SECTION 1

FACTS ABOUT ELECTRICAL SYMBOLS AND BLUEPRINT READING

1. All symbols used by Barber-Greene are in appendix "BB" and are J.I.C. (Joint Industrial Commission) approved.

2. The voltages on the coil and contacts may be different due to isolation between the coil and contacts in a relay.

3. Motor circuitry is shown separately and has a high voltage applied, i.e. usually 480 VAC. Also, all physical wires used are colored black.

4. Control circuitry is shown separatley with ladder type schematic and has a working voltage of 120 volts or less. There are two types of voltage used.

    A. AC when used is usually 120 volts.

    B. DC when used is uaually less than 100 volts.

    C. Neutral wires in control circuits are color coded white.

    D. Ground wires in control circuits are usually color coded green.

5. On the control schematics the numbers on the left hand side are line numbers used for reference.

6. On the control schematic the number on the right hand side along side of a relay coil are the line numbers of its contact. The number that is underlined designates a normally closed contact.

7. A dotted line between two contacts designate a mechanical connection between the contacts.

8. A dotted line between two wire numbers indicate a jumper. (Also, it might have a symbol of a △).

9. On time delay contacts the arrow on the contact is:

    A. Pointing up = energized delay

    B. Pointing down = de-energized delay

10. On limit switches the switch is drawn:

    A. Under the line - normally open

    B. Over the line - normally closed

11. For ease of identification on a schematic the motor and motor controls for each motor is assigned a letter identification.

"A" = Asphalt Pump
"F" = Fuel Pump
"N" = Blower
"P" = Incline Conveyor

12. All motor schematics are drawn with symbolic drawings and are not actual wire connection drawings.

13. Actual wire connection drawings are called wiring diagrams.

SECTION 2

THE ENGINEER'S CORNER

HOW HOT IS HOT?

How often do you see a person placing his hand on an electric motor to determine if it is operating properly? This is one of the simplest and most common checks used today. From it we can quickly tell if there is any excess vibration in the system, along with getting a general idea if the motor is operating within its prescribed temperature limits.

Years ago, this method of motor checking was more reliable than it is today. The sense of touch is still fairly accurate for making a quick check of system vibrations; however, we can no longer place as much reliability in the touch test for a temperature check. Old motors were generally much underrated and, therefore, normally ran fairly cool. If the temperature ever rose to the point where it became uncomfortable to the touch, you knew that something was not functioning properly. Many of the motors in use today operate at higher temperatures under normal operation. Therefore, it is essential that one has a better understanding of motor operating temperatures.

At one time, most motors were wound with Class A insulation, which has a rating of 105° C (Centigrade). This means that the total permissible temperature on the insulation is 105° C, even though the actual temperature in many of the old motors did not even begin to approach this limit. Motors being built and re-rated today are designed to carry greater loads on smaller frames. Consequently, higher motor operating temperatures result. In some instances, it became necessary to go to higher classes of insultion - such as B, F, and H - which permit total temperatures of 130, 155 and 180 degrees C, respectively.

Today, when a person gives a motor a quick touch test, he may be forced to withdraw his hand quickly. Even though this may result, this is by no means any assurance that the motor is not operating within safe temperature limits.

Stop to think for a moment of the relationship between (C) Centigrade and (F) Fahrenheit and just exactly when these temperatures become uncomfortable to the human body. Most people's concept of heat is in Fahrenheit and, even then, the majority are not even aware that water boils at 212° F and the body temperature is 98.6° F. These figures are based on an elevation of sea level. They know that boiling water on the skin is very uncomfortable and, therefore, the closer the temperature approaches 212° F, the more unpleasant it is to the touch.

Centigrade is converted to Fahrenheit, and vice versa, by the following formula:

°F + (C x 9/5) plus 32   °C = (F - 32) x 5/9

Therefore:

105°C equals 221°F
130°C equals 266°F
155°C equals 311°F
180°C equals 356°F

Consideration must be given to the fact that the temperature of the external surface of the motor will always be somewhat cooler that the winding temperature. The difference in the two will depend mainly upon the design and type of motor enclosure. Therefore, the temperature of the outer motor enclousre should never be that of the total permissible temperature rise; however, it can, in some instances, become quite warm.

What sometimes becomes very misleading to people is that permissible temperature rise of a motor from standstill to full load operation normally ranges from 40°C to 55°C rise, but can be as high as 115°C rise on special motors. This is the temperature rise over and above room ambient. Totalling of the two - namely, room ambient and full load rise - could give a rather high temperature that would be very unpleasant to the touch. In addition to this, one should also consider that the use of motor service factors can cause the temperature to exceed its normal rated rise, still remaining within permissible limits.

Remember this the next time you check a motor and say it feels "hot". Keep in mind that there will be a difference in temperature between the outside of the housing and that of the stator winding but that this is dependent basically upon the motor design and enclosure. In most cases, it is possible for a motor to be operating within safe temperature limits and still be very uncomfortable to the touch. So, when your hand tells you it is hot, it is best to check it by a thermometer for a more accurate reading.

Temperature readings on a motor can be made very simply by affixing a thermometer to the stator coil, core or yoke by means of putty. Another simple thermometer method is to remove the lifting hook from the yoke, fill the resulting hole with oil and insert the thermometer. This method is not necessarily too accurate. Additional methods with reliable accuracy are the "winding resistance change" and also by the use of embedded detectors.

Coil or core temperature readings are generally much more accurate because they are closer to the insulation temperature. It is more desirable to take the temperature readings with the motor operating but internal readings under such conditions sometimes becomes becomes difficult.

Just because a motor surface is hot to the touch, does not confirm a diagnosis of improper operation. Take a temperature reading to determine how "hot" and then decide for yourself if your operating temperature is within safe limits.

GROUNDING

Before we undertake the explanation of grounding, some ground work must be done, "terminology."

CONDUCTOR: subtance or body capable of transmitting electricity.

GROUND: a large conducting body (as the earth) used as a common return for an electric circuit and as an arbitrary zero of potential.

GROUNDED: *connected to the earth* or to some conducting body which serves in place of the earth.

GROUNDED CONDUCTOR: a conductor which is *intentionally grounded,* either solidly or through a current limiting device.

GROUNDING CONDUCTOR: a conductor used to connect an equipment device or wiring system with a grounding electrode or electrodes. Grounding conductors are not intended to transmit current except where, as in the case of system grounding conductors, excessive voltages are imposed upon the system. Such excessive charges may be caused by lightning, contact with high-voltage systems, or in the case of an equipment frame-grounding conductor, by the breakdown of insulation in the equipment which would make the frame "*alive.*"

The following is only a combination of facts that one should realize when working with electrical grounding:

Today there exists two general types of grounds;

1. SYSTEM GROUNDS — in which one conductor, of the system, is permanently connected to the earth or ground.

2. EQUIPMENT GROUNDS — in which the non-current carrying metal parts (or frames) of electrical equipment are grounded.

Safety is the main objective for grounding. Why? Without proper grounding, shorts, shocks, and fires are common occurrences. But what does "GROUNDING" actually do? — It decreases the voltage of grounded systems between high voltage conductors and the ground.

At any time, when dealing with ground, four *important* factors should be considered:

1. The selection of the conductor, of the system, of the metal part of equipment to be grounded;
2. The selection, of the point, where the conductor is to be grounded;
3. The selection of the size of the ground wire, the arrangement of its mechanical protection, and the mode of its connection to the ground;
4. The selection of the size of the ground electrodes and the limitation of their resistance to the ground.

A reminder — when wiring with conduit or cable with metal armor, a grounding wire is not needed because the conduit or the armor of the cable serve as the grounding conductor.

The resistance of all grounds should be measured at the time of installation; and periodically thereafter. Depth or contact area, taken alone, is not a sufficient indication that the ground will serve the protection purpose for which it is installed.

Dissimilar metals in contact at joints, which may cause galvanic action with resulting high joint resistance, should be avoided. Since copper conductors are generally used for grounding leads, *all* connections should be from copper to avoid "induced corrosion."

Grounding leads, from the apparatus to the ground, should be run in the most direct path possible and they should be well protected against mechanical injury.

Have you ever heard the terms *"SALT THE GROUND"*? By pouring salt water into the ground, around the grounding rod twice a year, it greatly reduces the ground resistance and gives a better ground.

ASPHALT PLANT GROUNDING

EQUIPMENT	TYPE OF GROUNDING
Plant Tower	Equipment Ground
Dryer	Equipment Ground
Burner Package	Equipment Ground
Incline Conveyor	Equipment Ground
Cold Feed	Equipment Ground
Collector Fans	Equipment Ground
Asphalt Transfer Pump Skid	Equipment Ground
Starter Panel	System Ground
Main Control Console	System Ground
Automatic Weighing Console	System Ground
Remote Scale System	System Ground
Burner Control Console	System Ground
Cold Feed Control Console	System Ground
Digital Recording (Printer) Console	System Ground
Accessories Console (Ammeters)	System Ground

INDEX

ELECTRICAL FUNDAMENTALS

COMPOSITION OF MATTER

1. All matter has as its basic components three minute particles . . . an electron, a proton, and a neutron.
2. An electron is a unit of negative electricity.
3. A proton is a unit of positive electricity.
4. A neutron has no electrical energy value. It contributes mass in the necleus of an atom.
5. Each electron is like all other electrons . . . each proton is like all other protons . . . each neutron is like all other neutrons.
6. Like units of electricity repel each other — opposite units attract.
7. Matter, in its different forms, is based on atomic structure the quantity of electrons and protons which band together in an atom explain the different properties in the approximately 100 elements known to man.
8. An atom is a structural unit consisting of a nucleus which houses protons and neutrons. It has electrons, in the same quantity as protons inside the nucleus, orbiting around the nucleus. The atom is also known as a basic element in nature.
9. An explanation of why there are comparatively few elementary combinations of electrons, protons, and neutrons known to man is not available. Accordingly, it is credited as being a "natural phenomenon".
10. A fixed number of electrons are required to complete an orbit or "energy level". An incomplete orbit contains free electrons; a complete orbit is stable.
11. Atoms with free electrons combine chemically with other atoms and serve as good conductors of electricity.
12. Atoms with stable structures avoid chemical combination and serve as good insulators.
13. Two atoms in combination are known as a molecule.

FUNDAMENTALS OF ELECTRICITY

1. Current flow is the movement of electrons from one atom to another under pressure.
2. Electrons move from one atom to another at the speed of light (186,000 m.p.s.).
3. The unit of measurement for electrical pressure is the volt. (The symbol for voltage is "E".)
4. The unit of measurement for the flow of an electric current is the ampere. (The symbol for amperage is "I".)
5. The unit of measurement for an electrical resistance is the ohm. (The symbol for resistance is "R".)
6. Ohm's law prescribes the following equations for the relationship between amperage, voltage, and resistance.
   $I = E/R$, $R = E/I$, and $E = I \times R$.
7. The same amount of current flows through all units of a series circuit.
8. The flow of current divides through units in a parallel circuit.

FUNDAMENTALS OF MAGNETISM

1. The north geographic pole is a south magnetic pole.
2. A magnet creates a field of force.
3. Only the magnetic materials, iron, nickel, cobalt, or their alloys can be strongly magnetized.
4. Like magnetic poles tend to repel each other.
5. Unlike magnetic poles tend to attract each other.
6. Lines of force are complete loops from the north pole to the south pole of a magnet.
7. Lines of force never cross each other.
8. There is no insulator for lines of force.
9. The space through which magnetic lines of force is called a magnetic circuit.
10. The conducting path for lines of force is called a magnetic circuit.
11. A current-carrying conductor creates a magnetic field around the conductor for the full length of the conductor.
12. Current-carrying conductors tend to move from a strong field into a weak field.
13. The magnetic strength of a coil is measured in ampere turns which is the product of amperes x turns.
14. Voltage is generated when a conductor is passed through lines of force.
15. Voltage is generated when lines of force are passed through a conductor.
16. The attractive force of an electro-magnet is not changed with polarity.

ELECTRICAL SYMBOLS

A. ELECTRICAL SYMBOLS — MOTOR STARTER CIRCUITS:

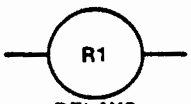
(Switches)

NORMALLY OPEN / NORMALLY CLOSED  LIQUID LEVEL	Liquid Level Switches are float actuated used in such places as Asphalt Liquid Overflow.
NORMALLY OPEN / NORMALLY CLOSED  VACUUM & PRESSURE	Pressure switch, normally open (NO). Pressure will close this switch, release of pressure opens it. Pressure switch, normally closed (NC). Actuated by gas or water pressure which opens circuit, stopping motor, closing valve, etc.
NORMALLY OPEN / NORMALLY CLOSED  TEMPERATURE	Temperature Switches are pyrometer actuated and used in Dryer Discharges, Hot Bins and Exhaust Ductwork.
 FLOW (AIR, WATER, ETC.)	Flow Switches are usually diaphram actuated switches. Example is a Draft Switch for Burner Control.
 CABLE OPERATED (EMERG.) SWITCH	Cable Operated Switches are usually option itmes for conveyor or elevator systems.

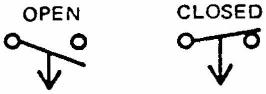
(Push buttons)

NORMALLY OPEN / NORMALLY CLOSED  SINGLE CIRCUIT	Push button switch, normally open (NO). Push switch to close circuit. May be used as a "START" button. Switch opens when pressure on button is released. Push button switch, normally closed (NC). Push to break or open circuit. May be used as a "STOP" button. Switch closes when pressure on button is released.

(Coils)

 RELAYS TIMERS OR TIMER COIL	Coil. The numeral and letter identify the coil in the circuit. This may be the operating coil of a starter, relay, timer, etc., which, when energized or de-energized, causes contacts to open or close.

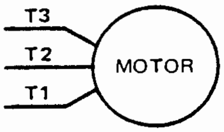
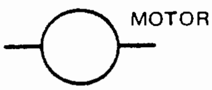
(Contacts)

NORMALLY OPEN NORMALLY CLOSED  RELAY ETC.	Contact, normally open (NO). Contact, normally closed (NC). May be from starter, relay, thermal overload, step switch, etc.
NORMALLY OPEN NORMALLY CLOSED  TIME DELAY ENERGIZED	This is the symbol for the contacts for a timer that closes a circuit a time interval after energizing of the timer coil. As shown, it is normally open (NO). When the circuit is broken by a switch or other means, the contacts will open and timer will reset. This is a normally closed timer (NC). It operates in the reverse manner from that described above in that its contact will open a time interval after energizing of the coil.
NORAMLLY OPEN NORMALLY CLOSED  TIME DELAY DE-ENERGIZED	Timer contact NO which closes on energizing the coil. When coil is de-energized there will be a time delay before contact opens. Timer contact NC which opens on energizing the coil. When coil de-energized there will be a time delay before contact closes.

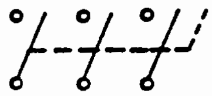
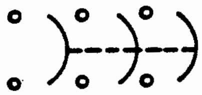
(Heaters)

 THERMAL OVERLOAD ELEMENT  THERMAL OVERLOAD	Thermal overload relays. The OL designates overload. Continuous overcurrent due to overload raises the temperature melting the alloy, allowing a ratchet wheel to rotate opening the overload contacts in the motor control circuit stopping the motor. A few moments after the motor control circuit has been broken, the melted alloy resolidifies and the relay may be reset.

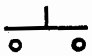
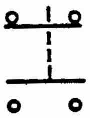
(Motors)

 AC 3 PHASE MOTOR	Three phase motor. Direction of rotation can be reversed by interchanging any two leads. Operates on 220 or 440 volts, 50 or 60 cycles. Will operate at other voltages and frequencies if so designed.
 DC MOTOR	DC Motors. This straight two lead type is used on special applications only. However, the variable D.C. motor with field and armature winding is used on Feeder Applications (4 leads).

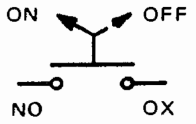
B. ELECTRICAL SYMBOLS — SYSTEM CONTROL CIRCUITS:
(Switches)

 DISCONNECT	Disconnect switch. This illustrates a disconnect switch for a three phase circuit. The three blades are connected by a non-conducting material which incorporates a handle for manually opening or closing the switch.
 CIRCUIT INTERRUPTER	Circuit breaker is a device which operates directly on overload current as compared to thermal protection which operates on the heat generated by the overload current. It is faster in operation than a fuse or a thermal overload and can be reset.
NORMALLY OPEN  NORAMLLY CLOSED  HELD OPEN  HELD CLOSED  LIMIT	Limit switches are actuated by some mechanical device. Limit switch, normally open (NO). Limit switch, normally closed (NC).
 TOGGLE	This is a two way toggle switch. It is either maintained open or maintained closed.

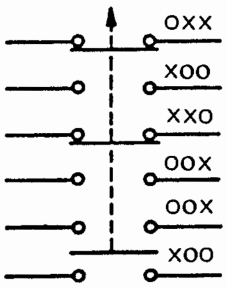
(Push buttons)

NORMALLY OPEN  NORMALLY CLOSED  SINGLE CIRCUIT	Push button switch, normally open (NO). Push switch to close circuit. May be used as a "START" button. Switch opens when pressure on button is released. Push button switch, normally closed (NC). Push to break or open circuit. May be used as a "STOP" button. Switch closes when pressure on button is released.
 DOUBLE CIRCUIT	

(Selector)

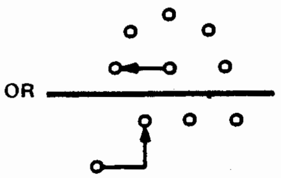
<table>
<tr><td>


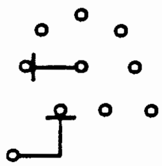
</td><td>Selector switch (2 position) — normally open (NO). Identified by a small lever or handle that is turned to close circuit. The top arrow points to the way switch is used (i.e.: N.O. in the ON position).</td></tr>
<tr><td>


2-POSITION
</td><td>Selector switch (2 position) — normally closed (NC). Turn handle to open circuit. The top arrow points to the way switch is used. (i.e.: N.C. in the ON position).</td></tr>
<tr><td>


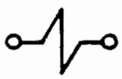
3-POSITION
</td><td>Selector switch (3 position). (0) indicates that the contact is open, (X) indicates contact is closed. Dotted line indicates both contacts are in the same switch.
TOP CONTACT — When handle is in center position or turned to left the circuit is open. Turning handle to right will close circuit.
LOWER CONTACT — When handle is in center position circuit is closed. When handle is to right, circuit is closed. When handle is turned to left, circuit is open. Contact blocks are marked (NO) or (NC) for ease of wiring.</td></tr>
</table>

(Rotary Selector)

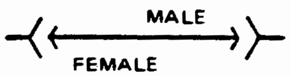
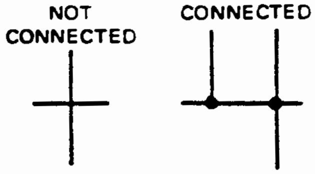
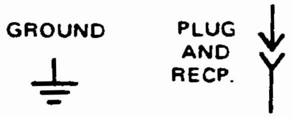
<table>
<tr><td>


NON-BRIDGING CONTACTS
</td><td>Rotary Selector Switch. This is used when manual switching of circuits is desired. The NON-BRIDGING Contacts make sure of a complete isolation of circuits between any two positions.</td></tr>
<tr><td>

†BRIDGING CONTACTS
</td><td>Rotary Selector Switches. The bridging contacts assure a non-break of circuits between any two positions.</td></tr>
</table>

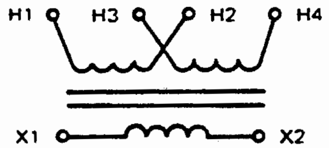
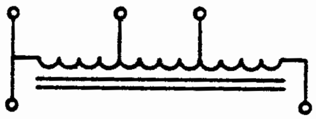
(Coils)

<table>
<tr><td>

SOLENOID
</td><td>Solenoid. An electrical device used to push or pull an iron core. This core may be directly connected to an operating device or used as a pilot device to direct air, oil, etc.</td></tr>
</table>

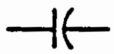
(Connections, Etc.)

	Plug-in connection. Symbol shown is for 2 pole. This may be any number of poles.
	
	

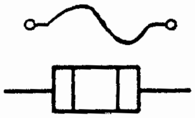
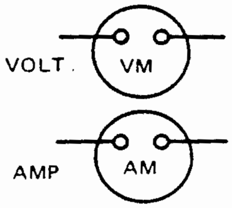
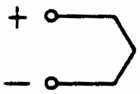
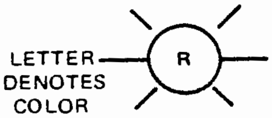
(Transformer)

 CONTROL CIRCUIT TRANSFORMER	Transformer. Used to step down or step up an AC voltage. In this illustration the top is the high voltage (primary) side, and the lower is the low voltage (secondary) side. Voltage induced in the secondary may be greater than or less than the primary voltage depending on the ratio of primary and secondary turns. Transformers are frequency rated and should not be operated at frequencies other than rated.
 AUTO TRANSFORMER	

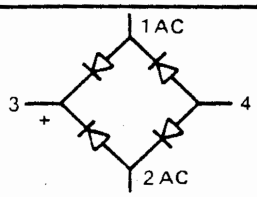
(Resistors, Capacitors, Etc.)

 RESISTOR	Fixed resistance unit. Will carry the letter "R" followed by a numeral to identify the resistor. Used as a voltage dropping or current limiting unit.
 POTENTIOMETER	Potentiometer — or pot. Used on back of scale, on preset or span adjust. Actually this is a small adjustable resistant unit used in balancing voltages in a circuit. Designated by an "R" followed by a numeral to identify resistor. (Scale pots are precision units and require special test procedure.)
 CAPACITORS FIXED	Capacitor is a device for storing electricity. Consists of two or more conducting surfaces separated by an insulator. Applying a voltage across the capacitor causes it to store a voltage equal to the applied voltage.

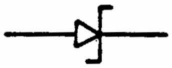
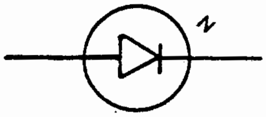
(Resistors, Capacitors, Etc. (cont'd.)

 FUSES (ALL TYPES)	Used as circuit protection device. If defective has to be replaced.
 METERS	Voltmeter — used in parallel to circuit being tested. Ammeter — used in series to circuit being tested.
 THERMOCOUPLE	The Thermocouple in most cases is an Iron - Constatan. The two wires are twisted together and are soldered together at tip. Polarity is important.
 BATTERY	Designates the storage type Battery.
 PILOT LIGHTS	Lamp. The letter "R" in the circle indicates a red light and the letter "G" indicates green. Bulbs are 110 volt, 6 watt, or 6 volt type if transformer indicator is used.

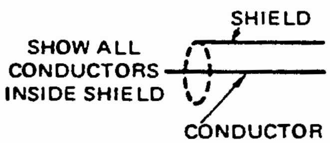
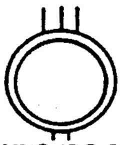
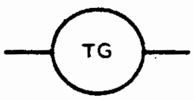
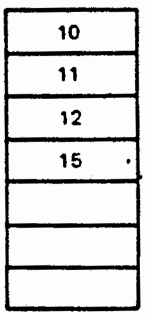
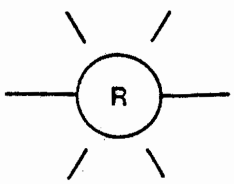
(Semiconductors)

 RECTIFIER DIODE	A semiconducter device which permits current to flow through it in one direction only.
 RECTIFIER BRIDGE	Rectifier (full wave) used to change AC power to DC power. This unit is a full wave rectifier circuit. The DC output is measured across terminals 3 and 4 when 1 and 2 are connected to an AC source of proper voltage.

(Semiconductors (cont'd)

 SILICON CONTROLLED RECTIFIER	A high powered device that will pass current through it when switched on by powering the gate.
 OPTO ISOLATOR	A light coupled relay that uses one signal to switch another signal. Operates identically to a relay except there is no mechanical linkage between the coil (Light) and the contacts (Photo Sensor). Input: Yellow 120V AC to 5V. DC. Output: Black 5V. DC to 120V AC.
 ZENER DIODE	A semiconducter device that is used as a voltage regulator. Example: A 5V. Zener will hold a steady 5V. if the voltage applied is higher (up to the point of peak inverse voltage (PIV)). If the voltage is below 5V. it will not pass any current.
 LED	A solid state device that emits light when a forward current is forced through it.
 THERMISTOR	

(Miscellaneous)

 HORN, SIREN ETC.	 SHIELDED CABLE	 SYNCHRO OR RESOLVER	 TACHOMETER GENERATOR
 TERMINAL BLOCK	 PILOT LIGHT LETTER INSIDE SYMBOL DENOTES COLOR OF LENS.		

C. ELECTRICAL SYMBOLS — ABBREVIATIONS

RELAYS

R = Main Control Relay
CR = Auto Weigh Control Relay
Example: CRIA = Control Relay No. 1 Aggregate
CRIT = Control Relay No. 1 Asphalt
BR = Burner Control Relay
FR = Cold Feeder Control Relay
PR = Ticket Printer Control Relay
X = Motor Interlock Relay

MOTOR AND STARTER

Letter designation for each motor
A = Asphalt Pump
B = Hydraulic Pump
C = Spray Pump
D = Pugmill

CONTROL COMPONENTS

R = Resistor
POT = Potentiometer
RT = Diodes & Rectifiers
IPB = Illuminated Push Button
CTR = Counter
SS = Selector Switch
BSS = Batch Size Selector
PT = Transformer
FS = Formula Selector
SU = Sensing Unit
CRS = Control Relay Stepping Switch

TIME DELAY RELAY

ED = Energize Delay Relay (On Delay)
DD = De-energize Delay Relay (Off Delay)

ELECTRICAL SCHEMATIC READING

A. MOTOR CONTROL CIRCUITS:

The motor starter schematic is divided into two types of symbolic layouts:

1. **Starter Circuit Schematic** — The circuit is all 110 Volts A.C. It consists of the starter push-buttons (located on the Main Control Console), overloads, starter coil and time delay relay (if used).

The Starter Circuit Schematic is drawn with two legs, the left leg is hot and the right leg is ground, (Refer to Figure BB-1.) Down the left leg the numbers are used as line numbers. The circuits are parallel with each other. With power applied (line 1) the starter circuit can be activated. Current flows through the normally closed STOP BUTTON (line 5). If the START BUTTON is then depressed, the

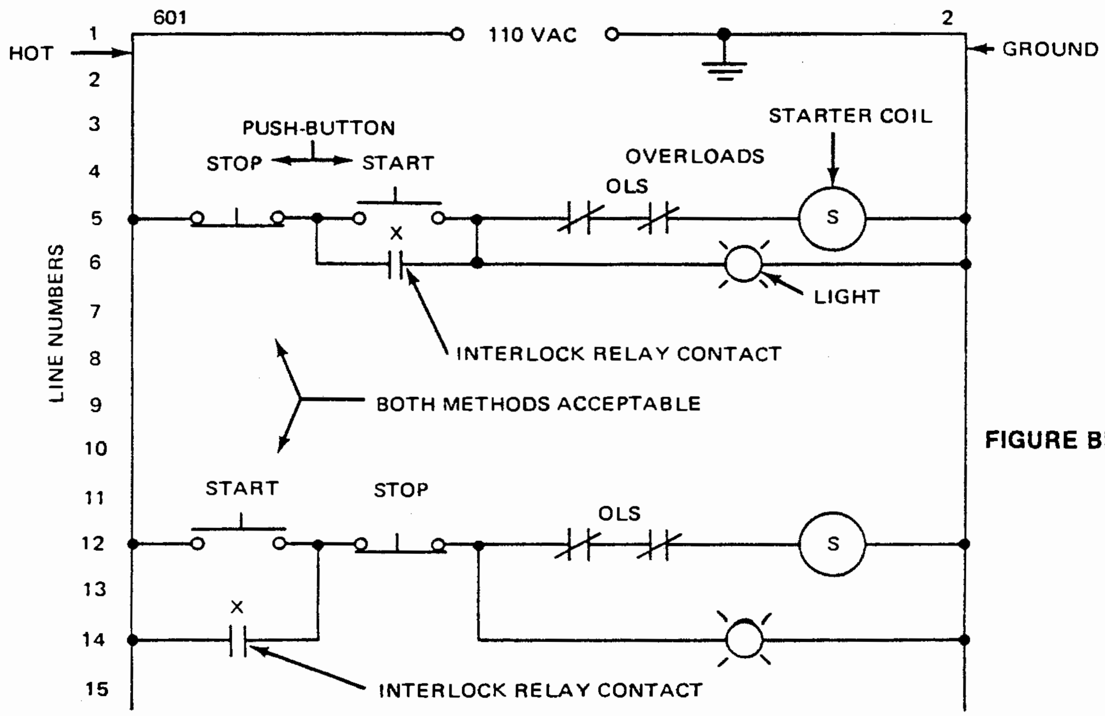


FIGURE BB-1 — "Starter Circuit - Typical" starter coil is energized. The starter then "closes" its contacts to give power to the motor and a interlock relay. The interlock relay being energized, "closes" the "X" interlock contact (line 6, Figure BB-1). This allows the start button to be released.

2. **Motor Circuit Schematic** — The circuit is high voltage (220 VAC or Higher). It consists of the starter main contacts, starter overloads, motor, and interlock "X" relay (if used). The Motor Circuit Schematic is drawn with Symbolic Diagrams rather than the actual wiring diagram in an effort to simplify the drawing. In a Symbolic Diagram, for the motor circuit wiring, the one line symbolic represents the three legs of the motor.

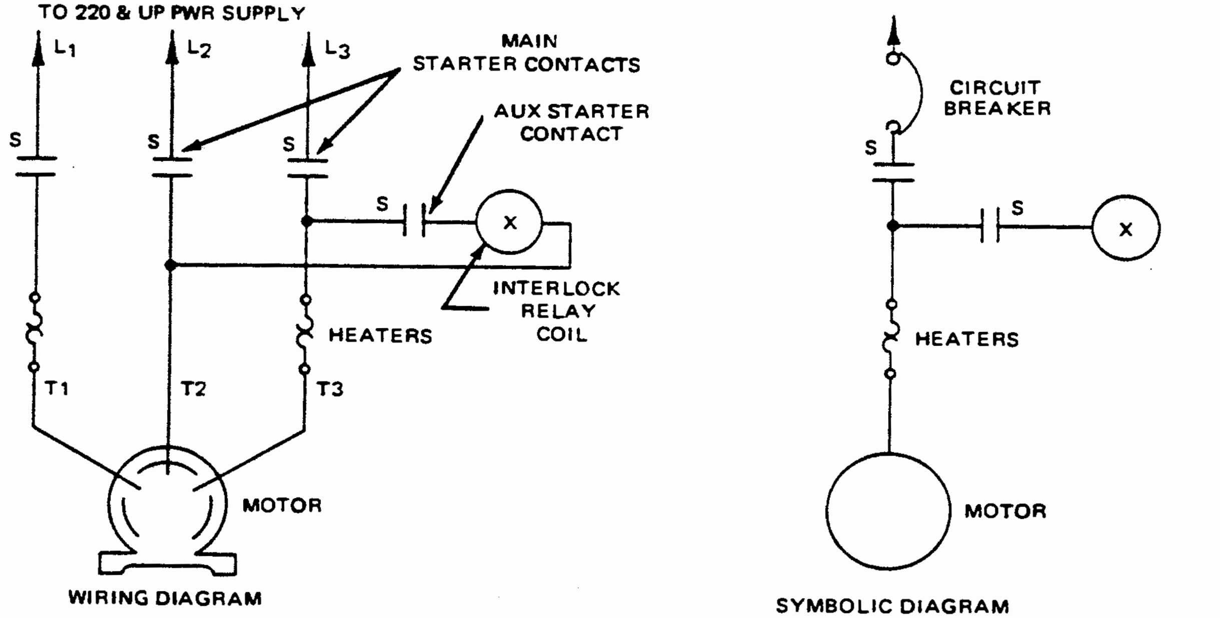


FIGURE BB-2 — "Motor Circuit - Symbolic"

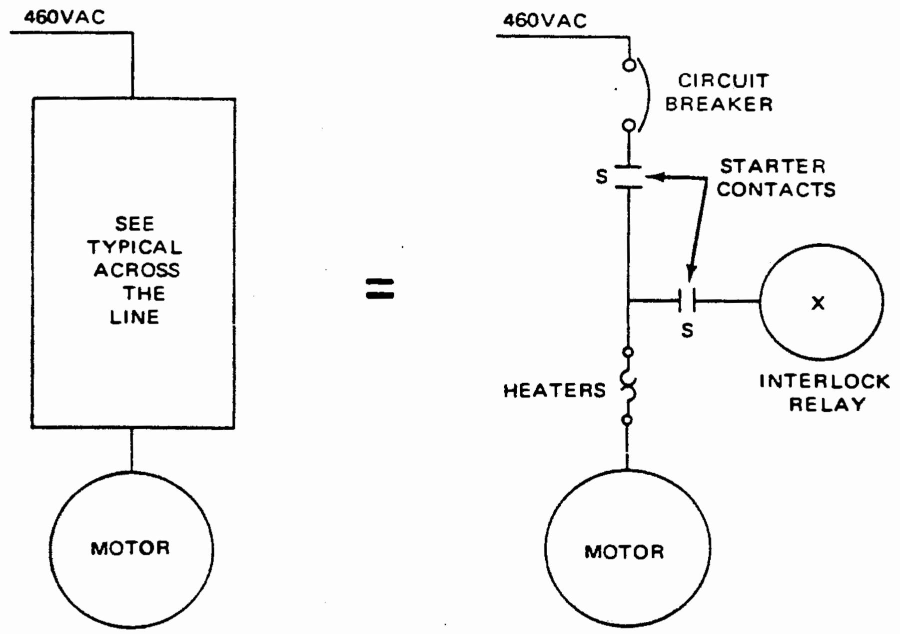


FIGURE BB-3 — "Motor Circuit - Typical"

Each motor, on the plant, is called out and given a letter designation. This letter is then used to identify the corresponding starter and interlock relay (if used).

EXAMPLE: A = Asphalt Pump
B = Spray Pump
C = Hydraulic Pump
D = Pugmill

When the main starter contacts are pulled in, current flows through to the thermal overload to give power to the motor. Current also flows to energize the interlock relay.

NOTE: Thermal Overload Relays — Continuous over-current, due to overload, raises the temperature that melts the alloy. The melting of the alloy allows a ratchet wheel to rotate and open the contacts in the motor circuit, stopping the motor. A few moments after the motor circuit has been broken, the melted alloy solidifies and the relay may be reset. Another method used is when continuous over-current, due to overload, raises the temperature to a heater; the heater expands and trips the overload relay switch.

In an effort to conserve space on a drawing, the following might be seen as a symbolic drawing for a motor schematic. (Refer to Figure BB-3.)

3. **Control Schematics** — The circuits used in the Barber-Greene Electrical Systems use a ladder type schematic and has a working voltage of 110 volts or less. There are two types of voltages used:
   a. A.C., when used, is usually 110 volts and the wire is physically color coded RED.
   b. D.C., when used, is usually less than 110 volts and the wire is physically color coded BLUE.
   c. Ground wires, in a control circuit, is usually color coded WHITE.

B. SYSTEM CONTROL CIRCUITS:

The Control Circuit Schematic is drawn with two legs. The left leg is hot; the right leg is ground and the circuits are parallel to each other, (Refer to Figure BB-5). Down the left leg the numbers are used as line numbers. Down the right side, along side of a relay coil, are the LINE numbers of its contacts. The numbers that are underlined designate a normally closed (N.C.) set of contacts.

The action of an electrical relay and how it is drawn in a schematic is illustrated in Figure BB-4.

A few other reminders when reading the Control Circuit Schematics are:

1. A dotted line between two contacts designate a mechanical connection between the contacts, usually in the same switch.

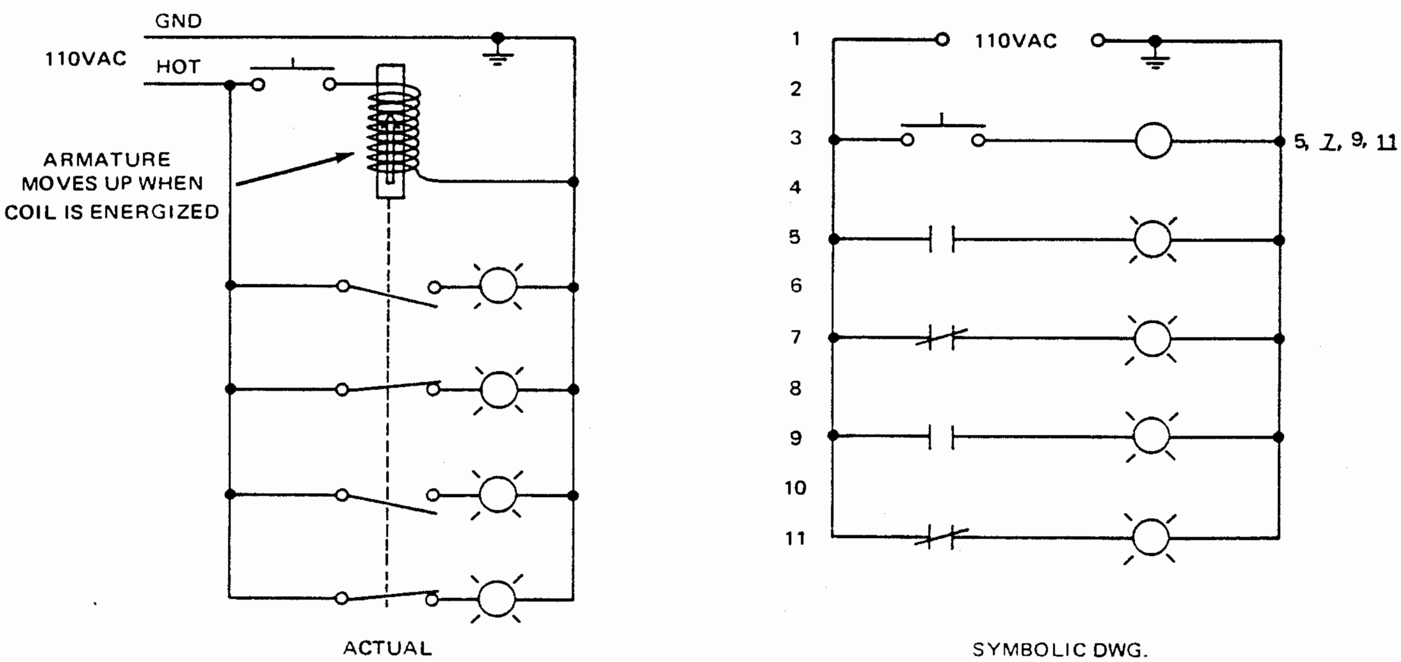


FIGURE BB-4 — "Relay Function"

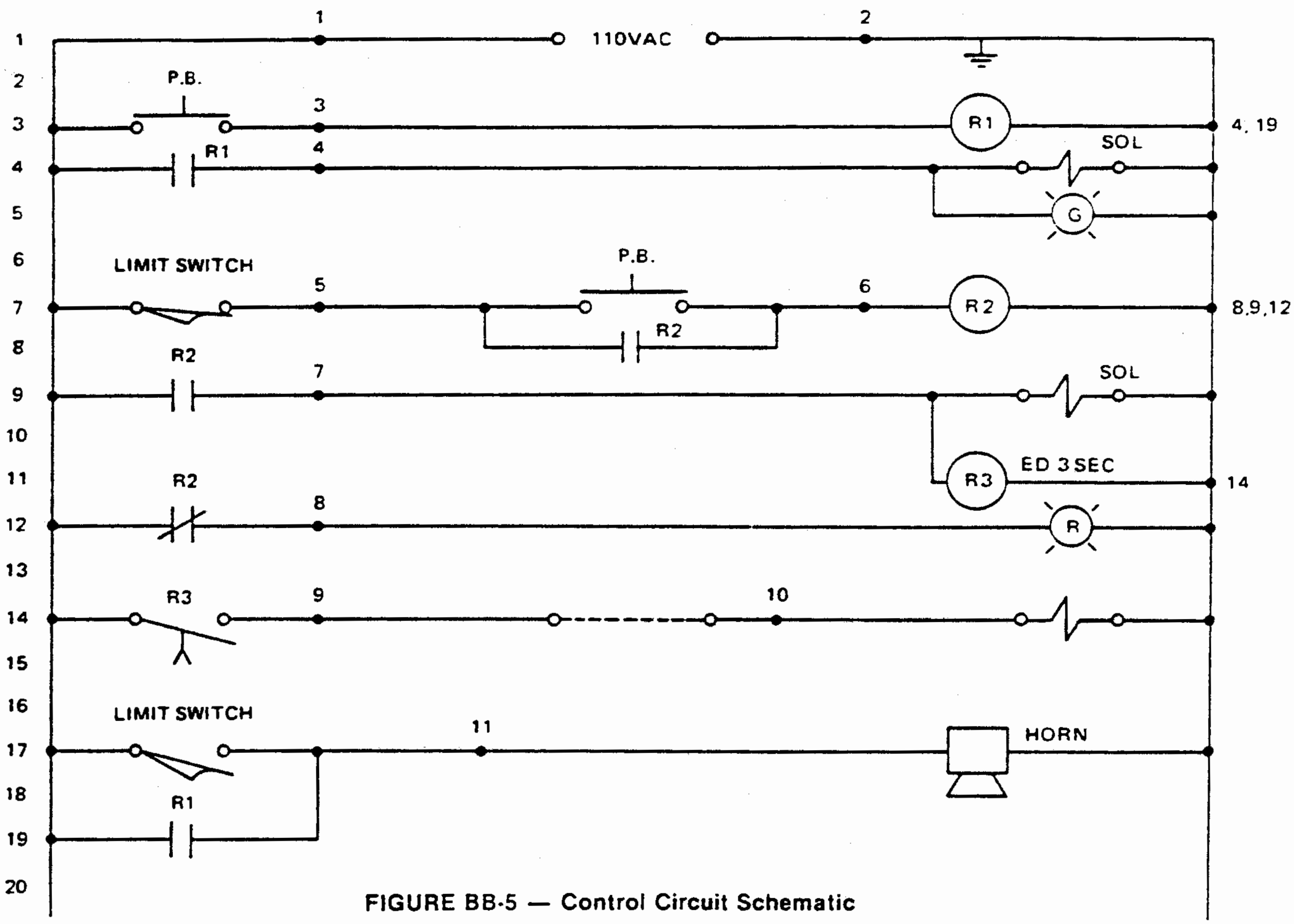


FIGURE BB-5 — Control Circuit Schematic

2. A dotted line between two wire numbers indicate a jumper.
3. On time delay contacts the arrow on the contacts indicate:
   Pointing up — Energize Delay
   Pointing down — De-energized Delay
4. On limit switches the switch is drawn:
   Under the line — Normally Open (N.O.)
   Over the line — Normally Closed (N.C.)

Referring to Figure BB-5 (Control Circuit Schematic) lets talk some of the circuit through.

On line 1, 110 volts A.C. is applied down the left leg. Then on line 3, if the normally open push button is depressed, the coil of the R1 relay is energized. When the R1 relay is energized, it closes a set of (N.O.) contacts on line 4 to energize a solenoid and lite a light. The R1 relay also closes a set of (N.O.) contacts, line 19, to sound a horn.

NOTE: The above circuit is only activated when a button is depressed, once you let up, the circuit collapses.

On line 7, if the limit switch is closed (drawn N.O., held closed) current passes to the normally open push button. If the push button is depressed, the R2 relay is energized which closes a set of (N.O.) contacts, line 8, establishing a holding circuit so you can release the push button. When R2 is energized it also opens a set of (N.C.) contacts, line 12, which de-energizes a light and closes a set of (N.O.) contacts, line 9, which energizes a solenoid and the R3 relay. When the R3 relay is energized, since it is a Energize Delay of three seconds, three seconds later its (N.O., E.D.) contacts, line 14, will close and energize a solenoid.

Whenever the limit switch (N.O., line 17) is tripped or held closed, it will sound a horn.

GLOSSARY OF TERMS

Actuator. The cam, arm or similar mechanical device used to trip limit switches.

Alternating Current. An electrical current which alternates back and forth in direction of flow.

Ambient Conditions. The condition of the atmosphere adjacent to the electrical apparatus. The specific reference may apply to temperature, contamination, humidity, etc.

Ambient Temperature. Ambient temperature is the temperature of the surrounding cooling medium, such as gas or liquid, which comes into contact with the heated parts of the apparatus.

Ammeter. An instrument for measuring the flow of an electric current.

Amplifier (Sensing Unit). A device of electronic components used to increase power, voltage or current of a signal.

Amphere. "Amps". The current flowing through 1 ohm resistance at 1 volt potential.

Armature. The movable part of a dynamo or motor consisting essentially of coils of wire around an iron core. When the armature moves through the magnetic field between the pole pieces, an electric current is induced (as in the dynamo); when the current is passed through the coils they are caused by electro-magnetic induction to move through this field (as in the motor). The movable part of a relay or electric bell, moving in a variable magnetic field.

Atom. The smallest particle of an element. This particle contains electrons, protons, and neutrons in a predetermined quantity of each.

Auxiliary Contacts. Auxiliary contacts of a switching device are contacts in addition to the main-circuit contacts and function with the movement of the latter.

Block Diagram. A block diagram is a diagram showing the relationship of separate sub-units (blocks) in the control system.

Brush. One of two or more plates, rods or bundles of some conducting material, esp. copper or carbon, bearing against a commutator, slip ring or the like, and providing a passage for electric current.

Calibration. The act of determining or rectifying the graduations used on a testing instrument.

Capacitor. A device used to block the flow of direct current while allowing alternating and pulsating currents to pass.

Chassis. Sheet metal box, frame, or simple plate on which electronic components and their associated circuits are mounted.

Circuit. The complete path of an electric current, including, usually, the generating device. This complete path is called a closed circuit, and when its continuity is broken, an open circuit.

Parallel (Circuit). That arrangement of an electrical system, as of the cells of a battery, in which all positive poles, terminals, etc., are joined to one conductor, and all negative poles, etc., to another conductor, so that each unit is practically on a parallel branch or shunt.

Primary (Circuit). In an induction coil or transformer pertaining to or designating the inducing current or its circuit, as a primary coil.

Secondary (Circuit). In an induction coil or transformer pertaining to or designating the induced current or its circuit; as the secondary coil; secondary winding.

Series (Circuit). The arrangement of connecting the separate parts of a circuit successively end to end to form a single path for the current, parts so arranged being in series.

Series — Parallel (Circuit). A combination of series and parallel circuits.

Circuit Breaker. A device designed to open and close a circuit by non-automatic means, and to open circuit automatically on a predetermined overload of current, without injury to itself when properly applied within its rating.

Coil. A spiral of wire, or an instrument composed of such a spiral and its accessories.

Compound. Matter produced by the union of several elements or parts.

Connector. A device used to link the components of an electrical circuit together.

Control Circuit. The control circuit of a control apparatus or system is the circuit which carries the electric signals directing the performance of the controller, but does not carry the main power circuit.

Control Circuit Transformer. A control circuit transformer is a voltage transformer utilized to supply a voltage suitable for the operation of control devices.

Current. A movement of electricity analogous to the flow of a stream of water. Sometimes used to identify the rate of such movement.

Direct Current. An electrical current flowing in one direction only.

Draw (Amperage). The quantity of current used to operate an electrical device.

Drop (Voltage). The net difference in electrical pressure when measured across a resistance.

GLOSSARY OF TERMS (Cont'd)

Dynamic Braking. Dynamic braking of an electric drive is a system of braking in which the motor is used as a generator, and the kinetic energy of the motor and driven machinery is employed as actuating means of exerting a retarding force.

Electricity. One of the fundamental quantities in nature, consisting of elementary particles, electrons and protons. Electricity is characterized especially by the fact that it gives rise to a field of force possessing potential energy and that, when moving in a stream (an electric current) it gives rise to a magnetic field of force with which kinetic energy is associated. The elementary particles of electricity, the electron and the proton, are opposites electrically.

Electrode. Either terminal of an electric source; especially either conductor by which the current enters and leaves an electrolyte. As a component of a spark plug, its insulated center rod.

Electrolyte. A substance in which the conduction of electricity is accompanied by chemical decomposition. In a battery it is a mixture of sulphuric acid and distilled water.

Electromotive Force. That which moves, or tends to move, electricity; the amount of energy derived from an electrical source per unit quantity of electricity passing through the source.

Electromagnet. A core of magnetic material, in practice always soft iron, surrounded by a coil of wire through which an electric current is passed to magnetize the core.

Electron. A very light particle associated with the elementary charge of negative electricity. Electrons are consitutents of atoms.

Element. An atom or fundamental form of matter. In a battery, one set of positive plates and set of negative plates complete with separators in assembled form.

Elementary (Schematic) Diagram. An elementary (schematic) wiring diagram is a diagram using symbols and a plan of connections to illustrate in simple form the scheme of control.

Energy. The capacity for doing work. This capacity may have as its source chemical reaction, electrical action or mechanical action.

Fail-Safe Operation. An electrical system so designed that the failure of any component in the system will prevent unsafe operation of the controlled equipment.

Farad. The unit of electrical capacity; the capacity of a condenser which, charged with one coulomb, gives a difference of potential of one volt.

Field. Short for field magnet, field winding, etc. Also used to designate the area in which a magnetic flow occurs.

Field Coil. A coil of insulated wire surrounding the field pole.

Flux Density. Flux is the rate of flow. Flux density is a rate — mass relationship. Also the lines of magnetic force passing or flowing in a magnetic field.

Fuse. An electrical safety device consisting of a wire or a strip of fusible metal inserted in a circuit which will melt when the current becomes too strong.

Gap. Any break in the continuity of a circuit.

Generator. A machine by which mechanical energy is changed into electrical energy.

Ground. The connection made in grounding a circuit. In automotive use, the result of attaching one battery cable to the body or frame which is used as a path by various electrical components for completing a circuit in lieu of a direct wire from that component.

Insulator. A non-conducting substance or body, as porcelain or glass, used in insulating wires, etc.

Interlock. An interlock is a device actuated by the operation of some other device with which it is directly associated, to govern succeeding operations of the same or allied devices.

NOTE: Interlocks may be either electrical or mechanical.

LED. A solid state device that emits light when a forward current is forced through it.

Limit Switch. A limit switch is a switch which is operated by some part or motion of a power-driven machine or equipment to alter the electric circuit associated with the machine or equipment.

Live. Electrical parts attached to the insulated part of an electrical system, often called the "hot lead".

Magnetism. A property of the molecules of certain substances such as iron, by which they may be magnetized.

Matter. That particle or combination of particles of which any physical object is composed; material, constiutents, also a particular kind or portion of material.

Megohm. 1,000,000 ohms.

Microfarad. 1/1,000,000 farad.

Milliampere. 1/1,000,000 ampere.

GLOSSARY OF TERMS (Cont'd)

Negative. Designating or pertaining to a kind of electricity. The negative plate of an electrolytic cell.

Negative Pole. The point from which an electrical current flows. Also referred to as the South Pole in magnetism.

Normally Open and Normally Closed. The terms "normally open" and "normally closed", when applied to a magnetically operated switching device, such as a contactor or relay, or to the contact thereof, signify the position taken when the operating magnet is de-energized. These terms apply only to non-latching types of devices.

Necleus. The central part of an atom, containing most of its mass and having a positive charge equal to the atomic number of the element. The nucleus of ordinary or light hydrogen as the proton; according to present theory, all other nuclei are combinations of protons and neutrons.

Neutron. An uncharged particle of slightly greater mass than the proton. Neutrons are constituents of atomic nuclei (except those of ordinary hydrogen).

Ohm. The practical unit for measuring electrical resistance, being the resistance of a circuit in which a potential difference of one volt produces a current of one ampere.

Opto Isolator: A light coupled relay that uses one signal to switch another signal. Operates identically to a relay except there is no mechanical linkage between the coil (Light) and the contacts (Photo Sensor). Input: Yellow 120V AC to 5V. DC. Output: Black 5V. DC to 120V AC.

Overload Relay. A device that provides overload protection for electrical equipment.

Plugging. Plugging is a control function which provides braking by reversing the motor line voltage polarity or phase sequence so that the motor develops a counter-torque which exerts a retarding force.

Polarity. The quality or condition inherent in a body which exhibits opposite, or contrasted, properties or power, in opposite or contrasted parts or directions; the having of poles, polarization.

Positive. Designating or pertaining to a kind of electricity tending to lose electrons and thus become positive (in sense).

Proton. nucleus of the atom of the light isotope of hydrogen, constituting the principal part of its mass and exhibiting a unit of all atoms.

Raceway. Any channel for holding wires, cables or busbars, which is designed expressly for, and used solely for, this purpose.

Rectifier. A device used to convert alternative current into a unidirectional current by removing or inverting that part of the wave lying on one side of the zero amplitude axis.

Rectifier Diode: A semiconducter device which permits current to flow through it in one direction only.

Relay. A relay is a device which is operative by a variation in the conditions of one electric circuit to effect the operation of other devices in the same or another electric circuit.

Resistance. The opposition offered by a substance or body to the passage through it of an electric current.

Resistor. A device which offers resistance to the flow of electric current. It's electrical size is specified in ohms.

Shielded Cable. Shielded cable is single or multiple conductor cable surrounded by a separate conductor (the "shield") intended to minimize the effect of adjacent electrical circuits.

Rheostat. A resistor for regulating a current by means of variable resistance.

Rotor. A rotating conductor which carries current from a central source to individual outlets, as required.

Short Circuit. Most often used to identify an unintentional grounding of a circuit.

Shunt. A conductor joining two points in a circuit so as to form a parallel or derived circuit through which a portion of the current may pass, in order to regulate the amount passing in the main circuit.

Silicon Controlled Rectifier: A high powered device that will pass current through it when switched on by powering the gate.

Solenoid. A solenoid magnet (solenoid) is an electromagnet having an energized coil approximately cylindrical in form and an armature whose motion is reciprocating within and along the axis of the coil.

Specific Gravity. The ratio of the weight of any volume of a substance to the weight of an equal volume of some substance taken as a standard or unit as, usually, water for solids and liquids and air or hydrogen for gases.

Static. Of, pertaining to, or designating stationary charges of electricity; also, producing such charges as by rubbing unlike bodies together.

GLOSSARY OF TERMS (Cont'd)

Stepping Relay (Switches). A multi-position relay in which moving wiper contacts mate with successive sets of fixed contacts in a series of steps, moving from one stop to the next in successive operations of the relay.

Switch. A device for making, breaking, or changing the connection in an electrical circuit.

Tachometer. A device for measuring and indicating the rotative speed of an engine.

Terminal. A point of connection in an electrical circuit.

Terminal Block. A terminal block is an insulating base or slab equipped with one or more terminal connectors for the purpose of making electrical connections thereto.

Transformer. A device, without moving parts, that transfers electromagnetic induction from one or more circuits to one or more other circuits. May be used to step up or step down voltage.

Variable Resistor (Potentiometer) "Pot". A resistor having a sliding contact so that it's resistance value can be changed.

Volt. The unit of electromotive force; defined by the Internation Electrical Congress in 1893 and by U.S. statute as that electromotive force which steadily applied to a conductor whose resistance is one ohm will produce a current of one ampere.

Voltage. The electrical pressure that makes current flow through a conductor. One volt is the force which will send one amphere through a resistance of one ohm.

Voltmeter. An instrument for measuring in volts the differences of potential between different points of an electrical circuit.

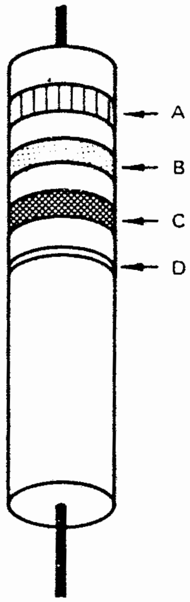
Watts. The practical unit of electric power, and in a direct current circuit, equal to volts multiplied by amperes. In an alternating current circuit, true watts are equal to effective volts multiplied by effective amperes, then multiplied by the circuit power factor.

Winding. The coiling of a wire about itself or about some object. Often identified as a series winding, a shunt winding, etc.

Zener Diode: A semiconducter device that is used as a voltage regulator. Example: A 5V. Zener will hold a steady 5V. if the voltage applied is higher (up to the point of peak inverse voltage (PIV)). If the voltage is below 5V. it will not pass any current.

COLOR CODE FOR RESISTORS

All carbon resistors are produced and color-coded to meet the standards set up by the RETMA (Radio, Electronics and Television Manufacturer's Association). Here is your guide to resistors by color bands.



COLOR-CODE CHART

BAND A		BAND B		BAND C		BAND D	
COLOR	VALUE	COLOR	VALUE	COLOR	VALUE	COLOR	TOLERANCE
Black	0	Black	0	Black	None	None	± 20%
Brown	1	Brown	1	Brown	0	Silver	± 10%
Red	2	Red	2	Red	00	Gold	± 5%
Orange	3	Orange	3	Orange	000		
Yellow	4	Yellow	4	Yellow	0000		
Green	5	Green	5	Green	00000		
Blue	6	Blue	6	Blue	000000		
Violet	7	Violet	7	Violet	0000000		
Gray	8	Gray	8	Gold	÷ 10		
White	9	White	9	Silver	÷ 100		

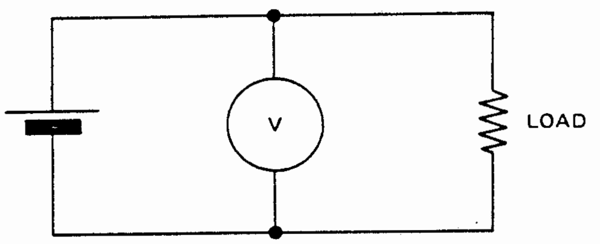
NOTE: The first band (A) shows the first figure of the resistor value, the second band (B) shows the second figure, and the third band (C) indicates the number of zeros to be added. The fourth band (D), which is not included in all resistors, merely indicates the tolerance. If the last band (D) is omitted, the tolerance of the resistor is plus or minus 20%.

INDEX

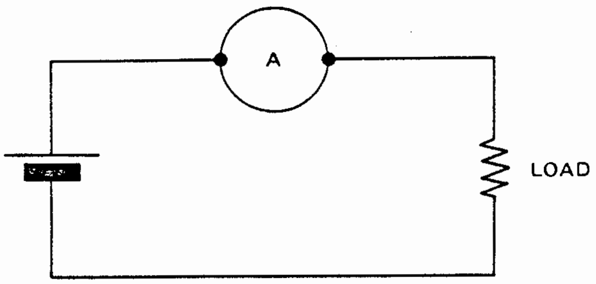
VOLT-OHM METER USAGE AND SOLDERING TECHNIQUES

Diagnosing troubles in the electrical system is one of the more important duties of the Asphalt Plant Technician. With proper instruments connected in the circuit he must be able to determine whether changes in adjustments are required, whether the system is performing satisfactorily or whether a specific unit or part needs repairs or replacement. Of course, the accuracy of the readings will depend upon the accuracy of the meters used. Voltmeter scales should be calibrated in 0.1 volt divisions, as settings with one-tenth volt variation will be specified. Ammeters may be calibrated in 0.5 ampere divisions. If a choice is available, greater accuracy is desired in the voltmeter than in the ammeter.

Most modern meter movements are of the moving-coil type which consists of a permanent horseshoe or hoop shaped magnet and a movable coil. Current flowing through coil reacts with the permanent magnetic field causing the coil to rotate against a light spring tension. The relative movement of the coil is in proportion to the amount of current flowing in the windings. A pointer attached to the coil moves across a calibrated scale indicating the amount of current flowing in the coil.



VOLTMETERS
CONNECTED
IN PARALLEL



AMMETERS
CONNECTED
IN SERIES

ILLUSTRATION A

The same meter movement may be used for either a voltmeter or ammeter. It becomes a voltmeter in series with the proper amount of external resistance. It becomes an ammeter when connected with the proper shunts.

AMMETERS are connected in SERIES with the circuit in which the current is to be measured. Where necessary external shunts are provided so that only a small proportional part of the total current passes through the instrument. Since the current value in a circuit should be the same after the meter is inserted in series as it was before the meter was hooked up, it follows that ammeters must have a low resistance between terminals. (See illustration A).

VOLTMETERS are connected ACROSS (in parallel with) the circuit. They must have a very high resistance so that the small amount of current they take will not disturb the circuit. The voltage of a circuit should be essentially the same after a voltmeter is hooked up across the circuit as it was before. If the voltmeter does not have a sufficiently high resistance, this will not be true.

VOLT — OHM METER USAGE

In addition to reading drawings, you must have a means of determining if a wire is alive or dead. In some cases, this can be accomplished with a test light using a small wattage bulb and suitable leads.

By using a volt-ohm meter more satisfactory results may be attained. The volt meter measures the voltage or difference in potential between two points. The ohm meter measures the resistance of a conductor to pass a current. By it, we can measure the continuity of a portion of a circuit. By continuity, we mean a continuous path for the electricity to follow.

Regardless of the brand name, or make Volt-Ohm Meter, you will find the meter has an Ohm scale and one or more volt scales.

To measure either volts or ohms (resistance), from zero to the maximum amount we are interested in, would require an extremely long scale. To keep the length of the scale within practical limits, the meter is made so we can change the range of the scale.

All meters are most accurate when reading in the mid-section of the scale. To accomplish this and to change the span, we have a selector switch.

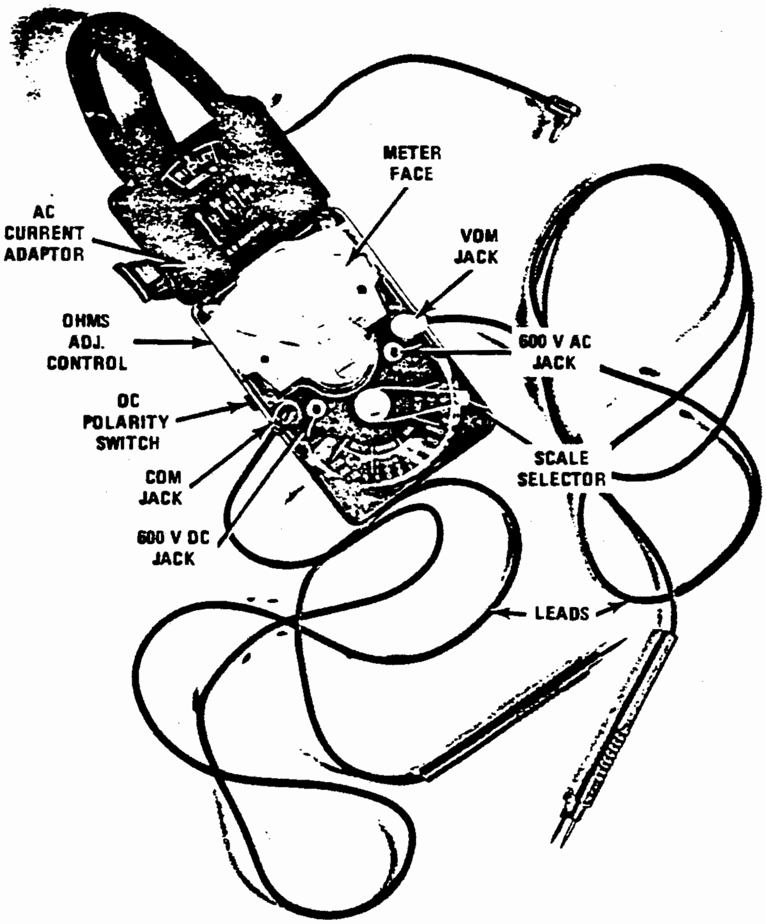


FIGURE 1 — Meter

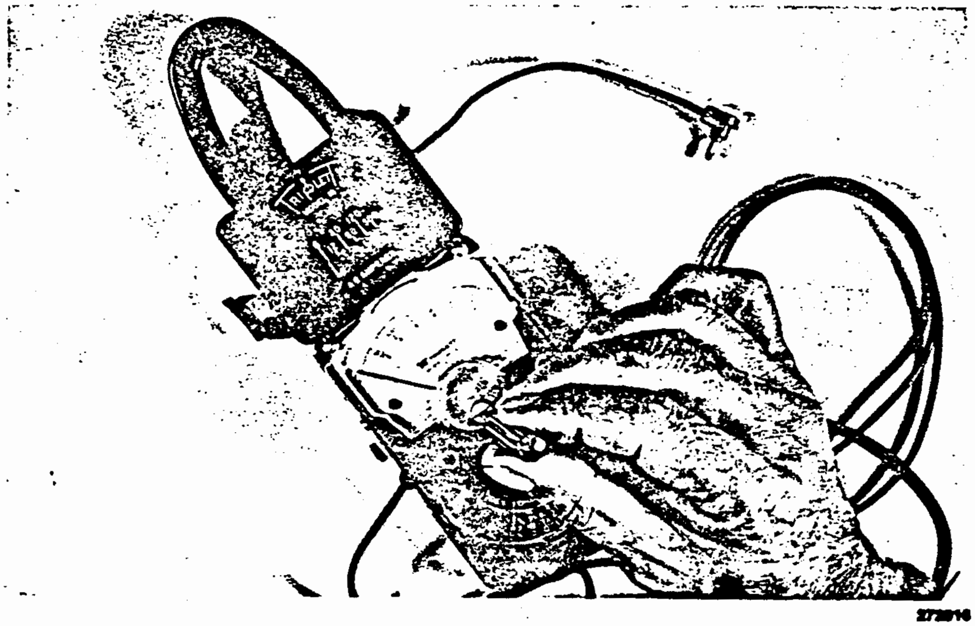


FIGURE 2 — Zero Adjust

The VOM we will use in the discussion is the triplett Model 310 with the Model 10 A C Amperes Adapter. However, the use and operation of any VOM is much the same and the knowledge learned here will greatly assist you.

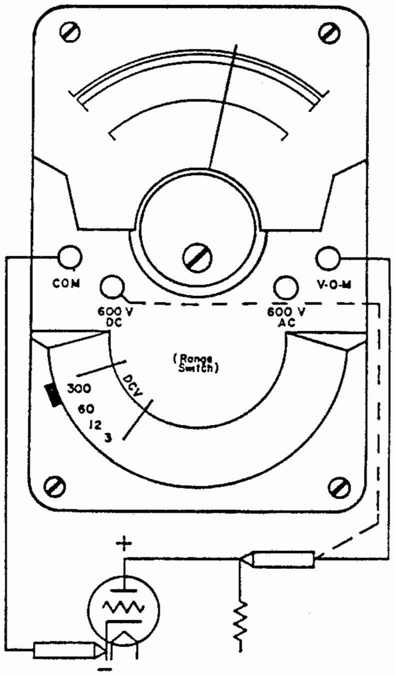


FIGURE 3 — DC Voltage

USING THE METER

A. Adjust the meter to read zero (Refer to Figure 2).
   1. Use screw driver of proper size and turn screw in center of meter at lower center of meter.

B. DC Voltage measurements (Refer to Figure 3).
   1. Select DC V scale higher than supply voltage. If not known, select highest scale and work down.
   2. Adjust meter to zero.
   3. Real all DC volts on black scale (only this meter).
   4. Plug black lead in "COM" jack.
   5. Plug red lead in "VOM" or "600 V DC" jack, and adjust scale to 300 DC V depending on voltage.

NOTE: Triplett Model 310 has 1200 DC jack.

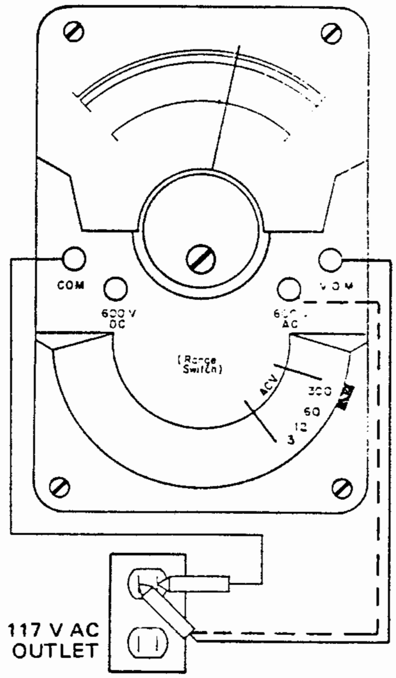


FIGURE 4 — AC Voltage

6. Touch leads across line (parallel).
   a. CAUTION: If needle travels down scale (below zero), change leads to correct polarity. (Red to Black, Black to Red).
   b. If meter shows only a small movement, change to lower scale.

CAUTION: Do not touch high voltage without proper insulation.

C. AC Voltage measurements (Refer to Figure 4).
   1. Select AC V scale higher than supply; if not known, select highest scale and work down.
   2. Adjust meter to zero.
   3. Read all AC volts on the red scale (this meter only).
   4. Plug black lead in "COM" jack.
   5. Plug red lead in "VOM" or "600 AC V" jack, and adjust scale to 300 AC V, depending on voltage.

NOTE: Triplett Model 310 has 1200 AC V jack.

6. Touch leads across line (parallel).
   a. If meter shows only small movement, change to lower scale.

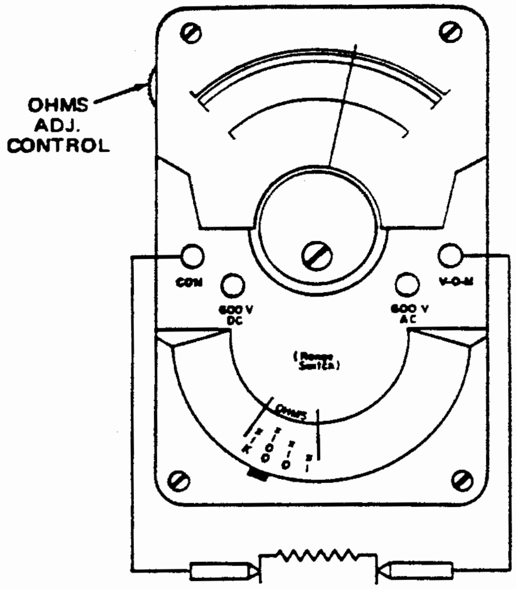


FIGURE 5 — Resistance

CAUTION: Do not touch voltage without proper insulation.

D. Resistance measurements (ohms scale).

READING RESISTANCE
(Refer to Figure 5)

Note the ohms scale first, it shows 0 on the right side and 500 or more on the left. Also note the divisions on the left cannot be read with any degree of accuracy. If the pointer is on the RX1 scale, the reading would be direct.

CAUTION: Do not use the ohm meter on any part of the circuit with power on.

Parts to be checked for resistance should be isolated from any other part of the circuit.

1. There are four resistance ranges on this meter:
   a. 0-20,000 ohms X-1
   b. 0-0200,000 ohms X-10
   c. 0-2 meg ohms X-100
   d. 0-20 meg ohms X-1K
   e. Other meters will have comparable scales.
2. Plug black lead in "COM" jack.
3. Plug red lead in "VOM" jack.

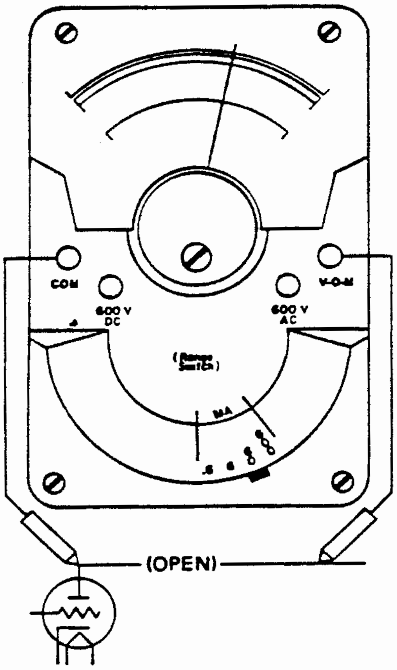


FIGURE 5 — DC Current

4. Select range to be used and short leads together, turn OHM Adjust Control until pointer rests on "0" of the Ohms scale.
   a. Right side of scale.
   The meter is actually measuring the current passing through the object being checked; therefore, it is wise to use the highest range possible and still read the scale on the meter. This will reduce the possibility of burning out the object being checked.
5. Do not touch the metal probes of the meter as it will pick up body resistance.
6. Read across the component with the component taken out of the circuit.
7. Do not use ohm meter on any circuit that has electricity or damage could occur to the meter. When through with the ohms scale, turn the pointer to one of the voltage scales to prevent accidentally shorting the leads and running down the batteries.

E. DC Current measurements. (Refer to Figure 6).

1. There are four current ranges on this meter.
   a. 0-6 Millamperes.
   b. 0-600 Microamperes.
   c. 0-60 Millamperes.
   d. 0-600 Millamperes.
2. All four ranges are read on 0-60 scale.
   a. 0-.6 divide reading by 100.
   b. 0-6 divide reading by 10.

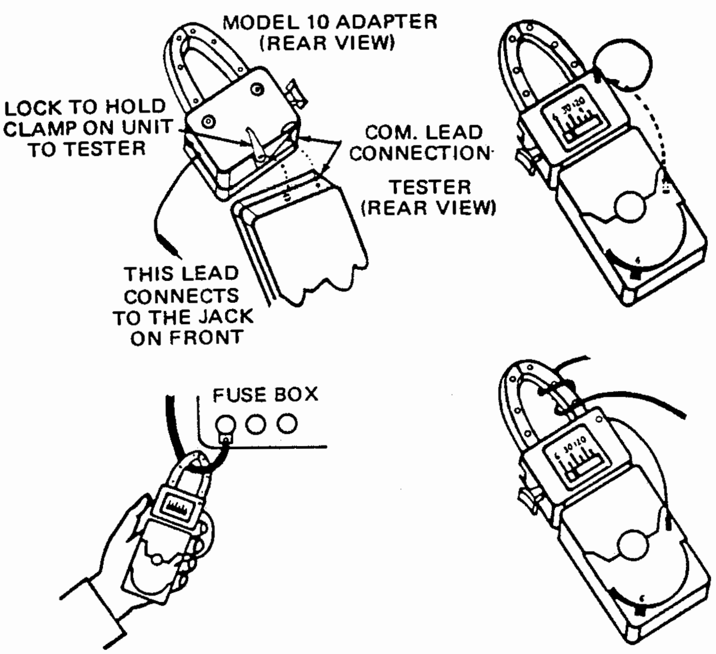


FIGURE 7 — Ammeter Adapter

c. 0-60 read scale directly.
d. 0-600 multiply the reading by 10 or add one zero.

3. Check zero of pointer.
4. Black lead in "COM" jack.
5. Red lead in "VOM" jack.
6. Select proper range.
7. Connect test probes in series, (in line) with the circuit to be measured.
   a. CAUTION: Do not test directly across any potential circuit (parallel) or damage will occur to the meter.
   b. The reading may be backwards; if so, simply reverse leads. Reverse reading does not damage the meter.

F. Using the Model 10 AC Adapter. (Refer to Figure 7).

1. Install the adapter to the meter.
   a. Plug red lead wire of adapter into "VOM" jack.
2. Set selector switch to 3 AC Volt position.
   a. Use 3 AC Volt for all Ampere tests. Read red 3 volt scale for reading.
3. Reading will be multiplied by ratio of range setting to 3 volt scale.
   a. EXAMPLE: Range switch on 6 multiplier would be 2; worked out this way $3\sqrt{6} = 2$.
      If meter reads 20.0, the ampere is 40 (2 x 20 = 40).
   b. EXAMPLE: Range switch on 120 multiplier would be 40; worked out in this way $3\sqrt{120} = 40$.
      If meter reads .5, the ampere is 20 (.5 x 40 = 20).
4. When reading is below half scale and range is on lowest scale (6 amp) greater accuracy may be had by wrapping the conductor around the jaws. Divide the reading by the number of wraps.
   a. 3 wraps — meter shows 1.5.
      $\frac{2 \text{ (multiplier) X } 1.5}{3} = \frac{3.0}{3} = 1 \text{ amp.}$
5. Ampere Adapter should only be used on single conductor.
   a. Keep jaw surfaces clean — if film appears, clean with very fine sand paper.
6. Take good care of your meter and it will take good care of you.
   a. A good idea is to have it tested once a year.
   b. You can quickly check the meter by using known values.
      1. Ohm meter use resistors, 1K, 5K, 10K, 20K.
      2. AC volts — House current.
      3. DC volts — Car battery.

SOLDERING TECHNIQUE

Soldering is the technique of joining pieces of metal under heat by means of a dissimiliar metal or alloy. The heat for soldering is produced in several different ways:

1. You can use an ordinary soldering iron to perform the electrical connections that need soldering. A guideline to size of soldering iron is:
   a. For circuit boards use a 15 Watt.
   b. For wire and plug connections use an iron 15 to 50 Watts, (use a halfway point and work toward size that fits your need).

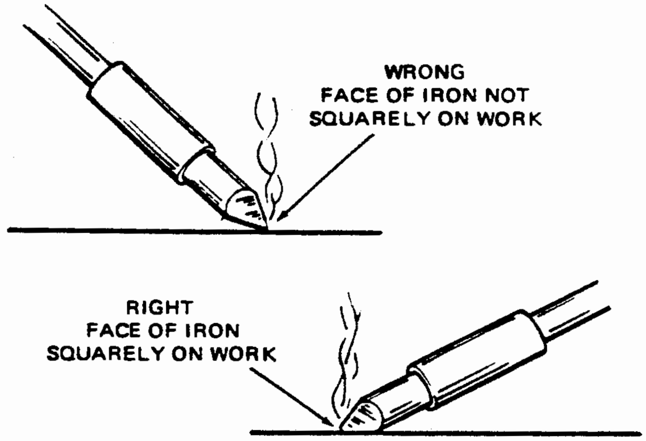
   The Electric Soldering Iron is made in a great number of sizes and has a resistance element which heats up when the unit is plugged into an outlet.
2. While an electric soldering iron takes a short time to heat up, an electric soldering gun is also available and ready for use within a few seconds after trigger is pulled.
3. TYPES OF FLUXES

   When any work is is to soldered, it is essential that the surfaces be perfectly clean. Furthermore, the metal solvent action — the actual joining of the metals by the solder — will not take place if the metals are separated or insulated from each other by a film or layer of oxide. For this reason, a chemical is used to insure the continuous removal of this oxide film as fast as it forms in order that the solder can adhere to the two surfaces.

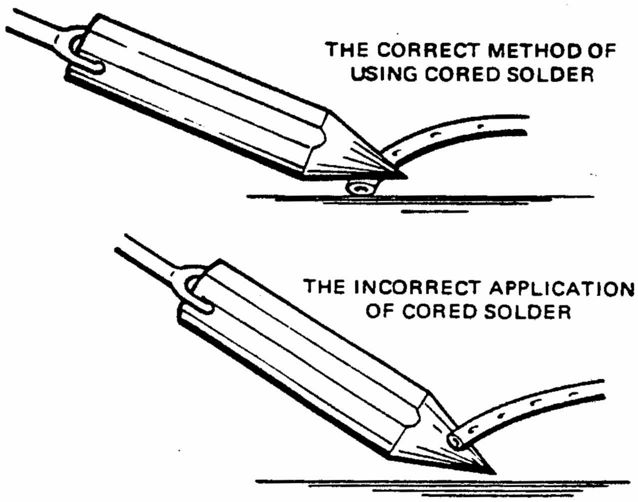
   Even when the metals are clean, a surface film of oxide will form quickly as heat is applied. The substance whose purpose is the removal and prevention of the oxide formation during soldering is known as a flux. It is necessary in all soldering.

SOLDER AND FLUX TO USE

METAL	SOLDER TO USE	FLUX TO USE
Aluminum	50/50	None
Black Iron	50/50	Zinc chloride or acid
Brass	50/50	Rosin or acid
Bronze	50/50	Rosin or acid
Copper	50/50	Rosin or acid
Electrical connections	50/50	Rosin—NEVER ACID
Galvanized steel	50/50	Acid
Lead	60/40	Rosin or acid
Pewter	80/20	Rosin or acid
Stainless steel	70/30	Glycerine
Tin	60/40	Acid
Tin-plated steel	60/40	Glycerine



PROPER WAY TO USE A SOLDERING TIP—THE FACE OF THE IRON SHOULD BE SQUARELY ON THE WORK.



CORRECT METHOD OF USING CORED SOLDER IS TO PLACE THE SOLDER BETWEEN THE WORK AND THE FACE OF THE IRON. HOWEVER, IF YOU USE A FLUX TO COVER THE METAL AND A PURE SOLDER, THEN IT IS PROPER TO HAVE THE SOLDER FLOW OFF THE FACE OF THE IRON ONTO THE WORK.

FIGURE 8

Fluxes are divided into three groups: (1) acid or chloride type fluxes, (2) organic type fluxes and (3) rosin type fluxes.

Some solders, known as cored solders, are made with the flux enclosed in the core, but you can purchase the fluxes separately and use pure solder with them.

4. In soldering, apply the hot soldering copper to the joint until the wire itself is hot enough to melt the solder when it is touched to the wire as shown in Figure 8. Having a bit of solder on the soldering copper, as it is held against the wire, forms a liquid contact between the soldering copper and the wire, leading to a more rapid heating of the wire than if the bare copper were used. If the soldering copper is at the right heat, the wire will quickly heat sufficiently for good soldering. If the soldering copper is not hot enough, the wire will heat slowly because the heat will flow from the splice onto the wire under the insulation, causing a poor joint and possibly damage to the insulation.

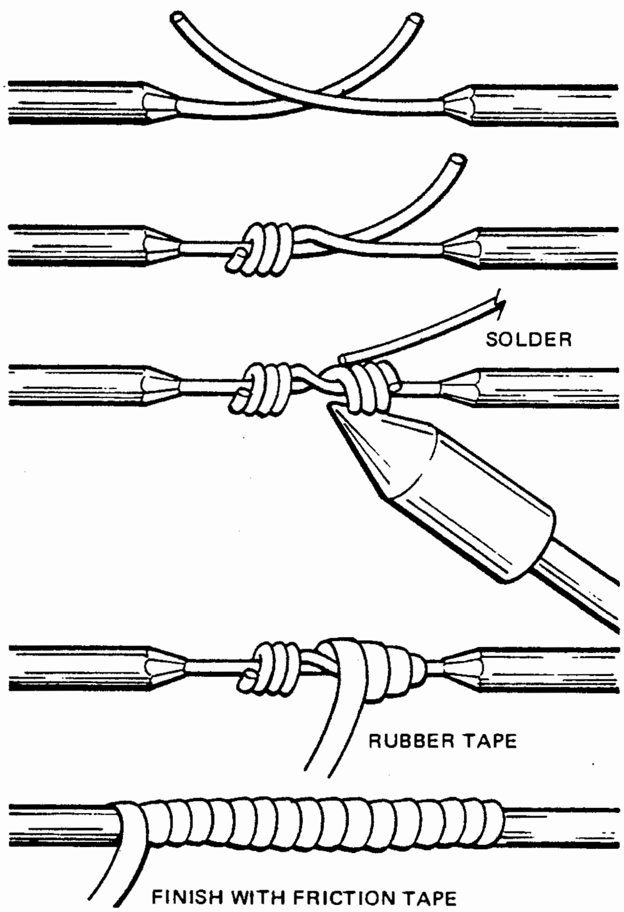


FIGURE 9 — How to make, solder and tape an electrical splice.