

## Steam Engines

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In the circuit 'B' of the illustration, what would be the result of the upper heating element being burned out and open circuited? Illustration EL-0041

**low heat (series) position would result in no heat at all medium heat (single) position would result in no heat at all high heat (parallel) position would result in medium heat**

Illustrations: EL0041\_AO\_030915WM

As shown in figure "1" of the illustration, a correctly connected synchronous transmission causes the receiver to be in correspondence with the transmitter. If the receiver is out of correspondence, 180 degrees out of zero, but the torque direction is correct as shown in figure "2", what figure shows the incorrect connections responsible for this condition? Illustration EL-0150

**B**

Illustrations: EL0150\_AO\_091611WM

As shown in the illustrated wiring diagram for an engine order telegraph system, what statement concerning the constant ringing and trouble alarm is true? Illustration EL-0113

**The constant ringing and trouble alarm sounds when the acknowledge handle and indicator arrow are not on the same order.**

Illustrations: EL0113\_AO\_070715WM

At a minimum threshold, how many milliamps of current through the body produces a condition where most people would be unable to let go of the energized electrical conductor due to involuntary muscular contraction?

**10 to 16 mA**

Illustrations: EFFECTS OF ELECTRICAL CURRENT

At a minimum threshold, how many milliamps of current through the body produces a condition where most people would experience respiratory paralysis and be unable to breathe while still in contact with the energized conductor?

**30 mA**

Illustrations: EFFECTS OF ELECTRICAL CURRENT

At a minimum threshold, how many milliamps of current through the body produces a condition where most people would suffer ventricular fibrillation and could only be resuscitated with a ventricular defibrillator?

**75 mA for 5 sec.**

Illustrations: EFFECTS OF ELECTRICAL CURRENT

At a minimum threshold, how many milliamps of current through the body produces a painful sensation that most people would perceive as an electric shock?

**3 to 7 mA**

Illustrations: EFFECTS OF ELECTRICAL CURRENT

In using a portable growler for the purpose of locating a shorted stator coil in an AC motor as shown in the illustration, what statement is true as the feeler is moved from slot to slot around the stator? Illustration EL-0200

**The feeler will vibrate in synchronism with the 60 Hz AC power source and produce a growling noise when the feeler is moved over a slot containing a shorted coil.**

Illustrations: EL0200\_AO\_051815WM

A digital multimeter is set up as shown in the illustration to evaluate the single-circuit stator windings of a squirrel cage induction three-phase motor. The following readings are taken: From T1 to T2 reads "OL" ohms. From T2 to T3 reads "OL" ohms. From T3 to T1 as shown reads "1.6" ohms. What condition is indicated? Illustration EL-0219

**Phase A (associated with T1) and Phase C (associated with T3) are undamaged. Phase B (associated with T2) is open-circuited.**

**Illustrations:** EL0219\_WM\_101118  
See REF354

As shown in the illustrated wound-rotor induction motor how is the direction of rotation of the motor reversed? Illustration EL-0148

**Any two of the "T1, T2, and T3" leads are reversed only.**

**Illustrations:** EL0148\_WM\_100918

What are the operational characteristics of the split phase motor shown in figure "B" of the illustration? Illustration EL-0215  
**The motor is reversible and dual-voltage, configured for high volts.**

**Illustrations:** EL0215\_AO\_051815WM

Within the split phase family of single phase motors, what are the operational characteristics of the motor shown in figure "B" of the illustration? Illustration EL-0207

**Relatively high starting torque and relatively low running efficiency**

**Illustrations:** EL0207\_WM\_101018

As shown in figures "A", "B", "C", and "D" of the illustration, what is the usual means by which the rotation direction of the motor is reversed? Illustration EL-0207

**Interchanging leads T5 and T8**

**Illustrations:** EL0207\_WM\_101018

Which of the pictured motors within the split phase family of single phase induction motors represents a capacitor start, induction run motor? Illustration EL-0146

**A**

**Illustrations:** EL0146\_AO\_091611WM

According to the sample sheet of a typical "List of Motors and Controls" as shown in the illustration, which of the following motor applications features a means of keeping the motor windings warm and dry when the motor is idle? Illustration EL-0204

**Amidship mooring winch**

**Illustrations:** EL0204\_AO\_051815WM

Which of the following statements describes what will occur if the motor torque-speed and current-speed curves shown in the illustration is required to carry 150% of full load? Illustration EL-0056

**The stator current will increase.**

**Illustrations:** EL0056\_WM\_100518

The torque-speed and current-speed curves for a three-phase induction motor with a squirrel-cage rotor are shown in figures "A" and "B" of the illustration. Which of the following statements is true concerning the depicted curves? Illustration EL-0056

**Starting current is approximately 4.75 times the normal full load current value.**

**Illustrations:** EL0056\_WM\_100518

Assuming that the 3-phase power source has a phase sequence of A-B-C and that the motor is connected as shown in figure "A", if the motor has a counterclockwise (CCW) rotation, what statement is true concerning the motors connected as shown in the other figures? Illustration EL-0156

**Motors "B" and "D" would have a clockwise (CW) rotation and motor "C" would have a counterclockwise (CCW) rotation.**

**Illustrations:** EL0156\_AO\_091611WM

What type of motor is illustrated by the schematic of figure "B" of the illustration and what type of starting relay is used? Illustration EL-0209

**capacitor start, induction run motor using a potential starting relay**

**Illustrations:** EL0209\_AO\_051815WM

Which of the pictured motors is a square core shaded pole motor used to drive very small electrical loads and is non-reversible \_\_\_\_\_? Illustration EL-0208

**B**

**Illustrations:** EL0208\_WM\_101018

Which of the illustrated motors has a totally enclosed, fan-cooled (TEFC) motor enclosure? Illustration EL-0001

**A**

**Illustrations:** EL0001\_WM\_100518

As shown in the two-speed single winding three phase motor connection diagrams illustrated in figure "B", what is the connection scheme associated with low speed operation? Illustration EL-0118

**series delta**

**Illustrations:** EL0118\_AO\_022818WM

If a digital multimeter is set up as shown in figure "A" of the illustration to test an AC contactor coil, what would the display read if the coil is open-circuited? Illustration EL-0214

**OL ohms**

**Illustrations:** EL0214\_WM\_101118

See REF354

As shown in figure "A" of the illustration, if in troubleshooting the control circuit using on-line techniques with a voltmeter with the start button depressed and the following readings are taken, what is the problem? "X1" to "X2" reads 115 VAC; "1" to "X2" reads 115 VAC; "2" to "X2" reads 0 VAC; and "3" to "X2" reads 0 VAC. Illustration EL-0123

**the stop button is open-circuited**

**Illustrations:** EL0123\_WM\_100918

Which device will stop the motor shown in the illustration in case of a short-circuit (high current) motor fault? Illustration EL-0080

**disconnect switch fuses FU1, FU2, and FU3**

Illustrations: EL0080\_WM\_100518

As shown in the illustrated electrically operated watertight door controller, how is the rotation direction of the door motor reversed? Illustration EL-0115

**reversing the direct current direction through the motor armature and maintaining the same direct current direction through the motor series field**

Illustrations: EL0115\_WM\_100918

As shown in the illustration, what type of starter is illustrated? Illustration EL-0104

**reduced voltage primary resistance starter**

Illustrations: EL0104\_WM\_100918

In the illustrated motor controller, what do the contacts across terminals "3" and "4" of the control circuit represent?

Illustration EL-0017

**normally-closed overload relay contact**

Illustrations: EL0017\_WM\_070819

As shown in the illustration, which of the following conditions will occur as a result of a momentary loss of power?

Illustration EL-0017

**The motor will automatically restart when power is restored.**

Illustrations: EL0017\_WM\_070819

As shown in the illustration, assuming power is available at the control circuit, which listed action will occur FIRST when the "off-run" switch is placed in the "run" position? Illustration EL-0017

**The contactor coil "M" energizes.**

Illustrations: EL0017\_WM\_070819

If the motor shown in the illustration will not start when the "off-run" switch is placed in the run position, which of the listed components should be checked FIRST? Illustration EL-0017

**check the overload relay for tripped condition, reset as necessary**

Illustrations: EL0017\_WM\_070819

When a motor is started by the controller shown in figure "C" of the illustration, what circuit components are in the holding current flow path through the control circuit while the motor is in operation? Illustration EL-0010

**the stop button contacts, the "B1" contacts, the "M" contacts, the "M" coil and the "OL" contacts**

Illustrations: EL0010\_AO\_022515WM

As shown in figure "A" and "B" of the illustration, the potable water pump is short cycling by the action of the pressure switch as a result of an unusually high level in the potable water hydro pneumatic header tank. What is most likely the cause? Illustration EL-0043

**The potable water hydro-pneumatic header tank is in need of recharging with compressed air due to absorption of air into the water over time.**

Illustrations: EL0043\_AO\_030915WM

In the illustration shown, what type of protection is provided the potable pump drive motor? Illustration EL-0043  
**thermal overload protection and low voltage release**

Illustrations: EL0043\_AO\_030915WM

Which of the following statements is true concerning the motor controller circuit shown in the illustration? Illustration EL-0004

**The controller is configured for use with a three phase non-reversible squirrel-cage induction motor.**

Illustrations: EL0004\_AO\_062617WM

Which of the following illustrated manual motor starters represents the wiring diagram illustrated in figure "A"? Illustration EL-0023

**1**

Illustrations: EL0023\_AO\_091817WM

As shown in figure "B" of the illustration, when the DC motor in figure "A" is operating at minimum speed what are the armature and field characteristics? Illustration EL-0153

**The motor is operating at minimum armature voltage and maximum field current.**

Illustrations: EL0153\_AO\_042715WM

As shown in figure "A" of the illustrated digital multimeter screen, what would be the significance of the symbol indicated by "2" being illuminated? Illustration EL-0047

**the selector switch is in the continuity/diode test position and the secondary function pushbutton is toggled for diode**

Illustrations: EL0047\_WM\_100518

As shown in figures "B" and "C" of the illustration, what should be the switch position and which test lead terminal jacks should be used if your intent is to measure DC currents anticipated as high as 200 milliamps? Illustration EL-0047

**switch position "6" and terminal jacks "1 and 4"**

Illustrations: EL0047\_WM\_100518

What controls rudder movement when the Operation Selector Switch shown in figure "A" of the illustration is in the "Controller" position? Illustration EL-0097

**non-follow-up controller**

Illustrations: EL0097\_AO\_041315WM

As shown in figure "A" of the illustration, fine adjustments such as "rate of turn signal" have no effect on steering stand operation when the 'operation selector switch' is in what position? Illustration EL-0097

**NFU**

Illustrations: EL0097\_AO\_041315WM

Erratic operation of the device represented in the diagram labeled "A" shown in the illustration could be traced to what condition? Illustration EL-0092

**improper contact at "R" slip rings or "S" connections**

Illustrations: EL0092\_WM\_100518

If it is required that the coils 'R1-R2-R3' in the indicator of figure "A", turn opposite to those in the transmitter, as shown in the illustration, what action should be taken? Illustration EL-0092

**Interchange leads 'R1' and 'R3'.**

Illustrations: EL0092\_WM\_100518

If coil 'R1-R2-R3' on the transmitter in figure "C" shown in the illustration is turned 30 degrees clockwise, how will the corresponding coils 'R1-R2-R3' on the receivers (indicators) respond? Illustration EL-0092

**torque will cause them to align to the same position**

Illustrations: EL0092\_WM\_100518

In actual applications, electrical connections associated with 'R1, R2 and R3' of the transmitter to 'R1, R2, and R3' of the indicators shown in figure "C" of the illustration are made by what means? Illustration EL-0092

**slip rings and brushes**

Illustrations: EL0092\_WM\_100518

As shown in the illustration, what is the functional purpose of the normally closed and normally open auxiliary contacts of the hoist and lower contactors respectively? Illustration EL-0102

**the normally closed hoist and lower contactor auxiliary contacts are interlock contacts preventing simultaneous pulling in both the hoist and lower contactors and the normally open contacts extend control power to the speed control circuits**

Illustrations: EL0102\_WM\_061319

The progressive operation of the contactors marked "1A" through "4A" provide the winch hoist controller shown in the illustration with what functionality? Illustration EL-0102

**acceleration**

Illustrations: EL0102\_WM\_061319

Which of the listed conditions occur when '4th point lower' is selected on the winch hoist controller shown in the illustration? Illustration EL-0102

**Contactors 'L', '1A', '2A' and '3A' pull in.**

Illustrations: EL0102\_WM\_061319

The winch shown in the illustration will operate normally in all speeds in both directions, with the exception that it will not accelerate into 'fifth point' hoist or 'fifth point' lower. What would be a possible cause? Illustration EL-0102

**time delay relay '3T' coil is open-circuited**

Illustrations: EL0102\_WM\_061319

As shown in the illustration, what is responsible for maintaining the "UV" relay energized when the master switch handle is moved away from the "off" position? Illustration EL-0102

**normally open 'UV' contacts**

Illustrations: EL0102\_WM\_061319

What functionality do the 'MS 1' contacts of the master switch shown in the illustration provide? Illustration EL-0102

**low voltage protection**

Illustrations: EL0102\_WM\_061319

What is the functional purpose of the 'LSH' contacts for the hoist controller circuit shown in the illustration? Illustration EL-0102

**it is a limit switch which automatically stops the winch drum rotation in the hoist direction before the hoist block is able to strike the boom**

Illustrations: EL0102\_WM\_061319

Concerning the illustrated fire detection and alarm system, what statement is true concerning the wiring between zones? Illustration EL-0114

**The zones are all connected in series by means of the fire locating switches and the ground locating switches.**

Illustrations: EL0114\_AO\_070715WM

If a digital multimeter is set up as shown in figure "A" of the illustration to test a capacitor, what would the display read if the capacitor is shorted? Illustration EL-0213

**the ohmic value would read very low and remain at that value**

Illustrations: EL0213\_WM\_092821

See REF354

If a digital multimeter is set up as shown in figure "B" of the illustration to test a capacitor, what would the display read if the capacitor was functioning properly? Illustration EL-0213 "

**the actual capacitance value of the capacitor will be displayed which should be within the tolerance range of the capacitor**

Illustrations: EL0213\_WM\_092821

See REF354

The characteristics of the device shown in figure "8" of the illustration includes a stable voltage and low current while operating. Because of this, it can be suitably used in what type of circuit? Illustration EL-0065

**switching and timing circuits**

Illustrations: EL0065\_WM\_100518

Which of the pictured solid-state semiconductor devices in the illustration is a rectifier bridge? Illustration EL-0068

**3**

Illustrations: EL0068\_WM\_100518

What is the name of the device shown in figure "2" of the illustration? Illustration EL-0068

**power rectifier diode**

Illustrations: EL0068\_WM\_100518

What does the drawing in the illustrated circuit represent? Illustration EL-0063

**a three phase full wave rectifier**

Illustrations: EL0063\_AO\_091411WM

All of the schematic diagrams shown in the illustration represent which of the listed solid-state circuits? Illustration EL-0069

**Full-wave rectifier**

Illustrations: EL0069\_AO\_091411WM



Given the circuit and individual AC and DC voltage waveforms shown in figure "A" producing the composite voltage waveform shown in figure "B", what would be the value of the average current passing through the load resistor with a resistance of 1 ohm? Illustration EL-0075

**20 amps**

**Illustrations:** EL0075\_WM\_100518

Which of the wave shapes shown in the illustration is termed a ramp or sawtooth wave? Illustration EL-0088

**C**

**Illustrations:** EL0088\_WM\_100518

See REF357

Which line in figure "B" shown in the illustration represents the trailing edge of the wave? Illustration EL-0088

**4**

**Illustrations:** EL0088\_WM\_100518

See REF357

The multiplier prefix 'giga' (G) such as used in "gigabytes" represents what multiplication factor?

**billion (10 to the 9th power)**

**Illustrations:** METRICPREFIXES

See REF1921

In the illustration shown, what would be the functional name for the coil represented as '1S'? Illustration EL-0012

**neutral contactor coil (for autotransformer wye connection)**

**Illustrations:** EL0012\_AO\_100518WM

As shown in the illustrated devices and symbols, which of the devices represents an open general purpose relay?

Illustration EL-0005

**A**

**Illustrations:** EL0005\_WM\_100518

See REF1920

What would be the source current and transformer current as shown in figure "B" of the illustration, with the secondary tap connected as shown, if the supply voltage at the branch circuit breaker is 440 VAC and the unity power factor load current draw is 50 amps? Illustration EL-0083

**source current is 12.5 amps, transformer current is 37.5 amps.**

**Illustrations:** EL0083\_WM\_100518

As shown in the wiring diagram of the semi-automatic navigation lighting panel circuit, what would cause the buzzer to sound and for the indicator light to illuminate in the line section for a particular navigation running light? Illustration EL-0108

**a burned out navigation light in effected line section**

**Illustrations:** EL0108\_WM\_051619

In the lighting distribution circuit shown in the illustrated lighting panel L110 of the illustration, if all circuit breakers are closed and due to a problem with the relevant feeder circuit breaker, there is a loss of power on the incoming phase A, which of the following statements is true? Illustration EL-0013

**Half of the accommodation lighting circuits on the 01 deck, port side would lose power.**

**Illustrations:** EL0013\_WM\_100518

As shown in the illustrated plots of uncorrected and temperature corrected insulation resistance readings for a particular piece of equipment, at what point in time should the equipment have been refurbished or replaced? Illustration EL-0120  
***no refurbishment or replacement was necessary through 2011***

**Illustrations:** EL0120\_WM\_100918

What is the resistance reading at "2" on the megger scale shown in figure "A" of the illustration? Illustration EL-0044  
***40 megohms***

**Illustrations:** EL0044\_AO\_030915WM

If a digital multimeter is set up as shown in figure "A" of the illustration, what would be displayed on the screen if the fuse being tested is not blown and has proper continuity? Illustration EL-0210  
***0.001 ohms***

**Illustrations:** EL0210\_WM\_101018  
See REF354

In order to definitively determine whether or not fuse "2", shown in the illustration is blown using an on-line testing technique, across what points would you connect the voltmeter leads? Illustration EL-0062  
***the bottom of fuse "2" to the top of either fuse "1 or 3"***

**Illustrations:** EL0062\_WM\_100518

Which of the following is a pictured three phase power transformer, usually used to step down line voltage for supplying reduced voltage lighting circuits? Illustration EL-0177  
***D***

**Illustrations:** EL0177\_WM\_101018

As shown in the illustration, which of the lighting fixtures represents an incandescent bulb? Illustration EL-0122  
***B***

**Illustrations:** EL0122\_WM\_10918

What is indicated by gradual blackening at the ends of component "4" shown in figures "B" and "C" of the illustration? Illustration EL-0081  
***The tube is nearing the end of its useful life.***

**Illustrations:** EL0081\_WM\_100518

During start-up of the circuit shown in figure "B" of the illustration, it is noted that the ends of component "4" alternately glow and become dark without the tube illuminating. What is the most probable cause for this condition? Illustration EL-0081  
***component "3" is shorted and therefore unable to produce the high voltage required to start the lamp***

**Illustrations:** EL0081\_WM\_100518

Which of the listed types of lighting fixtures does the diagram shown in figure "A" of the illustration represent? Illustration EL-0081  
***Low pressure mercury fluorescent***

**Illustrations:** EL0081\_WM\_100518

What is the functional purpose component "5" as shown in figure "B" of the illustration? Illustration EL-0081  
***initially heat the fluorescent tube filaments at startup and cause the ballast to strike the arc to fire the tube after warm-up***

Illustrations: EL0081\_WM\_100518

What is the purpose of the capacitor within component "5" of the circuit shown in figure "B" of the illustration? Illustration EL-0081  
***prolong the life of the component's contacts***

Illustrations: EL0081\_WM\_100518

As shown in the illustration of a vessels navigational lighting circuit, if port running light "1" burns out, the trouble buzzer will sound and the port running light trouble lamp will illuminate. Switching to port running light "2" clears the alarm. If port running light "1" is replaced with a light of a smaller wattage and the circuit is switched back to port running light "1", which of the following is true? Illustration EL-0058

***There may be insufficient current to energize the trouble relay coil and to open the contacts to silence the alarm.***

Illustrations: EL0058\_WM\_100518

As shown in the illustration, the change-over switch is what type of device? Illustration EL-0058  
***double-pole, double-throw switch***

Illustrations: EL0058\_WM\_100518

As shown in the illustration, what are the characteristics of the trouble relay contacts? Illustration EL-0058  
***two sets of normally closed contacts which open when the trouble relay coil is energized***

Illustrations: EL0058\_WM\_100518

What type of circuit is represented by the diagram shown in the illustration? Illustration EL-0058  
***navigation running light circuit***

Illustrations: EL0058\_WM\_100518

As shown in the illustration, what event would give the same indication that would occur when a stern light circuit fuse blows open? Illustration EL-0058  
***stern light "2" burns out***

Illustrations: EL0058\_WM\_100518

As shown in the illustration, what maintenance would be required of the circuit components? Illustration EL-0058  
***Clean the glass surrounding the individual navigation lights as needed.***

Illustrations: EL0058\_WM\_100518

Which of the illustrated safety disconnect switches represents a double throw switch? Illustration EL-0176  
***B and D***

Illustrations: EL0176\_WM\_101018

As shown in the illustration, which of the following pieces of equipment is provided with a remote pushbutton station? Illustration EL-0165  
***Cargo Oil Transfer Pump No. 1***

Illustrations: EL0165\_AO\_050415WM

As shown in figure "B" of the illustration, with respect to the common equipment grounding conductor, what statement is true? Illustration EL-0125

**The common equipment grounding conductor is solidly-grounded at the source and this is the least common arrangement onboard merchant vessels.**

Illustrations: EL0125\_WM\_100918

In which figure shown in the illustration will the highest voltage be induced? Illustration EL-0028  
**both figures "B" and "D"**

Illustrations: EL0028\_AO\_030915WM

Which of the following statements is true concerning the following illustration? Illustration EL-0028  
**The figures represent a basic DC generator**

Illustrations: EL0028\_AO\_030915WM

As shown in the illustration, which brush holder is of the reaction type? Illustration EL-0029  
**4**

Illustrations: EL0029\_WM\_100518, EL0029\_AO\_030915WM

As shown in the illustration, which brush holder would be appropriate to use in a bidirectional motor? Illustration EL-0029  
**radial mount**

Illustrations: EL0029\_WM\_100518, EL0029\_AO\_030915WM

As shown in the illustration, which brush holder is of the reaction type? Illustration EL-0029  
**4**

Illustrations: EL0029\_WM\_100518, EL0029\_AO\_030915WM

As shown in the illustration, which brush holder would be appropriate to use in a bidirectional motor? Illustration EL-0029  
**radial mount**

Illustrations: EL0029\_WM\_100518, EL0029\_AO\_030915WM

Which of the diagrams shown in the illustration depicts the proper method of aligning brushes on a commutator for a DC machine? Illustration EL-0057

**C**

Illustrations: EL0057\_AO\_033015WM

As shown in the illustrated DC machine which is configured as a generator, what type of machine is illustrated in terms of the configuration of the windings? Illustration EL-0052  
**shunt wound**

Illustrations: EL0052\_AO\_060216WM

See REF1889

Which electrical schematic symbol represents a normally open thermostat? Illustration EL-0059  
**9**

Illustrations: EL0059\_WM\_100518

Which of the electrical schematic symbols represents a normally open limit switch? Illustration EL-0059  
**12**

**Illustrations:** EL0059\_WM\_100518

Which of the illustrated resistors represents the schematic symbol shown in figure "C"? Illustration EL-0021  
**figure "6"**

**Illustrations:** EL0021\_WM\_100518  
See REF1855

The electrical diagram shown in figure "B" of the illustration represents what type of DC motor? Illustration EL-0054  
**compound-wound DC motor**

**Illustrations:** EL0054\_WM\_060216  
See REF1887

Which of the electronic schematic symbols represents the capacitor illustrated in figure "2" of the illustration? Illustration EL-0015  
**C**

**Illustrations:** EL0015\_WM\_100518

As shown in figure "6" of the illustration, what does the symbol represent as used in electrical drawings? Illustration EL-0026  
**maintaining type push button with a mechanical interlock**

**Illustrations:** EL0026\_WM\_100518

Which of the illustrated schematic symbols represents the type of switch pictured in figure "F" of the illustration? Illustration EL-0026  
**3**

**Illustrations:** EL0026\_WM\_100518

Which figure represents the schematic symbol shown in figure "2"? Illustration EL-0034  
**figure "B"**

**Illustrations:** EL0034\_WM\_100518

As shown in the illustrated one-line diagram of a two-tiered emergency power system for a passenger ship, what statement is true? Illustration EL-0166  
**On a restoration of normal ship's power, the final and temporary emergency loads power source is from the main switchboard.**

**Illustrations:** EL0166\_WM\_101018

Which of the listed figures in the illustration represents a transformer configured for single voltage primary and a tapped secondary? Illustration EL-0055  
**D**

**Illustrations:** EL0055\_WM\_100518

A load is connected across the secondary of the step up transformer shown in figure "B" of the illustration and the current drawn by the load is 10 amps. If the turns ratio is 1 to 10 and the input voltage is 110 VAC, what will be the current drawn by the primary? Illustration EL-0055

**100 amps**

**Illustrations:** EL0055\_WM\_100518

If the illustrated device in figure "B" has a step-up ratio of 10 to 1 what voltage would be measured at the secondary shortly after the primary of the device is connected to 110 volts DC with a current of 12 amps? Illustration EL-0055

**0 volts**

**Illustrations:** EL0055\_WM\_100518

The turns ratio of the step down transformer with dual voltage secondary as shown in figure "B" of the illustration is two to one (total). If 440 volts were applied to terminals 'H1' and 'H2', what would be measured across 'X1-X3' and 'X2-X4' assuming that the secondary windings are connected in parallel? Illustration EL-0082

**110 volts**

**Illustrations:** EL0082\_WM\_100518

See REF1885

What power would be consumed by the series resistor in the circuit shown in the illustration if the source is 30 volts, the resistance for R1 is 10 ohms, R2 is 10 ohms and R3 is 10 ohms? Illustration EL-0032

**40 watts**

**Illustrations:** EL0032\_WM\_100518, SERIESPARALLEL869

See REF1855

What does the symbol labeled "OL" represent as shown in the power circuit on lines T1 and T3 to the motor as shown in figure "A" of the illustration? Illustration EL-0011

**overload relay thermal heater**

**Illustrations:** EL0011\_WM\_100518

If the supply voltage is 220 volts 60 Hz, what is the operating voltage of the motor controller control circuit illustrated in figure A of the illustration? Illustration EL-0011

**220 volts AC**

**Illustrations:** EL0011\_WM\_100518

See REF1876

In the illustration, 1, 2, 3 and 4 are 12 volt batteries. What will be the nominal voltage as read by a voltmeter across the output of the battery bank? Illustration EL-0107

**24 volts**

**Illustrations:** EL0107\_AO\_021618WM

What would be the terminal voltage and ampere-hour capacity of the battery bank if each battery was rated at 50 amp-hours and 6 volts? Illustration EL-0107

**12 volts and 100 ampere-hours**

**Illustrations:** EL0107\_AO\_021618WM

A battery is connected to a circuit containing three resistors in parallel. The values of the three resistors are 2 ohms, 3 ohms, and 6 ohms. What is the voltage of the battery if the total circuit current is 12 amps?

**12 volts**

**Illustrations:** PARALLELCIRCUITS1511

See REF1855

What would be the total current flowing in the circuit shown in figure "B" of the illustration if the source is 30 volts, the resistance of R1 is 10 ohms, R2 is 10 ohms and R3 is 10 ohms, respectively? Illustration EL-0032

**2 amps**

**Illustrations:** EL0032\_WM\_100518

See REF1855

What power would be consumed by the series resistor in the circuit shown in the illustration if the source is 30 volts, the resistance for R1 is 10 ohms, R2 is 10 ohms and R3 is 10 ohms? Illustration EL-0032

**40 watts**

**Illustrations:** EL0032\_WM\_100518, SERIESPARALLEL869

See REF1855

What would be the voltage drop across the parallel branches of the circuit shown in figure "B" of the illustration if the source voltage is 30 volts, the resistance for R1 is 10 ohms, the resistance for R2 is 10 ohms and the resistance for R3 is 10 ohms? Illustration EL-0032

**10 volts**

**Illustrations:** EL0032\_WM\_100518

See REF1855

What will be the resulting current when a voltage of 110 VDC is applied to a resistance of 32 ohms in figure "A" of the illustrated circuit when the switch is closed? Illustration EL-0018

**3.44 amps**

**Illustrations:** EL0018\_WM\_100518

See REF1874

What will be the resulting current when a voltage of 115 VDC is applied to a resistance of 12 ohms in figure "A" of the illustrated circuit with the switch closed? Illustration EL-0018

**9.58 amps**

**Illustrations:** EL0018\_WM\_100518

See REF1874

What will be the resulting current when a voltage of 442.7 VDC is applied to a resistance of 1.25 ohms in figure "A" of the illustrated circuit when the switch is closed? Illustration EL-0018

**354.16 amps**

**Illustrations:** EL0018\_WM\_100518

See REF1874

In the illustrated views of a lead acid battery as shown in figures "A" and "B", what battery component has the sole function of preventing the individual plates in the negative plate group from coming into direct contact with the individual plates in the positive plate group? Illustration EL-0031

**separators**

**Illustrations:** EL0031\_WM\_100518

The wet-cell storage batteries shown in the illustration are connected in what configuration? Illustration EL-0070  
**parallel**

**Illustrations:** EL0070\_WM\_100518  
See REF1857

The individual 6 volt lead-acid batteries, when connected as shown in the illustration, as a battery bank would produce how many volts? Illustration EL-0070  
**6 volts**

**Illustrations:** EL0070\_WM\_100518  
See REF1857

As shown in figure "A" of the illustration, with the switch closed what statement is true if "R1" and "R2" have unequal resistance values? Illustration EL-0019  
**The current flow through 'R1' will differ from the current flow through 'R2'.**

**Illustrations:** EL0019\_WM\_100518  
See REF1855

What is the current flow through R1 of the circuit in figure "B" of the illustration with the switch closed if the resistance of R1 is 2 ohms, R2 is 3 ohms and R3 is 6 ohms and the battery voltage is 12 VDC? Illustration EL-0019  
**6 amps**

**Illustrations:** EL0019\_WM\_100518  
See REF1855

What statement is true concerning the electrical diagram shown in figure "B" of the illustration? Illustration EL-0019  
**R1', 'R2', and 'R3' are connected in parallel.**

**Illustrations:** EL0019\_WM\_100518  
See REF1855

What is the total resistance of the electrical circuit illustrated in figure "B" if the resistance of R1 is 2 ohms, R2 is 4 ohms, and R3 is 4 ohms and the battery voltage is 6 volts? Illustration EL-0019  
**1.00 ohms**

**Illustrations:** EL0019\_WM\_100518  
See REF1855

Which of the listed figures shown in the illustration represents a three phase transformer connected in a wye-delta configuration? Illustration EL-0084  
**4**

**Illustrations:** EL0084\_WM\_100518  
See REF360

In figure "2" of the diagram shown in the illustration, the three phase power transformer has a step-down turns ratio of four to one. If a three-phase 440 volt supply is connected to terminals "A1-B1-C1", what voltage should develop across terminals 'A2-B2-C2'? Illustration EL-0084  
**110 volts**

**Illustrations:** EL0084\_WM\_100518  
See REF360



In the illustrated one line diagram, if the ship's service generator on line fails, what statement is true concerning the operation of the emergency diesel generator? Illustration EL-0014

***It will automatically start and automatically supply power to the 450 VAC section of the emergency bus through the automatic bus transfer device.***

Illustrations: EL0014\_WM\_022120

What is a purpose of the automatic bus transfer device shown in the illustration? Illustration EL-0014

***Provide power to the 450 VAC emergency bus from the emergency generator in the emergency mode.***

Illustrations: EL0014\_WM\_022120

What would be the total capacitance of the circuit illustrated in figure "A" if the value of capacitor C1 was 100 microfarads and capacitor C2 was 50 microfarads? Illustration EL-0038

***150 microfarads***

Illustrations: EL0038\_WM\_100518

See REF1854

The motor fails to start on an attempted startup. With the start button depressed, a voltmeter reading between 1 and 5, as illustrated in figure "A", indicates line voltage available to the control circuit, what should be your next step in the troubleshooting process? Illustration EL-0007

***attempt to reset the overload relay and determine the cause of the overload if applicable***

Illustrations: EL0007\_WM\_100518

What type of electrical diagram is shown in figure "B" of the illustration? Illustration EL-0007

***schematic diagram***

Illustrations: EL0007\_WM\_100518

The motor starts when the start button in the illustration is pushed, but stops when the button is released. What is most likely the trouble? Illustration EL-0007

***an open auxiliary "M" contact***

Illustrations: EL0007\_WM\_100518

The illustrated motor fails to start and gives a loud hum when the start button is depressed, what should then be your first action? Illustration EL-0007

***push the stop button to deenergize the "M" coil***

Illustrations: EL0007\_WM\_100518

In the illustrated motor controller, the motor fails to start. A voltmeter reading between 1 and 5 reads line voltage, while the voltmeter reading between 2 and 5 reads 0 VAC. What is most likely the problem? Illustration EL-0007

***an open stop switch contact (when not pushed in)***

Illustrations: EL0007\_WM\_100518

If the circuit shown in the illustration were energized and operating properly, which of the devices listed would be open? Illustration EL-0007

***The start push-button***

Illustrations: EL0007\_WM\_100518

What is the name of the component labeled Q1 as shown in section "D" of the regulated DC power supply illustrated?

Illustration EL-0085

**NPN bipolar junction transistor**

**Illustrations:** EL0085\_WM\_100518

See REF357

In the regulated DC power supply illustrated, what is the function of section "B"? Illustration EL-0085

**full wave rectification**

**Illustrations:** EL0085\_WM\_100518

See REF357

Which section of the circuit shown in the illustration smoothes out highest degree of pulsations? Illustration EL-0085

**C**

**Illustrations:** EL0085\_WM\_100518

See REF357

What is the function of section "D" of the circuit shown in the illustration? Illustration EL-0085

**a voltage regulator**

**Illustrations:** EL0085\_WM\_100518

See REF357

What is the direction of electron current through the load resistor in the circuit shown in the illustration? Illustration EL-0085

**Always from the grounded end to point "TP5".**

**Illustrations:** EL0085\_WM\_100518

See REF357

In figure "1" of the illustration, what are the trip characteristics associated with this type of circuit breaker? Illustration EL-0033

**inverse-time delay characteristic for sustained overloads**

**Illustrations:** EL0033\_WM\_100518

In figure "A" of the illustration, what is the position of the circuit breaker? Illustration EL-0033

**off**

**Illustrations:** EL0033\_WM\_100518

What is the power consumed by 'R2' in the circuit illustrated in figure "B", if the applied voltage is 24 volts and the resistance of R1 is 3 ohms, R2 is 4 ohms, and R3 is 5 ohms, respectively? Illustration EL-0020

**16 watts**

**Illustrations:** EL0020\_WM\_100518

See REF355

What is the total resistance of figure "B" of the illustrated circuit if the resistance of R1 is 3 ohms, R2 is 4 ohms, and R3 is 5 ohms? Illustration EL-0020

**12 ohms**

**Illustrations:** EL0020\_WM\_100518

See REF355

As shown in figure "A" of the illustration if the applied voltage is 12 VDC, the resistance of R1 is 10 ohms, and R2 is 10 ohms what is the current flowing through R1 when the switch is closed? Illustration EL-0020

**0.6 amp**

**Illustrations:** EL0020\_WM\_100518  
See REF355

In figure of "A" of the illustrated circuit, what is the voltage measured across R1 if the battery voltage is 24 volts, the resistance of R1 is 34 ohms, and the resistance of R2 is 126 ohms when the switch is closed? Illustration EL-0020

**5.1 volts**

**Illustrations:** EL0020\_WM\_100518  
See REF355

What is the voltage across "R1" of figure "B" of the illustrated circuit with the switch closed if the applied voltage is 24 volts and resistance of R1 is 3 ohms, R2 is 4 ohms, and R3 is 5 ohms, respectively? Illustration EL-0020

**6 volts**

**Illustrations:** EL0020\_WM\_100518  
See REF355

Which of the following statements is correct for the illustrated circuit in figure "B"? Illustration EL-0020  
**R1', 'R2', and 'R3' are connected in series.**

**Illustrations:** EL0020\_WM\_100518  
See REF355

In the system shown in the illustration, the engine room station is unable to signal any other station, nor is any other station able to signal the engine room station. The engine room station can, however, ring itself by proper positioning of its selector switch. What is the most probable cause of this problem? Illustration EL-0093

**There is an open between terminal "C" of the problem station and the common wire of the multi-conductor cable to the other stations.**

**Illustrations:** EL0093\_WM\_100518

What does the component labeled "B" shown in the illustration represent? Illustration EL-0093  
**hand-cranked generator**

**Illustrations:** EL0093\_WM\_100518

As shown in the illustration, which of the following statements is correct concerning the circuits in a sound powered telephone system? Illustration EL-0093

**The talking circuit is a common circuit and the ringing circuit is a selective circuit. .**

**Illustrations:** EL0093\_WM\_100518

Where is the power necessary to energize the howler "relay" coil at the engine room station as shown in the illustration? Illustration EL-0093

**comes from each station's hand cranked generator**

**Illustrations:** EL0093\_WM\_100518

Using the illustrated catalog number selection chart, determine the correct catalog number for a motor starter that meets the following selection criteria: a 3-pole, vertically mounted, NEMA non-reversing starter with an open enclosure rated at 90 continuous amperes, fitted with an electronic overload relay with a standard feature set and an operating coil rated at 120 VAC/60Hz. Illustration EL-0180

**AN19KNVA5E100**

**Illustrations:** EL0180\_WM\_101018

If a digital multimeter is set up as shown in figures "A" and "B" to test a silicon diode, what is the status of the diode if the screen displays OL V when configured as in figure "A" and displays OL V when configured as in figure "B"? Illustration EL-0212

**diode is open**

**Illustrations:** EL0212\_AO\_061518WM

See REF354

If a digital multimeter is set up as shown in figures "A" and "B" of the illustration, what is the status of the silicon diode if the display reads OL ohms when configured as in figure "A" and reads OL ohms when configured as in figure "B"? Illustration EL-0211

**the diode is open**

**Illustrations:** EL0211\_WM\_101018

See REF354

What is the name of the DC motor speed control method utilized as shown in figure "B" of the illustration? Illustration EL-0101

**Ward-Leonard**

**Illustrations:** EL0101\_WM\_100918

AC circuits may develop resistance, inductance, and capacitance. What is the unit of measure used to express inductive reactance?

**ohms**

See REF1846

Which statement is true concerning the total power consumed in a parallel circuit?

**The total power is equal to the sum of the powers consumed by each individual load.**

In general, why are nickel-cadmium storage batteries superior to lead-acid batteries?

**they can remain idle and keep a full charge for a long time**

What is the proper way to mix the electrolyte for a lead-acid battery?

**pour the acid into the distilled water**

A three-phase alternator operates at 450 volts with a 0.8 power factor. If the ammeter indicates 250 amperes, what should be the kW meter reading?

**155.70 kW**

See REF1877

In a shunt-wound DC generator, with what generator component are the shunt field windings connected in parallel with?

**the armature circuit**

By what means is an AC generator prevented from becoming motorized?

**reverse power relay**

Under voltage trips are frequently installed on switchboard circuit breakers for what reason?

**trip out the generator when there is insufficient voltage being delivered to distribution circuits**

What statement is true concerning a ground in an 450 VAC electrical circuit outside the engine room?

**It is indicated by the ground detecting lamps on the main switchboard.**

When a transformer is used to step down voltage, what statement is true?

**The low voltage winding is the secondary coil.**

See REF1902

What should be included in the performance of routine maintenance of dry-type transformers?

**cleaning the windings, if accessible, with a vacuum cleaner or very low pressure air**

When a fluorescent lamp has reached the end of its useful life, it should be replaced immediately. If not, what condition could the resultant flashing cause?

**damaging the lamps starter and ballast circuit**

See REF1910

To minimize magnetic field interaction between electrical conductors in physical proximity, what is the best practice?

**at right angles and as far as practicable from each other**

When a solid-state component of an electronic circuit is mounted to a metallic mass, what is the general purpose of that mass?

**act as a heat sink**

A DC generator which is used to supply direct current in order to provide magnetizing current to an AC generator field is commonly known as what?

**exciter**

See REF1957

How will the value of the output frequency change if the load is removed from a turbo generator having a governor speed droop setting of 3%?

**It will increase.**

If rotor-to-stator air gap readings for an electrical generating machine have changed significantly from the last reading, what should be checked?

**the generator bearings for wear**

The counter EMF of a DC motor is maximum when the \_\_\_\_\_.

**motor is at rated speed**

See REF1973

In general, what can cause D.C. propulsion motor brush sparking to be excessive?

**incorrect brush grade, pressure or position**

What is the instrument called a galvanometer used to measure?

**very small amounts of current**

Which of the following methods should be used to dress the face of silver-plated contacts?

**Sanding with 0000 sandpaper**

See REF1954

Which of the following statements represents the FIRST step in seating new brushes on slip rings?

**Lay sandpaper between the brush and the slip ring and slide the sandpaper back and forth under the brush.**

See REF2004

AC circuits can possess characteristics of resistance, inductance, and capacitance. In terms of units of measure, how is the capacitive reactance of the circuit expressed?

**ohms**

See REF1846

What is the approximate voltage per cell produced by the nickel-iron (Edison) battery?

**1.37 volts**

See REF1860

When charging a 100 amp-hour lead-acid battery, what statement is true?

**insure adequate battery room ventilation**

See REF1865

What is the wattage of a heating element drawing a current of 30 amperes, at 120 volts?

**3600 watts**

See REF1878

A variable shunt, connected across the series field coils of a DC compound wound generator, permits adjustment of the degree of compounding. What is this variable shunt called?

**diverter**

Brushes in a DC generator must be positioned in the neutral plane to avoid excessive sparking associated with the brushes. What device is used to prevent the shifting of the neutral plane due to armature reaction for varying generator loads \_\_\_\_\_.

**commutating pole windings**

See REF1890

How can a motor be protected from overheating due to sustained motor overload?

**thermal circuit breaker**

When will the timer element of a reverse power relay activate the relay?

**the power flow is the same as the tripping direction**

Which of the following statements describes the difference between the primary windings and the secondary windings of a 2:1 step-down voltage transformer?

**The secondary windings have half as many turns as the primary windings.**

When replacing a defective transformer in a paralleled transformer configuration, which of the following actions must be carried out to insure proper operation of the equipment it serves?

**The transformer connections must be made as before with regard to the indicated polarity.**

See REF1892

When a fluorescent lamp fails to light and both ends of the tube are severely darkened, what must usually be replaced?

**the fluorescent lamp tube**

See REF1910

Although saturable reactors are extremely useful in some applications, why is their gain low?

**core hysteresis losses**

By what means is a diesel driven emergency generator prevented from being paralleled with the ship's service generators?

**an electrical interlock system**

How are the number of cycles per second developed by the alternator aboard your vessel determined?

***the speed of the engine driving the alternator***

In performing routine maintenance of a ship's service alternator, what should be included?

***periodic cleaning of the air filters or screens***

In terms of voltage potential and current sources, how are shunt wound, series wound, and compound wound DC motors designed to operate?

***constant potential, variable current DC sources***

What should be included in performing proper maintenance of a D.C. motor's commutator?

***side-cutting the copper segments and undercutting the mica***

Which of the following would best describe a standard electric meter movement that uses the principles of electromagnetism to measure current?

***moving coil meter movement***

See REF1933

If the pointer fails to return to zero when a hand-cranked megger is disconnected, what does this indicate?

***megger is operating normally***

See REF1984

Grease coatings on electrical contact surfaces increase contact resistance. How should grease accumulations be removed?

***clean dry cloth***

See REF1954

If a magnetic controller relay fails to drop out when the coil voltage is removed from the relay, what is the probable cause?

***welded contacts***

See REF1991

How is the difference between the synchronous speed of a three phase induction motor and its operating speed correctly expressed?

***slip***

By periodically checking the stator-to-rotor air gap clearance in an induction motor with a feeler gauge, what is prevented?

***rotor contact with the stator***

In a three-phase circuit, how far apart are the phase voltages?

***120° apart***

See REF1847

What will happen to the total circuit resistance when additional parallel circuits are added to a circuit?

***it will decrease, causing an increase in the total load current***

See REF1856

Which of the following statements concerning the specific gravity of a battery electrolyte is true?

***The specific gravity reading is lowered when the electrolyte temperature has increased.***

See REF1861

Which of the following statements concerning nickel-cadmium batteries is true?

***The state of charge cannot be determined by the specific gravity values.***

A 125 volt DC motor is rated at 10 kW. What is the current rating of the motor?

***80 amps***

REF1963

Electrolytic action may start in the presence of moisture, dampness, and condensation.

REF1964

An adjustable resistor that controls the voltage used to establish a magnetic field in an alternator. A build up of voltage indicates an open rheostat.

REF1965

If a wire has broken (i.e., is "open" ) in the field coil, no DC voltage can flow and create a magnetic field. Without magnetic lines of force to cut, electricity cannot be generated.

REF1973

Electromotive force, also called EMF, (denoted and measured in volts), refers to voltage generated by a battery or by the magnetic force according to Faraday's Law, which states that a time varying magnetic field will induce an electric current.

REF1974

A series wound motor has a very high starting torque and is often used as a starter motor and for other uses that require high torque. The field windings and armature are in series in this motor. When not under load, a series wound motor will "run away" and its speed will increase until it damages itself. Whatever happens to armature current as a result of driving a load is automatically felt in the field winding. When torque is high, speed is low. When speed is high, torque is low. Series wound DC motors are used to do the heavy work of winches, cranes, and electric locomotives.

REF1975

This means that there is an independent path for current to flow through each winding. Consequently, resistance can be placed in or removed from the path leading to each winding. The field current can be kept constant and the armature circuit alone can be used to control the motor.

REF1976

In a shunt wound motor, the field is in parallel with the armature. When you apply a load to this motor, it tends to slow down slightly.

REF1977

Eccentricity = out of round; off-center; egg shaped.

REF1978

A bar-to-bar test is made by passing about 10% of the rated current through the copper bars of the armature and measuring the voltage from bar to bar with a millivoltmeter. This test can determine whether winding turns are shorted (including partial shorts), if the mica insulation between the bars is shorted, or whether there are poorly soldered connections.

REF1979

If the air ducts within the rotor are clogged with dirt held together by damp air, oil, etc., . It is possible that this will cause the insulation to break down or the coils or windings coated with this glop to short circuit.

REF1980

If the turns in the field coil are shorted, the strength of the field is reduced This allows more current to flow to the armature. This will cause the armature to increase its speed If the field coil is "open " (i.e. fails), the motor could run away.

REF1981

A shunt allows only part of a current being measured to flow through the delicate meter movement. The shunt is a heavy-duty resistor and is connected in parallel with the meter movement. Only a specific percentage of the current is allowed to pass through the meter movement while most of the current passes through the shunt. When measuring current in a circuit, however, the meter with its shunt installed is connected in series with the power load and never in parallel with it.

REF1982



The shunt makes it possible to measure much larger currents flowing in a circuit than could be done if that current were routed through the tiny wire in the meter's coil. This effectively extends the range and usefulness of the meter.

REF1983

The high resistance restricts the flow of current through the meter coil.

REF1984

When the hand-cranked generator on the megger is not being operated, the pointer floats freely and may come to rest at any position on the scale. The megger needle at zero indicates a ground. Unless the megger is grounded, its needle will float at some other position.

REF1985

Across-the-line starting applies the full voltage available to start an electric motor. Autotransformers and resistors are used to start motors when it is necessary to regulate the inrush of electric current to either prevent damage to the motor or to protect the system that furnishes the electric power.

REF1986

When the relay senses an overcurrent in its operating coil, which is connected in series with an electric motor, it causes the contacts to open. The open contacts deenergize the motor controller. "Instantaneous" can mean as little as 0.02 seconds to clear a fault.

REF1987

46 CFR 111,

REF1988

The motor will slow but continue to run. However, it will also begin to heat up. The thermal overload relay will sense this overheating and trip the controller. If a three-phase motor stops, it will not restart with an open in one phase and will heat very rapidly.

REF1989

The preferred way to clean dust and foreign matter from electrical equipment is by vacuum suction.

REF1990

Low voltage causes a weak magnetic pull so that the contacts do not close tightly. It also causes a relatively high resistance between the stationary and the moving contact surfaces. If this resistance is greater than in the rest of the circuit, the heat generated at the contact surfaces may cause the contacts to weld together.

REF1991

Accidentally-welded contacts may prevent a relay from dropping out (i.e., opening) when it loses coil voltage.

REF1992

Chattering or humming in a circuit breaker, relay or controller may be caused by low operating coil voltage or dirt on the faces of the magnet. Dirty magnet faces prevent the magnetized coil, which is an electromagnet, from holding the contacts firmly closed.

REF1993

If a few turns become short circuited, the coil may weaken and may become unreliable.

REF1997

If you place a load on an operating motor, its rotor will slow down and its slip will increase. The rotating field will induce higher currents in the rotor. This will provide the increased torque that allows the motor to handle the load. However, if the motor is overloaded, it will slow down and stall.

REF1998

AC motor name plates contain information on the temperature rise the motor is designed for. Preserve the information on the name plate, you may have to call an electrician to simply identify a piece of equipment so that you can order a replacement.

REF1999

Universal motors operate on both AC and DC. They have brushes and commutators. They are used to power portable tools, small fans and other fractional horsepower applications.

REF2000

The starting winding on a split-phase induction motor is not designed to carry current when the motor is running. If the cutout switch for this winding does not operate (i.e., fails to open,) the winding will probably burn out. To change the direction of rotation of a three-phase induction motor, switch any two of the phase leads to the stator. An induction motor that operates at a fixed frequency can provide several different speeds only if you reconnect the stator windings (i.e., field windings) to provide a different number of poles.

REF2001

A squirrel-cage rotor consists of a laminated iron core that is slotted lengthwise all around its periphery. Solid bars of aluminum, copper, or other conductors are tightly pressed or embedded in its slots. At both ends of the rotor, short-circuiting rings are welded or brazed to the bars to make a solid structure which, if removed as a unit, would resemble a squirrel cage. The squirrel-cage rotor in an AC motor is very simple in construction when compared to a DC motor's armature with its complicated windings.

REF2002

What is the main function in the use of a capacitor for starting a single phase motor? Note: A capacitor-start motor and resistor-start motor are two types of single phase ac induction motors. The capacitor-start type motor develops a very high starting torque, and is used for loads which are hard to start. The resistor-start type motor develops a considerably smaller torque and is used for moderate starting loads, or where the load is applied after the motor has obtained its operating speed. A. Reduce radio interference Incorrect answer. Motors generate electrical "noise" which can interfere with radio reception. A ceramic capacitor properly connected to the motor can reduce the chance of this type of interference. This type of capacitor provides no function in the starting of the motor. B. Split the phase to establish a rotating magnetic field Correct answer. Induction motor action requires a rotating magnetic field. To obtain a rotating magnetic field from a single-phase system, the motor current is split into two separate windings. The capacitor-start motor uses a capacitor in series with an auxiliary (starting) winding which causes the current in the auxiliary winding to lead the current in the main winding. Consequently, the magnetic field in the auxiliary winding will reach its maximum value before that of the magnetic field in the main winding resulting in rotation of the motor rotor. The capacitor and auxiliary winding are disconnected from the circuit by an automatic switch when the motor reaches approximately 75% of its rated full load speed. C. Reduce the phase angle Incorrect answer. A capacitor inserted in series with the starting winding increases the phase angle (shift) resulting in a starting torque that is greater than that developed by the resistor-start motor. D. Prolong the life of the starting contacts Incorrect answer. Periodic checks and adjustment for any wear or misalignment, as well as the removal of dirt and grease from the contact faces will help prolong the life of contacts, not the use of a capacitor. Capacitor motors. This type of motor also operates only on single-phase AC. It is similar to the split-phase type, with the addition of a capacitor or a condenser that enables it to start much heavier loads. There are several grades of capacitor-type motors available, ranging from the home-workshop type that starts loads from 1 1/2 to 2 times as heavy as the split-phase, to the heavy-duty type that will start almost any type of load. Capacitor motors usually are more efficient than split-phase motors, using less power (watts) per horsepower. The amperage (I) consumed while starting is usually less than half that of the split-phase type. Capacitor motors are commonly used only in sizes up to 10 hp . Capacitor-type motors are frequently used in small portable pumps of low horsepower.

REF2003

You can change the speed of a synchronous motor by changing the frequency of the current to the stator and/or the number of poles in the stator. To reverse a turbo-electric, synchronous motor propulsion unit, change the phase sequence of power to the motor. To change the speed of such a unit, change the speed of the turbine itself. The input power from commercial sources is generally a constant 60 Hz and seldom varies.

REF2004

Sandpaper is a non-conductor of electricity. Emery cloth contains particles that could become embedded in the brushes, cause sparking, and grind and damage the surface of the commutator. The grit side of the sandpaper must face the brushes. The smooth side should follow the curvature of the commutator.

REF2005

The starting winding on a split-phase induction motor is not designed to carry current when the motor is running. If the cutout switch for this winding does not operate (i.e., fails to open,) the winding will probably burn out. If the starting winding

remains connected, the motor will draw excessive current from the line. The starting winding may overheat and be damaged. If this happens and the Winding burns out, the motor will not be able to start itself because it will no longer be able to split the single-phase current.

REF2006

To test for an open circuit, you must test each winding separately

REF2007

An "open " coil would provide infinite resistance. Infinite resistance is marked on the face of the meter with the symbol of "infinity."

REF2008

A growler is an instrument that is powered by AC power (i.e., plugged into a wall socket) and pulled across the coils in the stator of an AC motor. If it "growls, " the coil is shorted.

REF354

A multimeter is a combination of several instruments housed in a single, convenient, and portable case. Using a single-meter movement, a multimeter can measure volts, milliamps, and ohms. In many cases, it can replace at least three separate instruments-voltmeters, ammeters, and ohmmeters. Each of these meters may exist separately or can often be replaced by a single multimeter. A multi-meter (i.e., a volt-ohm-milliammeter) tests for voltage, current, resistance, grounds, and continuity (i.e., a continuous circuit with no breaks or opens in the circuit). A multi-meter uses internal batteries to measure for resistance. When measuring for a resistance, clip the two leads together and calibrate the instrument by adjusting the needle to 0 ohms with the adjusting knob. If you cannot adjust the zero reading, then you should replace the internal batteries. After adjusting a multi-meter to measure resistance, you must select the proper resistance range or you may the meter. If you have no idea what the resistance is, start by using the highest range; then work down to the range where a valid reading falls as nearly as possible in mid-range.

REF355

Here you can see one of the defining qualities of a series circuit. The flow of electricity runs through each resistance without branching. What is the total resistance of the resistor circuit if the resistance of R1 is 3 ohms, R2 is 4 ohms, and R3 is 5 ohms? To find the total resistance in the circuit, add all three resistors. R1 is 3 ohms R2 is 4 ohms R3 is 5 ohms The total resistance is 12 ohms.

REF357

An oscilloscope, previously called an oscillograph, and informally known as a scope, CRO (for cathode-ray oscilloscope), or DSO (for the more modern digital storage oscilloscope), is a type of electronic test instrument that allows observation of constantly varying signal voltages, usually as a two-dimensional graph of one or more electrical potential differences using the vertical or 'Y' axis, plotted as a function of time (horizontal or " axis). Many signals, for example sound, can be converted to voltages and displayed this way. Signals are often periodic and repeat constantly, so that multiple samples of a signal which is actually varying with time are displayed as a steady picture. Many oscilloscopes (storage oscilloscopes) can also capture non-repeating waveforms for a specified time, and show a steady display of the captured segment. Oscilloscopes are commonly used to observe the exact wave shape of an electrical signal. Oscilloscopes are usually calibrated so that voltage and time can be read as well as is possible by eye. This allows the measurement of, for example, peak-to-peak voltage of a waveform, the frequency of periodic signals, the time between pulses, the time taken for a signal to rise to full amplitude (rise time), and relative timing of several related signals. Oscilloscopes are used in the sciences, medicine, engineering, and telecommunications industry. General-purpose instruments are used for maintenance of electronic equipment and laboratory work. Special-purpose oscilloscopes may be used for such purposes as analyzing an automotive ignition system, or to display the waveform of the heartbeat as an electrocardiogram. Some computer sound software allows the sound being listened to be displayed on the screen as by an oscilloscope. Before the advent of digital electronics oscilloscopes used cathode ray tubes as their display element (hence were commonly referred to as CROs) and linear amplifiers for signal processing. More advanced storage oscilloscopes used special storage CRTs to maintain a steady display of a single brief signal. CROs were later largely superseded by digital storage oscilloscopes (DSOs) with thin panel displays, fast analog-to-digital converters and digital signal processors. DSOs without integrated displays (sometimes known as digitizers) are available at lower cost, and use a general-purpose digital computer to process and display waveforms.

REF360

Step down transformers reduce 120-volt AC line voltage to 12-volt AC or 32-volt AC voltage. This is a step-down three phase transformer with the voltage being reduced to one quarter of its original voltage. A transformer is an electrical device that is used in alternating current (AC) circuits to either step-up (i.e., increase) or step down (i.e., decrease) the voltage within that circuit. In doing so, the electrical energy is always changed or transferred from winding to winding inside the transformer without a change of frequency (i.e., Hertz or cycles). In other words, if 60-Hertz power enters a transformer, 60-Hertz power will leave it! However, a transformer will change both the voltage (E) and the current (I) by a predetermined amount. Transformers require little care and maintenance because of their simple and rugged construction. A transformer's efficiency is very high. There is generally little energy waste that appears in the form of heat. In part as a result of this fact, transformers are responsible for the more widespread use of alternating current (AC) than direct current (DC) throughout the world. A transformer has no moving parts and is, therefore, a very dull and uninspiring piece of equipment. It is usually protected by a suitable enclosure and left alone until such time as it bums out and becomes noticeable by the stench of its burning insulation. The typical transformer has two windings, called a primary and a secondary winding, that are insulated electrically from each other. In other words, there should be no direct contact between the electricity in one winding and the electricity in the other winding. In fact, direct contact must be avoided! When a transformer is used to step up the voltage, the low voltage winding is called the primary. Conversely, when a transformer is used to step down the voltage, the high-voltage winding is called the primary. The primary is always connected to the source of the power while the secondary is always connected to the load. It is common practice to refer to the windings as the primary and secondary rather than the high voltage and low voltage windings. The principal types of transformer construction are the core type and the shell type. The cores are built of thin stampings (i.e., sheets or laminations) of silicon steel. Eddy currents, generated in the core by the alternating flow of current as it cuts through the iron, are minimized by using thin laminations and by insulating adjacent laminations with insulating varnish. All transformer windings must be treated to resist moisture, sea atmosphere, and oil vapors. The permissible temperature rise is limited by the type of insulation used in the transformer windings. A heat build up in transformer windings will breakdown or melt the insulation and lead to short circuits and fire. Step down transformers reduce 120-volt AC line voltage to 12-volt AC or 32-volt AC voltage. When replacing a transformer, re-connect the polarity marks the same way as before to ensure that the equipment runs as it did before (i.e., that the motors rotate properly, etc.) Transformers are classed according to how they change the voltage. If the voltage on a transformer's secondary windings is higher than on its primary windings, it is called a "step-up transformer". If the secondary voltage is lower than the primary voltage, it is a "step-down transformer". You can determine the ratio of change in voltage by comparing the number of turns on the transformer's primary windings to the number of turns on the secondary. The change in current is inversely related to this ratio of turns. For example, if the secondary voltage is tripled (i.e., multiplied 3 times), the secondary amperage will be reduced to one-third the amperage of the primary. A study of basic electrical theory starts with a study of magnets and magnetism. A knowledge of how permanent magnets and electromagnets work is basic to an understanding of how transformers, electric motors and generators work.

#### REF361

A field coil is an electromagnet used to generate a magnetic field in an electro-magnetic machine, typically a rotating electrical machine such as a motor or generator. It consists of a coil of wire through which a current flows. In a rotating machine, the field coils are wound on an iron magnetic core which guides the magnetic field lines. The magnetic core is in two parts; a stator which is stationary, and a rotor, which rotates within it. The magnetic field lines pass in a continuous loop or magnetic circuit from the stator through the rotor and back through the stator again. The field coils may be on the stator or on the rotor. The magnetic path is characterized by poles, locations at equal angles around the rotor at which the magnetic field lines pass from stator to rotor or vice versa. The stator (and rotor) are classified by the number of poles they have. Most arrangements use one field coil per pole. Some older or simpler arrangements use a single field coil with a pole at each end. Although field coils are most commonly found in rotating machines, they are also used, although not always with the same terminology, in many other electromagnetic machines. These include simple electromagnets through to complex lab instruments such as mass spectrometers and NMR machines.

#### REF755

When paralleling generators and alternators, the machine coming on-line must have a slightly higher voltage so that it picks up some of the load when it is placed "on the by closing the circuit breaker. If machines are not "in phase" (i.e., synchronized) when they are paralleled, severe cross currents will occur and may cause damage. The maximum machines can be out of phase is 180°. Machines operating in parallel are both on line and sharing the load. However, they must have the same frequency, number of phases and phase rotation to do this. When paralleling, if the synchronizing lamps are dark and the synchroscope is at 12 o'clock (i.e., the 0° position), it indicates the oncoming alternator is "in phase" with the bus. To place an alternator "on line", adjust the oncoming machine's speed until the synchroscope revolves slowly in the "fast" direction. Then close the circuit breaker when the synchroscope is at the 12 o'clock (i.e., 0° position). The oncoming alternator should have slightly higher frequency than the "on-line" or bus frequency to: 1. Assume

its load immediately, 2. Not "float" on the line, 3. Not "motorize" and activate the reverse power relay. After closing the circuit breaker to "parallel" the two machines, you should balance the loads (kilowatts) between the two machines by adjusting the governor settings.

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