condition.
   d. rewind the whole motor.

10. When testing for shorts, what test instrument is used?

   a. amprobe.
   b. voltmeter.
   c. grower.
   d. ammeter.

LAP TEST ANSWER KEY: TROUBLESHOOTING UNIVERSAL MOTORS

1. A
2. C
3. C
4. A
5. D
6. D
7. D
8. C
9. B
10. C

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Date Published: 2-24-76

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Learning Activity Package

Student: ____________

Date: ____________

PERFORMANCE ACTIVITY: Repairing Universal Motors

OBJECTIVE:

Repair a universal motor following the steps for repair given in the attached checklists.

EVALUATION PROCEDURE:

The appliance must operate properly and the student is to make a checklist on repair of the motor that is consistent with the given checklists. Successfully complete at least 80% of the items on a multiple-choice test about this LAP.

RESOURCES:

Illustration of a Universal Motor. (Attached)
Checklist on repair of the motor. (Attached)
Universal motor.
Service Manuals.
Electric Motor Repair, by Robert Rosenberg, pages 264-265.
30-W oil

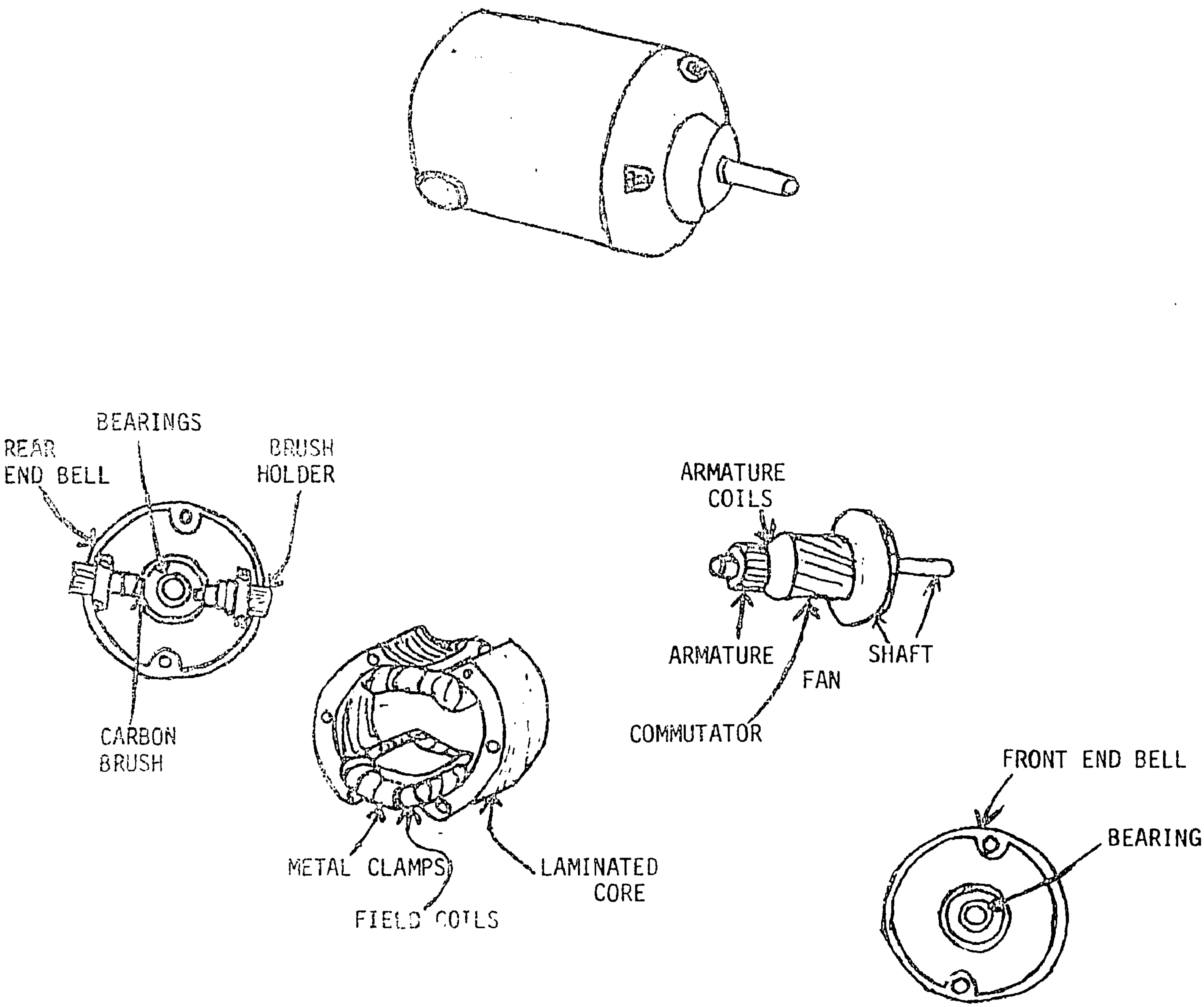
PROCEDURE:

Steps

1. Follow the checklists for repairing a motor. (Attached)
2. Complete the multiple-choice test items for this LAP.

Principal Author(s): T. Ziller

UNIVERSAL MOTOR



Student: ______________________ File Code: 78.01.08.04.A2-2

Date: ______________________ Date Published: 12-23-74

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Glasgow AFB, Montana 59231

LAP TEST: REPAIRING UNIVERSAL MOTORS

1. How many start windings are required by a shaded pole motor?

   a. three.
   b. four.
   c. two.
   d. one.

2. When are the field windings and armature in a universal motor tested for defects?

   a. after assembly.
   b. before assembly.
   c. before and after assembly.
   d. after cleaning and lubrication.

3. If a universal motor sparks badly, the trouble may be:

   a. shorted fields.
   b. overload.
   c. high mica.
   d. wrong voltage.

4. Reversed coil leads in a universal motor will cause:

   a. hot motor.
   b. bad sparking.
   c. smoke.
   d. poor torque.

5. If a universal motor has poor torque, the trouble may be:

   a. brushes off neutral.
   b. shorted armature.
   c. overload.
   d. shorted field.

6. If a universal motor smokes, the trouble may be:

   a. reversed coil leads.
   b. high mica.
   c. worn bearings.
   d. wrong brush position.

7. If a universal motor has dry bearings, it will:

   a. spark badly.
   b. smoke.
   c. have poor torque.
   d. run hot.

8. If a universal motor sparks badly, the trouble may be:

   a. brushes off neutral.
   b. overload.
   c. wrong voltage.
   d. shorted field poles.

9. How many coils are usually found in a universal motor armature slot?

   a. two.
   b. one.
   c. three.
   d. four.

10. When installing new insulation in a universal motor armature, how far should the insulation extend above the end of the slots?

   a. 1/4 inch.
   b. 1/16 inch.
   c. 3/8 inch.
   d. 1/2 inch.

LAP TEST ANSWER KEY: REPAIRING UNIVERSAL MOTORS

1. D
2. C
3. C
4. B
5. D
6. C
7. D
8. D
9. A
10. B

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File Code: 78.01.08.05.A2-0

Date Published: 2-24-76

Learning Activity Package

Student: ____________

Date: ____________

PERFORMANCE ACTIVITY: Operation of the Shaded Pole Motor

OBJECTIVE:

Describe the operation of a shaded pole motor.

EVALUATION PROCEDURE:

Student is to write a description about the operation of a shaded pole motor that is consistent with the attached checklist. Successfully complete ast least 80% of the items on a multiple-choice test about this LAP.

RESOURCES:

Checklist on operation of a shaded pole motor.
Electric Motor Repair, Robert Rosenberg, pages 265-267.
Introduction to Power Technology Principles of Electric Motors, Vega, pages 28-31.
Shaded pole motor.

PROCEDURE:

Steps

1. Read pages 265-267 in Electric Motor Repair.
2. Follow the checklist for operation of motors. (Attached)
3. Complete experiment #3 Shade-Pole Motors in Introduction to Power Technology pages 28-31.
4. Operate the motor and observe the characteristics of the motor according to the items listed on the operational checklist attached.
5. Complete the multiple-choice test items for this LAP.

Principal Author(s): T. Ziller

OPERATIONAL CHECKLIST FOR SHADED POLE MOTOR

1. Connect motor to power source.
2. Salient field pole is one heavy solid copper coil (1 turn).
3. Field coil lies on top.
4. Disconnect motor from power source.

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Date Published: 2-24-76

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Glasgow AFB, Montana 59231

Learning Activity Package

Student: ____________________

Date: ____________________

PERFORMANCE ACTIVITY: Shaded-Pole Motor Construction

OBJECTIVE:

Identify the component parts of a shaded-pole motor.

EVALUATION PROCEDURE:

Student is to identify by labeling the component parts of a shaded-pole motor that is consistent with the attached checklist. Successfully complete at least 80% of the items on a multiple-choice test about this LAP.

RESOURCES:

Illustration of a shaded-pole motor. (Attached)
Checklist on disassembly of a shaded-pole motor. (Attached)
Electric Motor Repair. Robert Rosenberg, pages 265-267.
Shaded-Pole motor.

PROCEDURE:

Steps

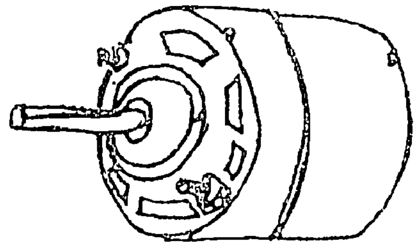
1. Review pages 265-267 in Electric Motor Repair.
2. Follow the checklist for disassembly of motors. (Attached)
3. Complete the multiple-choice test items for this LAP.

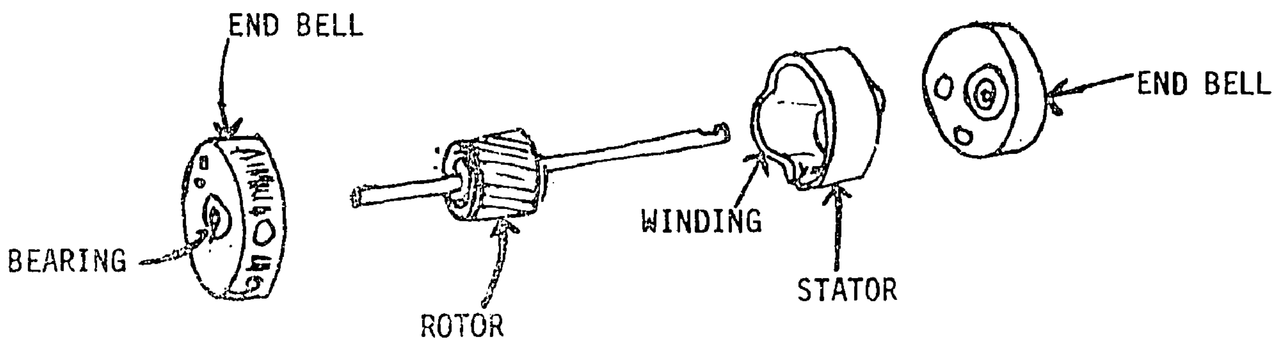
Principal Author(s): T. Miller

CHECKLIST FOR DISASSEMBLY: SHADED POLE MOTOR

1. Scratch two (2) lines on end of stator and end bell (about ½" long).
2. Scratch one (1) line on end of stator and other end bell (About ½" long).
3. Remove bolts (don't lose nuts and bolts).
4. Gently tap end bells and remove from stator.
5. Gently remove rotor from stator.
6. Refer to the exploded view.

SHADED POLE MOTOR





Student: ____________________ File Code: 78.01.08.06.A2-2

Date: ____________________ Date Published: 12-23-74

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LAP TEST: OPERATION AND CONSTRUCTION OF THE SHADED POLE MOTOR

78.01.08.05

1. How are the shaded poles connected?

   a. series opposing.
   b. parallel alternately.
   c. series alternately.
   d. parallel supporting.

2. During the part of the sine curve where the current drops near maximum to O, currect in the shaded coil will again be:

   a. lagging.
   b. opposed.
   c. dropped.
   d. induced.

3. A characteristic of a shaded pole motor is:

   a. poor starting torque.
   b. maximum torque on starting.
   c. low torque at high speeds.
   d. low RPM.

4. Where are shaded pole motors used?

   a. [illegible] devices.
   b. compressor motors.
   c. large appliances.
   d. power tools.

5. How are shaded pole motors reversed?

   a. reverse the current.
   b. reversed the brushes.
   c. reversed field coils.
   d. one shaded winding is closed one shaded winding is open.

78.01.08.06

6. Shaded pole motor consists of:

   a. two end bells, one stator, one rotor, and one set of brushes.
   b. two end bells, two stators and one rotor.
   c. two end bells, one rotor, one stator and one fan.
   d. two end bells, one rotor and one stator.

7. How can a shaded pole motor be reversed?

   a. by switching the positions of the end bells.
   b. by changing the windings.
   c. by reversing the stator.
   d. by reversing the rotor.

8. Identify item number 1 on the attached illustration?

   a. rotor.
   b. bearing.
   c. stator.
   d. winding.

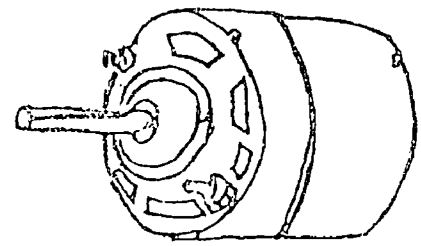
9. All shaded pole motors have rotors of what type?

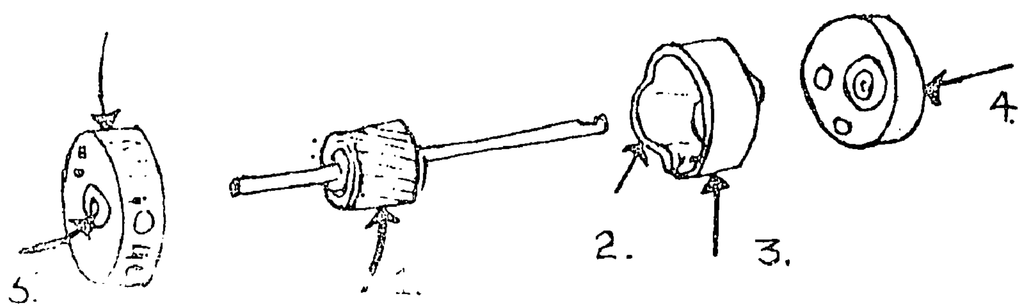
   a. squirrel cage.
   b. slotted.
   c. split phase.
   d. fast starting torque.

10. Why can only one end plate be removed on a shaded pole motor?

   a. its part of the frame.
   b. its spot welded.
   c. it has a special bearing.
   d. its part of the rotor.

SHADED POLE MOTOR





LAP TEST ANSWER KEY: OPERATION AND CONSTRUCTION OF THE SHADED POLE MOTOR

LAP .05

1. C
2. D
3. A
4. A
5. D

LAP .06

6. D
7. C
8. A
9. A
10. A

File Code: 78.01.08.07.A2-0

Date Published: 2-24-76

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Learning Activity Package

Student:

Date:

PERFORMANCE ACTIVITY: Troubleshooting Shaded Pole Motors

OBJECTIVE:

Troubleshoot shaded pole motors following the steps given on the attached checklist.

EVALUATION PROCEDURE:

The appliance must operate properly and the student is to make a checklist on troubleshooting the motor that is consistent with the given checklist. Successfully complete at least 80% of the items on a multiple-choice test about this LAP.

Ohmmeter
Growler
Ammeter
Voltmeter

RESOURCES:

Checklist on troubleshooting a motor. (Attached)
Shaded pole motor.
Service Manuals.
Electric Motor Repair, by Robert Rosenberg.

PROCEDURE:

Steps

1. Follow the checklist for troubleshooting a motor. (Attached)
2. Complete the multiple-choice test items for this LAP.

Principal Author(s): T. Miller

CHECKLIST FOR TROUBLESHOOTING: SHADED POLE MOTOR

1. Make a thorough visual inspection.

2. If motor runs hot, check for:

   a. Worn bearings.
   b. Dry bearings.
   c. Shorted fields (Ohmmeter) (Growler).
   d. Overload (Ammeter).

3. If motor smokes, check for:

   a. Worn bearings.
   b. Shorted fields (Ohmmeter) (Growler).
   c. Wrong voltage (Voltmeter).
   d. Overload (Ammeter).

4. If motor has poor torque, check for:

   a. Shorted field (Ohmmeter) (Growler).
   b. Worn bearings.
   c. Plugged with dirt.

5. Take a resistance reading on the motor field windings. (Record value).

6. Plug the motor into 115V AC power source.

7. Take a voltage reading on the motor terminals. (Record value) Compare with manufacturer's name plate.

8. Using an amprobe take a current reading on the motor (Record value). Compare with manufacturer's name plate.

9. Disconnect from AC power.

10. Connect fields to a low D.C. voltage.

11. Use a compass and check for polarity.

Student: ______________________ File Code: 78.01.08.07.A2-2

Date: ______________________ Date Published: 12/23/74

Mountain-Plains Education &
Economic Development
Program, Inc.
Glasgow AFB, Montana 59231

LAP TEST: TROUBLESHOOTING SHADED POLE MOTORS

1. If a shaded-pole motor has poor starting torque, the trouble might exist in:

   a. the voltage being applied.
   b. the load.
   c. the field.
   d. the armature.

2. If a shaded-pole motor smokes, the repairman should check for:

   a. dirt.
   b. a shorted armature.
   c. wrong voltage.
   d. a shorted auxiliary winding.

3. What piece of test equipment should be used to test for an open-field coil in a shaded-pole motor?

   a. an ohmmeter
   b. a wattmeter
   c. a voltmeter
   d. an ammeter

4. If a shaded-pole motor is plugged with dirt, one symptom will be:

   a. heat.
   b. a non-operational motor.
   c. smoke.
   d. poor torque.

5. If a shaded-pole motor is noisy, the trouble may be:

   a. bad brushes.
   b. the wrong brush setting.
   c. worn bearing.
   d. a shorted field.

6. When using a test lamp on a open-field coil of a shaded-pole motor, the light would:

   a. stay out.
   b. glow brightly.
   c. glow normally.
   d. glow dimly.

7. When using a test lamp on a shorted field-coil of a shaded-pole motor, the light would:

   a. glow dimly.
   b. glow brightly.
   c. glow normally.
   d. stay cut.

8. How many phases does a shaded-pole motor have?

   a. 2
   b. 1
   c. 3
   d. 4

9. What meter would you use to troubleshoot a shaded-pole motor?

   a. velocity meter
   b. ampmeter
   c. VOM
   d. micrometer

10. Windings in a stator in a shaded-pole motor must be connected so what will develop?

   a. alike polarity results
   b. variable polarity results
   c. consistant polarity results
   d. alternate polarity results

LAP TEST ANSWER KEY: TROUBLESHOOTING SHADED POLE MOTORS

1. C
2. C
3. A
4. D
5. C
6. A
7. C
8. B
9. C
10. D

File Code: 78.01.08.08.A2-0

Date Published: 2-24-76

Mountain-Plains Education &
Economic Development
Program, Inc.
Glasgow AFB, Montana 59231

Learning Activity Package

Student: ______

Date: ______

PERFORMANCE ACTIVITY: Repairing Shaded Pole Motors

OBJECTIVE:

Repair a shaded pole motor following the steps for repair given on the attached checklist.

EVALUATION PROCEDURE:

The appliance must operate properly and the student is to make a checklist on repair of the motor that is consistent with the given checklists. Successfully complete at least 80% of the items on a multiple-choice test about this LAP.

RESOURCES:

light machine oil
varnish

Illustration of shaded pole motor. (Attached)
Checklist on repair of the motor. (Attached)
Shaded pole motor.
Service Manuals.
Electric Motor Repair, by Robert Rosenberg.

PROCEDURE:

Steps

1. Follow the checklists for repairing a motor. (Attached)
2. Complete the multiple-choice test items for this LAP.

Principal Author(s): T. Ziller

CHECKLIST FOR REPAIRING SHADED POLE MOTORS

Service

1. Lubricate bearings. (light machine oil)
2. Insure that motor is not filled with lint or dirt.
3. Check for free rotation of shaft.

Repair

1. Using proper tools, remove bad bearings.
2. Replace bearing.
3. Lubricate new bearing.

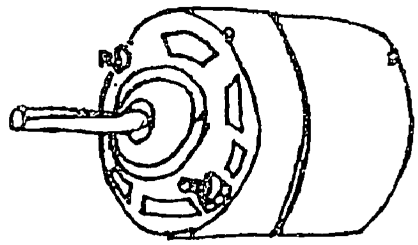
Rewinding

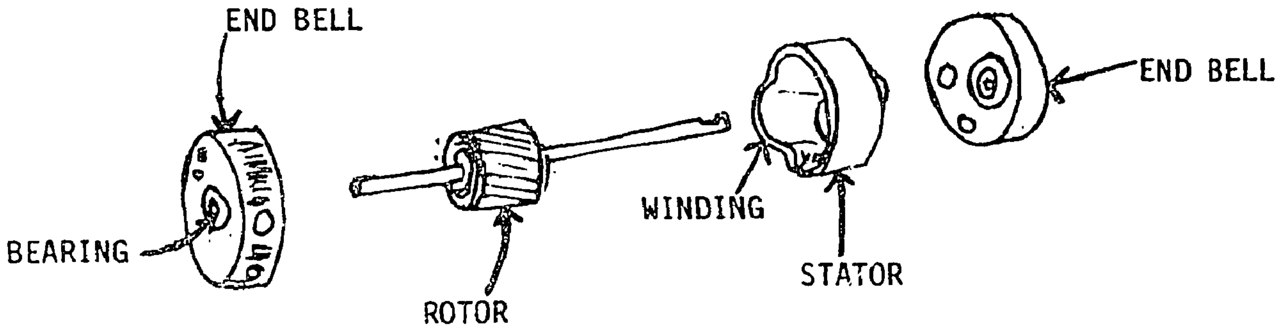
1. Strip the stator.
2. Check for correct size of magnetic wire.
3. Fit paper insulation in stator. (see instructor when completed)
4. Rewind motor using the form winding method.
5. Splice and connect leads. (see instructor when completed)
6. Test new winding with proper test equipment.
7. Dip stator in varnish.
8. Reassemble the motor.
9. Connect motor to power source.

Reassembly

1. Gently set rotor inside stator.
2. Align end bells.
3. Insert bolts and tighten.
4. Connect motor to power source.
5. Refer to exploded view.

SHADED POLE MOTOR





Student: ______________________ File Code: 78.01.08.08.A2-2

Date: ______________________ Date Published: 12-23-74

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

LAP TEST: REPAIRING SHADED POLE MOTORS

1. What method should be used to rewind a shaded pole motor?

   a. set winding.
   b. skein winding.
   c. hand winding.
   d. form winding.

2. What will an ohmmeter read when testing a shorted armature coil for a shaded pole motor?

   a. zero.
   b. a little resistance.
   c. infinite.
   d. the test cannot be performed with an ohmmeter.

3. Why should insulating paper be placed on the corners of a shaded pole motor or around its core?

   a. to prevent the coil from shorting.
   b. to prevent damage to the armature.
   c. to prevent the coil from grounding.
   d. to prevent a blown fuse.

4. The easiest way to reverse a shaded pole motor is to:

   a. reverse the field connections.
   b. reverse the stator in its housing.
   c. rewind the fields.
   d. rewind the stator.

5. If after repairing a shaded pole motor you find that the motor does not run, what may be the cause?

   a. magnetic flux lines are intersecting a 45 degree.
   b. loose bearings.
   c. magnetic flux lines are parallel.
   d. shorted field windings.

5. A shaded pole motor has which of the following characteristics?

   a. very long life.
   b. low starting torque.
   c. high starting torque.
   d. very high efficiency.

7. When are shaded pole motors used?

   a. where extremely long life is desired.
   b. where high starting torque is needed.
   c. where very high horsepower is needed.
   d. where high starting torque is not needed.

8. The stator on most shaded pole motors is constructed with what type of core?

   a. laminated core.
   b. solid core metalic.
   c. very soft core.
   d. resister nonmetallic core.

9. When repairing a field winding, how many turns should be in each field winding?

   a. as many as specifications call for.
   b. it depends on the horsepower of the motor.
   c. it depends on if the motor is AC or DC.
   d. all shaded pole motors require 1,237 field windings.

10. When repairing most shaded pole motors, what should be done with the shaft bushings or bearings?

   a. lubricated with graphite.
   b. greased with mutli purpose grease.
   c. oiled with heavy oil.
   d. oiled with light machine oil.

LAP TEST ANSWER KEY: REPAIRING SHADED POLE MOTORS

1. D
2. A
3. C
4. B
5. D
6. B
7. D
8. A
9. A
10. D

Student: ____________________ File Code: .8.01.08.00.B2-2

Date: ____________________ Date Published: 12-18-74

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

UNIT POST TEST: UNIVERSAL AND SHADED-POLE MOTORS

78.01.08.01

1. What are the two major characteristics of a universal motor?

   a. high starting torque and variable speed
   b. low starting torque and variable speed
   c. low starting torque and lots of power
   d. high starting torque and constant speed

2. Why is the universal motor the most popular type in the fractional horsepower size?

   a. it is inexpensive
   b. it is used on most household appliances
   c. it doesn't have field coils
   d. it can be used as a generator

3. What is the purpose of the field core in a universal motor?

   a. it houses the bearings
   b. it supports the outer housing
   c. it holds the armature
   d. it holds the coils

4. The type of motor that can be used on either AC or DC voltage is:

   a. a shaded-pole motor
   b. a split-phase motor
   c. a universal motor
   d. a repulsion motor

5. Universal motors run on what currents?

   a. 115 volts
   b. AC only
   c. DC only
   d. single-phase AC or DC

78.01.08.02

6. Where is the frame located on a universal motor?

   a. enc ates
   b. outer housing
   c. coil bracket
   d. field core

7. Why are universal motors usually built into the device they drive?

   a. they run at very low speed and cause vibration
   b. they don't have any moving parts
   c. they run at dangerously high speed without load
   d. the bearings don't have to be lubricated

8. Identify #1 on the exploded view of a universal motor.

   a. oil seal
   b. carbon brush holder
   c. bearings
   d. carbon brushes

9. Identify #2 on the attached figure.

   a. armature coils
   b. field coils
   c. commutator
   d. metal clamps

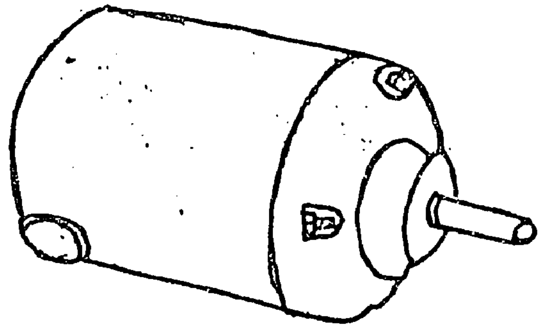
10. Identify #5 on the attached figure.

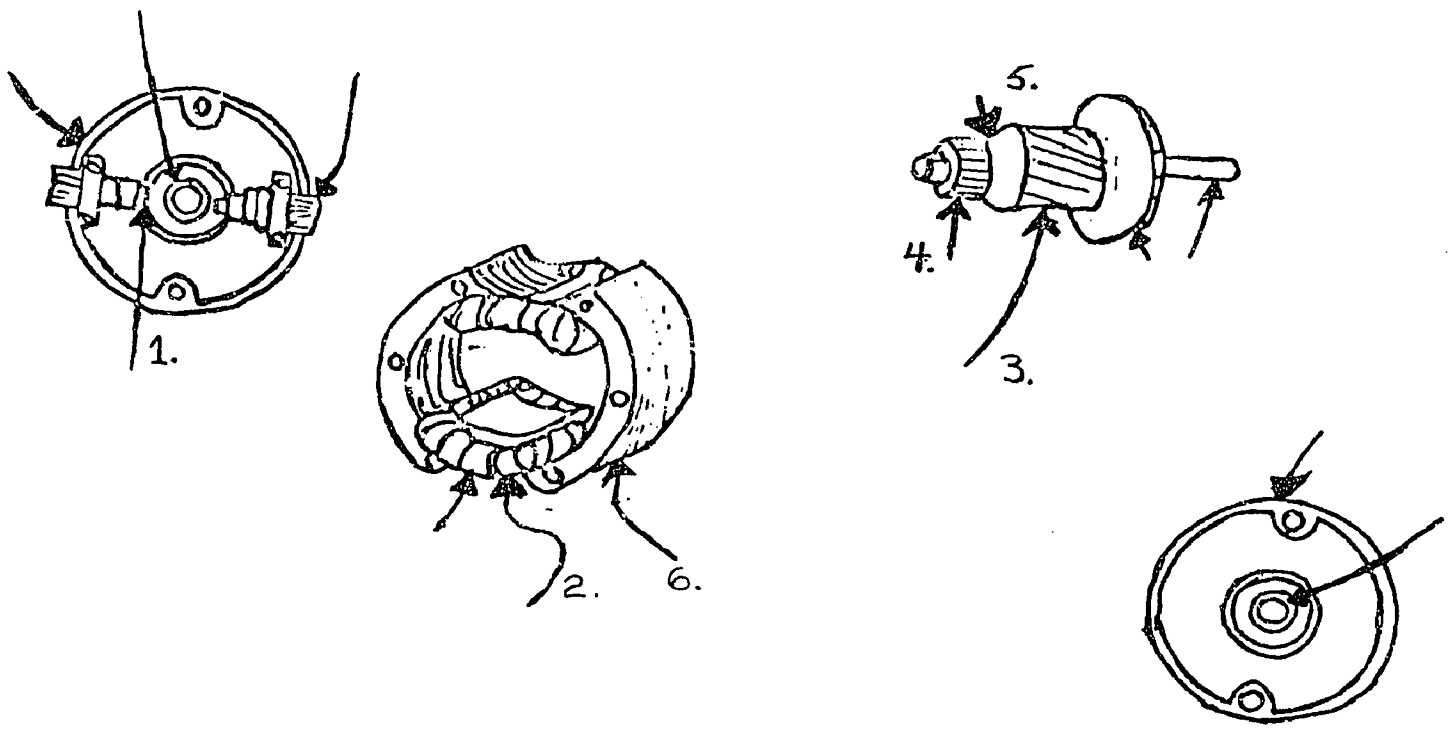
   a. commutator
   b. armature coils
   c. fan
   d. laminated core

78.01.08.03

11. If the bearing housing was hot in a universal motor, the problem might be:

   a. the wrong voltage being applied
   b. a shorted armature
   c. a bad or dry bearing
   d. an open field coil




1.
2.
3.
4.
5.
6.

78.01.08.03 (continued)

12. What piece of test equipment should be used to test for an open field coil winding in a universal motor?

    a. a voltmeter
    b. a wattmeter
    c. an ohmmeter
    d. an ammeter

13. When using a test lamp on an open-field coil of a universal motor, the light would:

    a. stay cut
    b. glow normally
    c. glow dimly
    d. glow brightly

14. When metering a universal motor's field coil, the meter is connected:

    a. in parallel with the commutator
    b. in parallel with the field coil
    c. in series with the stator windings
    d. in series with the field coil

15. If the insulation is burnt on the field coils:

    a. revarnish
    b. rewind the coils
    c. it is a normal condition
    d. rewind the whole motor

78.01.08.04

16. When are the field windings and armature in a universal motor tested for defects?

    a. after assembly
    b. before assembly
    c. before and after assembly
    d. after cleaning and lubrication

17. If a universal motor sparks badly, the trouble may be:

    a. shorted fields
    b. overload
    c. high mica
    d. wrong voltage

78.01.08.04 (continued)

18. If a universal motor has dry bearings, it will:

    a. spark badly
    b. smoke
    c. have poor torque
    d. run hot

19. If a universal motor sparks badly, the trouble may be:

    a. brushes off-neutral
    b. overload
    c. wrong voltage
    d. shorted field poles

20. How many coils are usually found in a universal motor armature slot?

    a. two
    b. one
    c. three
    d. four

78.01.08.05

21. Single phase induction motors require an auxiliary winding to provide t..e motor with starting torque. How is this done in a shaded-pole motor?

    a. one closed turn of heavy copper wire embedded in one side of each stator pole
    b. there is no need because it has very little torque
    c. many turns of light copper wire in the stator or frame
    d. it is wound at same time as the field coils

22. When does the magnetic axis flux shift from the unshaded part of the pole to the shaded part?

    a. in one full cycle
    b. it doesn't shift
    c. in one and a half cycles
    d. in one-half cycle

23. What is the phase difference between the shaded winding and the field windings?

    a. 45 degrees
    b. 180 degrees
    c. 90 degrees
    d. 270 degrees

78.01.08.05 (continued)

24. Shaded-pole motors have stators constructed similarly to what other motor?

a. split-phase
b. universal
c. polyphase
d. shunt wound

25. As current drops, what is induced in the shaded coil?

a. very little current
b. no current
c. a great amount of current
d. reverse current

78.01.08.06

26. Identify figure number 5 on the attached illustration:

a. rotor
b. end bell
c. bearing
d. rotor

27. Identify figure number 4 on the attached illustration:

a. end bell
b. bearing
c. stator
d. winding

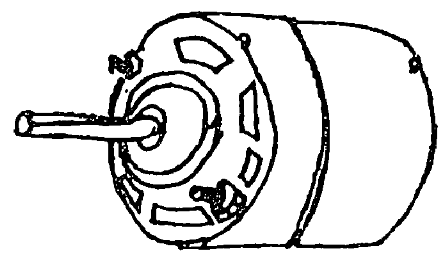
28. Identify item number 3 on the attached illustration:

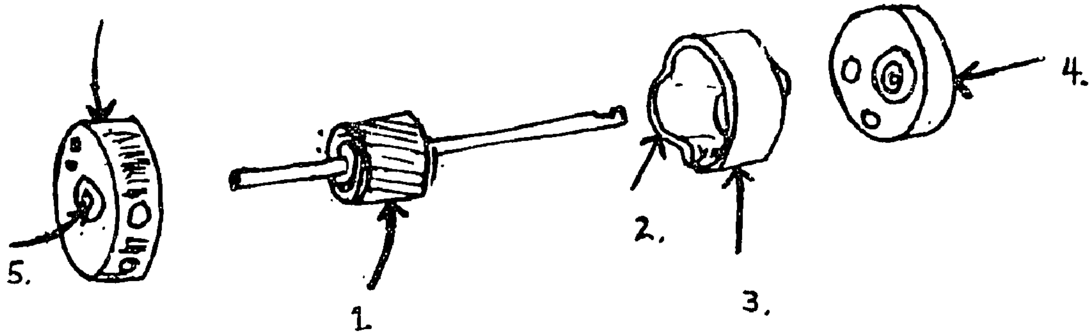
a. rotor
b. end bell
c. winding
d. stator

29. Identify item number 2 on the attached illustration:

a. stator
b. winding
c. end bell
d. rotor

SHADED POLE MOTOR





78.01.08.06 (continued)

30. Identify item number 1 on the attached illustration:

a. rotor
b. bearing
c. stator
d. winding

78.01.08.07

31. If a shaded-pole motor smokes, the repairman should check for:

a. dirt
b. a shorted armature
c. wrong voltage
d. a shorted auxiliary winding

32. What piece of test equipment should be used to test for an open-field coil in a shaded-pole motor?

a. an ohmmeter
b. a wattmeter
c. a voltmeter
d. an ammeter

33. If a shaded-pole motor is plugged with dirt, one symptom will be:

a. heat
b. a non-operational motor
c. smoke
d. poor torque

34. When using a test lamp on a shorted field-coil of a shaded-pole motor, the light would:

a. glow dimly
b. glow brightly
c. glow normally
d. stay out

35. Windings in a stator in a shaded pole motor must be connected so what will develop?

a. alike polarity results
b. variable polarity results
c. consistant polarity results
d. alternate polarity results

78.01.08.08

36. What will an ohmmeter read when testing a shorted armature coil of a shaded-pole motor?

    a. zero
    b. a little resistance
    c. infinite
    d. the test cannot be performed with an ohmmeter

37. Why should insulating paper be placed on the corners of a shaded-pole motor or around its core?

    a. to prevent the coil from shorting
    b. to prevent damage to the armature
    c. to prevent the coil from grounding
    d. to prevent a blown fuse

38. The easiest way to reverse a shaded pole motor is to:

    a. reverse the field connections
    b. reverse the stator in its housing
    c. rewind the fields
    d. rewind the stator

39. A shaded pole motor has which of the following characteristics?

    a. very long life
    b. low starting torque
    c. high starting torque
    d. very high efficiency

40. The stator on most shaded pole motors is constructed with what type of core?

    a. laminated core
    b. solid core nonmetallic
    c. very soft nonmetallic
    d. resistive nonmetallic

UNIT TEST ANSWER SHEET
UNIT POST TEST:
UNIVERSAL AND SHADED-POLE MOTORS

Occupational Area:
File Code: 78.01.08.00.B2-2
Name:

ANSWERS

78.01.08.01	1.	A	78.01.08.05	21.	A	41.	
	2.	B		22.	D	42.	
	3.	D		23.	C	43.	
	4.	C		24.	A	44.	
	5.	D		25.	A	45.	
78.01.08.02	6.	B	78.01.08.06	26.	C	46.	
	7.	C		27.	A	47.	
	8.	D		28.	D	48.	
	9.	B		29.	B	49.	
	10.	B		30.	A	50.	
78.01.08.03	11.	C	78.01.08.07	31.	C	51.	
	12.	C		32.	A	52.	
	13.	A		33.	D	53.	
	14.	D		34.	C	54.	
	15.	B		35.	C	55.	
78.01.08.04	16.	C	78.01.08.08	36.	A	56.	
	17.	C		37.	C	57.	
	18.	D		38.	B	58.	
	19.	D		39.	B	59.	
	20.	A		40.	A	60.	

Student: ______________________ File Code: 78.01.08.00.A1-5

Date: ______________________ Date Published: 11/15/74

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

Family Pay Number: __________ Sex: M F (Circle 1)

UNIT PERFORMANCE TEST: UNIVERSAL AND SHADED POLE MOTORS

OBJECTIVE 1:

Given a malfunctioning universal or shaded pole motor the student will service and repair a motor so that it functions according to the manufacturer's specifications, following safe practices and procedures.

OBJECTIVE 2:

Using appropriate tools and test equipment the student will take shorts and open tests.

OBJECTIVE 3:

Using appropriate equipment, the student will rewind a faulty universal or shaded pole motor.

OBJECTIVE 4:

Using appropriate tools and test equipment, the student will calculate and record amperage, voltage, resistance and wattage of the universal or shaded pole motor.

TASK:

The student will service and repair a universal or shaded pole motor and, in the process, he will make shorts and open and grounding tests, using appropriate test equipment.

ASSIGNMENT:

CONDITIONS:

The student will be given a malfunctioning universal or shaded pole motor. (It may be bugged by the instructor or it may be one brought in by a customer.) He will be required to service and repair the motor in conditions similar to those in a typical motor repair shop. He will be allowed to use any and all tools, equipment, service manuals, text books, etc., commonly found in a repair shop. He must complete it in a reasonable length of time with no assistance from the instructor(s) or students.

RESOURCES:

Tools: internal-external snap ring pliers
7-piece nut driver set
Tool box 18x8x9
Circular gauge
Hacksaws
Pulley puller
Arc joint pliers
Lineman's pliers
Diagonal cutting pliers
Long chain-nose pliers
Locking plier wrench
Coil tamping pliers
4-piece standard set screwdrivers
Center punch
Cold chisel
Ball pein hammer
Lug crimpers
Wire skinner and straightener

Equipment:

Coil stripping chisel
Armature winder
Coil winder
External Growler
Insulation former
Coil shapers

Student: ______________________ File Code: 78.01.08.00.A1-5

Date: ______________________ Date Published: 11/15/74

Family Pay Number: __________ Sex: M F (Circle 1)

Mountain-Plains Education & Economic Development Program, Inc.
Glasgow AFB, Montana 59231

PERFORMANCE CHECKLIST:

OVERALL PERFORMANCE: Satisfactory_____ Unsatisfactory_____

	CRITERION Met	Not Met
Objective 1:		
1. Follows safe practices and procedures.		
Criterion: a. No injury results to the student or equipment.		
b. Complies with OSHA requirements.		
2. Follows proper procedures for disassembly.		
Criterion: No damage results to the motor.		
3. Diagnoses and troubleshoots malfunctions properly.		
Criterion: When repaired, the motor functions according to		
the manufacturer's specifications.		
4. Reassembles the motor properly.		
Criterion: Appliance functions according to the manufacturer's		
specifications and the procedures followed agree		
with those described in the service literature.		
5. The repaired motor is repaired in a neat, professional		
manner.		

	CRITERION Met	Not Met
Criterion: No damage results to the motor such as opens and shorts.		
6. All connections and fastenings are properly completed.		
Criterion: The motor connection complies with the manufacturer's specifications. The connections are mechanically fastened and structurally sound. The connection is electrically fastened and free of defects.		
7. Motor functions according to the manufacturer's specifications.		
Criterion: Manufacturer's specifications.		
8. Uses appropriate repair part and supplies.		
Criterion: They match exactly those listed in the manufacturer's specifications.		
Objective 2:		
9. Test for grounded commentator, using test lamp.		
Criterion: Trouble-shooting techniques reveal the malfunction as identified on the job sheet.		
10. Test for shorted commentator, using test lamp.		
Criterion: Trouble-shooting techniques reveal the malfunction as identified by the job sheet.		
11. Test for grounds, using growler or millivolt meter.		

(Checklist continued)

	CRITERION Met	Not Met
Criterion: Trouble-shooting techniques reveal the malfunction		
as identified by job sheet.		
12. Test for shorts in the field coils, using a growler.		
Criterion: Trouble-shooting techniques reveal the malfunction		
as identified by job sheet.		
13. Test for shorts in the armature coil, using a growler.		
Criterion: Trouble-shooting techniques reveal the malfunction		
as identified by job sheet.		
14. Test for an open field coil, using an ohmmeter		
Criterion: Trouble-shooting techniques reveal the malfunction		
as identified by job sheet..		
15. Test for an open armature coil, using an ohmmeter.		
Criterion: Trouble-shooting techniques reveal the malfunction		
as identified by job sheet.		
16. Test for reversed coils, using a compass or bar		
magnet test.		
Criterion: Trouble-shooting techniques reveal the malfunction,		
as identified by job sheet.		
Objective 3:		
17. Uses coil-stripping tool to remove coils.		

	CRITERION Met	Not Met
18. Uses armature winder, if appropriate, when winding the		
armature.		
19. Uses coil winder, if appropriate, when winding field coil.		
20. Uses insulation former, if appropriate, when insulating.		
21. Uses coil shaper, if appropriate, on the field coils.		
Criterion: Proper equipment application results in a		
defect-free operative motor.		
Objective 4:		
22. Uses test equipment properly.		
23. Wattage readings are accurate.		
24. Voltage readings are accurate.		
25. Amperage readings are accurate.		
26. Resistance readings are accurate.		
Criterion: Manufacturer's specifications.		
27. When applicable, mathematical calculations are correct.		
Criterion: AC/DC Circuit Manuals, Westinghouse.		
28. The motor is repaired in a reasonable time.		
Criterion: Not to exceed 6 hours.		
The student must successfuly complete 25 out of 28 line items		
to achieve an overall score of satisfactory.		

"END OF DOCUMENT"