SERVICE MANUAL SECTION

TEST EQUIPMENT AND CONNECTOR REPAIR

s08010, Formerly CTS-5234

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1. ELECTRICAL CIRCUIT OPERATION

The description of electrical operation in each section provides a discussion of what is happening in each circuit. The discussion includes power application, ground paths, and component operation. The explanation refers to circuit diagrams, and in some cases, to specific switch movement or components in a circuit. These specific points are often identified by letters or numbers as shown in Figure 1 .

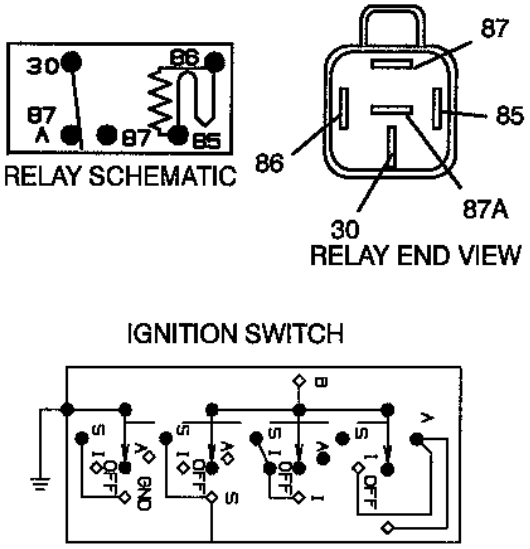

Figure 1 Sample Circuit Components

Figure 1 shows a suppressed relay widely used in the vehicle electrical system. The relay connection points 85 and 86 are the coil connections. Power is applied to one side of the coil and ground to the other, causing the coil to energize. Energizing the coil switches the contact from the normally closed contact 87A to the normally open contact 87.

Figure 1 also shows the symbol for an ignition key switch used on some International vehicles. Notice the points are labeled "A" for accessory, "S" for start, "I" for ignition and OFF. These correspond to the connections on the key switch in the vehicle. The "B" terminal is the power source point. Notice that the key switch is shown in the OFF position. When turned to ON (ignition) position, for example, all four switch arms move together.

1.1. CIRCUIT DIAGRAMS

Circuit diagrams can be found in GROUP 08-ELECTRICAL of the CTS-5000 Master Service Manual.

Circuit diagrams (Figure 2) provide a schematic picture of how a circuit is powered, what the current path is to circuit components, and how the circuit is grounded.

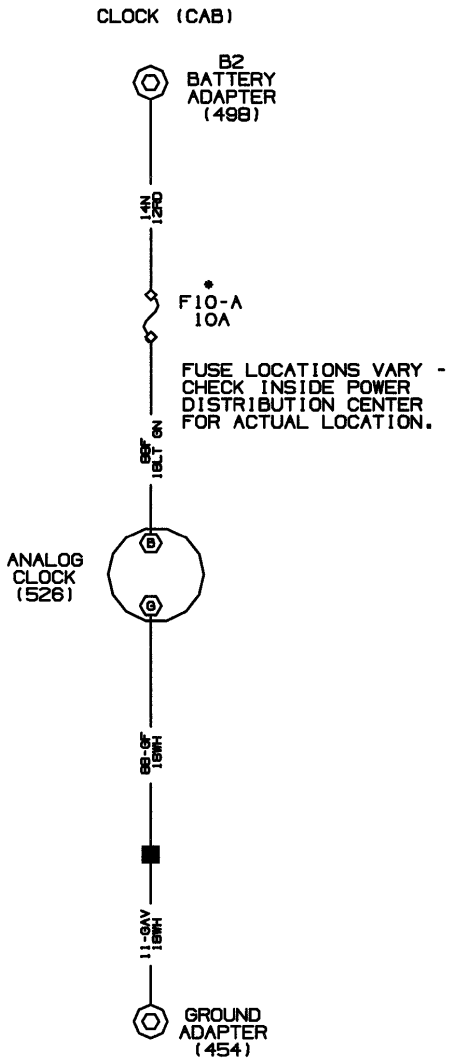

Figure 2 Sample Circuit Diagram

In most cases, the power source will appear at the top of the page, and the ground will be at the bottom of the page (or bottom of circuit). The circuit components are named, using capital letters. Abbreviations may be used (Figure 4).

IMPORTANT – Switch, relay and solenoid positions, as shown on circuit diagrams, indicate NORMAL position with the key switch in the OFF position, unless otherwise noted.

Components which work together are shown together. All electrical components used in any circuit are shown in the circuit diagram. The power source (fuse, circuit breaker, junction point, etc.) is usually shown or indicated at the top of the page. All wires, connectors, and other electrical components are shown in the signal flow to the bottom of the page (or bottom of the circuit).

Circuit Diagram Instructions

The circuit diagram instructions, abbreviations and symbols are included in Figure 3 , Figure 4 and Figure 5 .

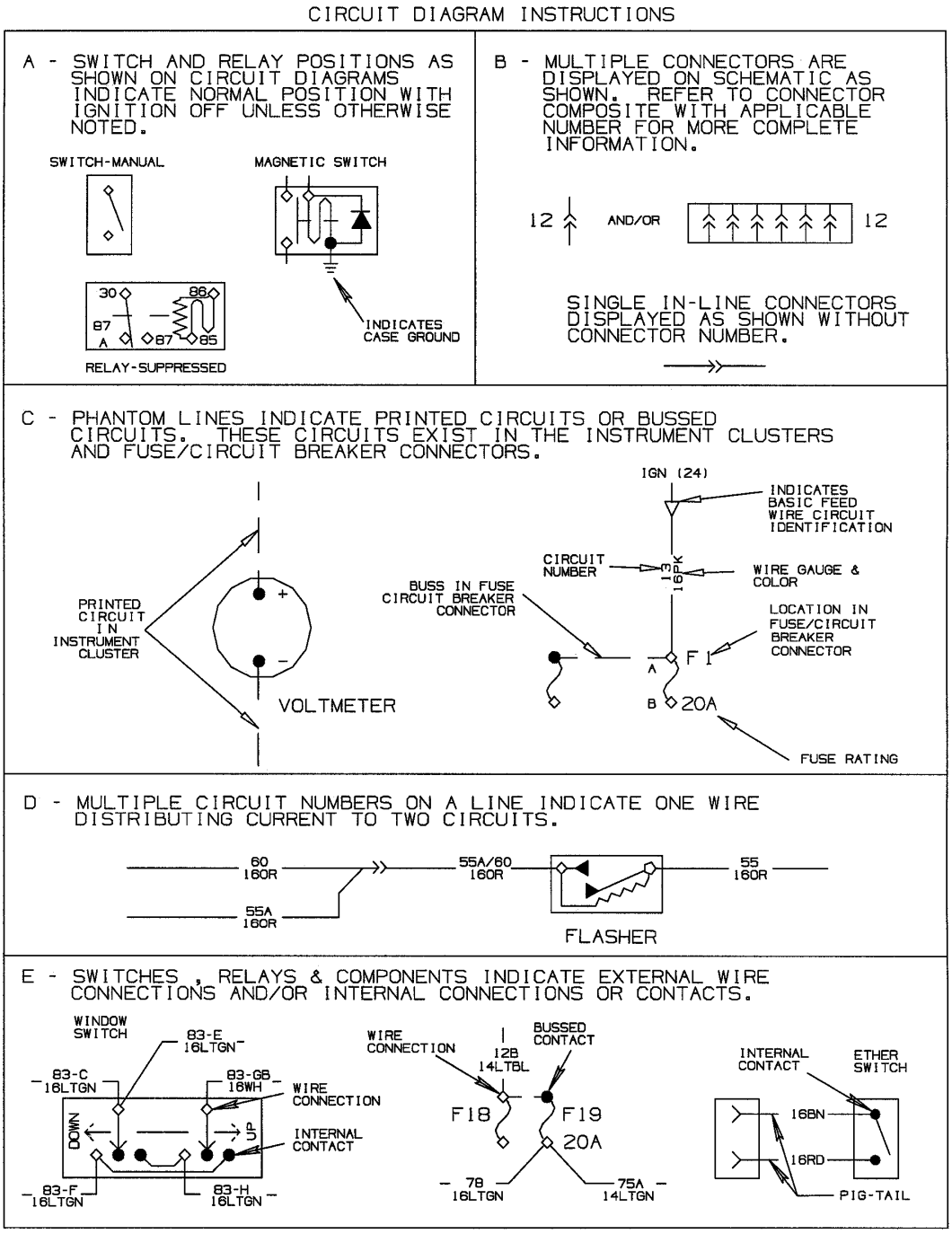

Figure 3 Sample Circuit Diagram Instructions

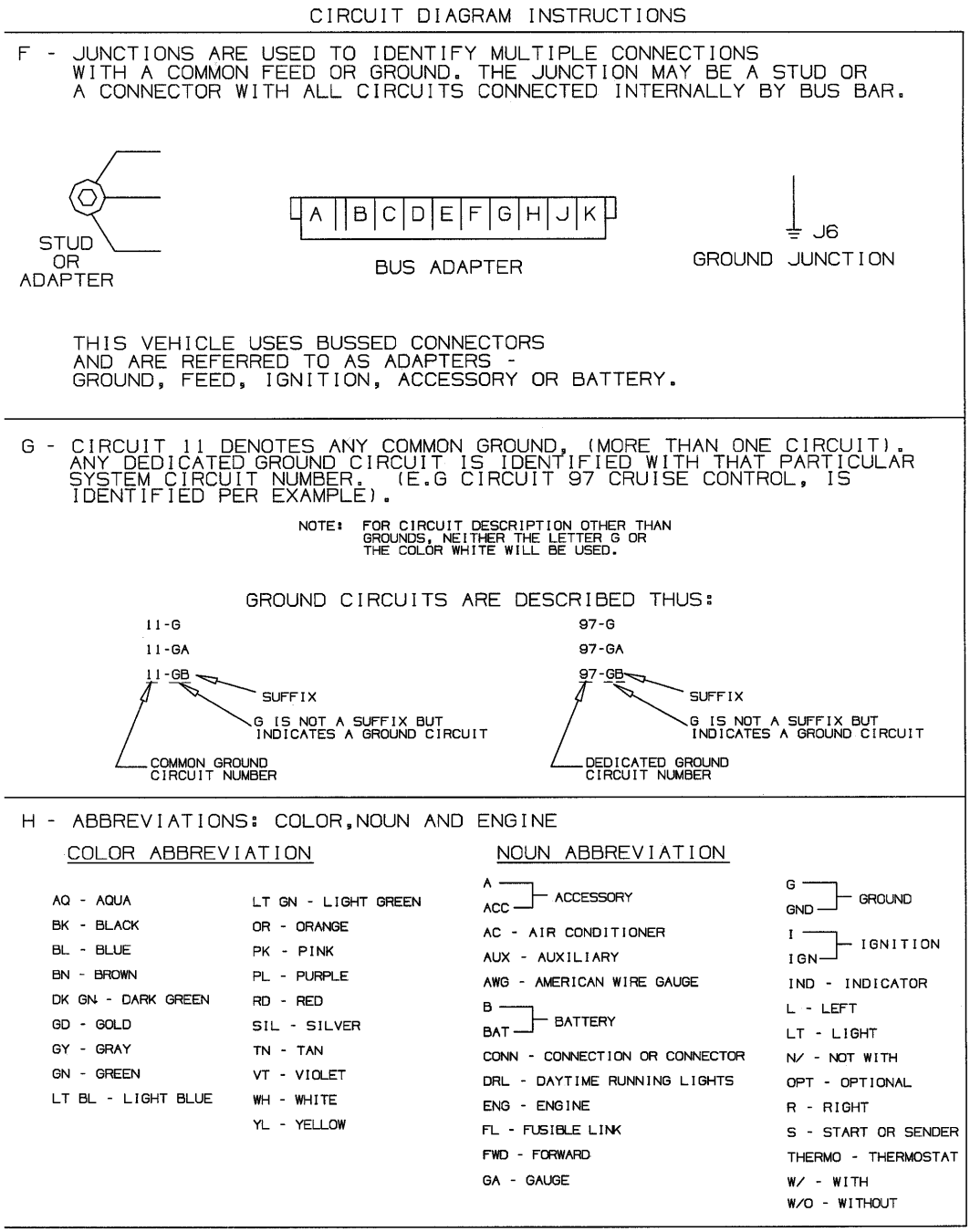

Figure 4 Sample Circuit Diagram Instructions and Abbreviations

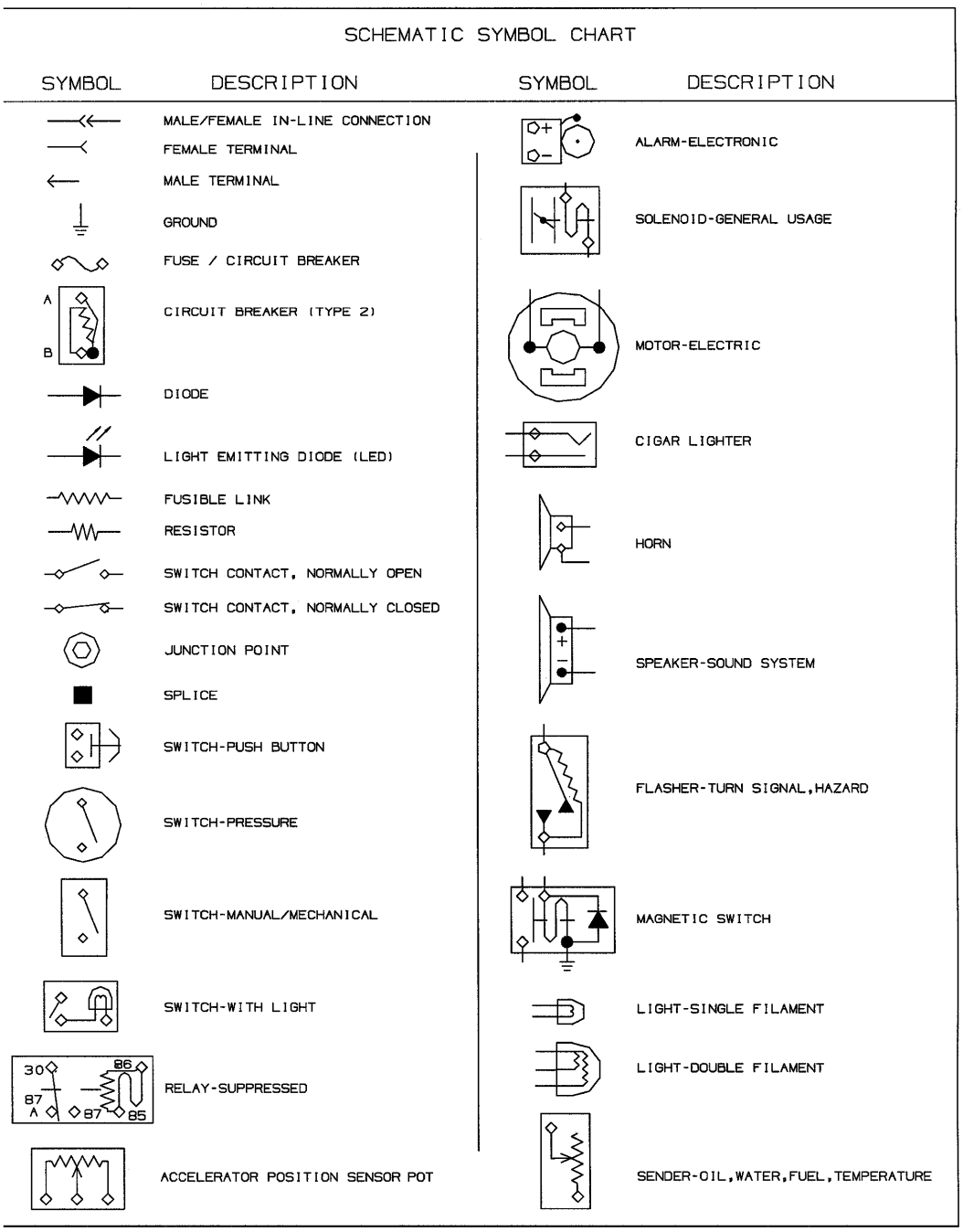

Figure 5 Schematic Symbol Chart

1.2. COMPONENT ILLUSTRATIONS

Each section will provide component location illustrations. The component location illustration (Figure 6) shows the location of a circuit component being discussed.

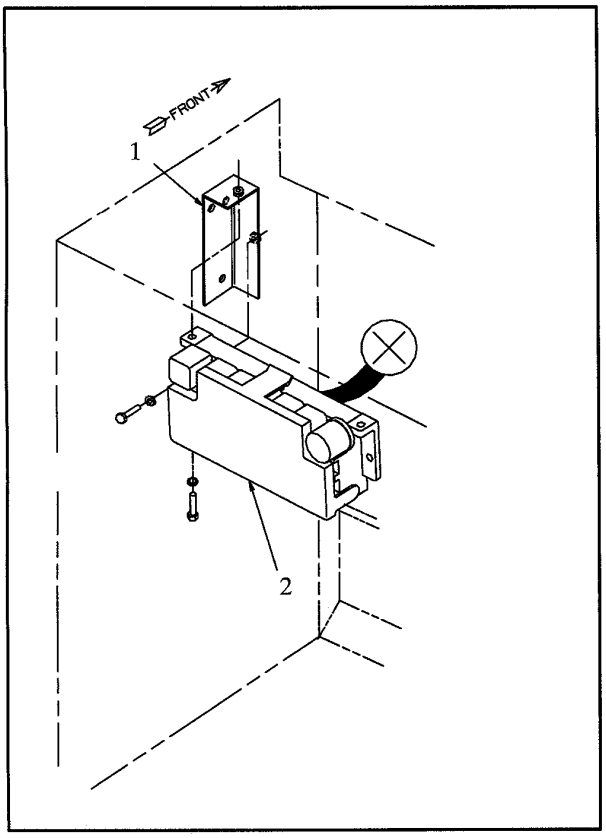

Figure 6 Component Location Illustration

1. FUSE PANEL MOUNTING BRACKET
2. FUSE PANEL

Connector end views found in the Circuit Diagram book provide information as to the location of the various connectors.

1.3. CONNECTOR BODY COMPOSITE

Connector Composites are located in Group 08 - Electrical CIRCUIT DIAGRAMS in the CTS-5000 Master Service Manual under Connector Body Composite (Mating End View). The composites show the pin configuration of the connector and which circuits are attached to the pins as shown in Figure 7 .

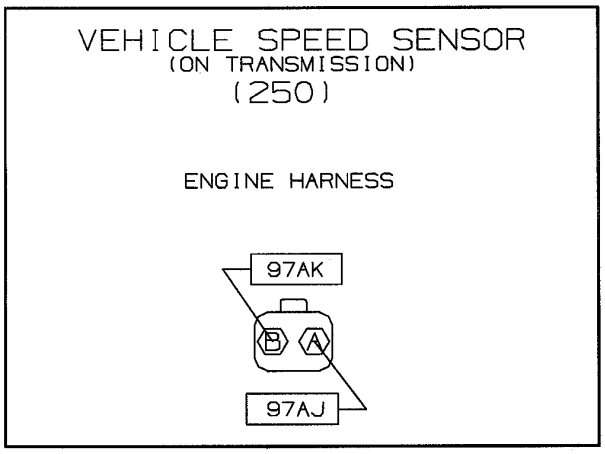

Figure 7 Pin Configuration

1.4. DIAGNOSTIC AND TEST CHARTS

Each section includes diagnostic and test procedures, either diagnostic forms or fault trees. Each process will generally cover one symptom.

2. TROUBLESHOOTING

Before beginning any troubleshooting, there are several important steps to be taken:

2.1. VERIFY THE PROBLEM

Operate the complete system and list all symptoms in order to:

1. Check the accuracy and completeness of the complaint.

2. Learn more that might give a clue to the nature and location of the problem.

3. Analyze what parts of the system are working.

2.2. READ "ELECTRICAL OPERATION"

Read the electrical operation for the problem circuit (while referring to the circuit diagram). By studying the circuit diagram and the electrical operation, enough information about circuit operation should be learned to narrow the cause of the problem to one component or portion of the circuit.

2.3. CHECK THE CIRCUIT DIAGRAM

Refer to the circuit diagram for possible clues to the problem. Location and identification of circuit components may give some idea of where the problem is located.

The circuit diagrams are designed to make it easy to identify common points in circuits. This can help narrow the problem to a specific area. For example, if several circuits fail at the same time, check for a common power source or common ground connection. Refer to POWER DISTRIBUTION AND GROUNDS in the ELECTRICAL SYSTEM TROUBLESHOOTING GUIDE. If part of a circuit fails, check the connections between the part that works and the part that doesn't work.

For example, if the low-beam headlights work, but both high-beam lights and the high-beam indicator do not work, then the power and ground paths must be good.

Since the dimmer switch is the component that switches the power to the high-beam headlights, it is the most likely cause of failure.

2.4. CHECK FOR CAUSE OF THE PROBLEM

Diagnostic charts are provided for many of the common faults that may occur. Refer to these charts in each section. Follow the procedures in the chart until the cause of the problem is located.

If the particular symptom found in the problem circuit is not covered by a diagnostic chart, refer to the general electrical troubleshooting information provided under ELECTRICAL TEST EQUIPMENT , below.

2.5. MAKE THE REPAIR

Repair the problem circuit as directed in the diagnostic charts.

2.6. VERIFY THE REPAIR IS COMPLETE

Operate the system and check that the repair has removed all symptoms, and also that the repair has not caused any new symptoms.

3. ELECTRICAL TEST EQUIPMENT

3.1. FLUKE 88 DIGITAL MULTIMETER (DMM)

The Fluke 88 Digital Multimeter (DMM) is the International recommended meter and discussions of meter use in this manual will refer to that meter.

The Fluke 88 Multimeter (Figure 8) is a digital meter, and is recommended because it uses very little current when performing tests. Digital meters have high impedance (resistance): 10 megohms. Thus they do not damage components or give misleading readings.

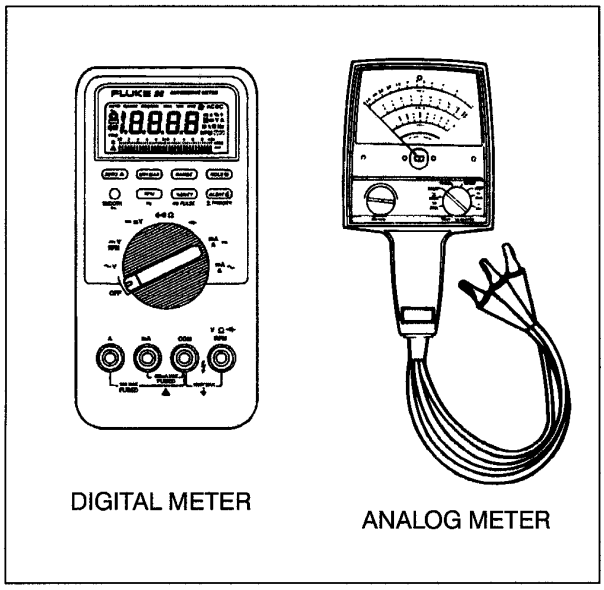

Figure 8 Digital and Analog Meters

CAUTION – Some of the devices in an electronic control system are not capable of carrying any appreciable amount of current. Therefore the test equipment used to troubleshoot an electronic system must be especially designed not to damage any part of it. Because most analog meters (Figure 8) use too much current to test an electronic control system, it is recommended that they not be used, unless specified. The use of any kind of battery-powered test light is not recommended when troubleshooting an electronic circuit, since it, too, could damage an electronic control circuit.

3.2. JUMPER WIRES AND TEST LEADS

Jumper Wires

Jumper wires allow "jumping" across a suspected open or break in a circuit.

1. If the circuit (Figure 9) works properly with the jumper wire in place, but does not work when the jumper wire is removed, the circuit has an open spot.

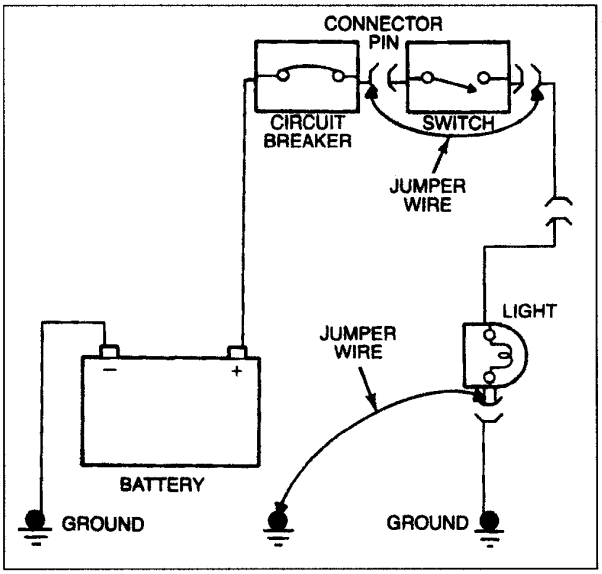

Figure 9 Circuit

2. A circuit without any opens or breaks has continuity (is continuous) and a DMM can be used to measure the continuity (resistance of a few ohms) of the circuit with the battery removed.

Jumper wires are fitted with several types of tips or ends. It will be helpful to have several jumper wires available with different tips.

If bypassing the switch with a jumper wire causes the light to illuminate, but closing the switch does not, it indicates the switch has failed.

If, when the switch is closed, the light does not illuminate, and "jumpering" the switch doesn't cause the light to operate, but "jumpering" the light to ground causes the light to operate, then there is an open in the ground circuit.

The jumper wire can be used to check for open relay contacts, wire breaks, poor ground connections, etc.

Test Leads

NEVER insert the test meter probe tip into connectors where the probe tip will expand the terminal. Expanded terminals will cause increased circuit resistance.

Construct test leads using a mating terminal, a short lead and an alligator clip. Insert the mating terminal into the connector and attach the alligator clip to the meter lead.

3.3. OHMS LAW REVIEW

Ohms Law describes the relationship of voltage, current and resistance, and provides us with a formula to make calculations as is shown in Figure 10 .

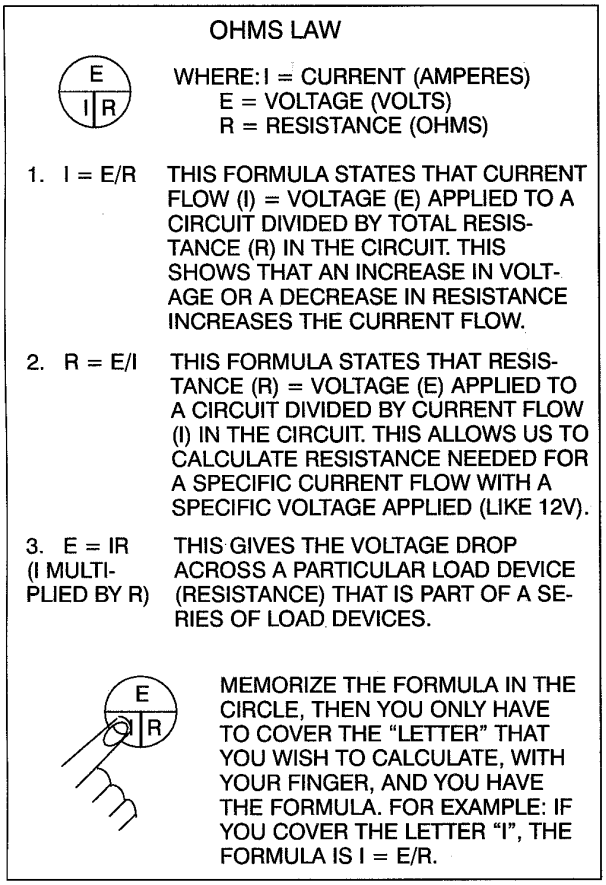

Figure 10 Ohms Law Formula

If any two of the values are known for a given circuit, the missing one can be found by substituting the values in amperes, volts, or ohms and solving for the missing value.

In a typical circuit, battery voltage is applied to a bulb through a 10-amp fuse and a switch (Figure 11). Closing the switch turns on the bulb.

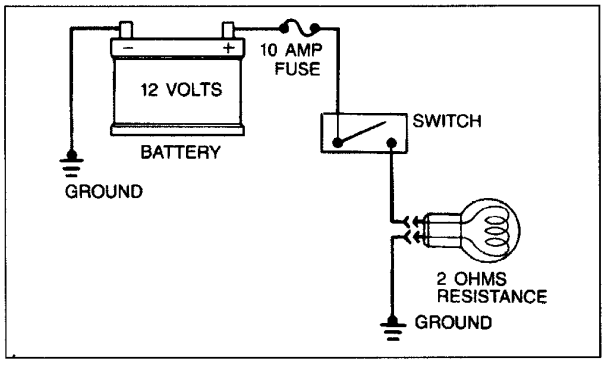

Figure 11 Typical Circuit

To find the current flow use the formula:

I = E / R

Filling in the numbers for the circuit in Figure 11 , we have:

I = 12V/2 ohms or I= 12 divided by 2 = 6 amperes of current flow.

The bulb in this circuit operates at 6 amps and is rated to operate at this level. With 12 volts applied, the bulb will glow at the rated output level (candlepower rating). However:

1. If the voltage applied is low (low battery), then (the value of E is lower) current flow will be less and the bulb will glow less brightly.

2. Or if the connections are loose, or the switch corroded, the circuit resistance will be greater (value of R will be larger) and the current flow will be reduced and the bulb will glow less brightly.

Being able to determine voltage drops is important because it provides the following information:

- Too high a voltage drop indicates excessive resistance. If, for instance, a blower motor runs too slowly or a light glows too dimly, one can be sure that there is excessive resistance in the circuit. By taking voltage drop readings in various parts of the circuit, the problem can be isolated (corroded or loose terminals for example).
- Too low of a voltage drop, likewise, indicates low resistance. If for instance, a blower motor ran too fast, the problem could be isolated to a low resistance in a resistor pack by taking voltage drop readings.
- Maximum allowable voltage drop under load is critical, especially if there is more than one high resistance problem in a circuit. It is important because all voltage drops in a circuit are cumulative. Corroded terminals, loose connections, damaged wires or other similar conditions create undesirable voltage drops that decrease the voltage available across the key circuit components.

Remember our earlier discussion, the increased resistance from the un- desirable conditions will also decrease the current flow in the circuit and all the affected components will operate at less than peak efficiency.

A small drop across wires (conductors), connectors, switches, etc. is normal. This is because all conductors have some resistance, but the total should be less than 10 percent of the total voltage drop in the circuit.

3.4. VOLTMETER

Voltage is an electrical pressure or force that pushes the current through a circuit. The pressure is measured in Volts and the symbol V (as in 12V) is used in the circuit diagrams. The letter "E" is also used for voltage and stands for Electromotive Force. Voltage can be compared to the pressure necessary to push water through a metering valve.

Low voltage to a lamp will cause the lamp to glow dimly. This can be caused by low source voltage (battery discharged or low alternator output), or by high circuit resistance in the circuit due to a poor connection. The resistance of the poor connection or poor ground acts as an additional load in the circuit, causing less voltage to be available to push current through the load device. Before making any meter measurements, it is important to briefly review the relationship between voltage, current, and resistance (Ohms Law, Figure 10).

Measuring Voltage

In electrical diagnosis, the voltmeter is used to answer:

1. Is voltage present?

2. What is the voltage reading?

3. What is the voltage drop across a load device?

When using a voltmeter to determine if voltage is present to power a device, connect the positive meter lead to input connection of the device (positive side) and connect the negative meter lead to good vehicle ground (Figure 12). A good ground would be any metallic bracket, body panel, or fastener that is free of paint, rust or corrosion, and is connected to the frame, engine, or body. Figure 12 shows how much of the source voltage is available to the device. Note that the meter is connected in parallel to the device.

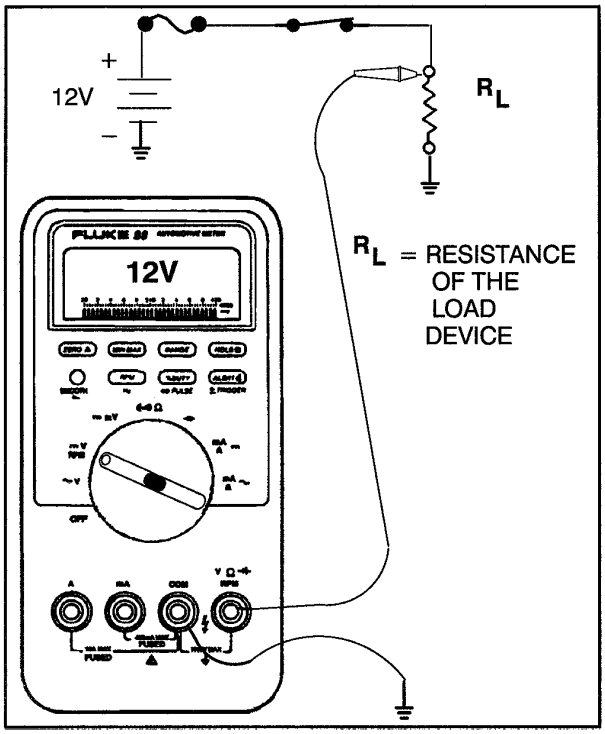

Figure 12 Voltmeter Lead Connections

Should we need to determine if voltage is available at a connector where we can't readily connect to the device, we can connect the meter in series between ground and the connector (voltage source) as shown in Figure 13 . The meter's internal resistance is very high so little current will flow in the circuit, and the voltage can be read accurately.

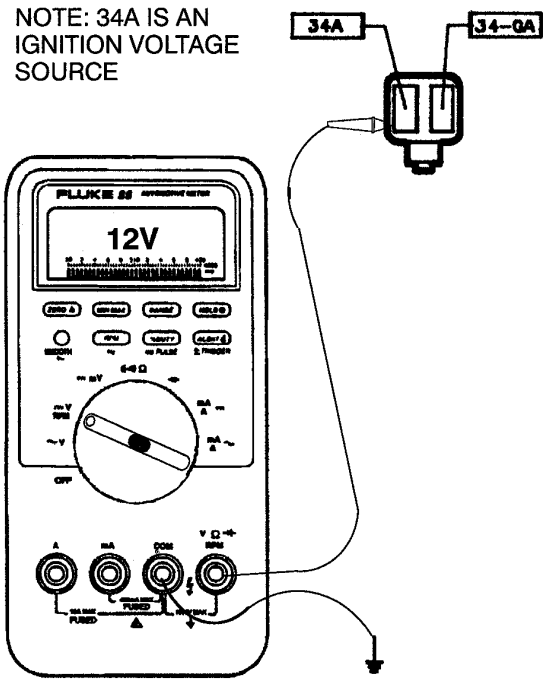

Figure 13 Connecting the Meter in Series

To check the voltage drop across a load device (Figure 14), connect the positive lead of the voltmeter to the positive side of the device and the negative meter lead to the negative side of the device. With the device operating, measure the voltage drop across the device. Notice in (Figure 14 , since we only have one device, all of the voltage should be dropped at the device. In any circuit, the voltage applied will equal the voltage dropped in the circuit. If in this circuit we only dropped 9V across the load, that would indicate that our wires, connections, etc. were dropping the other 3V, which would indicate excessive circuit resistance.

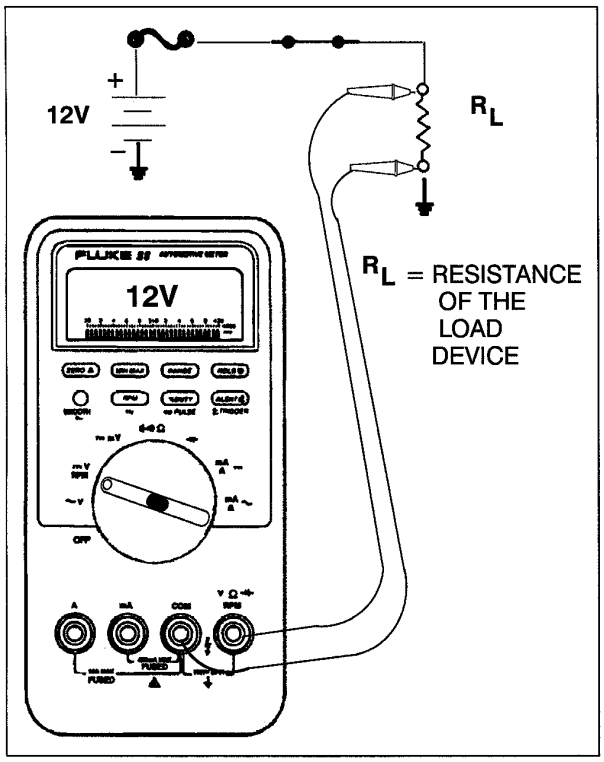

Figure 14 Checking Voltage Drop Across a Load Device

3.5. AMMETER

An ammeter is used to measure current flow (amperage) in a circuit. Amperes are units of electron flow, which indicate how many electrons are passing through the circuit. Ohms Law indicates that current flow in a circuit is equal to the circuit voltage divided by total circuit resistance. Since amps (I) is the current in the circuit, increasing voltage also increases the current level (amps). Also, any decrease in resistance (ohms) will increase current flow (amps).

At normal operating voltage, most circuits have a characteristic amount of current flow, referred to as current draw. Current draw can be measured with an ammeter. Referring to a specified current draw rating for a component (electrical device), measuring the current flow in the circuit, and comparing the two (the rated versus the actual measured) can provide valuable diagnostic information.

Measuring Amperage

An ammeter is connected in series with the load, switches, resistors, etc. (Figure 15). This causes all of the current to flow through the meter. The meter will measure current flow only when the circuit is powered and operating. Before measuring current flow, we need to know approximately how much current will be present to properly connect the meter. The DMM is fused to measure up 10 amps using the 10A connection point.

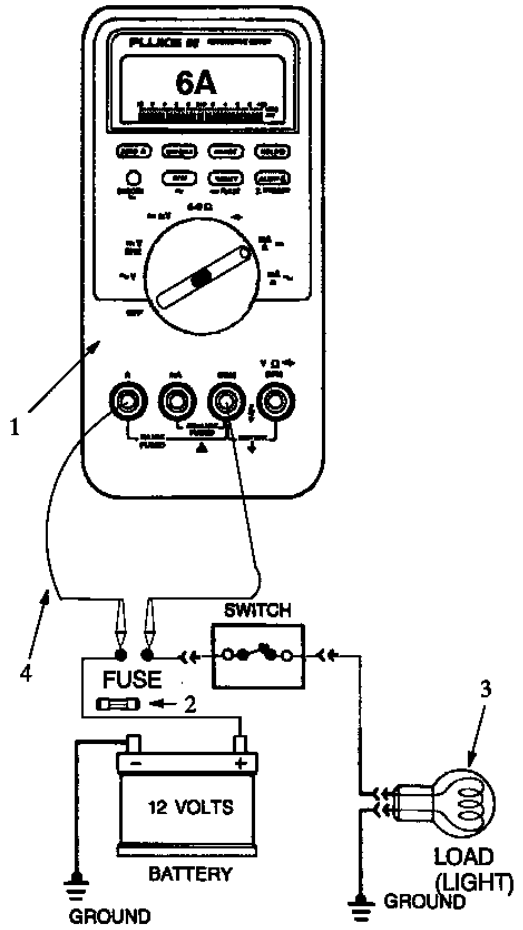

Figure 15 Measuring Current Flow

1. DMM SET TO MEASURE DC CURRENT
2. FUSE SHOWN REMOVED
3. LIGHT BULB (2 OHMS RESISTANCE)
4. METER LEAD CONNECTED TO 10A METER JACK

The estimate of current flow can easily be calculated. In Figure 15 , the resistance of the light bulb is 2 ohms. Applying Ohms Law, we can calculate that current flow will be 6 amps (6A = 12V/2 ohms). If we remove the fuse, and install the ammeter as shown, with the switch closed we will measure 6 amperes of current flowing in the circuit. Notice that the ammeter is installed so that all the current in the circuit flows through it. The ammeter is installed in series.

WARNING – Never attempt a voltage measurement with the test probe lead in the current jack (10A or 300mA). Meter damage or personal injury may result!

Always make sure the power is off before cutting, soldering or removing a circuit component to insert the DMM for current measurements. Even small amounts of current can be dangerous.

Excessive current draw means that more current is flowing in a circuit than the fuse and circuit were designed for. Excessive current will open fuses and circuit breakers. Excessive current draw can also quickly discharge batteries. An ammeter is useful to help diagnose these conditions.

On the other hand, there are times reduced current draw will cause a device (electric window motor for example) to operate poorly. Remember increased circuit resistance causes lower current to be available to the device. Loose or corroded connections can frequently cause this problem.

3.6. OHMMETER

The ohmmeter is used to measure resistance (ohms) in a circuit. Like the ammeter and voltmeter, there are both analog and digital meters available. It is recommended that the digital meter (Fluke 88 DMM) be used.

CAUTION – Some of the devices in an electronic control system are not capable of carrying any appreciable amount of current. Therefore the test equipment used to troubleshoot an electronic system must be especially designed not to damage any part of it. Because most analog meters (Figure 8) use too much current to test an electronic control system, it is recommended that they not be used, unless specified. The use of any kind of battery-powered test light is not recommended when troubleshooting an electronic circuit, since it, too, could damage an electronic control circuit.

CAUTION – The ohmmeter can only be used on circuits where power has been removed. The meter contains its own low voltage power supply and the power from 12-volt systems may damage the meter.

Ohmmeters use a small battery to supply the voltage and current which flow through the circuit being tested. The voltage of the meter battery and the amount of current flow in the circuit are used with Ohms Law, and the meter calculates the circuit resistance which is displayed by the meter. With the Fluke 88 DMM, range selection and meter adjustment are not necessary.

Measuring Resistance

Resistance measurements determine:

1. Resistance of a load
2. Resistance of conductors
3. Value of resistors
4. Operation of variable resistors.

To measure the resistance of a component or a circuit, power must first be removed from the circuit.

The component or circuit that is to be measured must be isolated from all other components or circuits so that meter current (from probe to probe) only flows through the desired circuit or component or the reading will not be accurate.

Notice in Figure 16 that if we wanted to measure the resistance of the load, most of the current flow from the meter would flow through the indicator lamp because it has less resistance. To measure the load, one connector

to the load should be removed. It is not always apparent when a component must be isolated in such a manner, so it is usually a good practice to isolate the circuit or component by physically disconnecting one circuit.

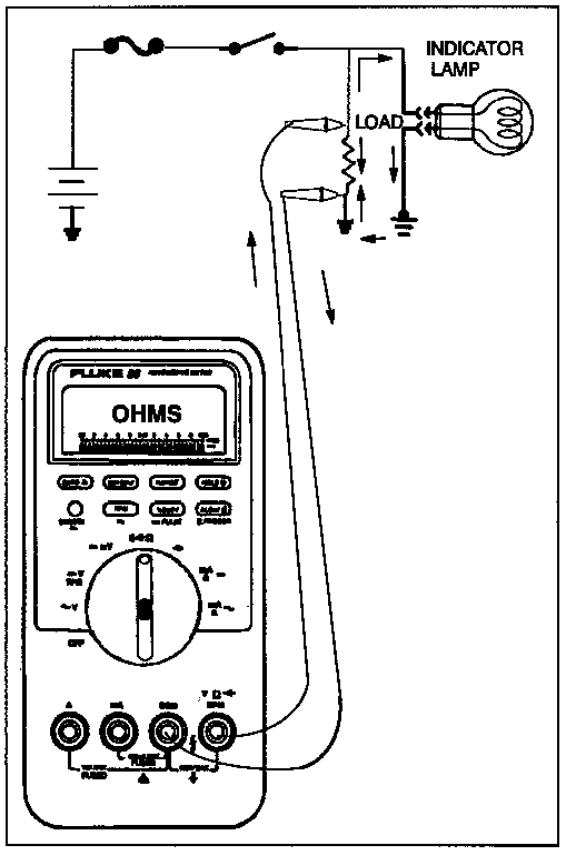

Figure 16 Measuring Resistance

The ohmmeter leads are then placed across the component or circuit and the resistance will be displayed in ohms (Figure 17). When checking a sensor or variable resistor such as fuel level gauge, heating the element or moving the arm should move the meter through a range of resistance that can be compared to a specification.

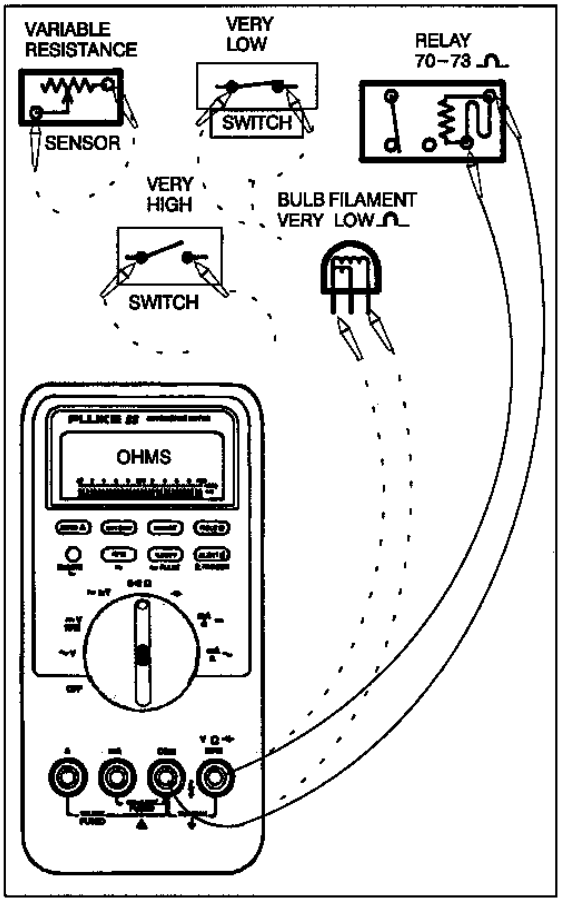

Figure 17 Placing Ohmmeter Leads Across a Component or Circuit

Checking For Open Circuits

Electrical circuits can be checked for opens using an ohmmeter. The circuit must first be disconnected from the power supply. The circuit to be checked must also be isolated from other circuits. Connect the meter to the open ends of the circuit as shown in Figure 18 . A high reading (infinity) indicates there is an open in the circuit. A near zero reading is an indication of a continuous circuit. Notice also in Figure 18 that we disconnected the circuit between the light and the ground. This precaution prevents reading a circuit as complete that may be open at the load (light) and shorted to ground ahead of the load device.

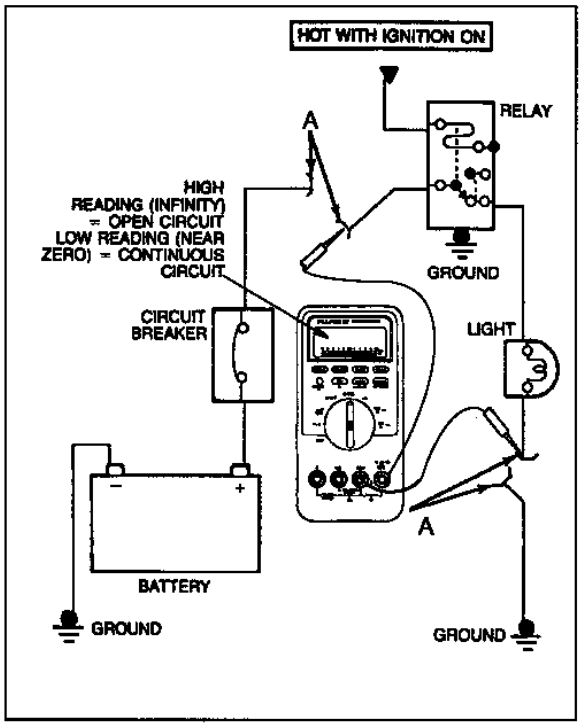

Figure 18 Checking For Open Circuits

A. DISCONNECTED CONNECTOR

Checking For Short Circuits

Checks for short circuits are made in a similar manner to that used to check for open circuits, except that the circuit to be checked must be isolated from both the power source and the ground point.

Connecting the ohmmeter as shown in Figure 19 between an isolated circuit and a good ground point will allow checking the circuit for a short to ground. A short to ground will be indicated by a near zero reading, while a circuit not shorted to ground will cause the meter to read very high (near infinity). With the Fluke 88 DMM, an open circuit will read "OL" on the meter display.

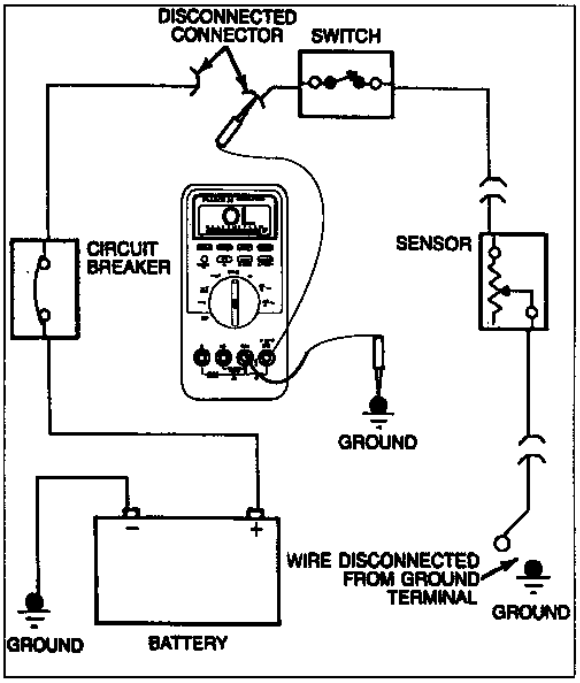

Figure 19 Checking For Short Circuits

4. CONNECTOR REPAIR

4.1. DEUTSCH CONNECTORS

HD Series Connectors Contact Removal

The Deutsch heavy-duty connectors used are designed to seal against moisture and contaminants. They also protect against damage from shock and vibration. The Deutsch part numbering system provides a complete description of the connector. A complete explanation is provided in Figure 20 , Figure 21 , and Figure 22 .

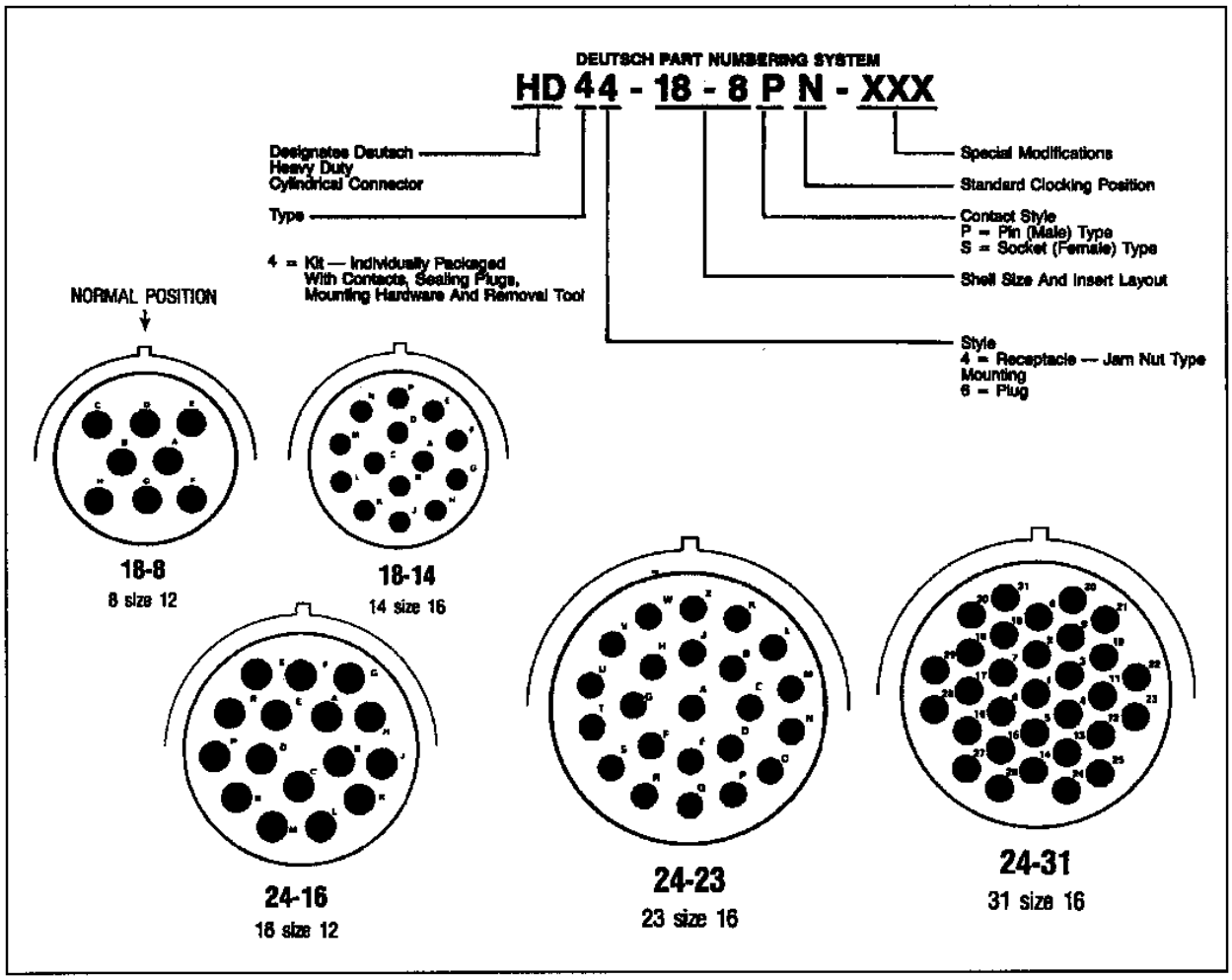

Figure 20 Deutsch Connectors

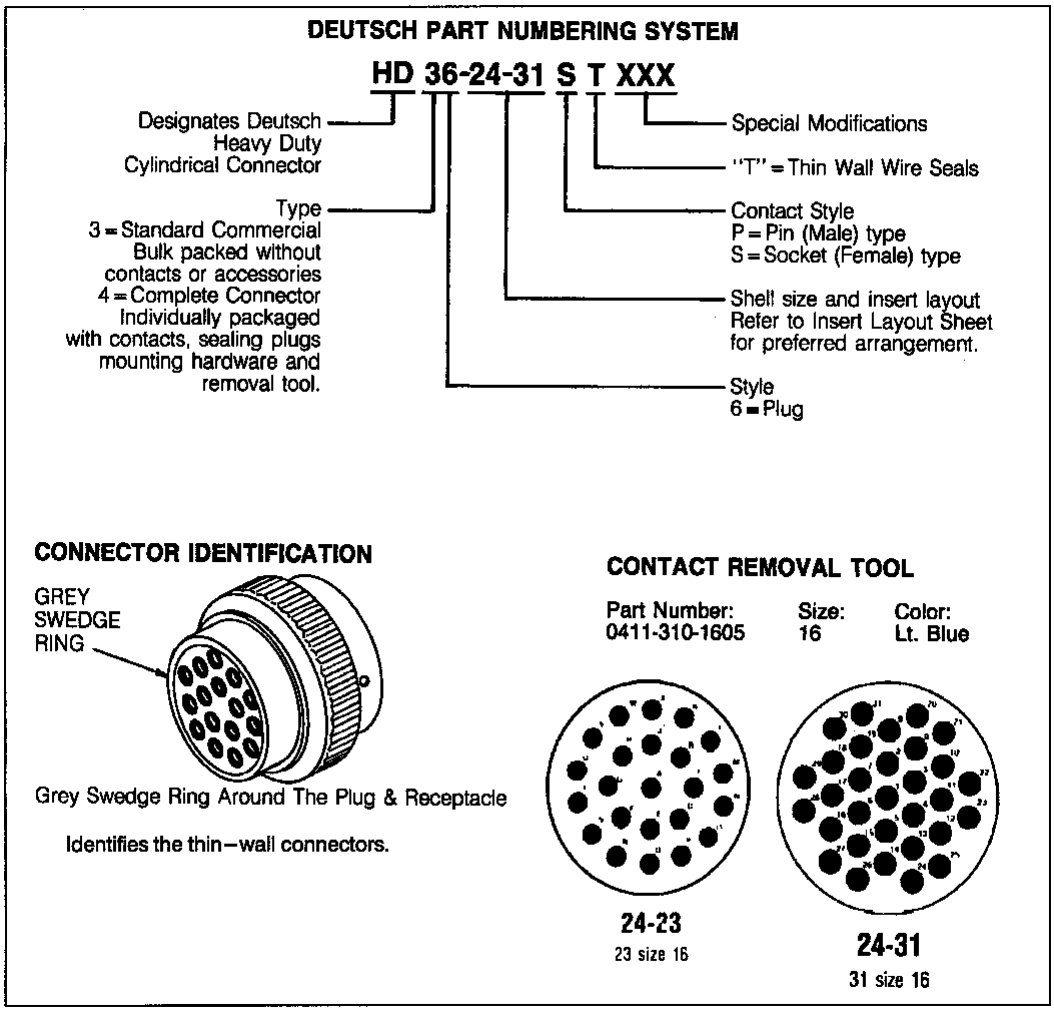

Figure 21 Deutsch Part Numbering System

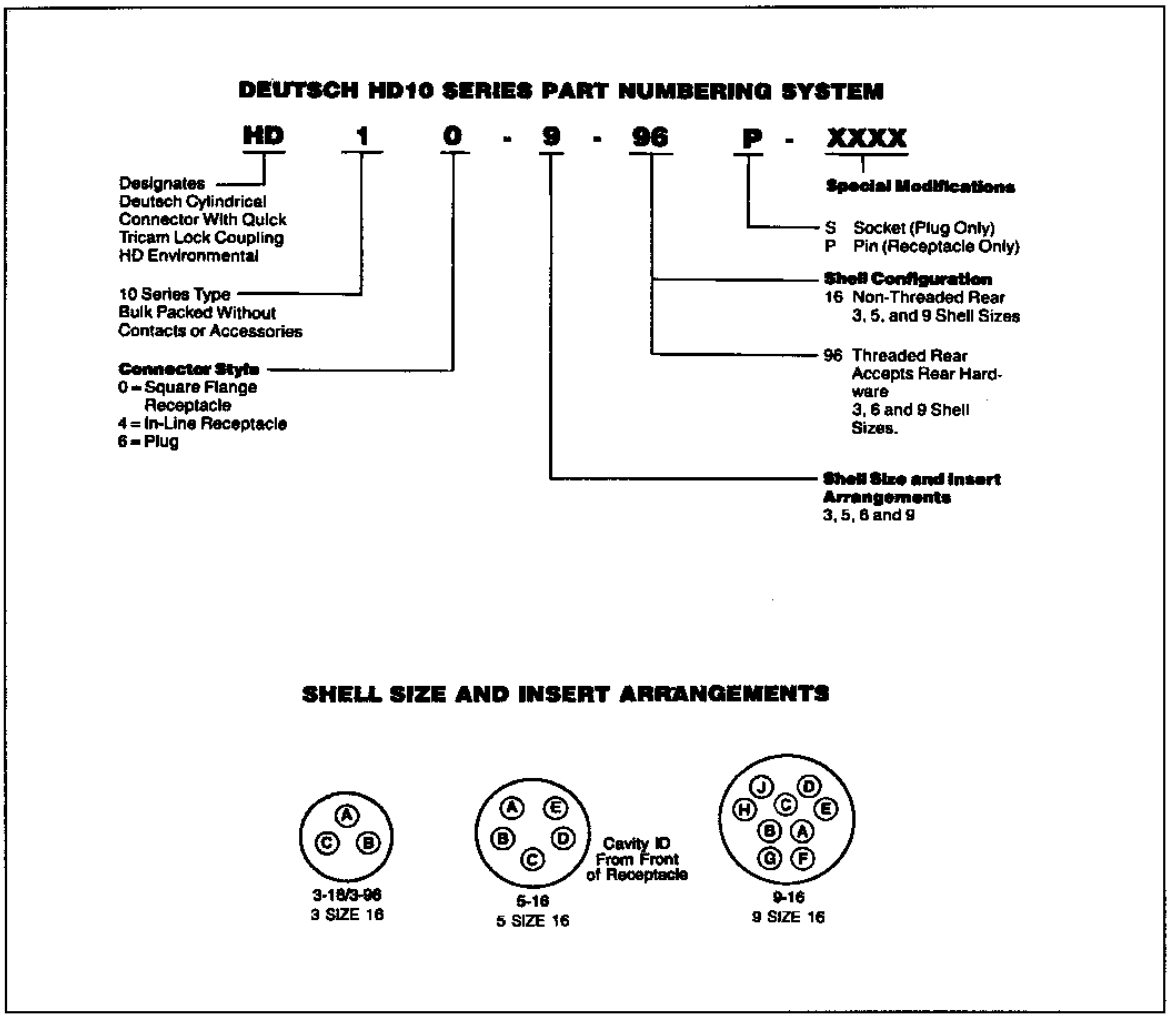

Figure 22 Deutsch HD10 Part Numbering System

1. To remove the damaged contact, snap an appropriate size plastic contact repair tool over the wire of the contact to be removed (Figure 23). If the wire to the contact is broken off, insert the tool into the applicable cavity over the contact. Use a Deutsch tool or equivalent.

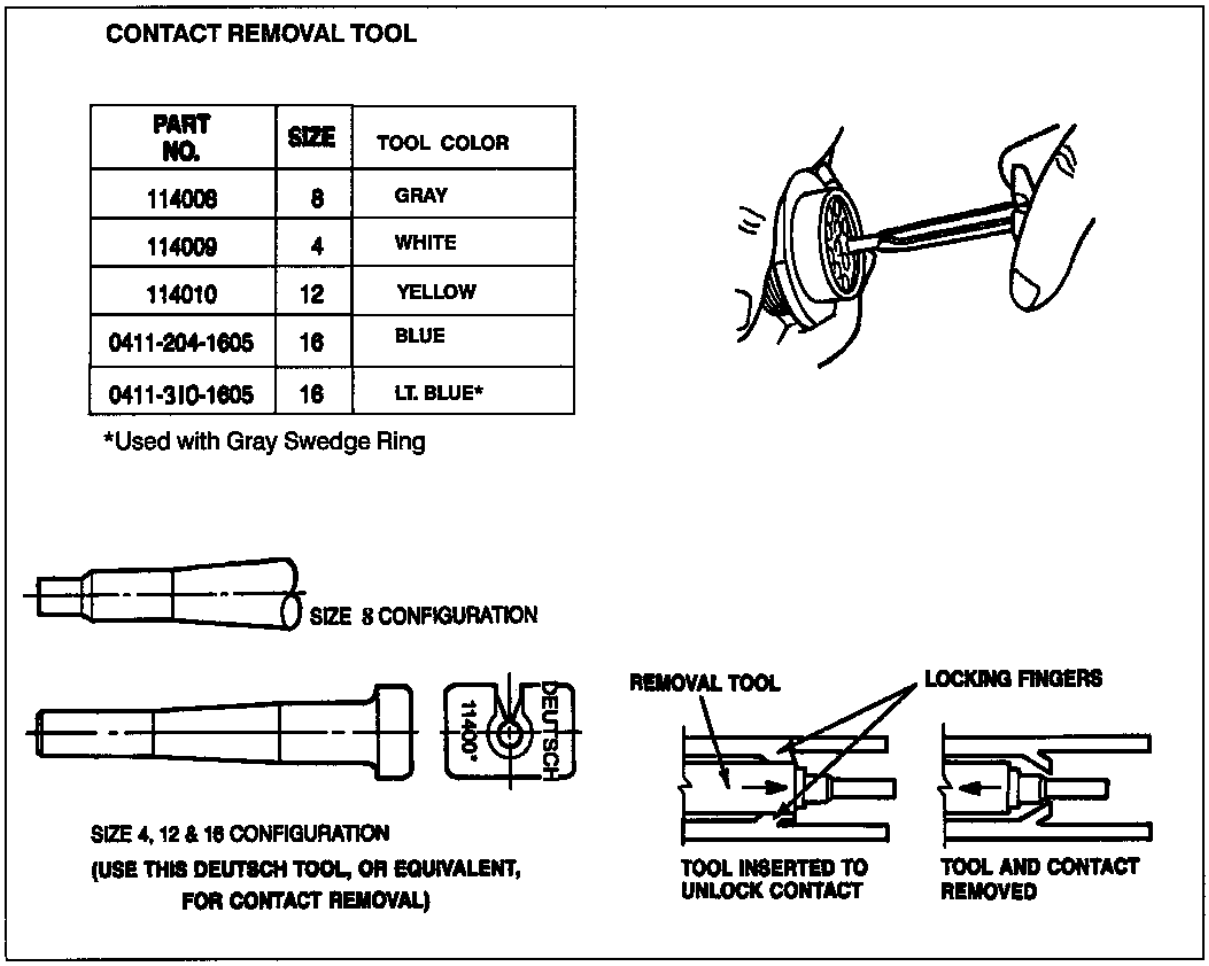

Figure 23 Contact Removal and Removal Tools

2. Slide the tool into the cavity over the contact until resistance is felt (locking fingers released) as shown in Figure 24 .

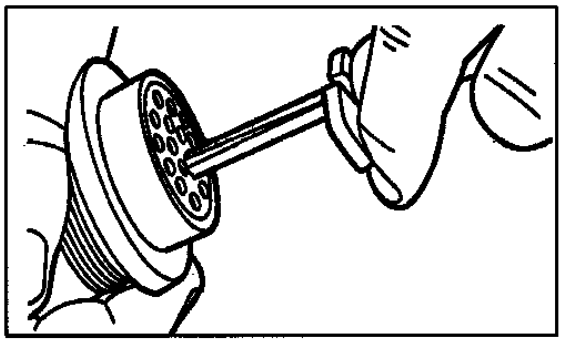

Figure 24 Slide Tool into Cavity Over Contact

3. Pull the contact/wire/tool assembly out of the connector (Figure 25).

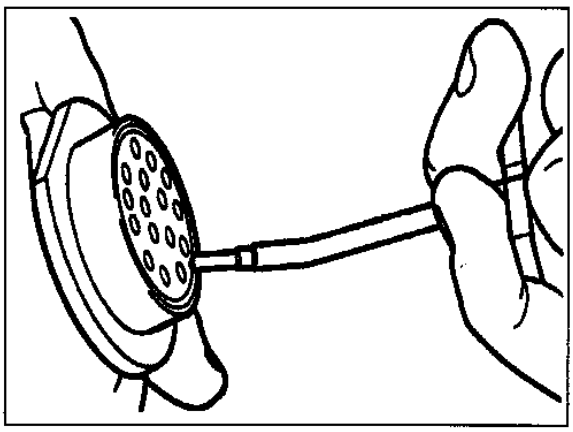

Figure 25 Pull Contact/Wire/Tool Assembly Out of Connector

HD Series Connector Contact And Wire Assembly

Contact and wire assembly is performed as follows:

1. Strip 0.253 ± 0.031 inch [approximately 1/4 inch (6.3 mm)] of insulation from end of wire using suitable stripping tool.

2. Position contact into Deutsch HDT-4800 hand crimping tool (or equivalent) so that the crimp barrel is 1/32 inch (0.8 mm) above the tool indenters (Figure 26). Hold contact in place by hand or by lightly squeezing the tool.

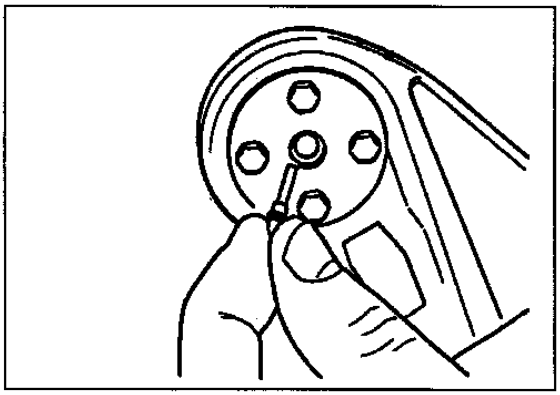

Figure 26 Position Contact into Hand Crimping Tool

3. Place the stripped end of the wire into the crimp barrel of the contact. Fully depress the tool handles. Release and remove wire/contact assembly (Figure 27).

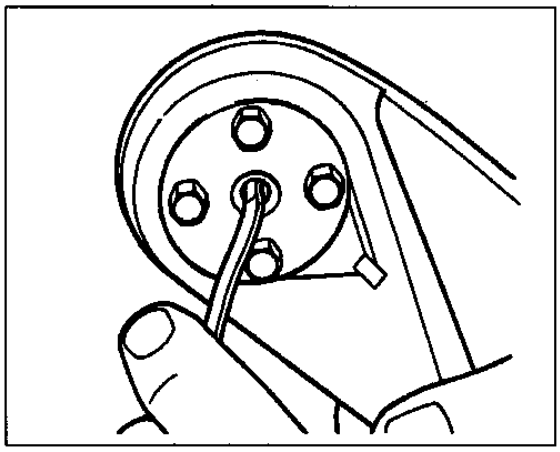

Figure 27 Release and Remove Wire/Contact Assembly

4. Inspect the wire/contact terminal to make sure that all wire strands are in the crimp barrel and that the crimp is secure (Figure 28).

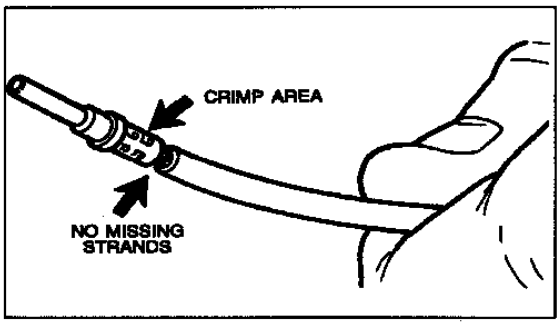

Figure 28 Inspect Wire/Contact Terminal

HD Series Connector Contact Insertion

1. Grasp the contact/wire assembly, between the thumb and forefinger, on the wire approximately one inch (25 mm) behind the contact crimp barrel (Figure 29).

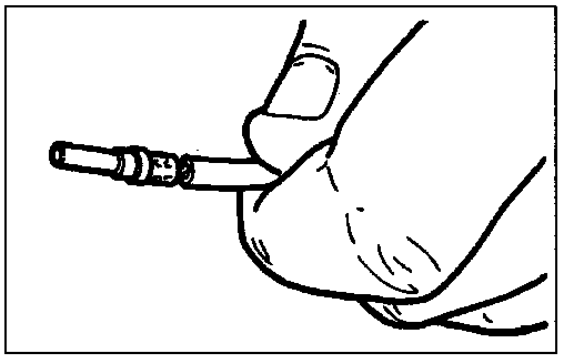

Figure 29 Grasp Contact/Wire Assembly Between Thumb and Forefinger

2. Hold the connector with the grommet facing the contact (Figure 30).

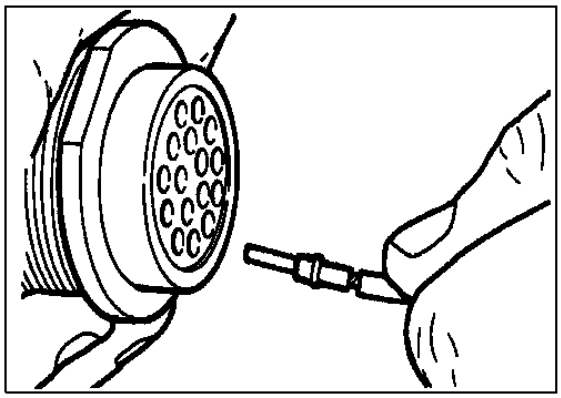

Figure 30 Hold Connector With Grommet Facing Contact

3. Push the contact straight into the appropriate cavity in the connector grommet until a positive stop is felt. The retaining fingers in the connector will snap behind the shoulder of the contact and lock it in place. A slight tug backward on the wire will verify that the contact is properly seated (Figure 31).

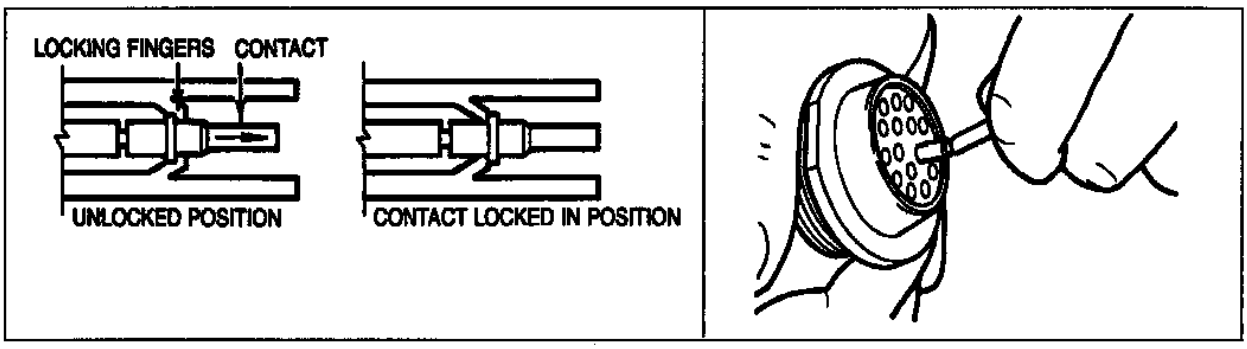

Figure 31 Push Contact Straight into Appropriate Cavity

DRC Connectors (With Cat. 3176 & PEEC III) Contact Removal

The Deutsch DRC connector used with International vehicles and Caterpillar electronically controlled engines is a heavy duty environmentally sealed connector.

The Deutsch part numbering system provides a complete description of the connector. The part number takes the form of DRC 14 - 40 P A - XXX. A complete explanation is included in Figure 32 .

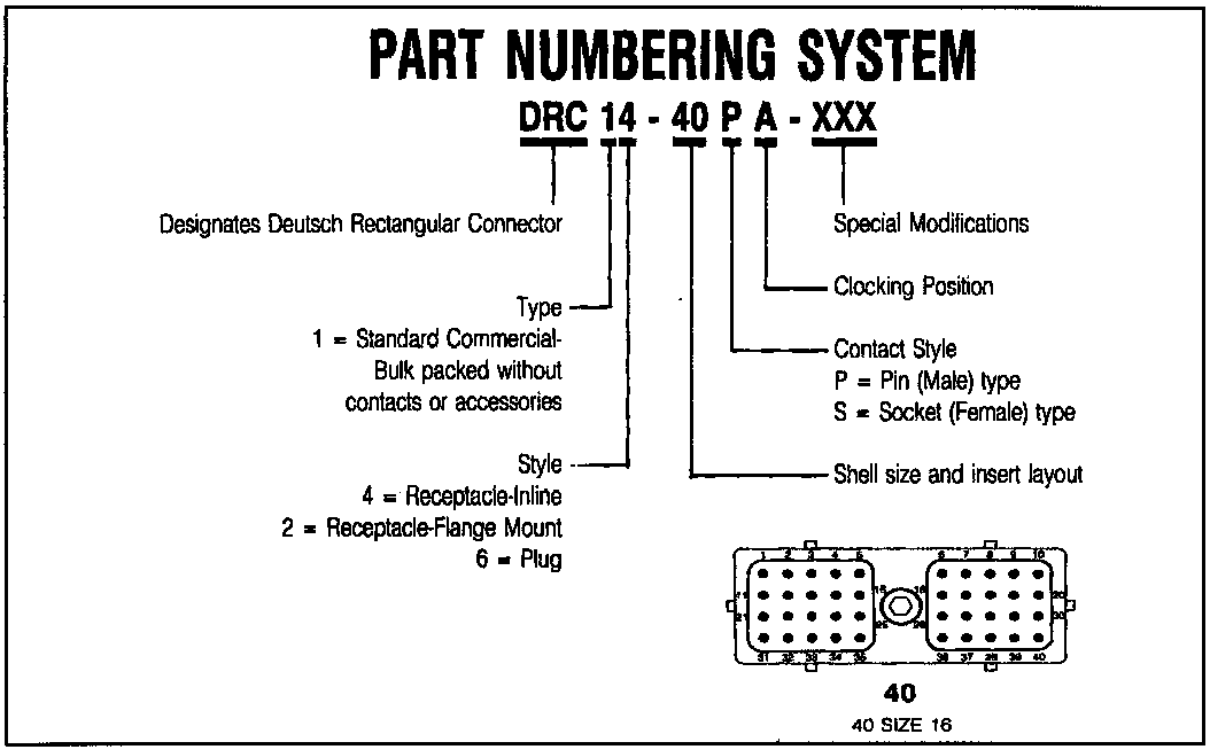

Figure 32 DRC Connector Part Numbering System

Since contacts are removed and installed from the rear of the connector (as opposed to the mating end), the illustrations are shown from the rear of the connector.

1. With the connector rear insert toward you, snap the appropriate size extractor tool (Deutsch Part No. 0411-204-1605) over the wire of terminal to be removed (Figure 33).

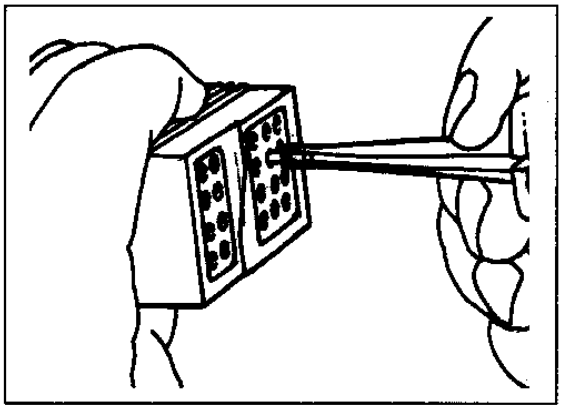

Figure 33 Snap Tool Over Wire of Terminal to be Removed

2. Slide extractor tool along wire straight into connector cavity until it contacts terminal and resistance is felt (Figure 34).

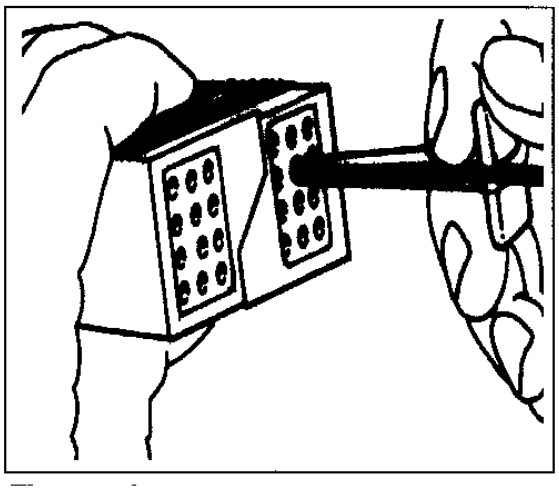

Figure 34 Slide Extractor Tool Along Wire Straight into Connector Cavity

NOTE – Do not twist or insert tool at an angle.

3. Pull terminal/wire assembly out of the connector (Figure 35).

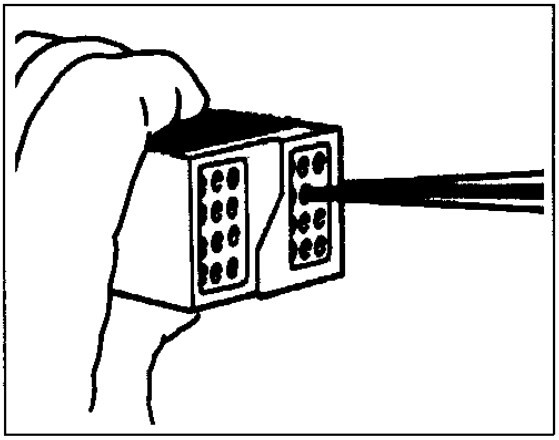

Figure 35 Pull Terminal/Wire Assembly Out of Connector

4. Inspect terminal.

   Terminal should be clean, free of corrosion or damage, and secured to wire. The terminal/wire assembly should withstand a 30 lbs. pull-test.

The wire in the terminal should be visible in the inspection hole (Figure 36). All of the wire strands should enter the terminal and not be damaged or missing. Replace terminal if it does not meet these conditions.

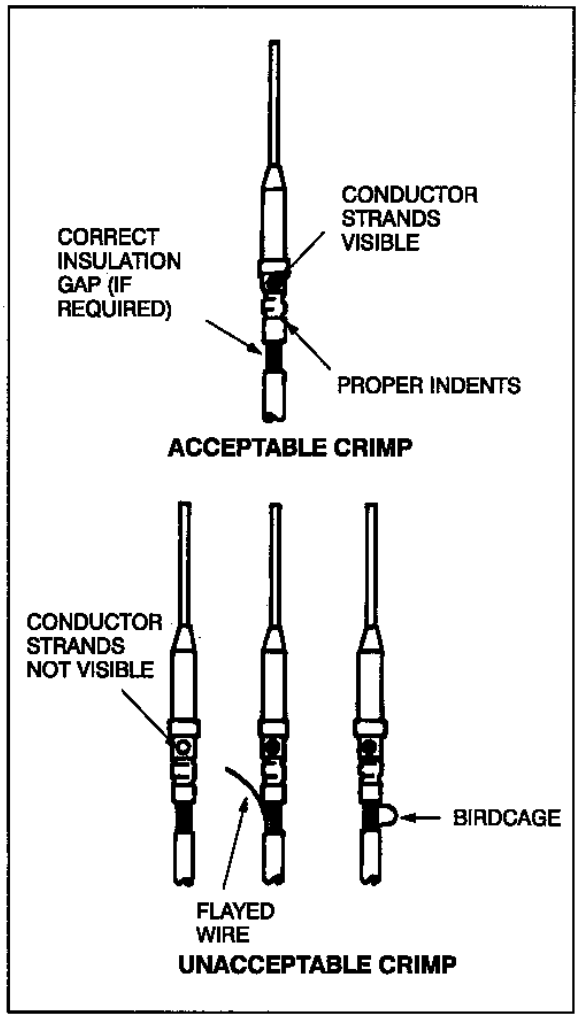

Figure 36 Wire in Terminal Should Be Visible in Inspection Hole

DRC Connectors (With Cat. 3176 & PEEC III) Terminal Installation

If a new terminal is to be installed, follow this procedure to install the terminal to the wire.

NOTE – This connector contains two different terminals. Those terminals attached to 14 gauge wires are International part number 1659751C1. Those terminals attached to 16 gauge wires are International part number 1651969C1. (International circuit diagrams indicate wire gauge.)

1. Strip 1/4 inch (6.3 mm) insulation from wire.

2. Raise Crimp Tool (Deutsch HDT-4800) selector knob and rotate until arrow is aligned with wire size to be crimped (Figure 37).

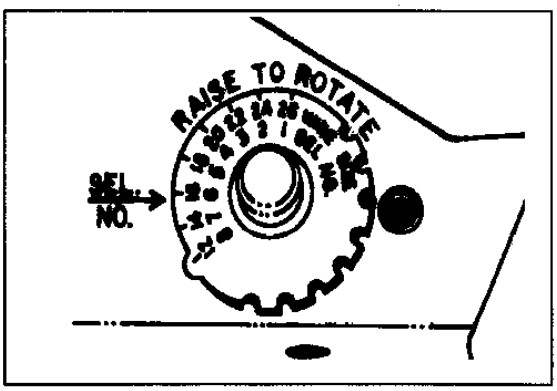

Figure 37 Rotate Selector Knob

3. Loosen lock nut and turn adjusting screw in until it stops.

4. Insert terminal (Figure 38) and turn adjusting screw counterclockwise out until terminal is flush with indenter cover. Tighten lock nut.

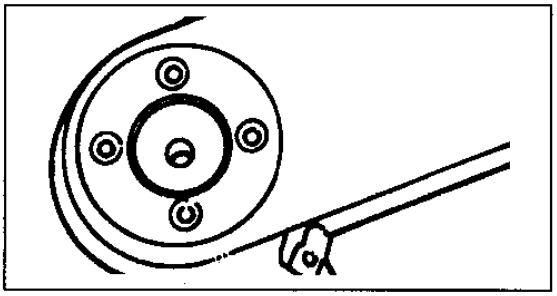

Figure 38 Insert Terminal

5. Insert wire into terminal; terminal must be centered between indicators. Close handles until handle contacts the stop (Figure 39). Release handles and remove crimped terminal.

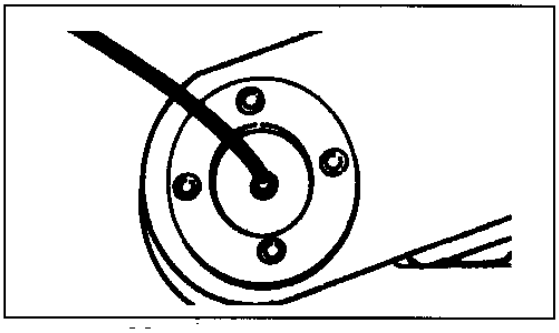

Figure 39 Insert Wire into Terminal

6. Inspect the terminal.

Terminal should be clean, free of corrosion or damage, and secured to wire. The terminal/wire assembly should withstand a 30 lbs. pull-test.

The wire in the terminal should be visible in the inspection hole (Figure 36). All of the wire strands should enter the terminal and not be damaged or missing. Replace terminal if it does not meet these conditions.

DRC Connectors (With Cat. 3176 & PEEC III) Terminal Insertion Into Connector

1. Grasp wire about 1 inch (25 mm) behind terminal barrel (Figure 40).

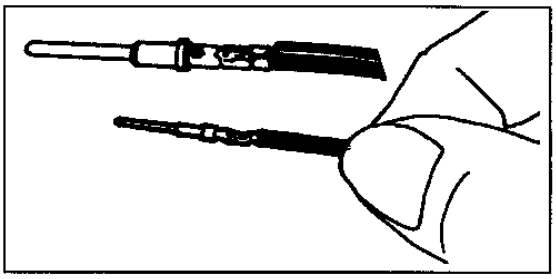

Figure 40 Grasp Wire About 1 Inch Behind Terminal Barrel

NOTE – Do not solder the terminal.

2. Hold connector with rear grommet facing you and push contact straight into connector grommet (Figure 41) until a positive stop is felt. A slight tug (10 lbs.) will confirm that it is properly locked in place.

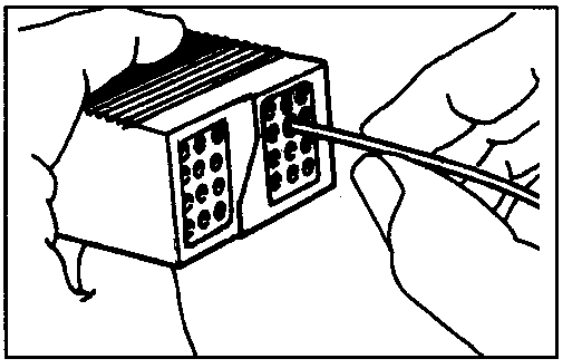

Figure 41 Push Contact Straight into Connector Grommet

4.2. PACKARD CONNECTORS

Weather Pack Series Connector Repair

Weather Pack connector terminals use the flex-pin and lap-lock terminal design. Weather Pack terminals have dual lock tangs which lock the terminal into the connector cavity and prevent backing out. In addition, Weather Pack terminals have serrated core crimp wings. The terminals also have cable seal crimp wings to reduce strain on the cable core and assure proper position of the cable seal on the cable. Refer to Additional Connectors, which shows various additional Packard connectors.

1. Disconnect the connector bodies (Figure 42). Unlatch and open the secondary lock on the connector.

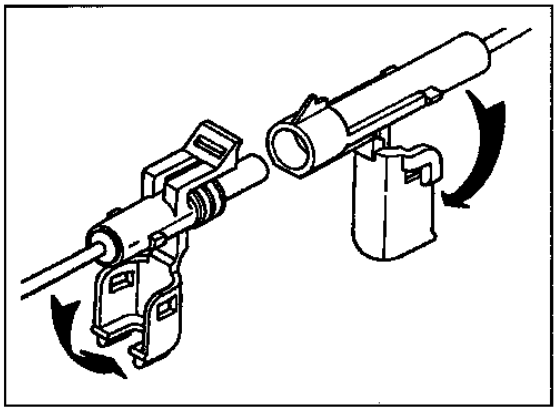

Figure 42 Disconnect Connector Bodies

2. Remove terminals using Weather Pack terminal removal tool (12014012) or equivalent (Figure 43).

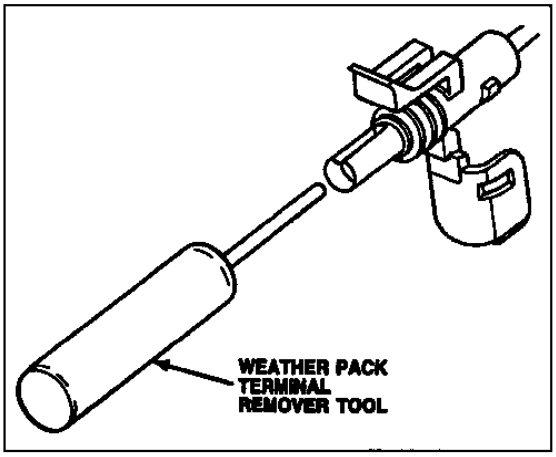

Figure 43 Remove Terminals

3. Cut wire immediately behind cable seal (Figure 44).

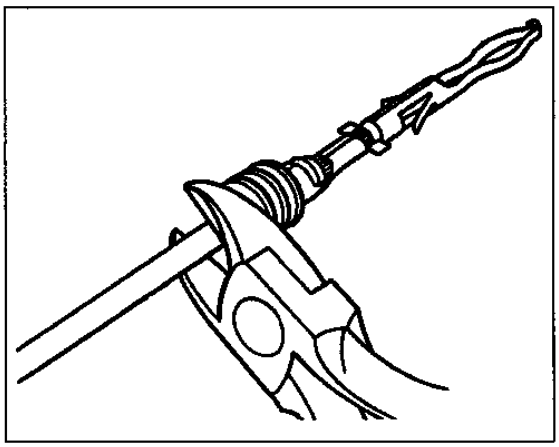

Figure 44 Cut Wire Immediately Behind Cable Seal

4. Slip new cable seal onto wire in direction shown. Strip .22 in. ± 0.02 in. (5.5 mm ± 0.5 mm) insulation from wire. Position cable seal as shown in Figure 45 .

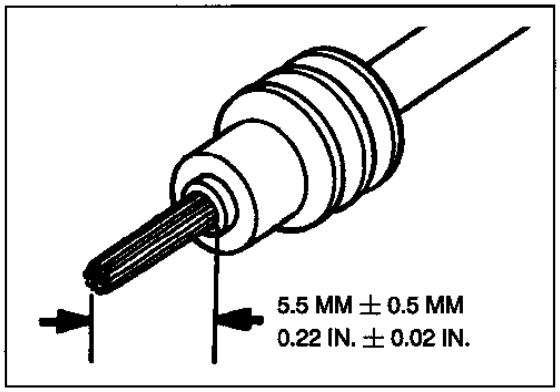

Figure 45 Strip Approximately .22 Inch Insulation From Wire

5. Using standard crimp tool (12085270) or equivalent (Figure 46), crimp a new terminal onto the wire. The core crimp may be soldered with rosin core solder.

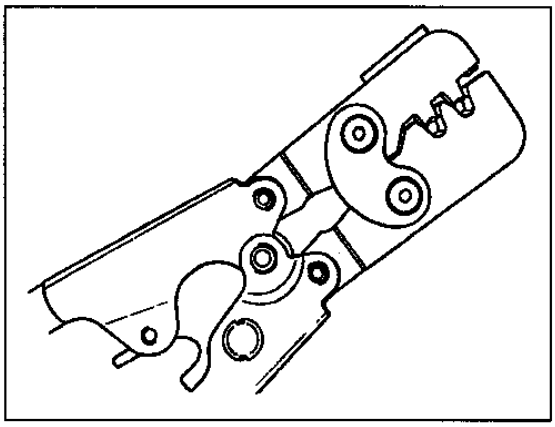

Figure 46 Standard Crimp Tool

Insulation crimp must grip cable seals as shown in Figure 47 .

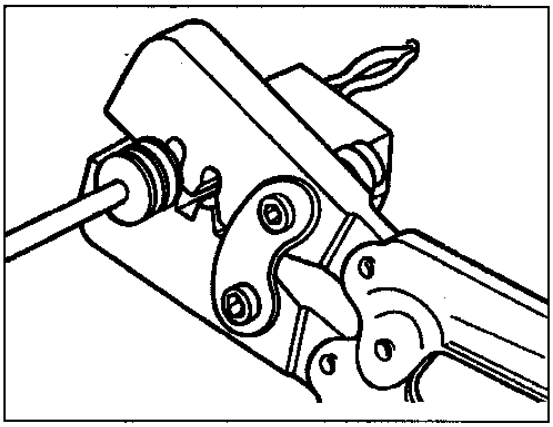

Figure 47 Grip Cable Seals

6. Insert new terminals into connector until they click (Figure 48) and lock into place. Be sure to maintain indexing by placing the proper wires into the same cavities as the original connector.

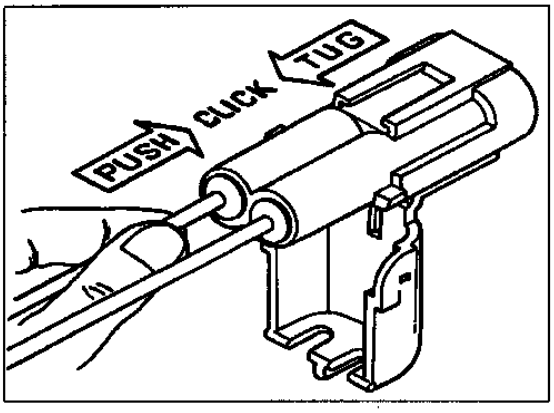

Figure 48 Insert New Terminals into Connector

7. Close and latch secondary lock on connector body, and mate the connector halves (Figure 49).

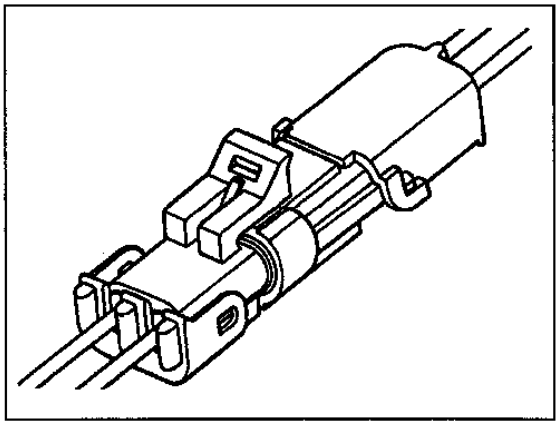

Figure 49 Mate Connector Halves

Series 56 Connector Terminal Removal

The Series 56 Packard connectors (Figure 50) provide positive locking of both connectors and terminals. The female terminal has a spring-loaded tang that maintains constant pressure against the male blade to provide positive contact.

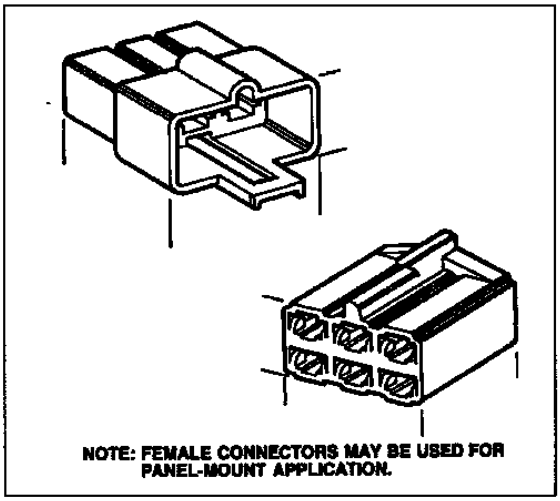

Figure 50 Series 56 Packard Connector

On female terminals, insert a fine blade screwdriver (Figure 51) between the terminal's locking tang. Then pull on the cable to remove the terminal. If wire is disconnected, use needle-nose pliers to pull terminal from the connector.

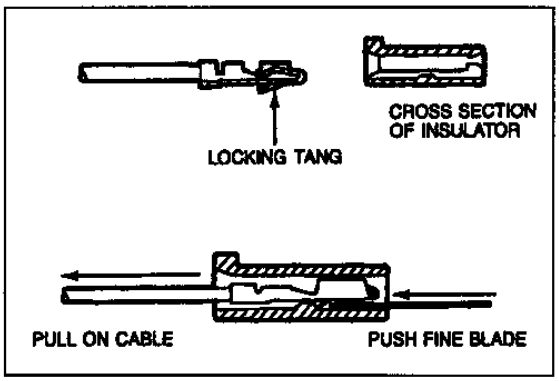

Figure 51 Insert Screwdriver Between Terminal's Locking Tang

On many terminals (Figure 52), insert a fine blade between the locking tang and the insulator to compress the tang. Then pull on the cable to remove the terminal. If wire is disconnected, use needle-nose pliers to pull terminal from the connector.

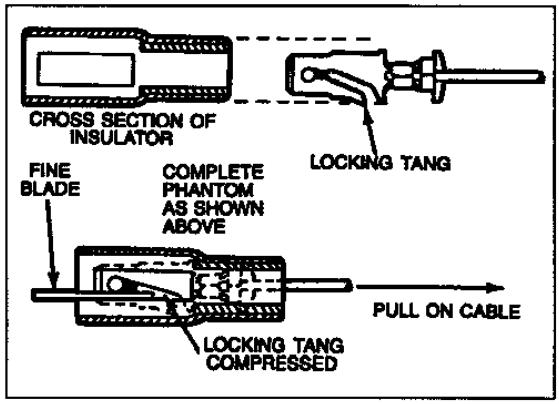

Figure 52 Insert Blade Between Locking Tang and Insulator

Series 56 Connector Terminal/Wire Assembly

For the following procedure to install terminals on the wire, refer to Figure 53 and Figure 54 .

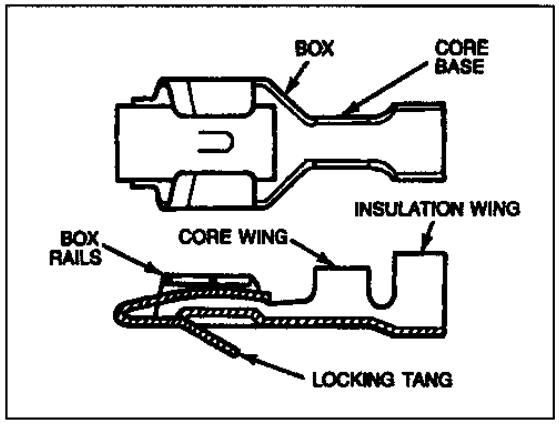

Figure 53 Terminal/Wire Assembly

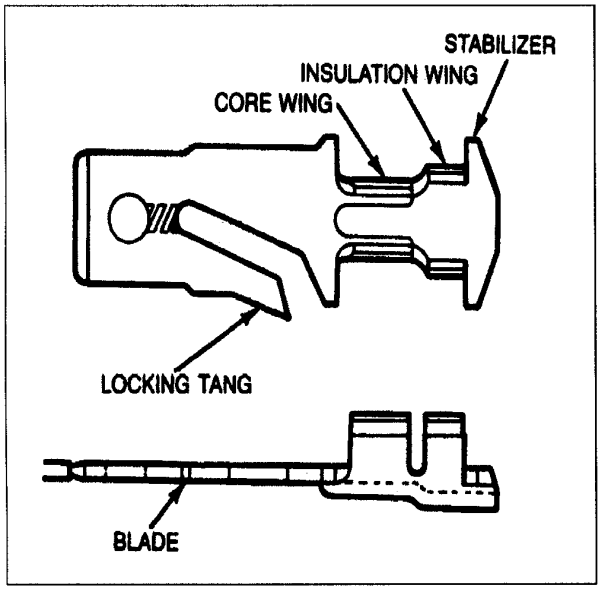

Figure 54 Terminal/Wire Assembly

1. Strip approximately 1/4 inch (6.3 mm) of insulation from the end of the wire.

2. Insert the wire into the box (on female terminal) or blade (on male terminal), and core base of the terminal.

3. Using Packard crimping tool (12085270) or equivalent, crimp the core wings so that the wire core is visible, extending slightly past the core wings.

4. Crimp the insulation wings so that the wings cover the insulation of wire. No core should be visible under the insulation wings.

5. On female terminals, make certain that the box rails are straight, that box and core base are straight, and that the tang protrudes to lock the terminal in place when installed in the insulator connector.

Series 56 Connector Terminal Installation

Both female and male terminals are installed into the connector body by pushing the terminal/wire assembly into the back of the connector. The locking tang will lock the terminal into place when the terminal has been fully inserted. On male terminals, make certain that the tang is not bent inward. If it is bent, use a fine-blade screwdriver to push the tang out into its proper position. Tug on the wire to make certain that the terminal is seated and locked into place.

Micro-Pack Connector Terminal Removal

To remove terminals from the Micro-Pack connector, refer to the following procedure. The terminals are inserted and removed from the back of the connector. Terminals are installed on the wires in the same manner described above.

1. Remove the loose-piece comb lock. Do not use terminal removal tool for this step; damage to the tool may result.

2. Grasp the lead and push the terminal forward to the most forward position (Figure 55).

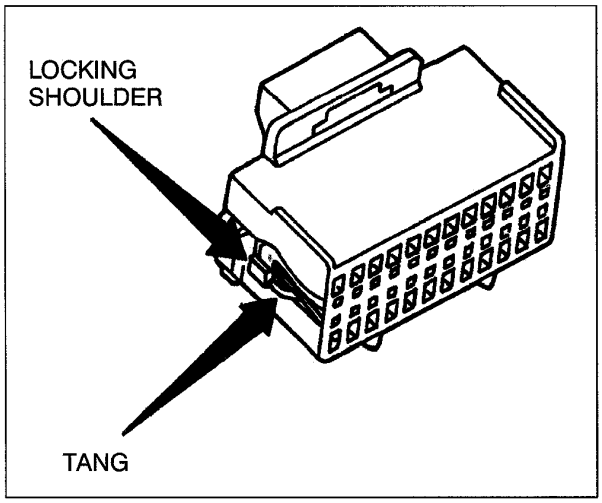

Figure 55 Push Terminal Forward to Most Forward Position

3. Locate the terminal lock tang in the connector cavity, then insert the Terminal Removal Tool straight into the front of the connector cavity as shown in Figure 56 . Do not angle or rock the tool because it could damage the connector wall.

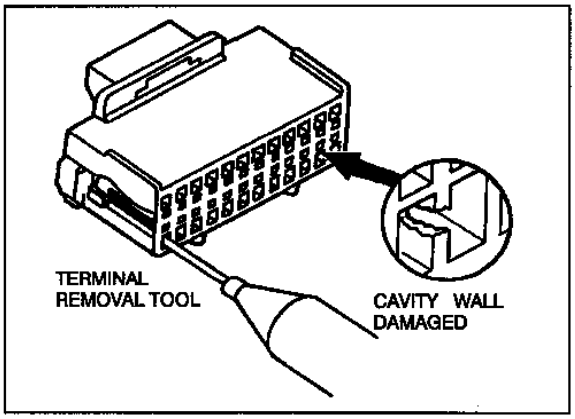

Figure 56 Insert Tool Straight into Front of Connector Cavity

4. While holding the tool securely in place, gently pull on the cable to remove terminal. Never use force to remove the tool.

5. Visually inspect the terminal and connector for damage, and replace if necessary (Figure 57). Replace the terminal if the radius of tang is flattened or terminal is otherwise damaged.

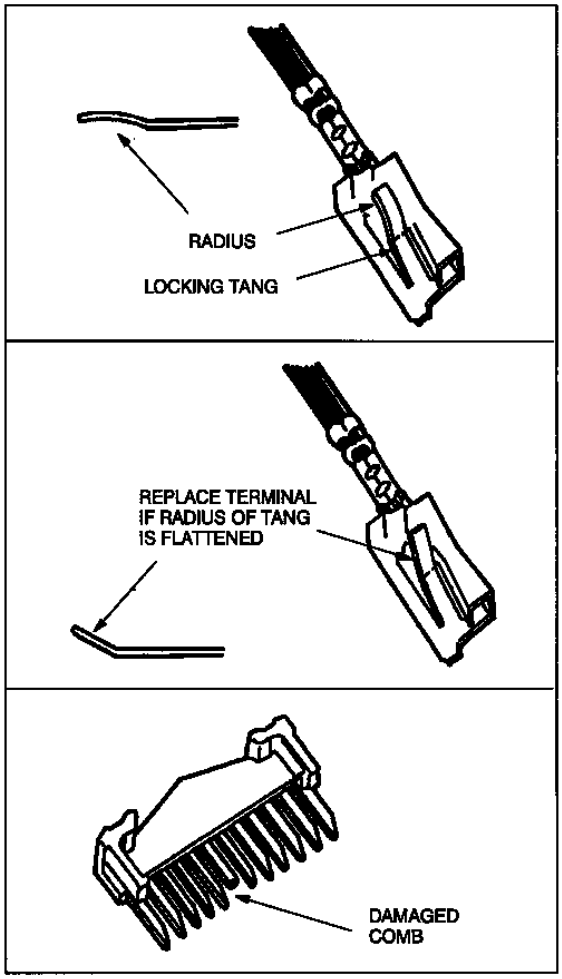

Figure 57 Inspect Terminal and Connector For Damage

After repair is complete, insert Comb/Terminal Position Assurances, or lock secondary lock after repair is made. Do not re-use a damaged comb (Figure 57).

Metri-Pack Terminal Removal (Pull-To-Seat) - Installing Terminals

Connectors discussed here use Weather Pack Seals inserted into the shell of the connector instead of being installed on each wire. To remove terminals from the Metri- Pack connector, refer to the following procedure.

Terminals are installed on the wires after wire has been pushed through the connector. Do not strip the wire until it has been pushed through to avoid fraying the wire strands.

1. From the back side of the connector, insert the wire (unstripped) through the seal and correct cavity of the connector, so that it protrudes from the mating end of the connector.

2. Strip insulation to leave 0.2 inch (5 mm) of bare wire end (do not cut wire strands).

3. Use 12085271 (or other appropriate crimper) to crimp terminal to wire. Inspect terminal for correct installation. Be sure there are no cut strands. Pull test to 10 - 15 lbs. to be sure the terminal is on securely.

4. To install, pull gently back into the connector until it locks into place.

Metri-Pack Terminal Removal (Pull-To-Seat) - Removing Terminals From Connector

1. If applicable, remove Comb/Terminal Position Assurance (TPA) using appropriate tool. Do not use the terminal removal tool for this step as damage will result.

   Choose the correct size pick to use by the size of the entry canal.

2. Using the pick, locate terminal lock tang in the connector.

3. Insert pick straight into entry canal at front of connector (Figure 58).

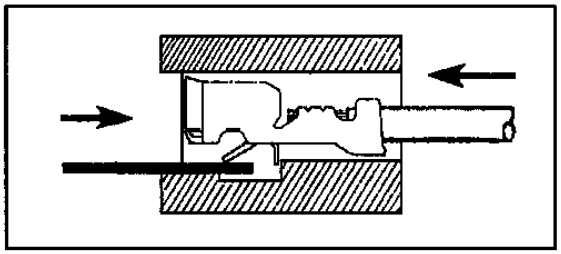

Figure 58 Insert Pick Straight into Entry Canal

4. Depress lock tang to unseat terminal. Never use force to pull terminal out of connector.

5. Gently push on cable to remove terminal through the front of the connector.

6. Inspect the terminal and wire for damage and replace if necessary. If applicable, insert Comb/Terminal Position Assurance (TPA) after repair has been made.

Additional Connectors

Several different types of electrical connectors are used on International vehicles. Refer to Figure 59 , Figure 60 and Figure 61 for additional connector illustrations.

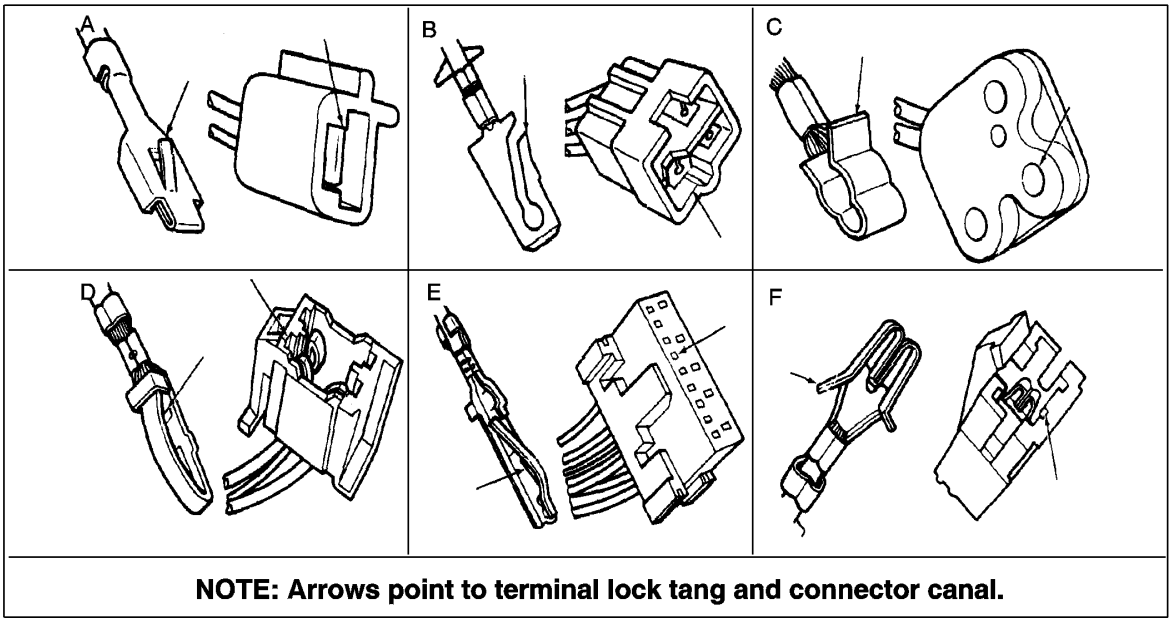

Figure 59 Additional Connectors

A. 56/59 SERIES (FEMALE)
B. 56 SERIES (MALE)
C. PIN GRIP (FEMALE)
D. PRINTED CIRCUIT (BOW)
E. PRINTED CIRCUIT (EDGE BOARD)
F. PACK CON I AND II (FEMALE)

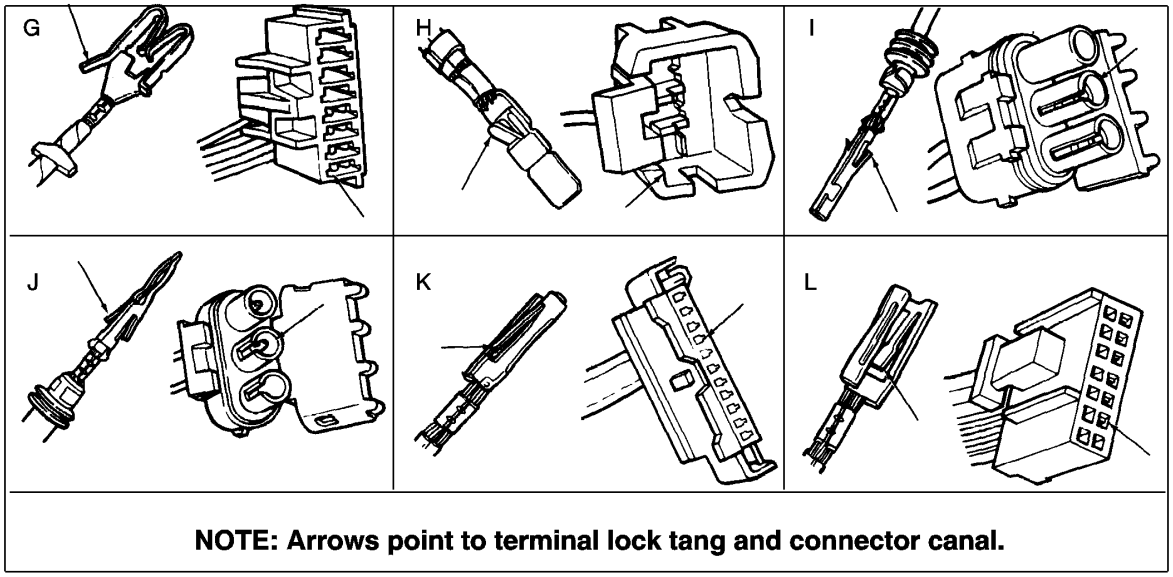

Figure 60 Additional Connectors

G. PACK CON (FEMALE) HEAVY DUTY/III SERIES
H. PACK CON I/HEAVY DUTY
I. WEATHER PACK (FEMALE) SLEEVE
J. WEATHER PACK (MALE) PIN
K. MICRO-PACK (FEMALE)
L. MICRO-PACK (FEMALE)

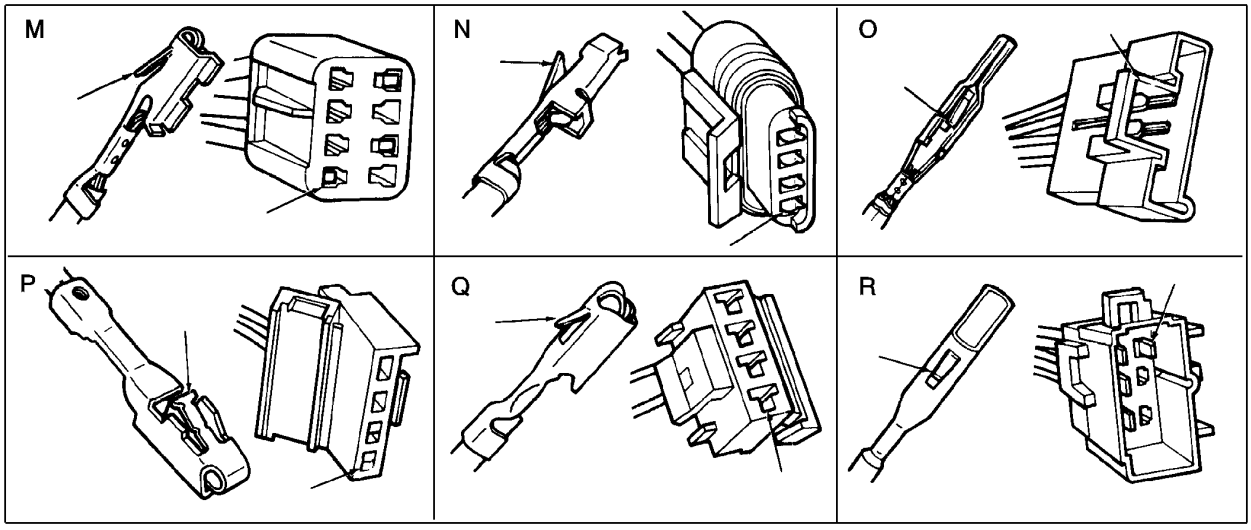

Figure 61 Additional Connectors

M. METRI-PACK (FEMALE)150 SERIES
N. METRI-PACK (FEMALE) 150 SERIES-PULL TO SEAT
O. METRI-PACK (MALE) 150-280 SERIES, 150-280 SERIES (SEALED)
P. METRI-PACK (FEMALE) 280 SERIES, 280 SERIES SEALED
Q. METRI-PACK (FEMALE) 480-630 SERIES, 480 SERIES SEALED
R. METRI-PACK (MALE) 480-630 SERIES

4.3. AMP CONNECTORS

28-Way Connector (Used With Celect Electronic Controls) - Remove and Inspect

The AMP type connector (Figure 62) is used to connect the International engine harness to the Cummins Electronic Control Module (ECM). Cummins also uses two of the same type connectors to connect other engine controls to the ECM.

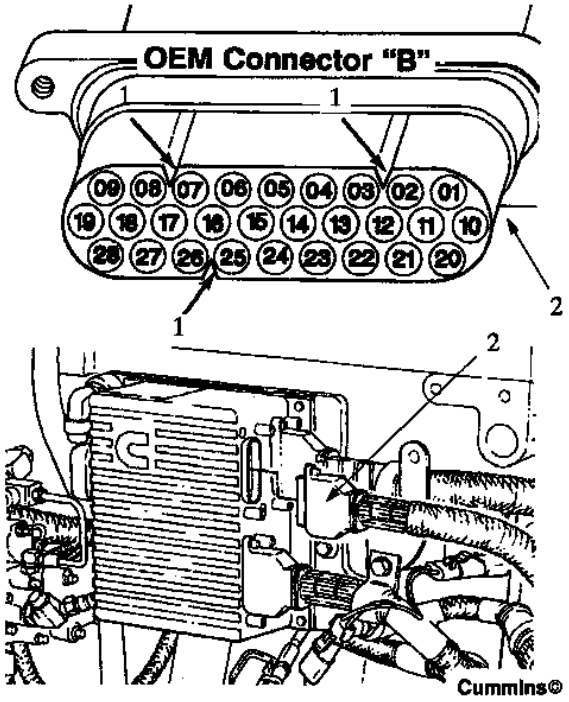

Figure 62 AMP Type Connector

1. SPECIAL "KEYS" FOR INTERNATIONAL ENGINE HARNESS CONNECTOR
2. INTERNATIONAL ECM CONNECTOR - 263

NOTE – Each of the three AMP connectors connecting to the ECM has a special "key" so that it cannot be interchanged with the other two connectors.

To inspect the Electronic Control Module (ECM) side of the connection, refer to the Cummins Service Manual. The following procedure applies to the International engine harness connector (263) that connects to the ECM.

The ECM and the mating connectors have gold-plated pins/mating terminals that are manufactured to a very close tolerance. The connector and terminals must only be replaced using approved parts.

1. Remove the connector from the ECM by first removing the two capscrews. Then carefully pull the connector straight out of the ECM.

2. Inspect the connector for "pushed back" or "expanded" terminals, using a special tool, Cummins Part No. 3823383, Figure 63 . Insert the tool into each AMP connector terminal. Do not force the tool into the terminal.

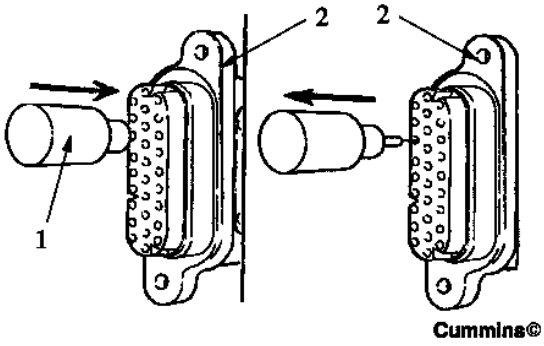

Figure 63 Special Tool

1. SPECIAL TOOL
2. ECM INTERNATIONAL ENGINE HARNESS CONNECTOR

A terminal that is not pushed back or expanded will have a surface to tool gap (Figure 64) of approximately 0.050 in. (1.3 mm). If the tool touches the connector (without forcing), replace the terminal.

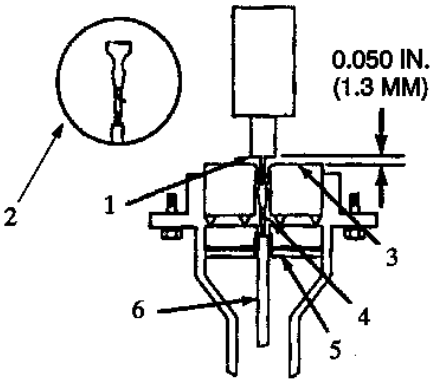

Figure 64 Terminal Surface to Tool Gap

1. TOOL GAUGE (CUMMINS PART NO. 3823383)
2. TERMINAL
3. AMP SURFACE
4. LOCKING LANCE
5. WEATHER SEAL
6. WIRE

3. In this step, push the tool into the terminal until the tool touches the connector (Figure 65), then slowly remove the tool from the terminal. A small resistance (6 to 10 oz.) must be felt. If the resistance is not felt, the terminal is expanded and must be replaced.

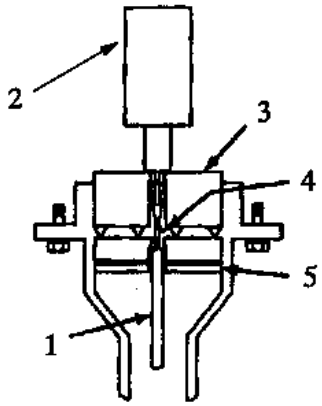

Figure 65 Push Tool into Terminal

1. WIRE
2. SPECIAL TOOL (CUMMINS PART NO. 3823383)
3. AMP SURFACE
4. LOCKING LANCE
5. WEATHER SEAL

4. Repeat Steps 2 and 3 checking for "pushed back" or "expanded" terminals for each terminal in the connector.

28-Way Connector (Used With Celect Electronic Controls) - Repairing Terminals

1. With the AMP connector removed from the ECM, cut and remove the plastic wire tie that holds the cover to the connector body (Figure 66).

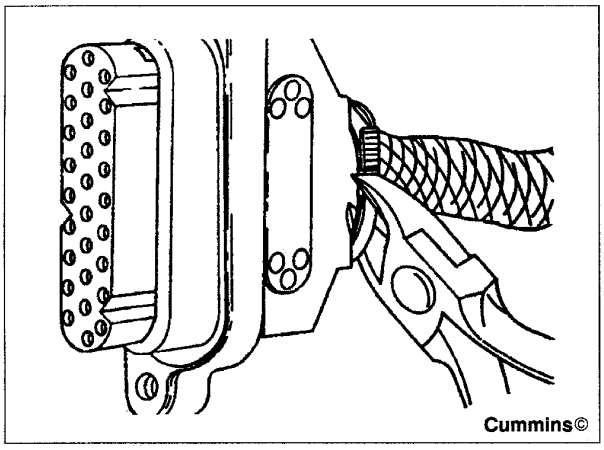

Figure 66 Remove Plastic Tie

2. Pull the locking tabs apart on the cover. Remove the cover from the connector. Cut the plastic wire ties under the cover (Figure 67).

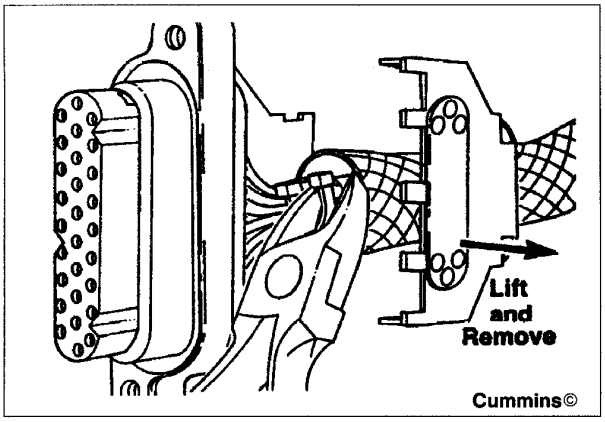

Figure 67 Cut Plastic Wire Ties

3. Locate the damaged terminal. Insert terminal removal tool, Cummins Part No. 3822759, in the terminal about 0.7 in. (18 mm). Push the tool to the bottom of the cavity (Figure 68).

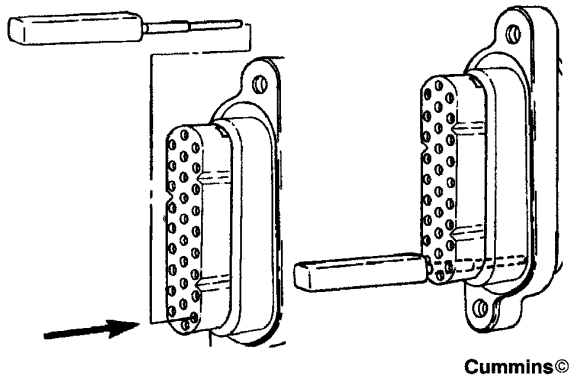

Figure 68 Push Tool to Bottom of Cavity

4. Hold the tool in the connector, and pull the terminal out of the connector (Figure 69).

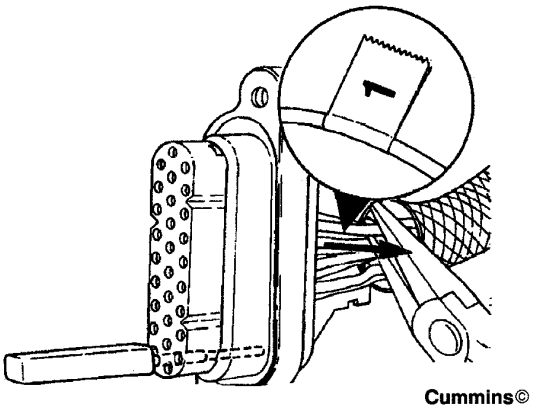

Figure 69 Pull Terminal Out of Connector

5. The female replacement terminal, wire and splice assembly is Cummins Part Number 3822919. The assembly is 5 inches (127 mm) long. Cut the same length (including terminal) from the damaged terminal/wire in the engine harness. Strip 1/4 in. (6.3 mm) from end of the harness wire (Figure 70).

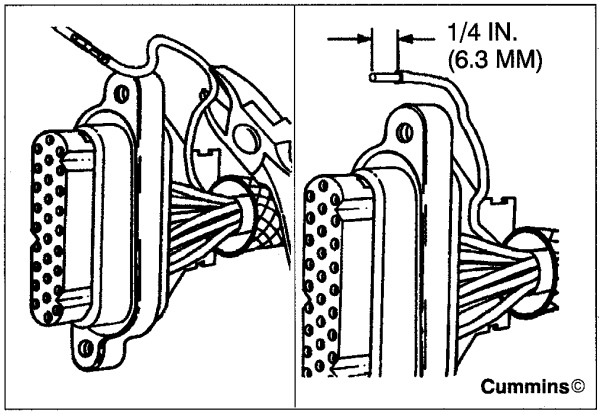

Figure 70 Strip 1/4 Inch From End of Harness Wire

6. Install replacement terminal/wire on the stripped wire end. **NOTE: Make sure the bare wire extends into the splice connector** (Figure 71).

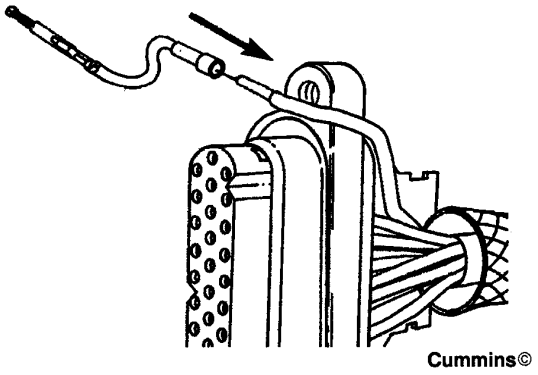

Figure 71 Make Sure Bare Wire Extends into Splice Connector

7. Crimp the terminal repair wire on the bare wire (Figure 72).

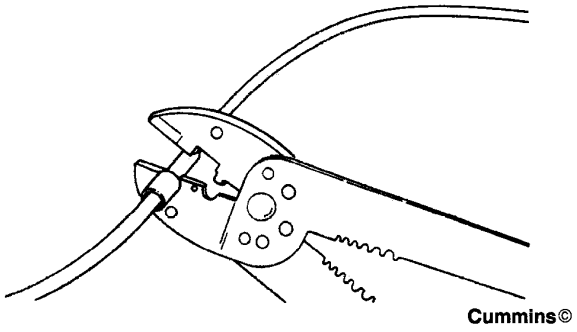

Figure 72 Crimp Terminal Repair Wire on Bare Wire

8. Use a heat gun or an open flame to heat the shrink tubing. The tubing will shrink and make the connection waterproof (Figure 73).

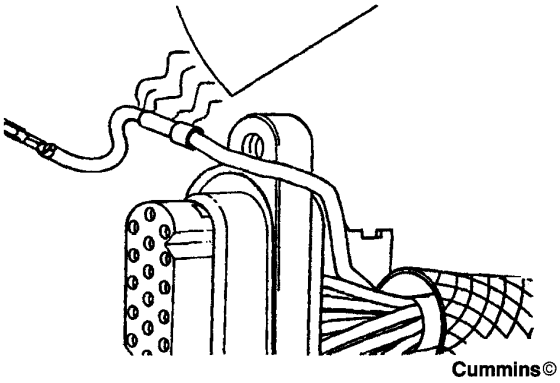

Figure 73 Heat Shrink Tubing

9. If it was removed, insert the tool, Cummins Part No. 3822759, in the location of the repaired terminal. Make sure the tool is pushed to the bottom of the cavity (Figure 74).

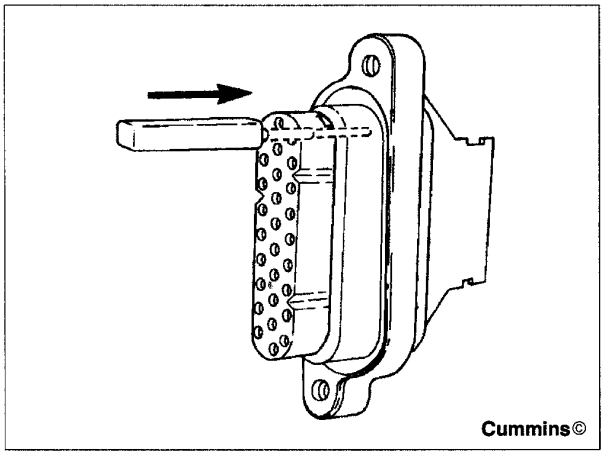

Figure 74 Make Sure Tool is Pushed to Bottom of Cavity

10. Insert the repair terminal into the connector body. Remove the tool. Push the wire into the cavity until it clicks (Figure 75). Then pull on the wire while holding the connector firmly. The terminal must hold the wire in the connector.

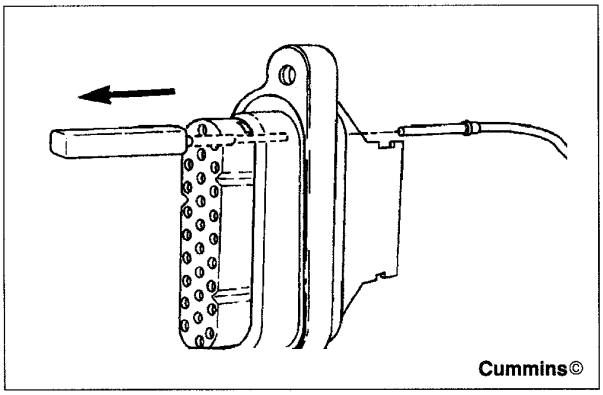

Figure 75 Push Wire into Cavity

11. Install new plastic wire ties, Cummins Part No. 3822925, under the cover. Install the cover on the connector body. Insert the tabs in the slots. Snap the locking tabs on the cover into place (Figure 76).

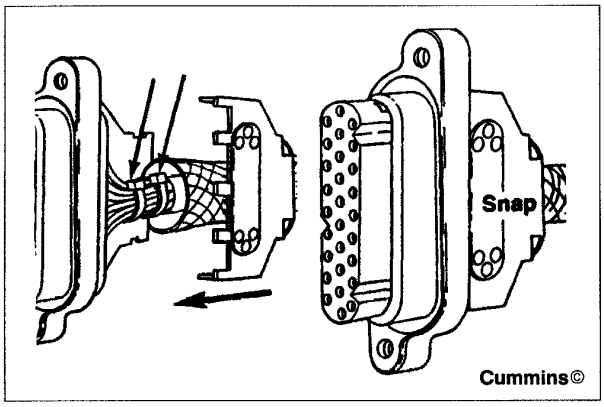

Figure 76 Snap Locking Tabs on Cover into Place

12. Install a new plastic wire tie, Cummins Part No. 3822924, through the cover and around the rear of the connector (Figure 77).

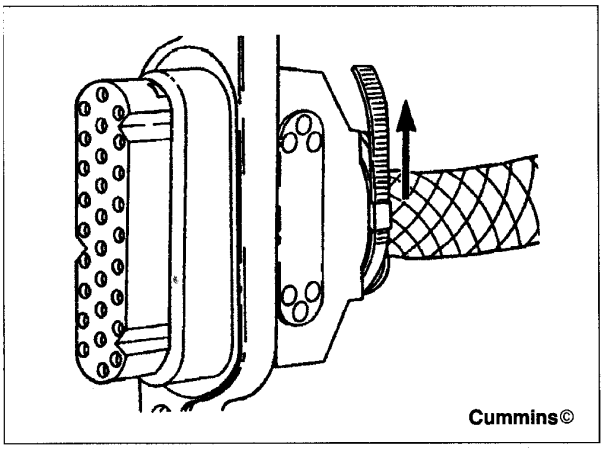

Figure 77 Install New Plastic Wire Tie

13. Make sure the female replacement terminal was not damaged during the installation process. Insert the Cummins terminal gauge, Part No. 3823383. Slowly remove the tool from the terminal. A small resistance (6 to 10 oz.) must be felt (Figure 78).

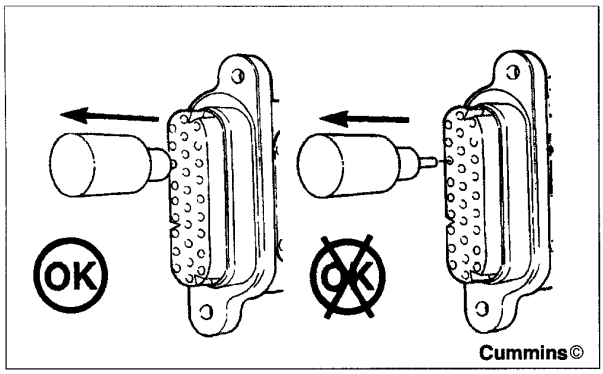

Figure 78 Slowly Remove Tool From Terminal

28-Way Connector (Used With Celect Electronic Controls) - Replacing The 28-Pin Connector (International Harness Connector C263 to ECM)

The 28-pin International engine harness connector, C263, that mates to the ECM has special "keys" so that it cannot be interchanged with the other two Cummins connectors. When replacing the connector, be sure the correct key piece is used (Figure 79).

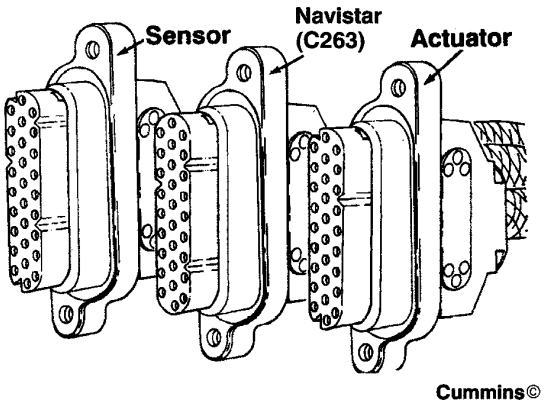

Figure 79 Be Sure Correct Key Piece is Used

1. With International C263 removed from the electronic control module (ECM), cut and remove the plastic wire tie that holds the cover to the connector body (Figure 80).

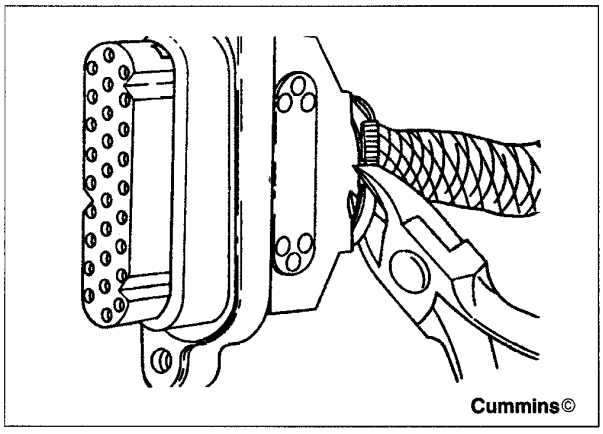

Figure 80 Cut Plastic Wire Tie

2. Pull the locking tabs apart on the cover. Remove the cover from the connector. Cut the plastic wire ties under the cover (Figure 81).

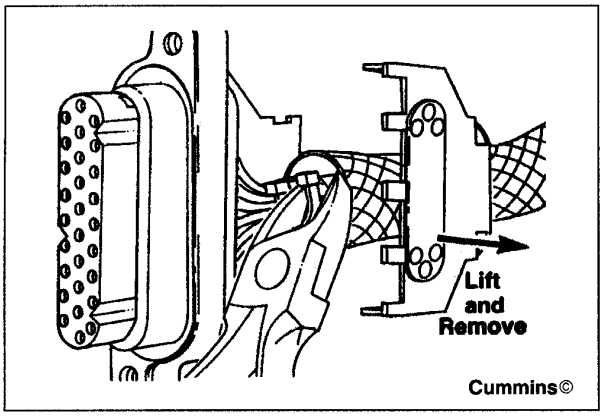

Figure 81 Cut Plastic Wire Ties Under Cover

3. Remove the number one terminal connection pin from the damaged AMP connector. Insert terminal removal tool, Cummins Part No. 3822759, in the terminal about 0.7 in. (18 mm). Push the tool to the bottom of the cavity (Figure 82).

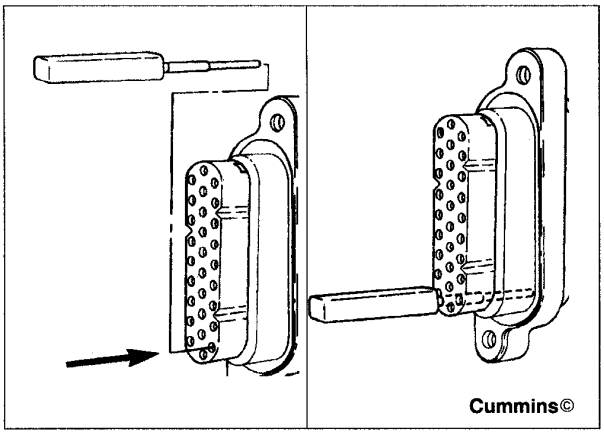

Figure 82 Push Tool to Bottom of Cavity

4. Hold the tool in the connector and pull the terminal out of the connector. Attach a tag to the terminal connection wire and mark it number one (Figure 83).

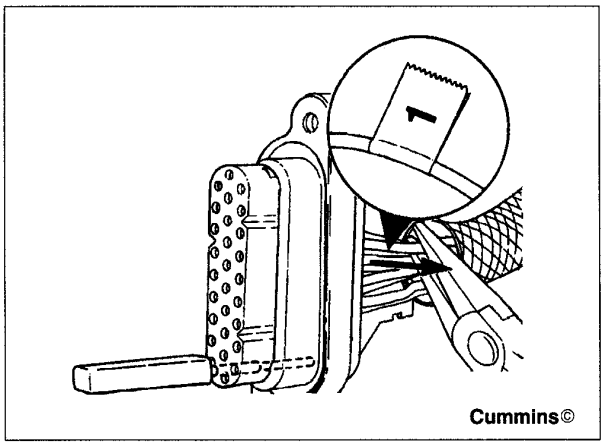

Figure 83 Attach Tag to Terminal Connection Wire

5. Remove all of the terminals from the AMP connector labeling each terminal with the AMP cavity number as it is removed (Figure 84).

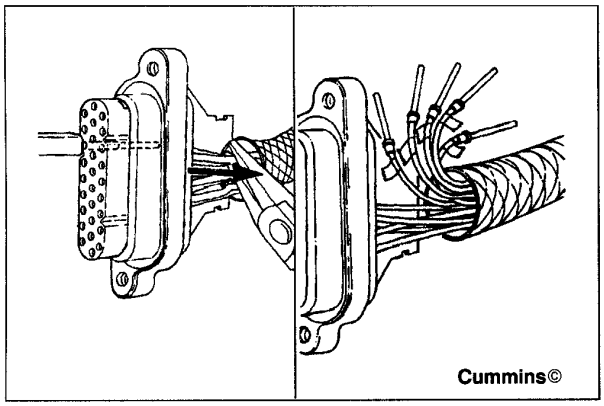

Figure 84 Label Each Terminal as It is Removed

6. Select the correct AMP replacement connector (International Part No. 1663985C1 or Cummins Part No. 3048603). Make sure the connector "keys" are correct (Figure 85).

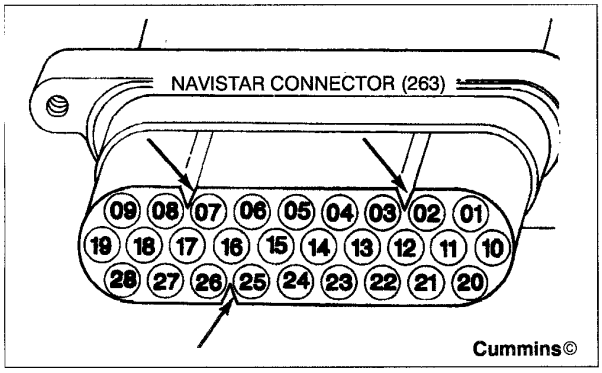

Figure 85 Make Sure Connector "Keys" Are Correct

7. Insert tool, Cummins Part No. 3822759, in the number one hole of the connector. Make sure the tool is pushed to the bottom of the cavity (Figure 86).

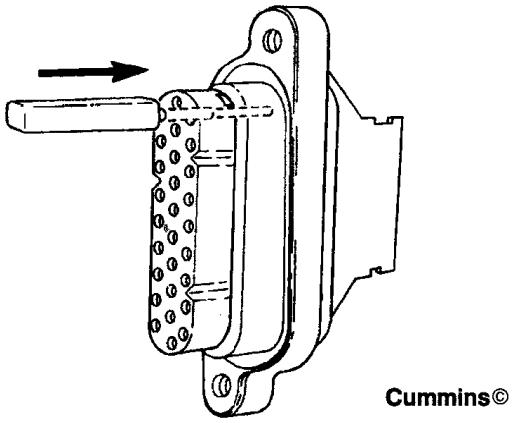

Figure 86 Make Sure Tool is Pushed to Bottom of Cavity

8. Insert the wire labeled number 1 into the number one hole of the connector of the connector body. Remove the tool. Push the wire into the cavity until it "clicks" into position (Figure 87).

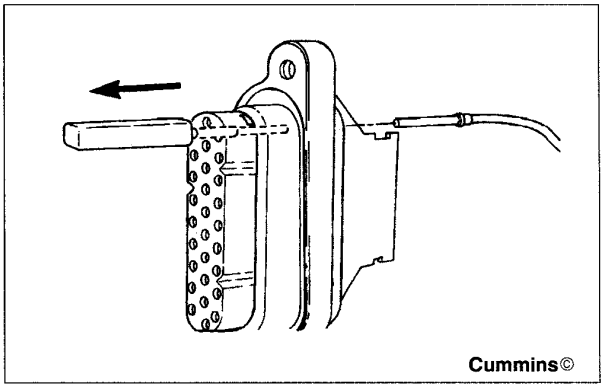

Figure 87 Push Wire into Cavity

9. Tug on the wire. The terminal must hold the wire in the connector (Figure 88).

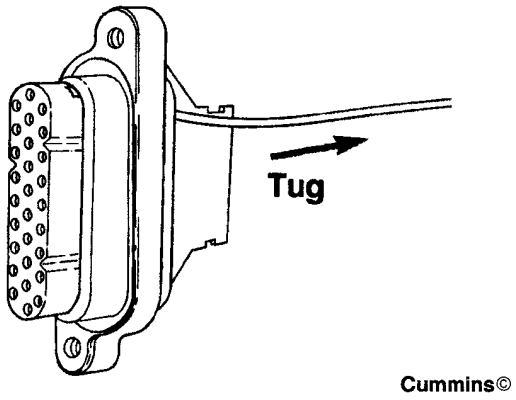

Figure 88 Tug on Wire

10. Repeat steps 7 through 9 to insert all of the wires into the connector body cavities.

11. Install new plastic wire ties, Cummins Part No. 3822925, under the cover (Figure 89). Install the cover on the connector body. Insert the tabs in the slots. Snap the locking tabs on the cover.

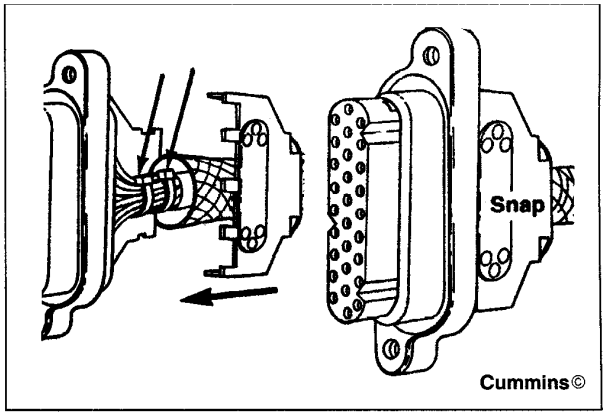

Figure 89 Install New Plastic Wire Ties

12. Install a new plastic wire tie, Part No. 3822924, through the cover and around the rear of the connector (Figure 90).

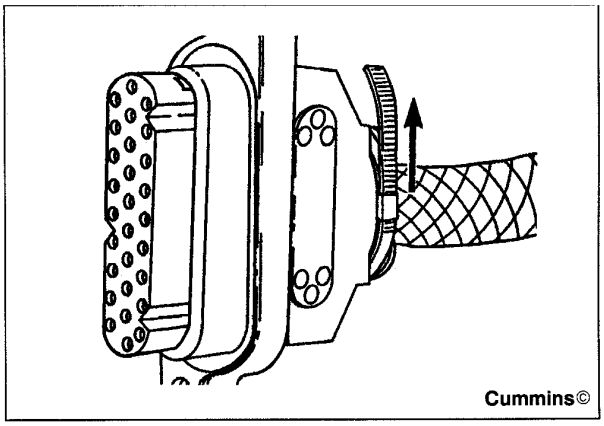

Figure 90 Install New Plastic Wire Tie Through Cover

13. When all wires are inserted into connector, make sure the terminals were not damaged during replacement. Inspect the connector for "pushed back" or "expanded" terminals, using a special tool, Cummins Part No. 3823383 (Figure 91). Insert the tool into each AMP connector terminal. Do not force the tool into the terminal.

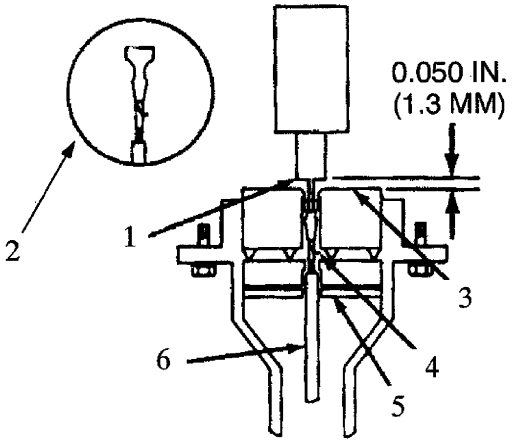

Figure 91 Insert Tool into Each AMP Connector Terminal

1. TOOL GAUGE (CUMMINS PART NO. 3823383)
2. TERMINAL
3. AMP SURFACE
4. LOCKING LANCE
5. WEATHER SEAL
6. WIRE

A terminal that is not pushed back or expanded will have a surface to tool gap (Figure 91) of approximately 0.050 in. (1.3 mm). If the tool touches the connector (without forcing), replace the terminal.

14. In this step, push the tool into the terminal until the tool touches the connector (Figure 92), then slowly remove the tool from the terminal. A small resistance (6 to 10 oz.) must be felt. If some resistance is not felt, the terminal is expanded and must be replaced.

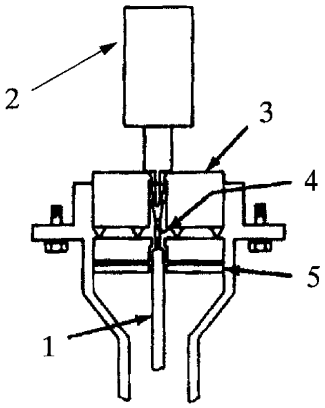

Figure 92 Push Tool into Terminal

1. WIRE
2. SPECIAL TOOL (CUMMINS PART NO. 3823383)
3. AMP SURFACE
4. LOCKING LANCE
5. WEATHER SEAL

15. Repeat Steps 13 and 14 checking for "pushed back" or "expanded" terminals for each terminal in the connector. If repair is required, refer to 28-Way Connector - Repairing Terminals.

4.4. STANDARD TERMINALS AND SPLICES

Standard Terminals

Refer to Figure 93 .

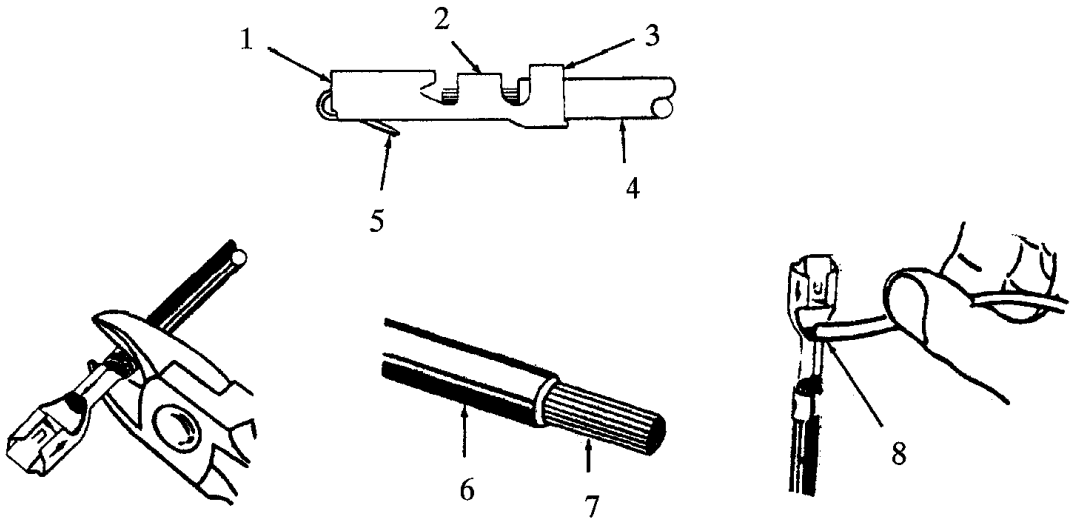

Figure 93 Standard Terminal

1. MATING END
2. CORE WINGS
3. INSULATION WINGS
4. CABLE
5. LOCK TANG
6. INSULATION
7. WIRE STRANDS
8. SOLDER

1. Cut the cable just before the insulation wings on the terminal.
2. Remove the insulation being careful not to cut any of the wire strands.
3. Position cable in the new terminal.
4. Hand crimp the core wings first, then the insulation wings.

   NOTE – Always use the recommended crimp tool for each terminal. A detailed crimp chart is included in the repair kit.

5. Solder all hand crimped terminals and electrically check for continuity.

Splice Inspection

Refer to Figure 94 .

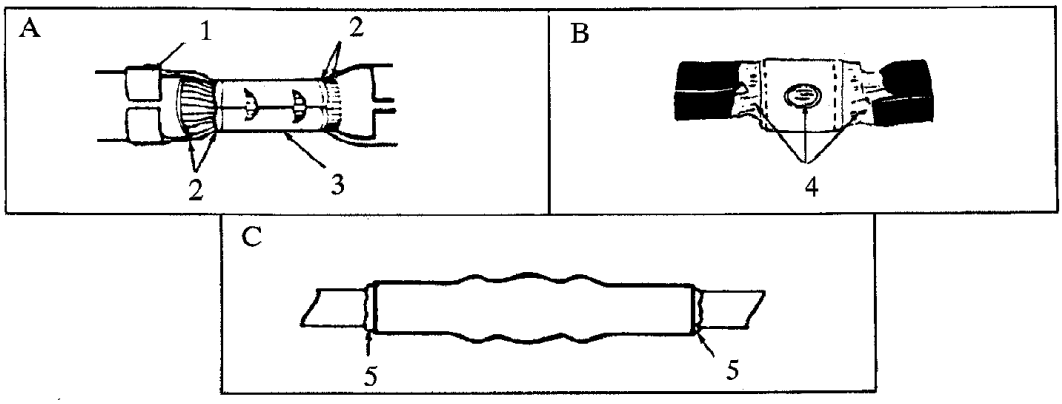

Figure 94 Splice Inspection

A. TERMINAL APPLICATION
B. SOLDER APPLICATION
C. CRIMP AND SEAL HEAT APPLICATION
1. INSULATION CRIMP
2. WIRE STRANDS VISIBLE IN THIS AREA
3. CORE CRIMP
4. GOOD SOLDER APPLICATION
5. EVIDENCE OF GLUE

Splice Clip Installation

Refer to Figure 95 .

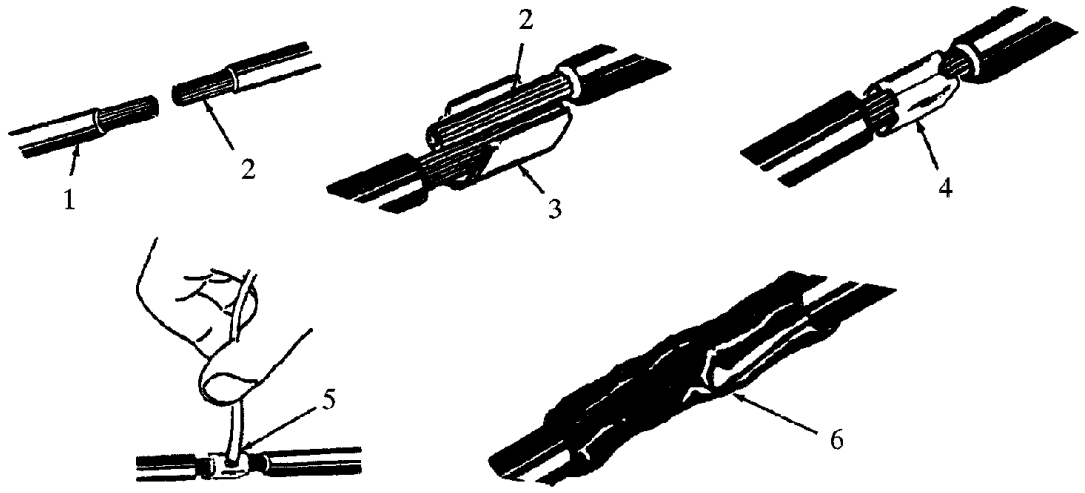

Figure 95 Splice Clip Installation

1. INSULATION
2. WIRE STRANDS
3. CLIP (POSITIONED CORRECTLY)
4. CRIMPED CORRECTLY
5. SOLDER
6. TAPE

NOTE – A new clip must be located a minimum of 1.5 inches (40 mm) from a connector, sleeve or another clip.

1. Cut off the old clip or bad section of wire.
2. Remove the insulation being careful not to cut any of the wire strands.
3. Install the proper clip on the wire strands.
4. Hand crimp the clip until securely fastened.
5. Solder the clip and electrically check for continuity.
6. Cover the entire splice with splice tape. Extend the tape onto the insulation on both sides of the splice(s).

Crimp And Seal Splice Sleeve Installation

Refer to Figure 96 .

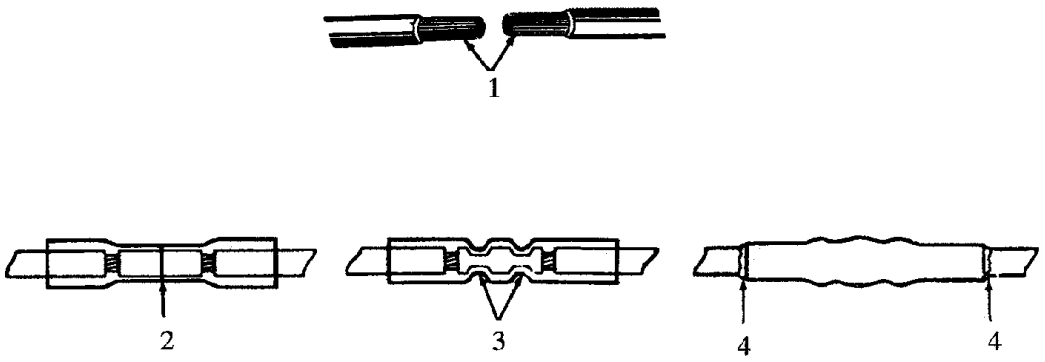

Figure 96 Crimp and Seal Splice Sleeve Installation

1. WIRE STRANDS
2. WIRE STOP
3. CRIMP CONNECTOR
4. EVIDENCE OF GLUE

NOTE – A new sleeve must be located a minimum of 1.5 inches (40 mm) from a connector, clip or another sleeve.

1. Cut off the old sleeve or bad section of the wire.
2. Remove insulation being careful not to cut any of the wire strands.
3. Install the proper sleeve on the wire strands, making sure the ends of the wire hit the stop.
4. Hand crimp to the sleeve. Gently tug on the wire to make sure that they are secure.

   NOTE – Always use the recommended crimp tool for each sleeve. A detailed crimp chart is included in the Repair Kit.

   CAUTION – Do not use a match or open flame to heat the sleeve seal.

5. Electrically check the sleeve and wire cable for continuity.

5. SPECIAL TOOLS

5.1. TERMINAL REMOVAL TOOL CROSS REFERENCE

Table 1 Terminal Removal Tool Cross Reference

Terminal Series	Male Terminal Tool #	Female Terminal Tool #
56 Series	8912269-3	8913369-3
58 Series	8912369-3	8913369-3
59 Series	8912369-3	8913369-3
Metri-Pack	8912369-3	8913369-3
150 Series	12012000-3	1203121
150PTS	—-	12032198
150.1PTS	—-	12032198
280 Series	12012000-3	12012000-3
480 Series	12012000-3	12012000-3
630	12012000-3	12012000-3
630PTS	—-	12032198
Weather-Pack	12014012	12014012
Micro-Pack	12012000-3	12031876
Pack-Con II	12012000-3	12012000-3
Pack-Con III	12012000-3	12093078-1
Pack-Con IV	12012000-3	12056848-1

5.2. PACKARD HAND CRIMPERS

The following hand crimpers are available from Packard (Figure 97 and Figure 98).

1. 12085271 - Will crimp most stamped terminals from 10 gauge to 22 gauge terminals.
2. 12085270 - Will crimp the cable seal wings on Packard Metri-Pack and Weather Pack terminals.
3. 12085115 - Will crimp thicker stocked 1/4” blade terminals and also double crimp terminals.

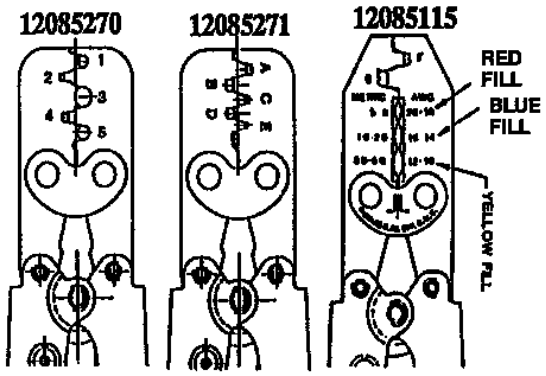

Figure 97 Hand Crimpers

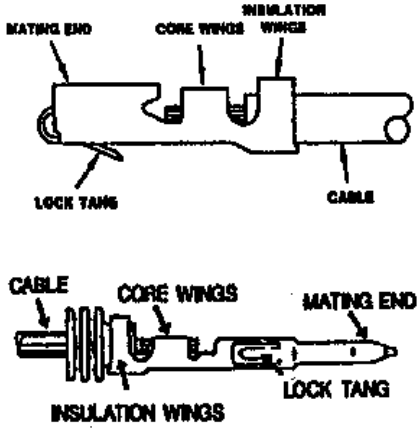

Figure 98 Core Wings

1. COMPRESS HANDLES UNTIL RATCHET AUTOMATICALLY OPENS.

2. CORE WINGS SHOULD BE CRIMPED FIRST. LAY THE BACK OF THE TERMINAL CORE WINGS ON APPROPRIATE ANVIL. BE SURE THE CORE WINGS ARE POINTING TOWARD THE FORMING JAWS.

3. GENTLY APPLY PRESSURE TO HANDLES UNTIL CRIMPERS SLIGHTLY SECURE THE TERMINAL CORE WINGS.

4. INSERT STRIPPED CABLE THROUGH CORE CRIMP WINGS OF TERMINAL AND POSITION PROPERLY.

5. COMPRESS THE HANDLES UNTIL RATCHET AUTOMATICALLY RELEASES.

6. REPEAT STEPS 2 AND 3 FOR INSULATION CRIMP.

7. INSPECT TERMINAL CLOSELY FOR DAMAGE BEFORE APPLYING SOLDER.