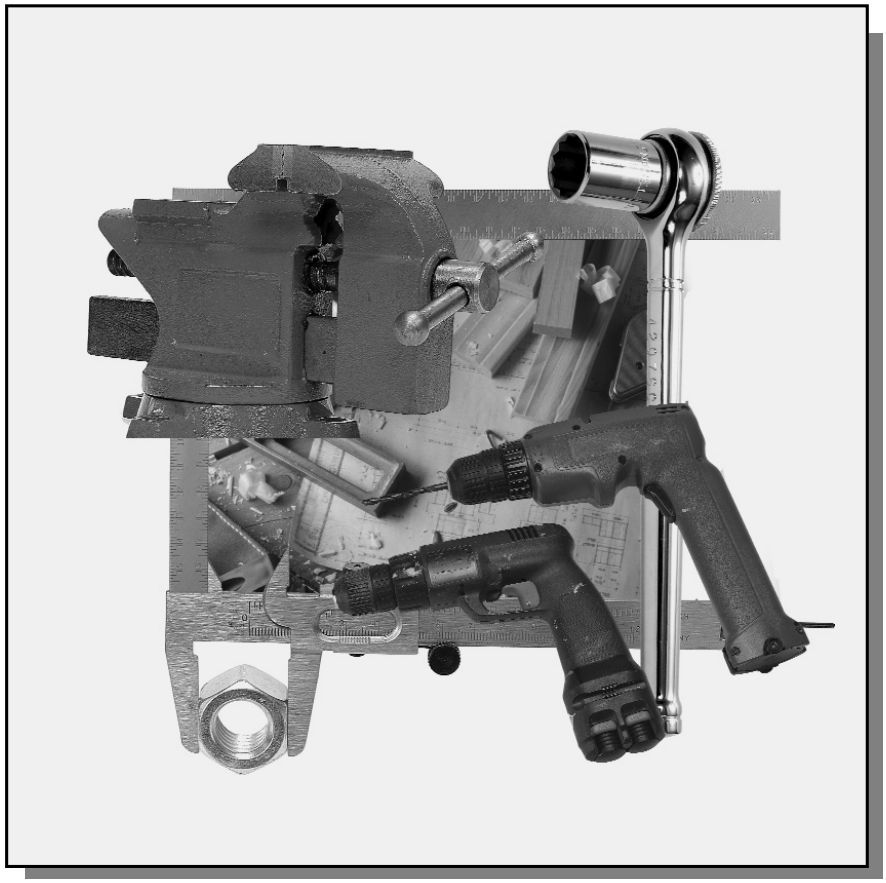
Character and Skills for Home and Careers

This chapter requires a companion activity book in which students respond to questions on text content. Answers are found in the *Teacher's Resource Kit*.



Chapter 4

PROFESSIONAL CREDITS

Character and Skills for Home and Careers

Publisher and Managing Editor
Ronald E. Johnson, Ph.D.

Writers
David Browder
Charles Hambrick
Ronald E. Johnson
Kermit Northcutt

Technical Editor
David Browder

Content Editor
Nancy S. Johnson

Production Manager
H. Michael Young

Page Composition
Debbie L. Dial
Kathy L. Dial
Douglas G. New
H. Michael Young

Graphic Artists
Debbie L. Dial
Austin Fox
Douglas G. New
Lydia Seals
Don Ward
H. Michael Young

Quality Assurance
Nancy S. Johnson

CHAPTER 4
TABLE OF CONTENTS

Warning

Students under the age of 18 should not attempt projects described in this course without supervision by a competent adult.

PAGE

SECTION 1


1. A NEW JOB 1-2


2. THE FIRST DAY'S TRAVEL 3-4


3. PRACTICE SAFETY 5-8


4. STRAPPING ON THE TOOLS . .9-10


5. WIRING BASICS 11-12

SECTION 2


6. FINDING THE POWER 13-14


7. BOX INSTALLATION 15-16


8. GETTING PLUGGED IN 17-18


9. SELECTING SWITCHES 19-20


10. CUTTING, STRIPPING AND SPLICING WIRE 21-22

PAGE

SECTION 3


11. INSTALLING RECEPTACLES . . 23-24

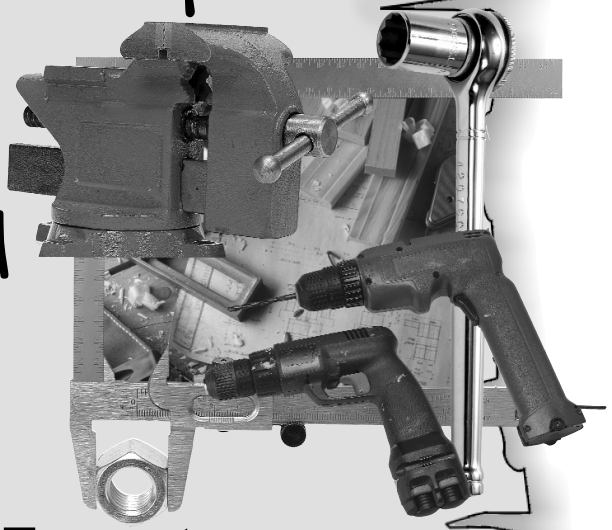

12. INSTALLING SWITCHES 25-26


13. HERE COMES THE LIGHT . . . 27-28

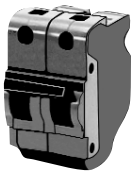

14. INSTALLING THE LIGHTS 29-30


15. A JOB WELL DONE 31-34

"To be a success in any line of work requires courage, persistence, a willingness to pinch and go without many pleasures and pastimes while you are young and getting a good start in life."



—Lee De Forest



Electrical

Lesson 1

Chapter 4

Section 1

Lessons 1-5

A NEW JOB

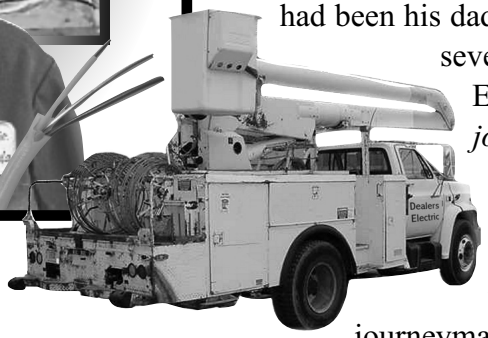


As Edward Estrada put on his newly starched shirt, he read the ***embroidered*** nametag that stated:



Edward was so proud that finally he was able to represent the electrical company that also had been his dad's employer for the past seventeen years. His dad, Samuel Estrada, was a ***licensed*** *journeyman* electrician. He had gone through an apprenticeship program at Dealers Electric and had continued to work for them while completing his journeyman certification. Mr. Estrada had explained to Edward that an *apprentice* electrician program is five years in duration and consists of 8,000 hours of on-the-job training plus a minimum of 900 hours of related classroom instruction. Only a licensed journeyman or *master* electrician may officially instruct an apprentice. Classroom hours may be attained through ***self-study*** or by attending a specific electrician's school. Under the direct supervision of an upper-level electrician, the apprentice will learn the skills associated with being an electrician.

According to Mr. Estrada, electricians assemble, install, maintain, and test electrical equipment and wiring systems in ***residential***, ***commercial***, and ***industrial*** settings. ***On-the-job training*** might include mounting electrical boxes, installing various types of equipment and lighting fixtures, bending and installing ***conduit***, wiring switches, outlets, phones, circuit panels, and working on various kinds of electrical systems such as fire alarms, security systems and temperature controls. Edward had learned that a journeyman electrician earns $29.00 an hour at Dealers Electric. In addition to the hourly wage, Dealers Electric



VOCABULARY

Embroidered: fine needlework used for ornamental purposes
Licensed: possessing an official document that gives permission to engage in a specific activity
Self-study: course setup that allows students to work at their own pace
Residential: pertaining to dwellings used as family residences
Commercial: pertaining to the buying or selling of goods or other business related items
Industrial: pertaining to the production and sale of goods and services
On-the-job training: program that allows students to receive instruction while working for pay
Conduit: a channel such as a pipe or tube for protecting electrical wires

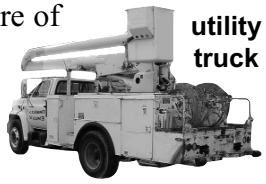
also provides its employees with a pension plan; medical, dental, and optical insurance; and a life insurance plan. A full-time apprentice earns $11.00 an hour and receives the same benefit package as a journeyman.

At Dealers Electric, Edward would be able to earn good wages and be provided with opportunities for advancement as his skills increased. Edward was also excited about the prospect of working and learning under his father's supervision. Edward considered his dad also to be his friend and hero. Edward's mother had died from a cancer-related illness six years ago, and since that time, Mr. Estrada had worked hard to be father and friend to Samuel. Samuel was also close to his younger brother, Mario. The four-year difference in their ages seemed to serve them well. They were not in direct competition with one another; however, they were close enough in age to share common interests.

Edward could hardly wait to begin his first day on the job! As he was daydreaming about what he could do with all his wages, Dad came out of his bedroom wearing his company uniform—it was identical to Edward's new work clothes.

"Ready for your first day on the job, Son?" Mr. Estrada asked.

"I sure am!" Edward replied as a big grin spread across his face. As the father and son headed out the front door, Mario grabbed the camera from a shelf and said, "Stand by, fellas, while I get a picture of you in front of the electric company's truck."


utility truck

After several poses beside the truck, Dad announced, "Get in, Edward. It's time to earn our wages!"

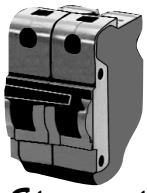
As Edward and Mr. Estrada pulled away from the curb, Mario hurried back to the house to put up the camera. He grabbed his school books, locked the door, and walked to the school bus stop.

LIFE PRINCIPLE

"Every job is a self-portrait of the person who does it. Autograph your work with excellence."

—Anonymous





Electrical

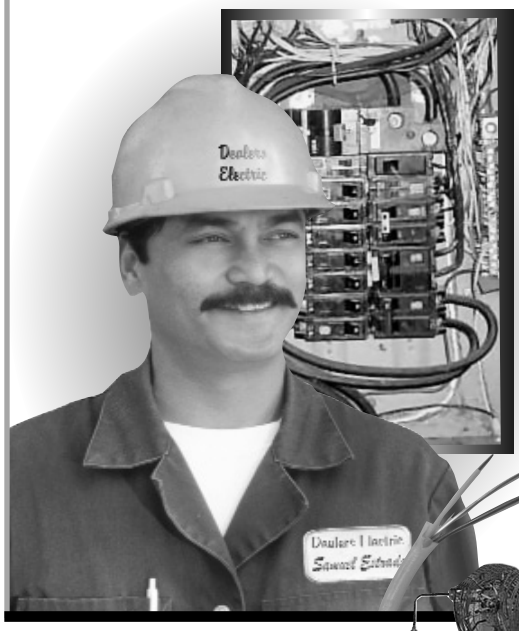
Lesson 2

Chapter 4

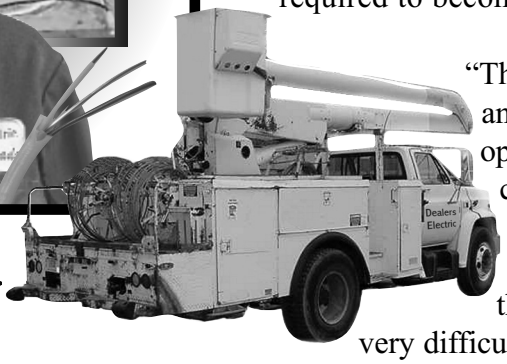
Section 1

Lessons 1-5

THE FIRST DAY'S TRAVEL



While Edward and his dad were driving to the Dealers Electric office to get their daily ***log*** and to pick up their supplies for the day, Mr. Estrada reminded Edward that he would be the tenth apprentice to be trained by his dad. All but two of those apprentices had become journeyman electricians. The two young men who quit did not like the long hours and hard physical labor required to become skilled workmen.



Mr. Estrada addressed his son, "The travel time to and from work and to and from job sites allows opportunity for me to explain the concept of electricity to you. Electricity has become so much a part of customers' lives that most people would find life very difficult without electrical power. The consumer ***instinctively*** reaches for a switch in the dark, and a light comes on. The customer gives little thought to circuitry, to switches, or to the flow of electric current. The customer just expects the power to be available; and most of the time, it is. Only when electrical systems fail does the customer give any thought as to the *why* and *how* of electricity. Most people simply want the electrical power to function properly. The average consumer thinks of electricity as a dangerous but mysterious light."

Edward responded, "You're right, Dad. I guess we all take electricity for granted to a large extent."

Mr. Estrada continued, "The truth of the matter is that electricity can be confusing when used to power complicated ***electronic*** devices. But...you don't have to start learning at a complex level. As an apprentice, you will be able to start with simple repair jobs and work your way up from there."

"Electricity," explained Mr. Estrada, "is learnable because it is ***logical***, especially in practice. It is ***sequential***, and, therefore, predictable. Electrical current runs along wires as simply as water

VOCABULARY

Log: a record of performance, events, or day-to-day activities
Instinctively: based on reactions below the conscious level
Electronics: a form of science that addresses the effects of electrons
Logical: being in agreement with what may be reasonably expected
Sequential: arranged in an orderly or connected series
Distribution: the position, arrangement, or frequency of occurrence over an area
Voltage: a unit of measure of electrical pressure
Service drop: the place where the electrical supplier brings in electricity

passes through pipes. Switches interrupt electrical current just as faucets interrupt the flow of water. Just remember that learning to think in simple progressions is the key to understanding electrical systems."



"I'm a little overwhelmed by the magnitude of electricity," admitted Edward.

His dad cautioned, "Don't try to understand the entire system all at once. Instead, think in steps until the system becomes obvious. At first, work hard to learn basic principles and terms associated with electricity and how they function together."

As Edward and his dad drove by the hydroelectric dam on Tradinghouse Lake, Mr. Estrada pointed out the massive buildings and towers that served as the Tradinghouse Electrical Generation Plant. He explained, "Electricity is created by generators that may be powered by water, oil, coal, or nuclear power. From these generators, electricity is channeled to ***distribution*** stations where the ***voltage*** is reduced, split, and distributed to cities and rural regions. From a local substation, electricity is either provided to buildings through overhead wires or underground cables. Each home, business, or industry is then attached to the main distribution line by means of a ***service drop***. These drops make electricity accessible to the main network of electrical current flow."

Mr. Estrada informed Edward that as employees of Dealers Electric, their main responsibility was to make necessary electrical connections in homes, businesses, or industries using the ***NEC*** (National Electric Code) or the ***UL*** (Underwriters' Laboratory) standards which were established to protect customers.

The two men arrived at the Dealer's Electric office. Edward was eager to continue his conversation with his dad (especially about safety issues), but the time had come to punch his time card by inserting it into a small machine that noted the time he reported for work. Thus began Edward's first day of employment.

VOCABULARY

NEC: National Electric Code; regulations approved by the National Board of Fare Underwriters for the safety of electrical wiring

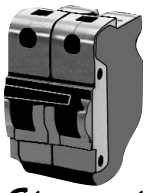
UL: Underwriters' Laboratory; a national organization that tests all types of wiring materials and devices

LIFE PRINCIPLE



"Keep company with good men, and good men you will imitate."

—Anonymous



Electrical

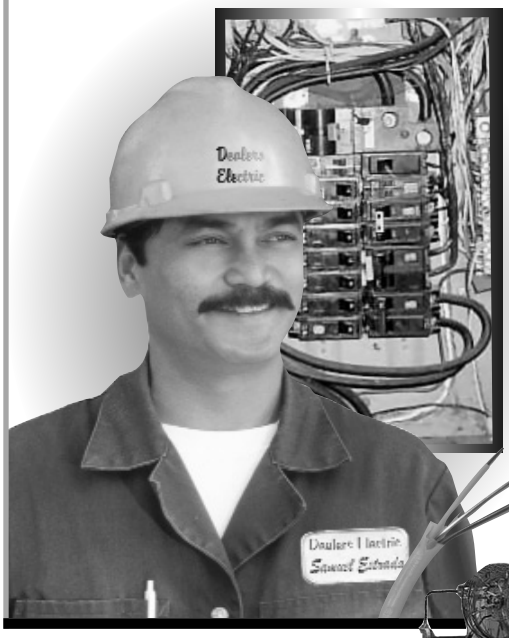
Lesson 3

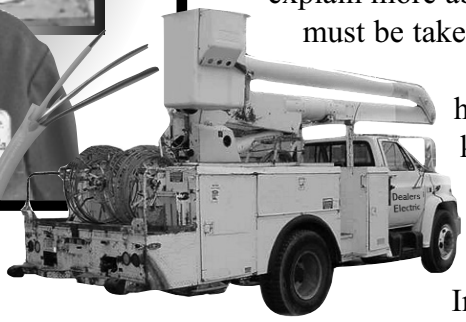
Chapter 4

Section 1

Lessons 1-5

PRACTICE SAFETY





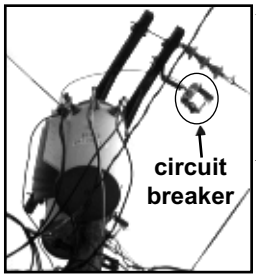
The Dealers Electric truck was loaded with supplies, and the work order determined that Mr. Estrada and Edward would be going to the Douglas ***residence*** to wire a garage and workshop extension.

Edward still had the subject of safety on his mind. While on the way to the job, he started the conversation with his dad by asking, "Could you explain more about the safety precautions that must be taken when dealing with electricity?"

Mr. Estrada said, "Electricity has the potential to injure or even kill a person; however, with a few precautions, you can eliminate the doubt factor and work without fear of being hurt. In fact, you are probably more likely to ***electrocute*** yourself through careless living habits than when doing wiring on the job site."

He further explained, "Openings or breaks created in electrical current flow are the primary source of safety. These breaks, called ***circuit breakers***, start at the power generating plant and are generally located high up on an electric pole or tower. They are usually "tripped" and closed by a person using ***insulated*** poles and rubber gloves covered with leather gloves."

Edward listened as his dad explained that the circuit breakers most commonly used by electricians are located at the service drop. "In the service drop box, a 200 ***ampere*** or 100 ampere circuit breaker will be installed. When this breaker is tripped or thrown to the off position, all of the current to the entire home, business, or industry is stopped."



Edward interrupted, "I see; the circuit breaker shuts off the flow of electric current and allows the electrician to do his work safely."

VOCABULARY

Residence: a place where a family lives

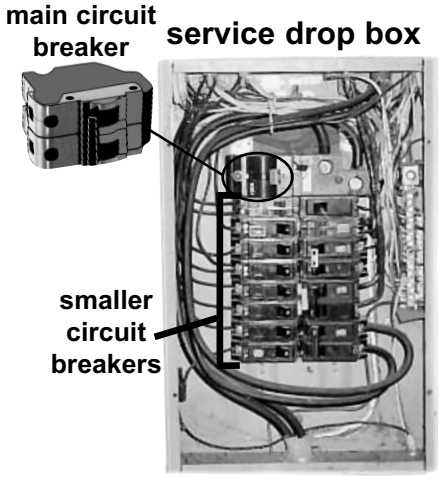
Electrocute: to receive a shock from electrical current that causes serious injury or death

Circuit Breakers: devices used to protect circuits from an overload of current; may be manually reset

Insulated: a material that will not conduct electricity and is usually made of glass, Bakelite, rubber or fiberglass

Ampere: a measurement in units of the rate of flow of electrical current

"That's right," said Mr. Estrada, "but there's more to know. Located just below the service drop entrance panel are a series of smaller circuit breakers that control the current to individual rooms or appliances. These also can be turned off so you can control the current flow to certain areas of the structure without shutting off electricity to other rooms. These ***fuses*** and circuit breakers are also safety buffers that keep an electrical malfunction from starting a fire."



VOCABULARY

Fuses: devices used to protect circuits from an overload of current
Socket: a place where lights are connected into the electrical current
Short: a direct connection between two 'hot' wires, between a 'hot' and neutral wire, or between a 'hot' wire and ground
CPR: Cardio(heart)-Pulmonary(lung) resuscitation—to revive heart and lung functions
Carotid arteries: chief arteries in the neck supplying blood to the brain
Sternum: center-chest bone connecting ribs on left and right sides of body; also called the *breastbone*
Elaborated: explained in more detail


screw-in type fuse

Mr. Estrada described how a fuse can be "blown" or a circuit breaker tripped when one of three things happens:

1. Overloaded circuit—This is the most frequent cause of trouble. When too many lights or appliances are plugged into a circuit, more current is drawn than the circuit can deliver. This amperage overload causes the conductors or wires to heat up, thereby causing the fuses to blow or circuit breakers to trip.
2. Short circuit—Careless wiring of connections can cause a fuse to blow because of the greatly increased electrical charge sent through the circuit.
3. Loose wiring in circuit breaker or loose fuse in ***socket*** (old type panels used screw-in type fuses).

Mr. Estrada cautioned, "A loose fuse is easy to remedy; overloaded circuits and ***short*** circuits are not always so accommodating. Electricians must determine exactly what may be causing a fuse to blow or a circuit breaker to trip repeatedly.

The human body easily conducts electricity," he continued. "When an electrical current flows through a person's body, the current can stop regular heart beat and interrupt breathing impulses controlled by the brain. A person who comes into contact with an electrical short usually will not be able to let go of the wire. His muscles will contract and cause him to hold the wire tightly.

If you see someone being electrocuted, use a dry towel, a dry broomstick, or any poor conductor of electricity that is dry to pull the victim free of the current. If nothing else is available, try to knock him loose with a foot (with shoe on) or closed hand. Do not grab onto him or maintain contact for more than a split second. To do so would be to become part of the short circuit; then you, also, would be unable to let go.

The longer a person is in contact with

an electrical shock, the more damage is done. One of the best ways to help someone who is being shocked is to go to the service drop entrance panel and simply pull the main circuit breaker located at the top of the box. This action will shut off all of the available current in the home, business, or industry. Regardless of what you do, you will have very little time to react, so move quickly but carefully."

Mr. Estrada then handed Edward a safety checklist. "Here is a list of actions that should be followed if you see anyone who has been electrocuted." The pamphlet stated the following:

1. Shout for help!
2. Isolate the victim from the short circuit.
3. Call 9-1-1
4. Check for victim's responsiveness by shouting, "Are you all right?" Do NOT shake or move the victim if you suspect he has broken bones or spinal injuries.
5. If the victim is unresponsive/unconscious/ not breathing, begin the **ABCs** of ***CPR***:
    * **A**irway: Tilt the head back and lift the neck to clear the airway (tongue often obstructs airway).
    * **B**reathing: Pinch the victim's nose shut, administer two full breaths, watching for the chest to rise (with each breath).
    * **C**irculation: Check for pulse at ***carotid artery***. If there is no pulse, perform 15 chest compressions on the ***sternum***, using 2 hands. Push down about 2 inches and release at the rate of about one compression per second (the time it takes quickly to say "one thousand").
6. Continue the cycle of 15 compressions followed by 2 breaths until the victim resumes a pulse or until medical assistance arrives.
7. If victim has a pulse but is not breathing, give resuscitation breaths every 5 seconds until the victim begins breathing, or medical help arrives.

The pamphlet ***elaborated***,

*(1) "To resuscitate the lungs, keep the victim's head tilted back with one hand on the forehead. Pinch the victim's nostrils shut with your thumb and forefinger.

*(2) Take a deep breath, and cover the victim's mouth with your own, making a seal. Blow deeply and slowly into the mouth, watching to see if the person's chest is rising. Ventilate the victim's lungs two times with slow, full breaths."

*(3) "To determine a pulse, place 2 fingers on the victim's carotid artery on the side of the neck between the chin and the ears."

*(4) "To locate the correct hand position on the sternum, measure up two finger widths from the bottom of the sternum.

*(5) "Next, place the heel of your other hand beside your fingers. Then put one hand on top of the other and interlock your fingers."

*(6) "Lock your elbows and use your upper body weight to compress the chest 15 times in quick succession as you count aloud to 15."

"Another point to remember is to keep the victim warm with blankets or coats until medical help arrives," noted Mr. Estrada.

Edward responded, "Wow! That's a lot to remember!"

"Yes, it is," said Dad, "But you could save someone's life if you learn it well! Notice the diagram on the back of the safety pamphlet. It walks you through the process of CPR using images as well. "

Edward turned over the paper and studied the images. With all of the new information swimming around in his head, he was surprised to feel the truck coming to a halt. They stopped in front of a house with a new addition. Edward was eager to begin his first assignment with dad.

***(1) Preparing for CPR**



***(2) Giving Breaths**



***(3) Locating the carotid artery pulse**



***(4) Locating the sternum**



***(5) Placement of hands**



***(6) Compressing the sternum/heart**

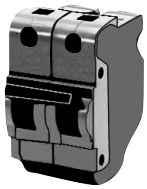


LIFE PRINCIPLE



"You have to prepare yourself so that when the time comes, you are ready."

—Oprah Winfrey



Electrical

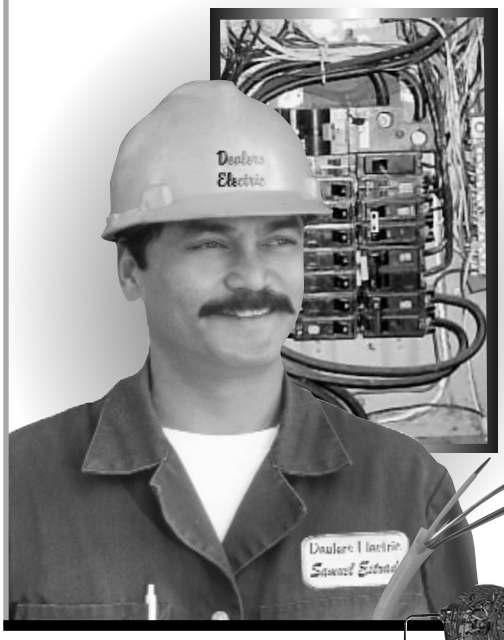
Lesson 4

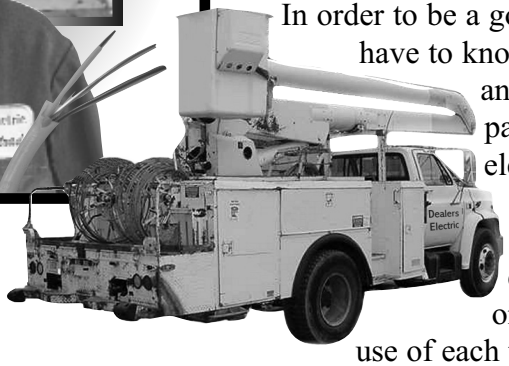
Chapter 4

Section 1

Lessons 1-5

STRAPPING ON THE TOOLS





Mr. Estrada told Edward that today he would learn how to be a 'gofer'. Edward laughed and replied, “I don’t think that I have the proper teeth to be a good gopher, Dad.”

Chuckling, Mr. Estrada said, *gofer* is a term used in the business world to describe a person who runs errands for someone else. In the electrical business, a gofer is someone who goes to get tools and equipment out of the truck and to the job site. In order to be a good ‘gofer,’ you're going to have to know the names of all the tools and equipment, as well as all the parts that pertain to proper electrical ***installation***.”

The two men began unloading the tools. As the tools began to emerge, Edward concentrated on learning the ***terminology*** and use of each tool involved in electrical work.

Mr. Estrada remarked, “I have taken the liberty of purchasing your tool belt and the supplies that you will need. I have done that for each apprentice I have trained over the years; however, equipping a belt for my own son is special.”

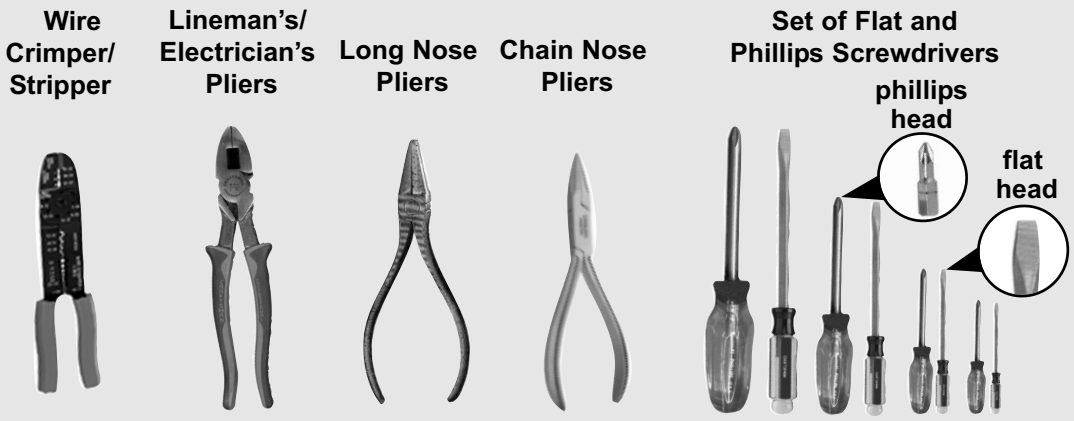
The proud father proceeded to pull out of his tool box a leather electrician’s apron. The apron was made of heavy-duty, top-grain leather and featured eleven pockets. The pockets were double-stitched and had extra rivet reinforcement throughout. On the belt was a small brass plate boasting Edward’s engraved initials. Edward was thrilled to get the belt and thanked his dad profusely.

“The best is yet to come!” Mr. Estrada responded with enthusiasm. He pulled out several different types of hand tools. The first one he handed to Edward was a wire ***stripping***, ***crimping***, and cutting tool. “This crimper/stripper all-purpose wiring tool cuts, strips and crimps insulated and non-insulated 22 to 10 ***gauge*** wire and cuts 6 sizes of bolts. The tool is also equipped with plastic comfort handles, as you can see,” explained Mr. Estrada. The next item he displayed to Edward was a set of pliers. Included in the

VOCABULARY

Installation: to set in position and connect for use
Terminology: the vocabulary of technical terms used in a particular field
Stripping: removing an outside coating
Crimping: pressing or pinching into small, regular folds or ridges
Gauge: thickness or diameter of wire
Warehouse: a place where goods or merchandise is stored

Common Tools for an Electrician



set were lineman's/electrician's pliers used to cut thick wire and to make sharp crimps.

Next were $7\frac{1}{2}$-inch long nose pliers with cutters on the side, used to get a firm grip for precision work in tight places. A pair of 7 inch chain nose pliers with cutters was also included for work in tight places. The next tools were two sets of screwdrivers, including 3-inch, 4-inch, 6-inch and 8-inch lengths of both flat and phillips-type screwdrivers with cushion-grip handles.

Edward exclaimed, "My belt is getting full!"

Mr. Estrada grinned and commented, "This last tool is probably the most valuable one to be included in the belt. This tool is a clamp-on ammeter. It is designed to test voltage and amperage (current) as well as to determine open or closed circuits. This device will also measure electrical resistance in the wiring. A large part of your training will revolve around using this device to test circuits."

Edward was so excited about his new tools that he had almost forgotten about the job he had been assigned to complete. He asked, "When are we going to get started on the wiring job? I'm eager to try my new tools."

His dad laughed and said, "You still have to learn about some of the equipment



clamp-on ammeter

used in the electrician's trade. Sending you to the truck to get something would not be helpful if you didn't know what you were going after. The truck is loaded with the necessary equipment before going on the job site; this saves a lot of time going back and forth from Dealers Electric's ***warehouse*** to the job site."

Edward commented, "I'm ready to learn all the information I can, Dad. But, I am still nervous about making a mistake."

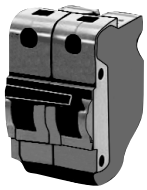
The father assured his son, "Don't worry. That is why apprentices are placed with older, experienced electricians. I'll make sure that you don't do anything dangerous at the beginning of your training!"

LIFE PRINCIPLE



"Many receive advice; only the wise profit by it."

–Syrus



Electrical

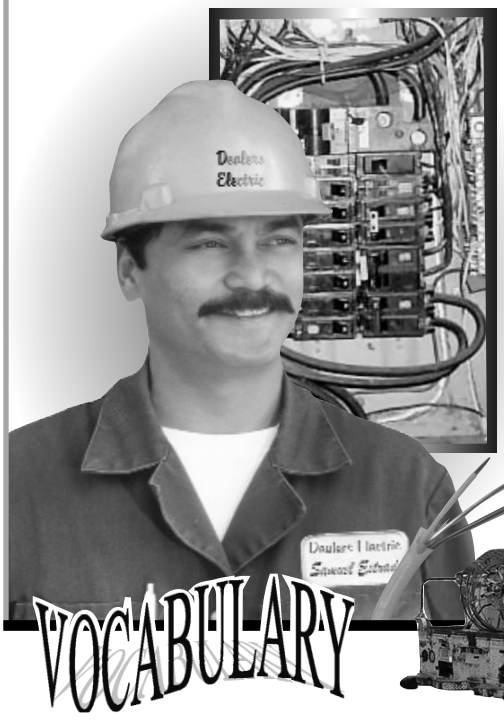
Lesson 5

Chapter 4

Section 1

Lessons 1-5

WIRING BASICS



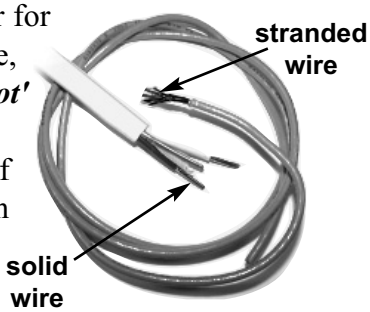
Mr. Estrada informed Edward, "You are now ready to earn the title of 'gofer', but first we need to look at the electrical ***schematic*** plan of the house and estimate the amount and size of wire that will be needed for the job."

"I'm ready!" was Edward's enthusiastic response.

Mr. Estrada explained, "Wire is made in two major types—solid and stranded. ***Stranded wire*** is more flexible than solid wire; therefore, stranded wire works better in tight places. Solid wire is more ***rigid*** and works better where several wires have to be pushed through a hole or when wires are connected to terminals, for instance."

Edward continued to listen to his father's instructions: "Wire is sized by *gauge*; the larger the number, the smaller the wire. Common, small-stranded wire sizes are numbers 18 and 16. These wires are used for individual appliances and light-duty extension cords. Large-stranded wire sizes are used as leads into ***service entrance panels*** and for connectors to heavy-duty appliances, such as air conditioners. The two most common types of solid wire used in homes are numbers 14 and 12. The number 12 solid wire is the most popular size wire for residential wiring. It generally is used for room to room wiring inside the home."

Mr. Estrada continued, "The insulated coating of the wires helps determine what wire to use. The NEC has designated a standard insulation color for each conductor function. A black wire, for example, should always be the ***'hot'*** or ***positive*** side of the circuit. A red wire also indicates 'hot' or positive. If you see a black wire and a red wire in the same cable, you know that the circuit has two 'hot' wires and,



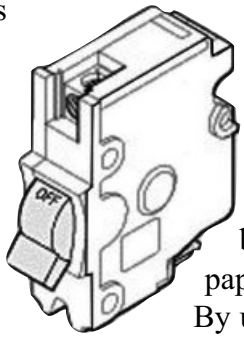
VOCABULARY

Schematic: a structural diagram, especially of an electrical system
Stranded wire: several wires enclosed in a rubber covering to form one wire
Rigid: not flexible; stiff
Service entrance panel: a metal, wall mounted case that contains circuit breakers (including the main breaker); also called *circuit breaker box* or *panel*
'Hot': an electrical wire that has electrical current flowing
Positive: the side of an electrical circuit that carries electrical current
Ground wires: neutral wires that at some point in a building or circuit are tied to a metal rod driven into the ground for the purpose of preventing shocks; discharge voltage buildup into the ground.
Sheath: a close fitting case for something (for example, electric wires)

therefore, must be a 240-volt circuit. A white wire is always neutral (not 'hot')."

"Wait! I'm getting confused!" Edward complained.

Mr. Estrada continued, "Green, yellow, and bare copper are always *neutral* or ***ground wires***. While these color designations are excellent indicators, don't trust your life to them! Protect yourself by testing each circuit on which you wish to work with an ammeter or other voltage tester before starting. Then, make sure that the circuit is 'open' by checking the circuit breakers and making sure that the current with which you are working is turned off."



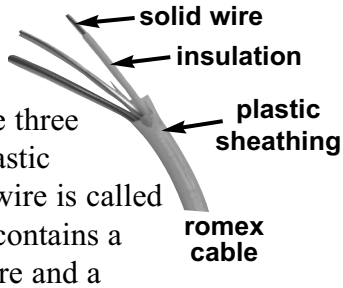
circuit breaker

"I'll try to remember your advice, Dad," said Edward.

"O.K., Son. Now, go unload the two boxes of wire from the truck."

As he grabbed both boxes and lifted them out of the back of the truck, Edward commented, "Boy! These are heavy!"

His dad laughed and said, "They should be heavy because the wire is made mostly of metal. The metal most often used in wiring is copper because it is an excellent conductor of electricity.



You will find that both boxes contain rolls of wire that have three wires covered in a plastic ***sheath***. This type of wire is called *romex* and generally contains a black wire, a white wire and a paper wrapped, bare, copper ground wire. By using all three wires in the same sheath, electricians can easily run common household wire (a hot, a neutral, and a ground) all at one time. Now carry the two rolls of wire into the garage. Then we'll lay out the junction and outlet boxes."

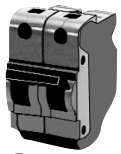
As Edward carried the wire into the garage, his mind was reeling from all of the information he had been given about the two rolls of wire that he was carrying. *What a big responsibility an electrician has!* he thought.

LIFE PRINCIPLE



"Learn by experience— preferably other people's."

—Anonymous



Electrical

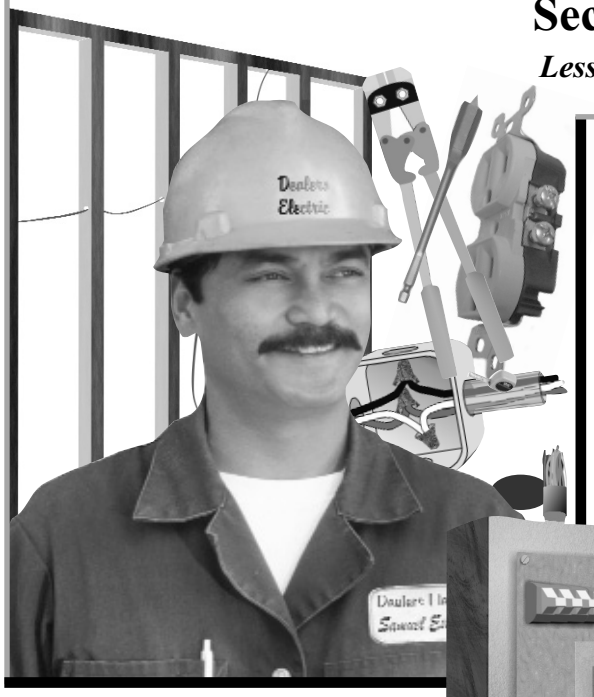
Lesson 6

Chapter 4

FINDING THE POWER

Section 2

Lessons 6-10



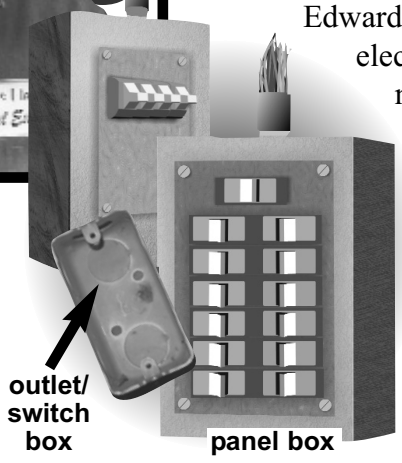
After Edward had carried the romex cable into the garage, Mr. Estrada said, "Now we need to do a walk through of the structure to determine where the wiring is to be installed. We'll follow the ***blueprint*** schematic to figure out where the ***junction boxes*** need to be placed. We'll also mark the location points for the ***outlet/switch boxes*** that need to be installed."



junction box

Edward remarked, "We talked briefly about electrical circuits earlier. My question now is, how are circuits designed, and how do we know that the circuit will be adequate for present and future electrical needs?"

Mr. Estrada replied, "As we discussed earlier, a circuit is a flow of electricity that starts at the power source or panel and continues through appliances and comes back to the source in a continuous pattern. On a practical level, think of a circuit not as a flow of electrons but as wires that carry electrical flow. Electricians have to visualize wires threaded through walls to carry electricity to lights and appliances. We'll be using the romex cable that you carried into the garage when we first arrived."



outlet/ switch box

panel box

Following his dad's instructions, Edward went to the truck and unloaded the electrical supply box marked *60 amp. subpanel.* He then carried it into the garage, and proceeded to find the installation point according to the blueprint. The ***subpanel box*** was large enough to supply present electrical needs and would allow for future expansion in the event the home owner wanted to add more outlets. Edward had brought a claw hammer and nails from the truck, as well as a 25-foot tape measure. Mr. Estrada marked the



claw hammer

tape measure

VOCABULARY

Blueprint: a photographic print of building plans, usually blue and white colored; a detailed plan

Junction boxes: devices where wires are pulled to an area (such as a room) and other wires are attached or joined together

Outlet/switch boxes: hold wire connections for light switches/ receptacles in the walls

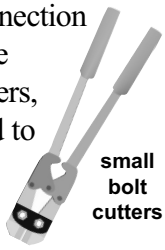
Subpanel box: (or subpanel) a junior-sized circuit breaker box

Nonmetallic composition: not made of metal

Plastic: a chemical material that is rigid and strong which replaces metal in many situations

2” x 4” stud framing at a height of 4 ft. 6 in. and instructed Edward to nail the subpanel box to the 2” x 4” stud, placing the bottom of the box by the proper mark. Edward then hammered nails through the designated openings in the side of the box into the stud and secured the box to the wall.

At that point, Mr. Estrada said, “Look inside the box and determine where the wires should be attached. We’ll start by running the heavy #6 cable between the service entrance panel and the subpanel. We’ll run the wires to the subpanel first, but not make a connection now at the service entrance panel. The subpanel is designed for circuit breakers, rather than fuses. Now, Son, you need to go to the truck and get 25 feet of #6 gauge red, black, white and green wire. You also need to bring the small bolt cutters to cut the heavy gauge wire.”



small bolt cutters



plastic conduit

While Edward was gone to the truck, Mr. Estrada installed some rigid plastic *conduit* from the service entrance panel to the subpanel. When Edward arrived with the wires, he cut them and handed them to his dad, who taped them together and pushed them through the rigid conduit he had just put in place. The red and black wires were then attached with screws to the breaker bar, and the white and green wires were screwed to the neutral bar (also called a “bus” bar), inside the subpanel. This assured the correct connection to the subpanel.

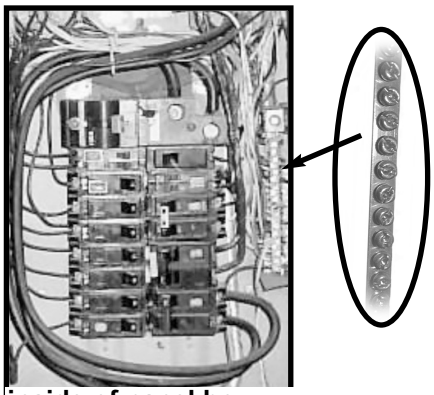
After the wiring of the panel box was accomplished, Mr. Estrada said, “Okay, son, now we need 14 outlet boxes and 3 fixture boxes.” He paused to explain, “When you go out to the truck, you will notice three types of outlet boxes—metal, ***nonmetallic composition*** material, and ***plastic***. Some cities require all wiring to be installed through metal conduit and metal boxes. Plastic boxes are substantially less expensive than metal or nonmetallic boxes, and, in our community, they are approved for houses. When using plastic boxes, the ground wires must be tied together to carry the grounding effect to an outside grounding device.”



outlet/ switch box

Once at the truck, Edward soon found the proper boxes and brought them to his dad. Edward quipped, “After making so many trips out to the truck and back, I think I’m beginning to come to a better understanding of the term ‘gofer’!”

Mr. Estrada laughed and complimented Edward. “You’re developing into a really good ‘gofer’ at that, Son!”



neutral “bus” bar

inside of panel box after wiring is complete

LIFE PRINCIPLE



“Habits are like electric wires; they transport our character.”

—Anonymous



Electrical

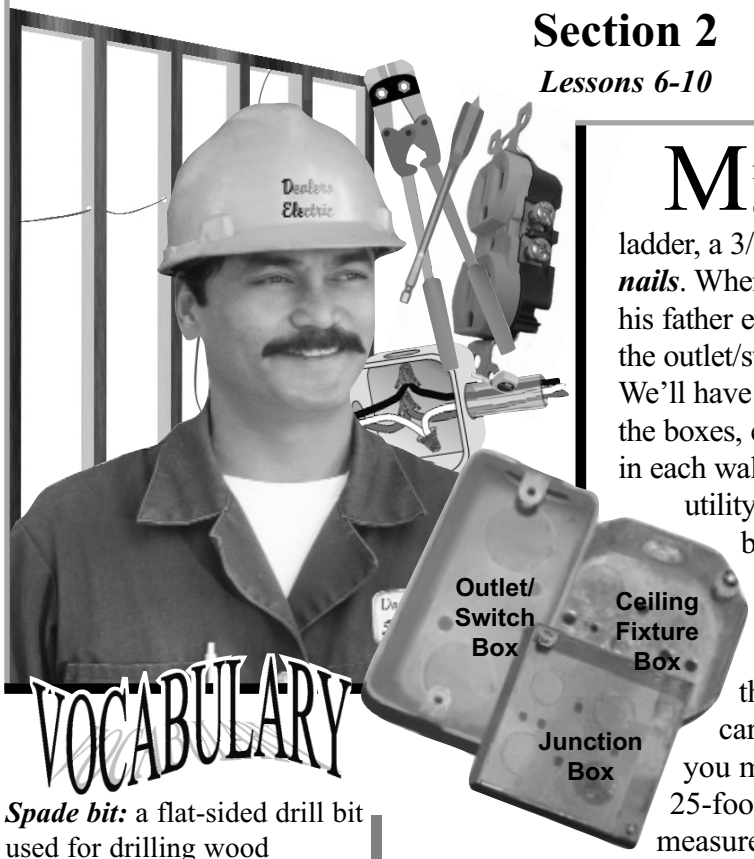
Lesson 7

Chapter 4

BOX INSTALLATION

Section 2

Lessons 6-10



Mr. Estrada sent Edward to get a 3/8-inch chuck cordless drill, an 8 foot step ladder, a 3/4 inch ***spade bit***, and more number ***8d nails***. When Edward arrived with all of these items, his father explained, "Now it is time to install the outlet/switch boxes, and ***fixture boxes***. We'll have to measure and mark the position of the boxes, exactly. Two outlet boxes will be installed in each wall of the new garage. Additionally, inside the utility room, each long wall will get two outlet boxes, and the short wall will get one outlet. The garage will receive two switch boxes, and the utility room will get one."



spade bit

At that point, Mr. Estrada picked up the measuring tape and handed a carpenter's pencil to Edward. "I'll measure; you mark," he told his son. Mr. Estrada used the 25-foot tape to measure one of the walls. He measured up from the floor one foot and told Edward to mark the place for the outlet to be installed. The two men went around the entire garage and utility room measuring and marking the places where the other outlet boxes would be installed.

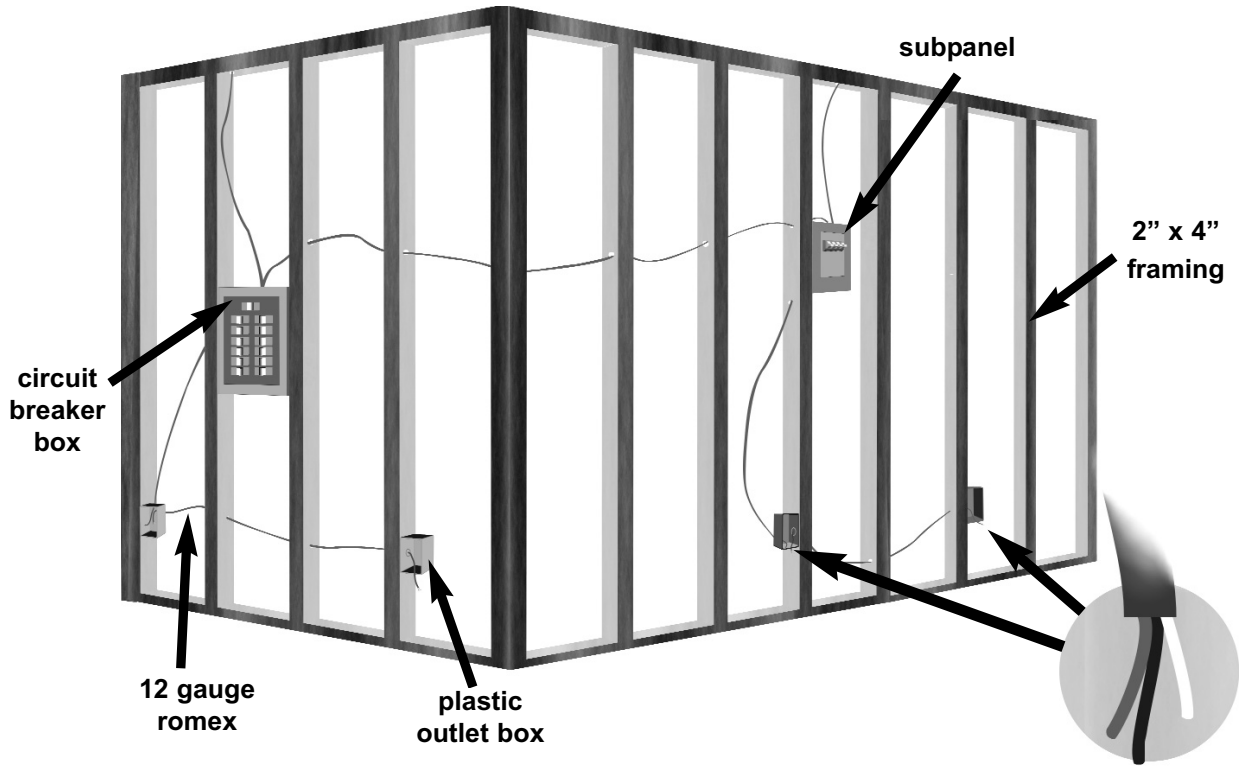
Next, Edward set up the stepladder in the center of the garage. He watched intently as his dad climbed up on the ladder and installed a ceiling fixture box in the center of the room. The box was positioned $\frac{1}{2}$ inch below a 2" x 4" ***joist*** so that the ***Sheetrock™*** panels could be installed later, and the fixture would be ***flush*** with the Sheetrock. Edward then carried the stepladder into the utility room.

Mr. Estrada grinned and said, "Now, it's your turn to install the ceiling fixture box in this room!" Edward went up the ladder and installed the fixture as his dad called out instructions from below. "You did a good job on that, Edward! Now, we'll see what we can do about installing the wall outlets," said Mr. Estrada.

The two men took a water break out at the truck. Then, Mr. Estrada handed Edward a small piece of $\frac{1}{2}$-inch plywood and said, "This will help us get the installation of the outlet boxes at the right ***dimension***."

VOCABULARY

Spade bit: a flat-sided drill bit used for drilling wood
8d nails: a nail approximately two inches in length
Fixture boxes: boxes for holding wire connections
Joist: wooden or metal beams for supporting a ceiling
Sheetrock: a material made of gypsum and covered in paper, used as an interior wallboard
Flush: two or more things arranged to form a continuous, even surface.
Dimension: a certain length measured from point to point
Faceplates: plastic coverings for light switches and outlets to improve appearance and promote safety.
Function: to work properly



The father handed his son another hammer from the truck as they went back into the garage to begin installing the plastic outlet boxes. The outlet boxes were placed at the one-foot height that had been marked earlier. Edward and his father used pieces of $\frac{1}{2}$ inch plywood to install the boxes so that they extended $\frac{1}{2}$ inch from the 2" x 4" framing studs. This was necessary so that when the Sheetrock was installed, the outlet boxes would be flush with the surface of the Sheetrock and allow the ***face plates*** to fit properly.


face plate

Mr. Estrada then told Edward, "Get the cordless drill and install the $\frac{3}{4}$ inch spade bit. We will drill holes in the 2" x 4" studs so that the number 12 gauge romex wire (cable) can be run to each outlet box and fixture box." Mr. Estrada walked throughout the structure and marked places where holes for wires were to be drilled. Edward followed, drilling holes in the proper locations. Then Mr. Estrada announced, "Now, we'll run the romex cable to the outlet boxes. Each wall will be placed on a separate circuit because these receptacles might carry a heavier electrical load than the normal household electrical outlets. These outlets might be used for air compressors, battery chargers, welders, freezers, or refrigerators. All of those appliances require more amperes to ***function***, thus these electric boxes must be able to handle a large amount of amperage."

The romex cable was pulled from the subpanel box to the individual outlets in the walls and fixtures in the ceiling.

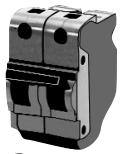
Presently, his dad said, "That'll do for this morning. Let's take a lunch break. When we come back, we should be able to complete this job in a few hours."

LIFE PRINCIPLE



"He who has learned to obey will know how to command."

—Greek Axiom



Electrical

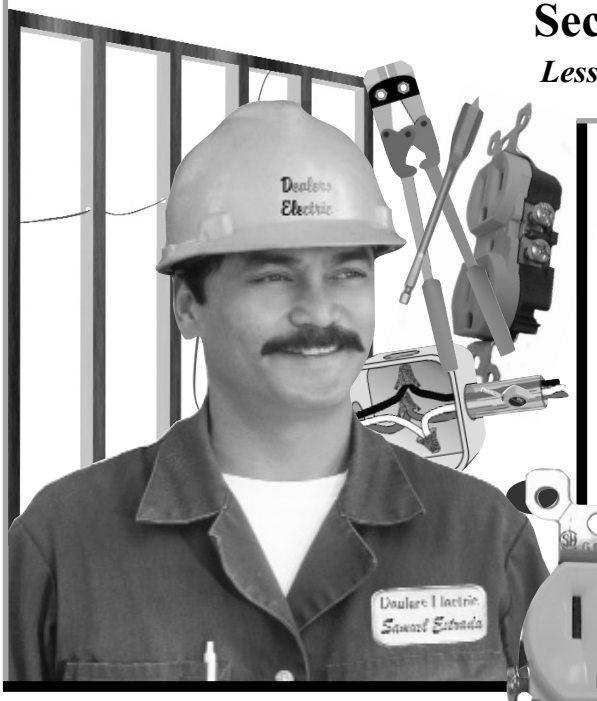
Lesson 8

Chapter 4

GETTING PLUGGED IN

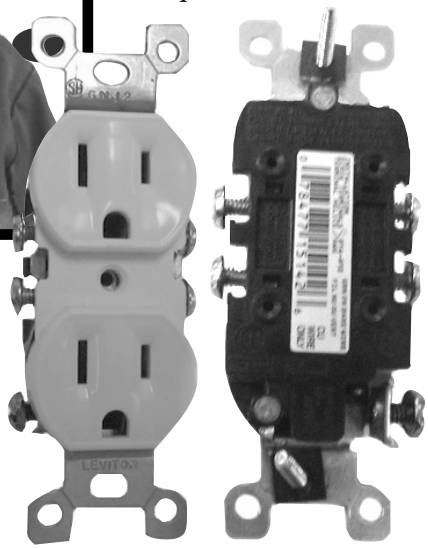
Section 2

Lessons 6-10



After the outlet boxes were installed, Edward began to wonder how to wire the actual outlet plugs. Mr. Estrada pulled an outlet from his pocket and said, "This is called a *receptacle*. Come over here so you can study its details. Receptacles are stamped with a variety of symbols that should be checked to be sure that the receptacle meets the requirements for each job."

Mr. Estrada explained that stamped on each receptacle should be the ampere rating and voltage rating, as well as the name of the laboratory where each receptacle was tested and approved. The ***mounting yoke*** may also indicate the type of wire each receptacle is approved to carry.



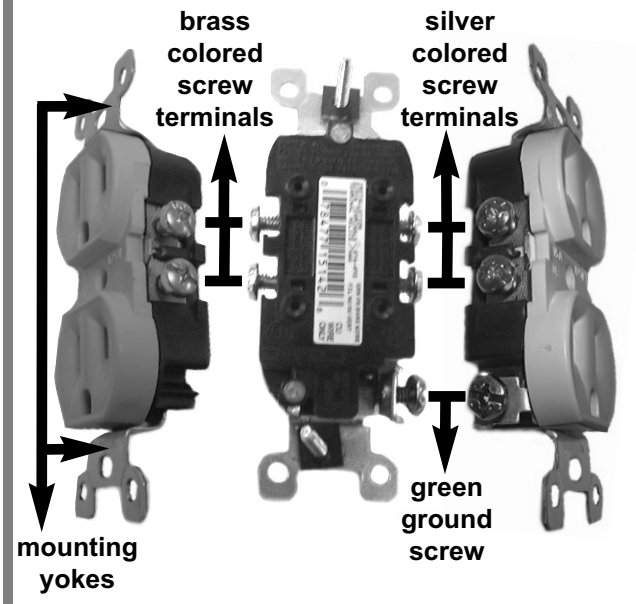
receptacle (front and back)

Mr. Estrada further explained, "Another, more accurate name for this type of receptacle would be a *duplex grounded outlet* receptacle. This name tells us that the receptacle has two outlets, and each outlet includes a ground wire outlet. When you look at the front of the receptacle, you will see two outlets with two long slots and one semi-round slot, making a total of six openings in each receptacle. When you look at the front of a grounded duplex outlet receptacle with the ground outlets at the bottom, the two bar slots on the left side of the receptacle will be longer than the ones on the right side. The receptacle is made this way so the ***polarized*** electrical devices can only be plugged into the receptacle one way. This is a safety feature that protects the flow of the electrical current, especially in ***motorized*** equipment. Of course, the ground outlet allows electricity to go to a grounding source, in the event a

VOCABULARY

Mounting Yoke: metal piece on both top and bottom of receptacle; used for securing receptacle to outlet box
Polarized: attraction of electricity toward a particular object or specific direction
Motorized: using electric current to convert electric power into rotational power
Terminals: places of connection
Clockwise: the direction in which the hands on a clock move
Capabilities: features or facilities that can be developed
Initially: at the beginning; first
Versatility: changing easily from one thing to another

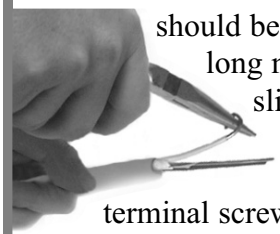
short circuit occurs. This helps prevent electrical shock—assuming the ground receptacle is installed properly and grounded to an outside source."



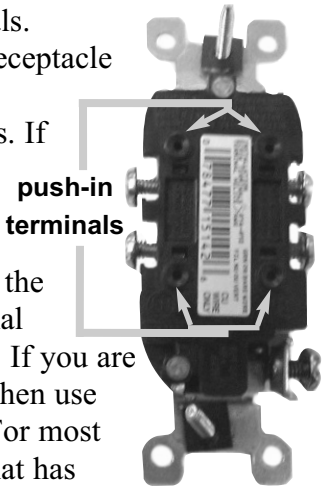
Turning over the receptacle, Mr. Estrada explained, "When the receptacle is flipped over and examined from the back, you will observe four screws located on each side of the receptacle. Upon closer examination, you will discover that one set of screws is brass colored, and the other set of screws is silver colored. Furthermore, a green ground screw is located at the bottom of the receptacle. The rule for attaching wires to the side screw ***terminals*** is that, black, or 'hot' wires are attached to the brass-colored screws, and the white or neutral wires are attached to the silver terminals. The bare or green ground wire is attached to the green screw terminal."

"Black or 'hot' wires go to the brass; white or neutral wires go to silver," repeated Edward.

Mr. Estrada paused to say, "That's correct." Then he continued, "The wires should be bent, with the aid of long nose pliers, into loops that slip around the terminal screws, with the loop going around the terminal screw in the direction for tightening the screws (***clockwise***). This type of connector may also be referred to as *side wired* with screw terminals.



Another type of receptacle is a *back wired* one and features push-in terminals. If you are working with wire that already has been shaped to fit under the terminal screws, then the side-wired type of terminal would be the best choice. If you are working with new wire, then use back-wired receptacles. For most occasions, a receptacle that has both side wire and back wire ***capabilities*** would be ideal for all wiring jobs."



When his dad paused, Edward questioned, "So what is the receptacle of choice for Dealers Electric?"

"That would be a polarized, duplex grounded receptacle with side-wire and back-wire features," responded Mr. Estrada. "Even though that type of receptacle costs a little more money ***initially***, the extra expense is offset by safety and ***versatility***."

Mr. Estrada pulled his long-nose pliers from his belt and broke the connecting bar on each side of the receptacle. He then said, "This action makes each outlet separate from the other and requires that they be wired independently. This simple action allows more uses of the receptacle."

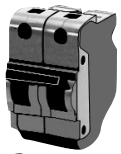
Edward commented, "I've observed receptacles all of my life, but I had no idea they played such an important role!"

Mr. Estrada laughed, "We've only *talked* about the selection and operation of receptacles. The installation is still ahead."

LIFE PRINCIPLE

"Conquer yourself rather than the world." —Descartes





Electrical

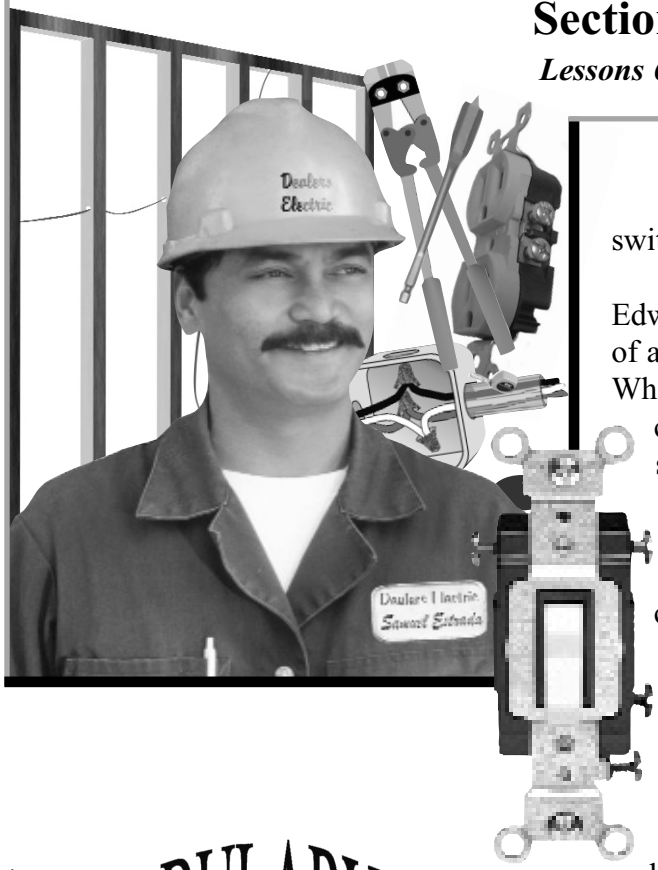
Lesson 9

Chapter 4

SELECTING SWITCHES

Section 2

Lessons 6-10



Ever eager to learn, Edward asked his dad, "I know how to turn on a light with a wall switch, but exactly what is the function of a switch?"

Mr. Estrada responded with a question to Edward, "Do you remember that the simple function of a switch is to break the electrical current flow? When the switch is installed properly, it will be connected to the black or 'hot' wire. When the switch is turned off, the current flow stops at the open switch, and the rest of the electrical circuit controlled by the switch is not ***electrified***. When the switch is in a closed position, the circuit is completed, and the electrical current flows according to demand in order to operate appliances, lights, or tools."

Mr. Estrada picked up four switches as he said, "These switches represent the four basic types used in residential wiring."

As Edward moved in for a closer inspection, his dad continued his explanation. "The most basic and most frequently used switch is the *single-pole* switch. It is used to open or close a simple, two-wire circuit. It can be identified by the fact that it has two terminal screws and the words 'On' and 'Off' marked on the ***toggle*** of the switch.

The next most commonly used switch is the *three-way* switch, which is most often used to provide two switching locations for a single overhead light. These switches have three screw terminals, and the toggle will not be marked.

A third commonly used household switch is the *four-way* switch. It allows control of an appliance from three or more locations. This switch has four terminals and an unmarked toggle. The last type is the *double-pole* switch. Double-pole switches can handle two 'hot' wires, and are, therefore, commonly used to switch 240-volt outlets and appliances. Like single-pole switches, double-pole have 'On' and 'Off' toggle ***designations***."

3-way switch



4-way switch



VOCABULARY

Electrified: having electric current flowing through it

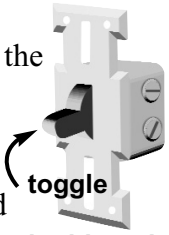
Toggle: the "handle" of the switch by which the switch is turned on or off

Designations: having to do with, indicating or specifying certain functions of a thing

Aluminum-clad (wires): non-aluminum wires, that have been electroplated or otherwise only coated with aluminum

Dimmer: a device for regulating the intensity of an electric lighting unit

Mr. Estrada handed Edward the single-pole switch, and said, "Now, let's take a look at each switch just as we looked at each receptacle. A great deal of information is stamped into the metal yoke and plastic body of a switch. You will see the amperage rating, the voltage rating, the approved wire type, the testing laboratory's approval, and the type of current approved. Newer models also include a gauge to indicate how much wire to strip from the conductors. If you make a mistake pushing the wires into the push-in terminals, the release slot is even marked so you can pull the wires back out without damaging the switch. Carefully read the information on the switch you are about to install to make sure it is the proper switch. Probably the most important designations on new switches are the UL approval stamp and the CO/ARL rating. The UL listing is your assurance of quality, and the CO/ARL rating tells you that this particular switch can be used safely with aluminum, ***aluminum-clad***, or copper wires."



double-pole switch

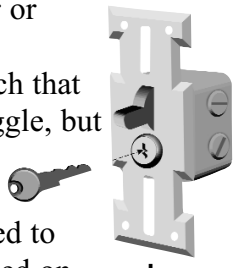
Edward stated, "I'll be sure to read the information on the switches carefully."

Mr. Estrada went back to a storage bin on the truck and brought out other types of switches. He commented, "I brought all of these switches along to show you the varied applications of different switches."


dimmer switch

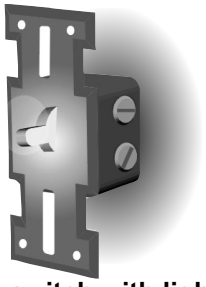
Mr. Estrada held up a switch that had a round knob on it and said, "This is a ***dimmer*** switch, which is used to adjust the amount of standard lighting. It makes the light shine brighter or dimmer."

The next switch that he held up had an On/Off toggle, but it was operated by a key. Edward learned that this particular switch was designed to prevent the circuit being turned on or off without the key.


key switch

Mr. Estrada displayed another switch that looked like a regular switch. He handed it to Edward and said, "I want you to find out what makes this switch special."

Edward looked at it closely and then exclaimed, "I can see a small light behind the clear toggle switch!"


switch with light that stays on

Mr. Estrada smiled and said, "You have found the secret. The light stays on all the time, allowing this switch to be seen in dark places."

The next switch was held up for Edward to study. He proudly informed his dad, "I recognize that type of switch! It's a *time-delay* switch and is designed to allow time for current flow after the switch is turned off. Such switches allow lights or alarms to remain on while a person exits."


time-delay switch

"That's right, Son," Mr. Estrada complimented. Then he said, "I have only two switches remaining. This is a *time clock* switch that can be set to come on or off at programmed intervals, and this last one has a built-in light that lights up only when the switch is on to indicate that it is on."



time clock switch


switch that lights up when on

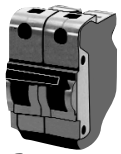
"Wow! I'm amazed at all the different types of switches that are available," exclaimed Edward. "I have a lot to learn about being an electrician! I'm beginning to understand why training covers such a long time period."

LIFE PRINCIPLE



"Success is knowing the difference between 'cornering' people and getting them in your corner."

—Bill Copeland



Electrical

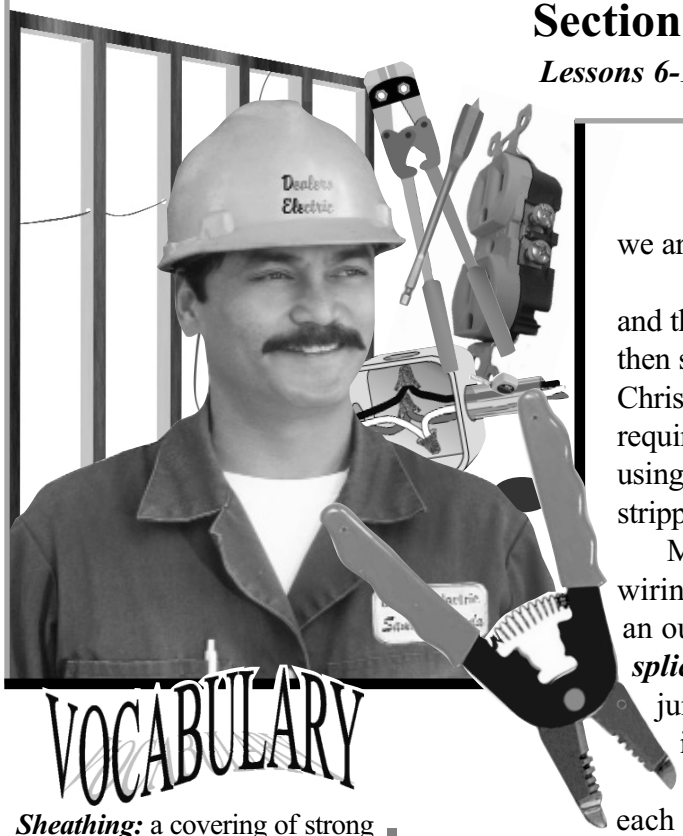
Lesson 10

Chapter 4

CUTTING, STRIPPING AND SPLICING WIRE

Section 2

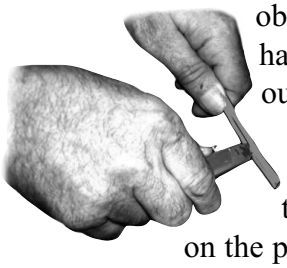
Lessons 6-10



Mr. Estrada instructed Edward by saying, "Strap on your electrician's belt because we are finally going to do some actual wiring!"

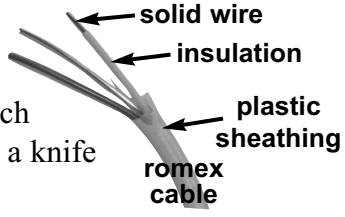
Edward complied with his father's instruction, and the two men entered the work area. Mr. Estrada then said, "Get that pocket knife I gave you for Christmas. The initial electrical wiring really doesn't require a lot of fancy tools; it can be done either by using a sharp pocket knife like yours, a ***sheathing*** stripper, long-nose pliers, or wire crimper/strippers."

Mr. Estrada continued to explain, "In residential wiring, every wire connection must be made within an outlet box. For safety reasons, you should never ***splice*** two wires together outside of an outlet or junction box. When we pulled the romex cable into the outlet boxes, I made sure that at least six inches of electrical wire was sticking out of each box." Edward looked around the room and observed that all of the outlet boxes did, indeed, have at least six inches of romex cable sticking out of them.



Mr. Estrada selected one of the outlet boxes and asked for Edward's knife. Placing the blade of the knife about three inches up on the plastic sheathing of the cable, Edward's dad cut along the middle of one side and commented, "Always cut away from yourself with a knife in order to avoid being cut. Place the wire to be cut against a solid surface and draw the knife through the plastic material. Make the cut shallow to avoid nicking the wires. Pull the split sheathing back from the wires and cut off the unneeded sheathing."

Next, Mr. Estrada used his wire crimper/stripper tool and ***stripped*** approximately $\frac{1}{2}$ inch of ***insulation*** from each insulated wire. Edward asked, "Can you use a knife for that job?"



VOCABULARY

Sheathing: a covering of strong material for protection of wires
Splice: to bind together, join or unite two things in order to lengthen or strengthen each part
Stripped: removed the outside cover (sheathing) of wires
Insulation: a protective covering
Routine: done or happening regularly
Resistance: flow of electrons is slowed down by a blockage or breakage of flow
Plastic connector: a covering for wire connections; also called solderless connectors and wire nuts
Mentor: an older, experienced person who teaches a younger person

"A knife could be used, but a multi-purpose tool works better," Mr. Estrada replied. He continued, "It is very important not to cut into the copper wire, as this would make the wire weak. Also, it would cause the wire to heat up at that point and could possibly result in a fire.

In using the crimper/stripper tool, place the wire in the properly numbered gauge slot in the handle of the tool; then squeeze, twist, and pull. If you have the wire in the right hole, the insulation will strip right off. Okay, son, work with the six inches of wire outside the box," instructed Mr. Estrada.

Under the watchful eye of his dad, Edward proceeded from one outlet box to another with his tools and stripped the sheathing away from all of the cut wires. He then used his crimper/strippers to strip away $\frac{1}{2}$ inch length of insulation from each wire. Edward noticed this process took him considerably more time to complete than it did for his dad. Edward realized that all of the years his dad had done this ***routine*** job naturally made him speedier and more efficient.

When Edward completed the job, his dad said, "Now, I'll show you how to make a good connection. Wire connections must be made properly. They must be very tight, because loose connections create electric ***resistance***, which, in turn, causes heat. Hot connections trip breakers. If connections spark, they can cause fires."

Mr. Estrada continued, "To join two solid wires, you should strip $\frac{1}{2}$ inch from each wire and twist them together with lineman's pliers in a clockwise direction. Then, select a ***plastic connector*** large enough to slide over the twisted wires about half way. Insert the twisted wires into the connector, and turn it until the wire is drawn in, and the connector no longer turns."



plastic connectors

Mr. Estrada added, "The more wires you join, the larger the connector you will need. Sizes are determined by color. Larger connectors are gray or red, and some others are orange, green, and yellow. Make sure that no wire shows outside the connector. It is easier to join all corresponding wires out of the box where you can work unencumbered. Finally, carefully fold them into the outlet box when finished."

Edward watched closely as his dad demonstrated this skill. Edward was glad to have such a skilled and patient ***mentor***.

LIFE PRINCIPLE



"A man of character is like a light switch; he controls what flows through his mind."

—Ron Johnson



Electrical

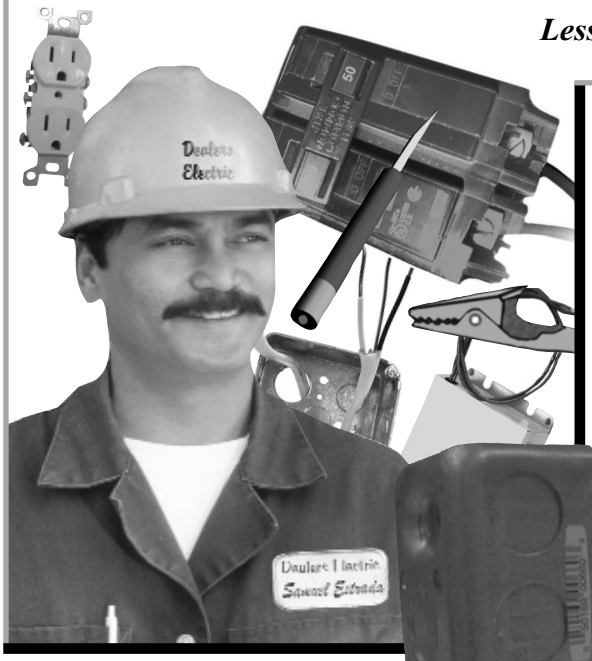
Lesson 11

Chapter 4

INSTALLING RECEPTACLES

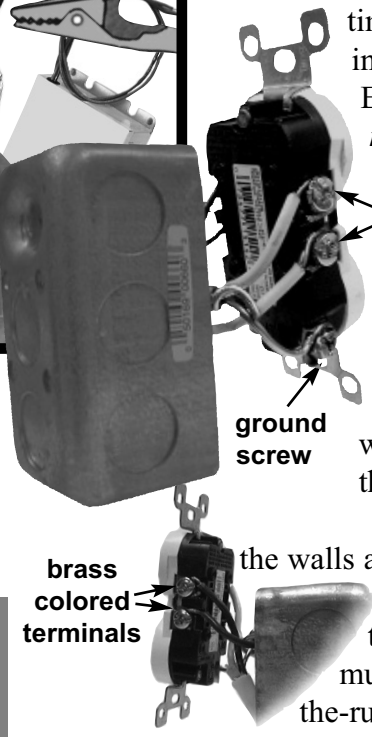
Section

Lessons 11-15



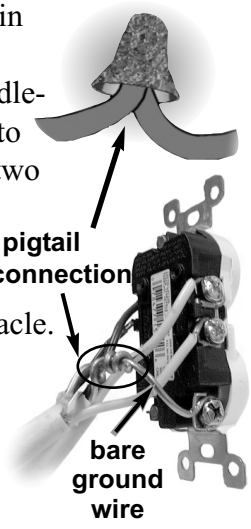
Edward remarked to his dad, "Do you think we'll be able to install all of those receptacles today? It looks like alot of work for one day."

Mr. Estrada laughed and said, "Well, as a matter of fact, I was just thinking that now is the time for that particular job." As they stood in the center of the garage addition, Mr. Estrada pointed out, "Two basic wiring ***methods*** are used for receptacles. The method used in wiring the circuit will depend upon where the receptacle is located in the circuit. If the receptacle is in the middle of the circuit, use a *middle-of-the-run* wiring method. On the other hand, if you are wiring the last receptacle on a circuit, use the *end-of-the-run* method."



Mr. Estrada walked over to one of the walls and continued, "A middle-of-the-run receptacle must pass electricity along to the other receptacles in a circuit, and it must be wired accordingly. A middle-of-the-run outlet box will contain two romex cables with six wires: two black, two white, and two bare ground-wires. To wire a middle-of-the-run receptacle, attach the two black wires to the two brass colored terminals. Then attach the two white wires to the two silver colored terminals.

To ground a receptacle in a metal box, make a ***pigtail connection*** between the bare ground wires and the ground screw on the receptacle. Then attach another pigtail to the box with a ***machine screw***. If you are installing a receptacle in a nonmetallic box, simply attach the ground wires to the receptacle ground."



VOCABULARY

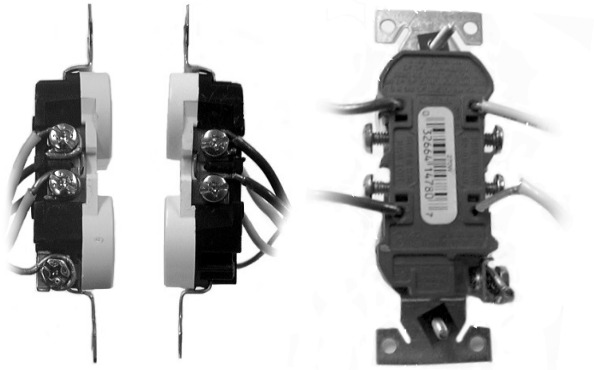
Methods: orderly procedures for doing something
Pigtail connection: a connection of wire made by twisting the wires in a clockwise direction that resembles a pig's tail
Machine screw: a screw designed for thin metal applications
Perimeter: the outside edge of something
Probe: a device used to stick into an opening
Alligator clip: a fastener with "teeth" in the clip that resembles an alligator's mouth
Continuity: uninterrupted flow or connection

While his dad spoke, Edward watched intently and scribbled notes for later study. "I think I've got that," he said as he scrawled this last piece of information.

"Good!" Mr. Estrada said; then he continued, "On each end-of-the-run connection, you must install an end-of-the-run receptacle. The end-of-the-run receptacle needs to be wired so that the circuit is completed across its own terminals. To wire an end-of-the-run receptacle, simply attach the single black wire to the brass terminal and the single white wire to the silver terminal. Then use a pigtail from the incoming ground wire to the ground screw on the receptacle and to the metal box. If you are working with a nonmetallic box, attach the ground wire directly to the receptacle ground screw."

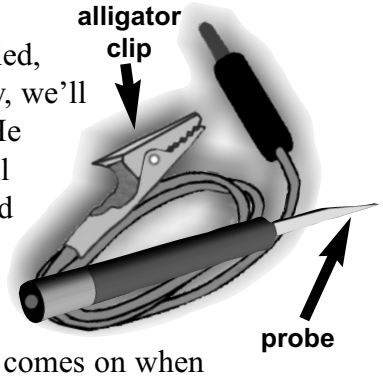
Edward remembered that the two methods of connection on the receptacle were screw-in type and push-in type. Dealers Electric preferred the push-in type.

screw-in type **push-in type**



Mr. Estrada followed Edward around the ***perimeter*** of the room while he attached the wires to the receptacles. Mr. Estrada wanted to make sure that his son plugged the wires into the terminals securely and that he did not attach black wires to silver colored terminals or white wires to brass colored terminals. Such a connection would affect the polarity of the wires. Loose connections also had to be avoided because they would cause heating and loss of voltage at the point of the loose connection, possibly resulting in a fire.

After all of the receptacles were installed, Mr. Estrada said, "Now, we'll test each receptacle." He showed Edward a small device with a ***probe*** and ***alligator clip*** attachments. He said, "This device is battery powered. A small light comes on when the circuit is completed and is designed to test the ***continuity*** of an electrical circuit without actually connecting electrical power. That is why it is called a *continuity* tester, and it must be used only when the current is turned off. This factor makes it ideal for testing new wiring connections. The continuity tester works on the principle that by completing a circuit between the probe and the alligator clip, the light is turned on in the tester."



Each receptacle passed the continuity test. Edward was proud that his worked was proven to have integrity and all of his connections were ready for the power to be turned on. Mr. Estrada congratulated Edward on his first wiring job and reminded him, "We still have more circuits to wire before the electric current can be connected and turned on to the entire system."

LIFE PRINCIPLE



"A teacher affects eternity; he can never tell where his influence stops."

—Henry Adams



Electrical

Lesson 12

Chapter 4

INSTALLING SWITCHES

Section

Lessons 11-15



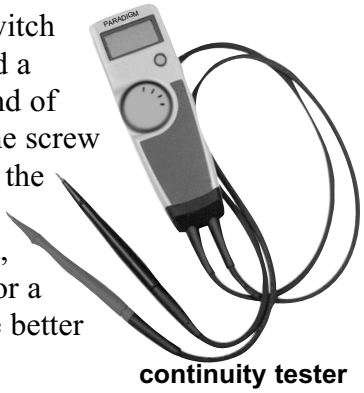
Mr. Estrada told Edward to get three, single-pole switches from the side panel of the truck. Edward remembered to identify a single-pole switch by the brass colored screw terminals and a toggle marked with an 'On' and 'Off' designation.

When Edward returned, he examined the switch box located four feet from the floor. He noted it had two romex cables and a total of six wires. He said, "Let's see if I remember this process correctly. If a switch is located on the hot wire, both black wires will go under the brass colored switch terminal screws. One of these black wires will be wired hot as an incoming wire, and the other black wire will be 'hot' when the switch is in the 'On' position. The two white wires will be pigtailed together, giving the circuit a solid neutral wire back to the source. Then the ground wires will be pigtailed together."



Edward turned to his dad and asked, "Would it be all right to attach the wires around the screw terminals?"

Edward's dad agreed to this process because both men believed that it would be easier to see the black-to-brass connection necessary for a proper switch connection. Edward used his pliers to bend a wire into a hook or loop on the stripped end of one black wire, then placed the hook on the screw so that the clockwise motion of tightening the screw would not make the wire come out from under the screw. Edward commented, "The wire is difficult to bend into a hoop or a loop, but I think with practice, I'll become better and faster."



continuity tester

VOCABULARY

Fluorescent light: a tube-style electric light bulb, coated on the inside with fluorescent material; contains mercury vapor that is bombarded by electrons to emit light

Tabs: an extension of something

Scored: to mark with lines, grooves, scratches, or notches

Code: a system used to represent assigned meanings

Mr. Estrada agreed and said, "That's right." Then he said, "Now we will test the switches. We will use the continuity tester just as we did with the receptacles.

First, Mr. Estrada demonstrated how to fold the six inches of wires into the outlet box so the switches and receptacles would fit flat in the boxes. Because the connections had been checked by the continuity tester, Mr. Estrada began to attach the switches and receptacles to the outlet boxes. He selected a flat-head screwdriver from his tool belt and positioned the two small screws located on the switch. He placed these screws in some small holes located in the body of the outlet box. He then turned the screws in a clockwise direction and tightened them, securing the mounting yoke to the outlet box.

Next, Mr. Estrada instructed Edward to check to see if one of the romex cables from the switch outlet box went to the ceiling fixture box in the garage and the utility room. Edward found that it did. He said, "This is the wire to which we attach the light fixture."

Mr. Estrada informed Edward that the plans called for a ceiling receptacle to be placed in the ceiling fixture box. This receptacle was to be wired as a *split receptacle,* which meant that one of the receptacles would be hot all of the time, and the other receptacle would be wired to the light. The purpose of the split receptacle in the ceiling was that a hot source would be available for a garage door opener and that a ***fluorescent light*** could be plugged into the switch side of the receptacle. This would allow the fluorescent light fixture to be suspended from the ceiling with chains giving a choice of heights.

Mr. Estrada said, "To split a receptacle so that half of it is hot, full time, and the other half is switch-controlled, start by looking closely at the receptacle. As you hold the receptacle with the sockets facing you, you will see that the terminals on both sides are tied together with metal strips. You will also see that the strips have metal ***tabs*** that are ***scored*** part way through. These metal strips join both halves of the receptacles, which allows you to wire to only one terminal on each side and still have power to both sockets."

Edward's dad continued, "In the case of a split receptacle, you will no longer want the top and bottom sockets tied together on the hot side. To separate the top and bottom sockets, use long-nosed pliers and break the tab off from the metal strip on the 'hot' side only. Do not break the tab on the neutral side." Mr. Estrada demonstrated as he spoke. "To wire a split receptacle to a switch, bring your three-wire romex cable from the power source to the receptacle box, then continue to the switch box. Connect the incoming white wire to the silver terminal of the split receptacle. After that, connect the outgoing white wire to a brass terminal. In this case, the white wire will be the 'hot' wire of the switch loop. This is one of those exceptions on the wire colors we talked about earlier."

Mr. Estrada paused, then said, "To keep from becoming confused, ***code*** the white wire with a piece of black tape. Then tie all the black wires together, and pigtail them over to the remaining brass terminal. To connect the switch, all you will have to do is tie the black wire to one terminal and the white, hot wire to the other terminal. Then tie all of the ground wires together, using a pigtail connection."

"That's a bunch of information you've given me, Dad!" exclaimed Edward.

Mr. Estrada replied, "You're right, son, but don't worry about it. I'll show you how, step by step. Then we will be ready to start preparing for the actual lighting part of this electrical job!"

LIFE PRINCIPLE



"Set worthy goals—which you may fail to reach the 1st time—but keep reaching until you succeed."

—Kermit Northcutt



Electrical

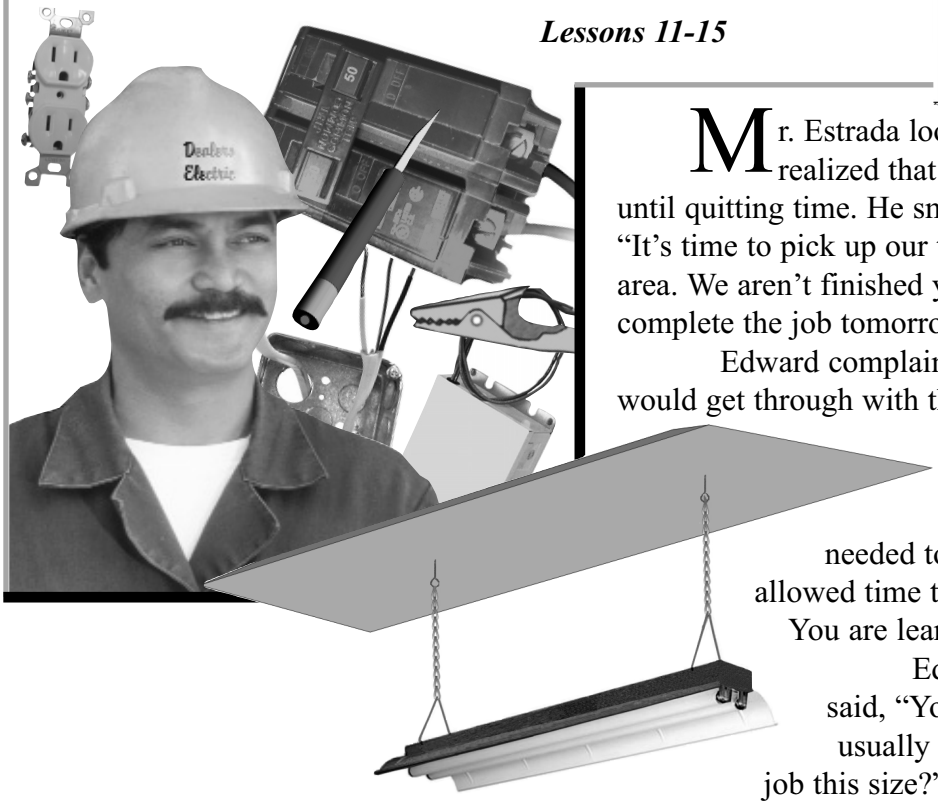
Lesson 13

Chapter 4

HERE COMES THE LIGHT

Section

Lessons 11-15



Mr. Estrada looked at his wristwatch and realized that it was just thirty minutes until quitting time. He smiled at Edward and said, "It's time to pick up our tools and clean up the work area. We aren't finished yet, but we should complete the job tomorrow."

Edward complained, "I was sure that we would get through with this job in one day."

Mr. Estrada laughed and said, "I didn't underestimate the time needed to complete this job. I allowed time to train my new apprentice. You are learning quickly, though."

Edward shook his head and said, "You mean that you don't usually spend this much time on a job this size?"

Mr. Estrada laughed as he responded, "It is okay not to know what to do and to receive instruction. People learn by asking questions and performing the tasks under the direction of a knowledgeable person. A new employee is usually slower at first; but you are a *good* employee. You will speed up in your work as the skills that you are learning become routine."

Edward thanked his dad again for being patient with him and felt confident that, with experience, he would become a better employee.

As Mr. Estrada and Edward prepared for work the next morning, his dad said, "We need to go by Gresham Lighting and pick up the fixtures that our customer chose and that will be required to complete the wiring job."

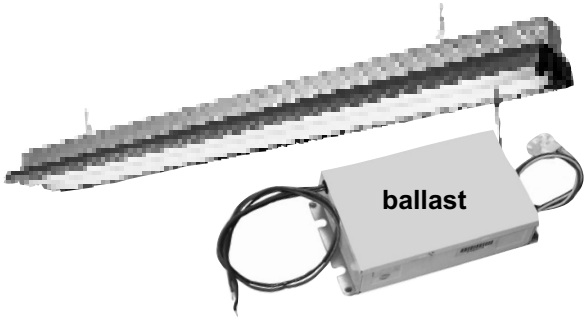
Once there, Edward had an opportunity to go into the ***lighting showroom*** and look around. He was ***fascinated*** by all of the brightness and glitter that the many lights produced. He also noticed that the use of mirrors enhanced the beauty of all of the different light fixtures.

VOCABULARY

Lighting showroom: a display room where many light fixtures are "showcased" or exhibited
Fascinated: to allure and hold by charming qualities
Incandescent: white or glowing with intense heat, brightness, or clearness
Surge: a transient, sudden rise of current or voltage in an electric current
Intensifies: increasing the magnitude of force or energy per unit

Mr. Estrada selected a two-bulb ***incandescent*** fixture for the utility room and a four-foot fluorescent fixture containing two 40-watt bulbs for the garage.

Edward began to read the box that contained the fluorescent fixture and asked, "What is a watt, and what is a ballast?"



Mr. Estrada placed the light fixtures in the truck as he explained that a ballast is found in each fluorescent fixture and that the ballast acts as an electric booster station, sending a ***surge*** of electricity into the fluorescent tube. Older models of fixtures include a starter to help the ballast reach maximum power in less time. This increased surge of electricity then charges gases in the bulb which, in turn, create a faint light. The light then ***intensifies*** a chemical coating on the inner wall of the bulb, causing the bulb to emit a bright light.

Mr. Estrada continued explaining, "A watt is a unit of measure in electric current flow that represents a unit of power. It is normally used when heat and light are created by electric current flow."

Then, Mr. Estrada asked, "Can you identify the three different units used to measure electric current?"

Edward remembered that the three measures of electric current were voltage, amperage, and wattage. He responded, "Wattage represents power; voltage represents the pressure of electric current flow; and amperage represents current strength or rate of flow. The three are related and can be changed from one to the other."

"That's correct, son," complimented his dad. As he drove down the road toward the work site at the garage utility addition, he explained the following formulas:

watts = volts * amperes
amperes = watts / volts
volts = watts / amperes

"As an example, if the volts were 120 and the amperes 15, the watts would be 1800."

(120 Volts * 15 Amperes = 1800 Watts)

"Another example would be if the watts were 2400 and the amps 10, the volts would be 240."

(2400 Watt / 10 Amperes = 240 Volts)

"The third example would be if the watts were 1200 and the volts 120, the amperage would be 10."

(1200 Watts / 120 Volts =10 Amperes)

Edward said, "I'll write down these formulas and study them carefully, because they are sure to be on my electrician's exam."

LIFE PRINCIPLE



"Knowledge . . . is power."

—Francis Bacon

Electrical

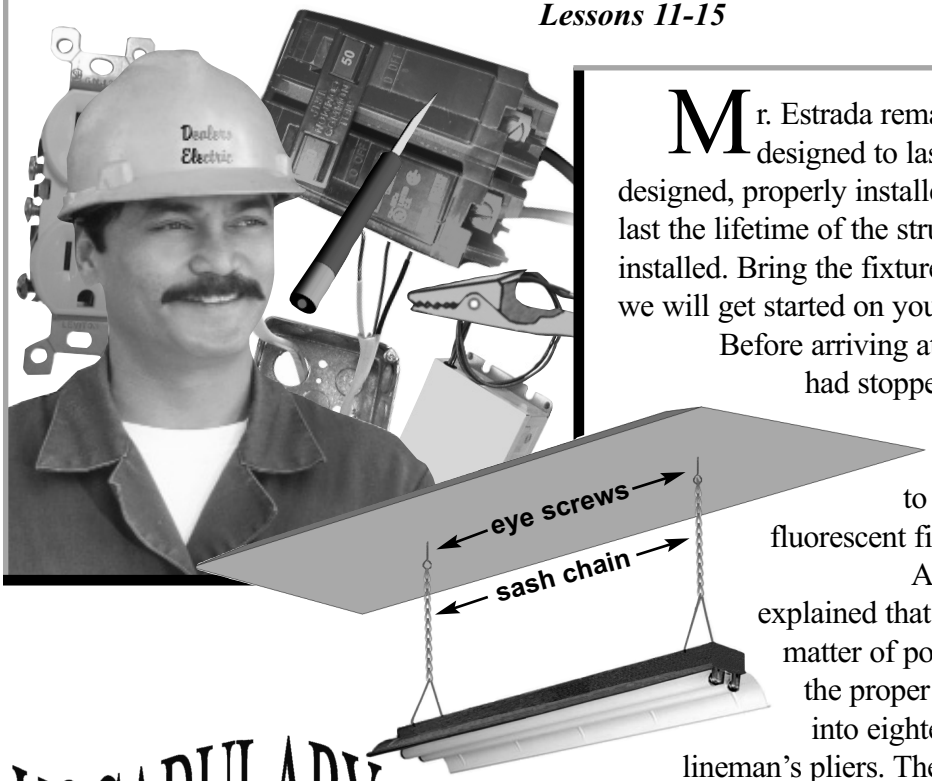
Lesson 14

Chapter 4

INSTALLING THE LIGHTS

Section

Lessons 11-15



Mr. Estrada remarked, "The light fixtures are designed to last a long time. A well designed, properly installed electrical system should last the lifetime of the structure in which it was installed. Bring the fixture boxes into the garage, and we will get started on your next project."

Before arriving at the job site, the two men had stopped by the hardware store and had picked up some small ***sash chain*** and ***eye screws*** to use in installing the fluorescent fixture.

At the work site, Mr. Estrada explained that installation was a simple matter of positioning the eye screws in the proper places and cutting the chain into eighteen-inch lengths by using the lineman's pliers. The chain was then attached to the four-foot fixture and was hung on the eye screws. This would allow the fixture to be adjusted to the desired height. The three-pronged plug was then plugged into the outlet receptacle wired to the wall switch. When that was accomplished, Edward and his dad gathered up the tools and moved into the utility room.

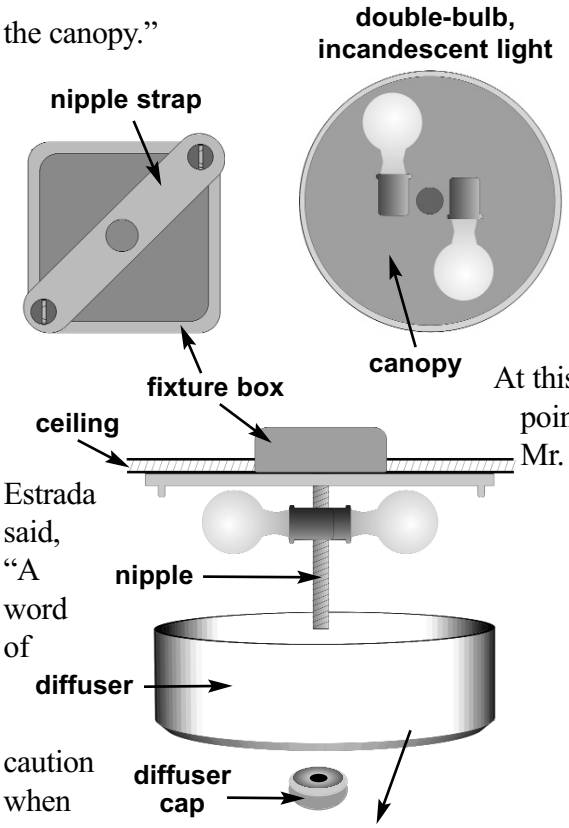
The light that was going to be placed in the utility room was a double-bulb, incandescent light with a round ***frosted*** glass cover. All fixtures, regardless of outward appearance, have similar internal parts. Likewise, most fixtures are attached to ceiling outlet boxes in a ***universal*** manner.

Mr. Estrada instructed, "To install a new fixture, start by fastening the ***nipple*** strap to the outlet box. Next, thread the nipple into the strap. Then, hold the fixture up to the box so that the fixture *lead wires* can be attached to the *switch wires* in the box. Hold each color-matched set of wires together and tighten a plastic connector over them. No bare wire should be showing when the connectors are in place. With the switch wires connected to the lead wires, fasten the canopy to the nipple or nipple strap, and connect the glass ***diffuser*** to

VOCABULARY

Sash chain: a small, flat brass chain that was originally used in wooden window units
Eye screws: a round loop with a screw shank used for hanging items
Frosted: something with a coating resembling frost
Universal: something that can be used all over the world without change
Nipple: the part of a light made of small pipe used to connect pieces together
Diffusers: spreads light and breaks up light intensity

the canopy."



At this point, Mr. Estrada said, "A word of caution when installing ceiling fixtures, especially those with closed diffusers—never install a bulb with a higher wattage rating than the fixture is designed to fit. Bulbs of higher wattage can overheat the socket wiring. Hot fixtures start fires. The recommended wattage will be stamped somewhere on the fixture."

"I'll be sure to look for that each time," promised Edward.

"We are close to completing this job, but I noticed yesterday that a 240-volt outlet for a welder has been added to the plans for the garage," said Mr. Estrada. "Several different types of 240-volt receptacles are available and are rated by amperage. I brought one receptacle that should be rated for the amperage for a welder. I also purchased an outlet box with enough #6 gauge wire cable to run from the garage to the subpanel box."

Edward already knew which tools and equipment would be necessary to do this job, so he went to the truck and returned with the necessary items. Mr. Estrada had marked the places for installing the cable through the walls, and Edward drilled the holes through which to run the cables. Once the cable was run through the wall to the subpanel, Mr. Estrada installed the outlet box. He then showed Edward the 240-volt receptacle, and instructed him, "Strip all of the wires in the cable."


a 240-volt outlet

Edward found that the cable contained a black wire, a red wire, and a white wire as well as a bare ground wire. The back of the receptacle was Y-shaped with recessed screws designed to tighten against the cable wires.

Mr. Estrada noted, "The white, neutral wire *always* goes on the bottom of the Y, and the two hot wires go on the top of the "V" part of the Y. The bare ground wire attaches to the receptacle box. For all practical purposes, 240-volt circuits are just two 120-volt circuits tied together. In actuality, this is not so because each 120 volts comes from a separate phase of a transformer. However, when you run wires and hook up breakers and receptacles, there really isn't much difference in the basic technique."

Mr. Estrada continued, "Working with 240 volts should not be any more dangerous than working with 120-volt circuits. In fact, there is probably less danger with 240 volts because of the split amperage.

Edward, I want to compliment you. You've done a good job in preparing for the wiring of the 240-volt outlet. I think this job has gone very smoothly."

Grinning, Edward said, "Thanks, Dad. I hope to improve and learn a lot more!"

LIFE PRINCIPLE



"Everything comes to him who hustles while he waits." —Thomas Edison

Electrical

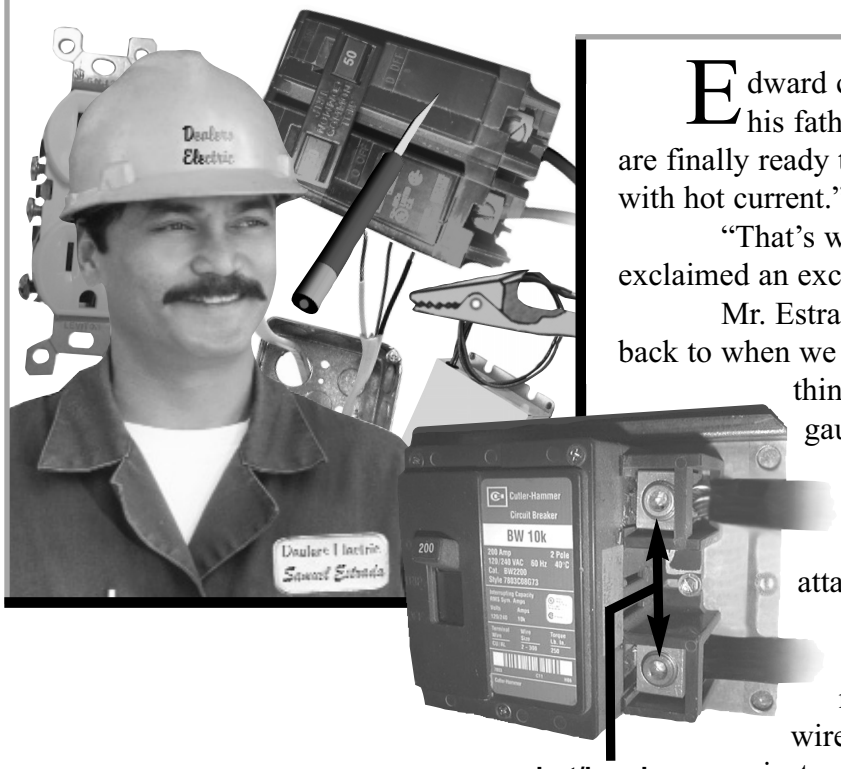
Lesson 15

Chapter 4

A JOB WELL DONE

Section

Lessons 11-15



hot/breaker bus bars

Edward could hardly believe his ears when his father said, "Believe it or not, son, we are finally ready to test the entire wiring system with hot current."

"That's what I've been waiting to hear!" exclaimed an excited Edward.

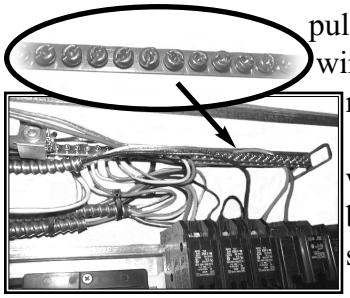
Mr. Estrada said, "If you can remember back to when we started the job, one of the first things that we did was to pull #6 gauge wires from the service panel to the subpanel."

Edward responded, "I do remember that, but we didn't attach the wires to either panel."

Mr. Estrada grinned and said, "You have a pretty good memory, son. Not connecting the wires enabled us to wire the entire project without fear of being ***shocked***. Now we are going to connect the wires in the service panel and the subpanel. First, we will attach the wires in the proper places in the subpanel box."

Mr. Estrada explained, "The wires from the service panel enter the subpanel through the top of the subpanel box. The white wire is connected to the *neutral* ***bus bar***. The black and red wires are connected to the *hot bus bars,* and the green or ground wire is attached to the *ground bus bar*."

ground/neutral bus bar



As father and son looked at the wires that came from the panel, they counted eight wires pulled to the subpanel box. Each of these wires was then stripped back and made ready to be attached to the subpanel.

Mr. Estrada continued, "All of the white wires are attached to the neutral bus bar and screwed down, using a flat screwdriver. The ground wire goes under

VOCABULARY

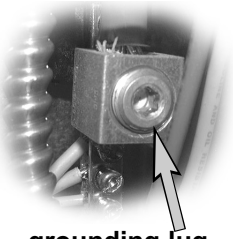
Shocked: sudden stimulation of the nerves and convulsive contraction of muscles caused by electricity

Bus bar: a conductor for collecting electric currents and distributing them to outgoing circuits

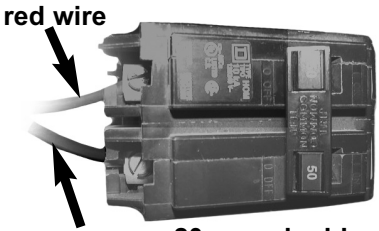
Lug: a fitting by which various wires are connected to a bus bar

Base: the threaded part of a light socket

the *grounding* ***lug***. Next, we need to locate the #6 cable coming from the service panel and connect the red wire to one of the bus bars in the subpanel."


grounding lug

The black wire coming from the service panel was connected to the other bus bar in the subpanel. Finally, the red and black wires that were attached to the welder receptacle were connected to the two lugs on a 20-amp, double pole 240-volt circuit breaker.



Mr. Estrada demonstrated, "Now, we put the circuit breaker into place where it will engage the black hot bus bar and the red hot bus bar. Now, all the wiring is attached together to the subpanel."

At this juncture, Mr. Estrada and Edward went to the service panel. The first thing his dad did at the service panel box was to flip the main breaker located at the top of the box to the 'Off' position. He said, "This circuit breaker has a 100 ampere rating and carries all of the current for the entire home. All other circuit breakers are operated under this circuit breaker, so when it is turned off, all the power in the entire house is turned off which allows us to work safely on any of the electrical circuits."

Mr. Estrada reviewed their work, "The #6 gauge white wire is attached to the neutral bus bar. The ground wire is attached to the ground bus bar, leaving the red wire and black wire to be connected to a 60-amp, double pole, 240-volt circuit breaker. The breaker is snapped into the hot bus bar. The 60-amp breaker is in the 'Off' position."

"Now, let's see what happens," said Mr. Estrada, as he turned on the main breaker.

"Should we use the voltmeter?" asked Edward.


voltmeter

"Yes!" answered his dad. "We now need to test the entire circuit together."

The first thing they tested was the 60-amp circuit breaker. They placed one probe on the backside of the circuit breaker on the red wire and the other probe on the black wire. The circuit breaker was turned on, and a voltage reading was taken that indicated the circuit breaker was carrying 240-volts to the subpanel. The two men next went to the subpanel and turned on each circuit breaker. They tested each circuit, which revealed a 120-volt reading except for the circuit breaker for the welder, which showed a 240-volt reading.

At that point, the men were ready to test each individual outlet. Mr. Estrada took his tester and went one way while Edward, with his tester, went in the opposite direction. They tested each duplex outlet receptacle to see if all of them were registering 120 volts.

When testing was completed, they compared results and found that all of the receptacles were operating properly. Getting a 120-volt reading when checking voltage between each hot wire and neutral wire tested the 240-volt receptacle. When testing the voltage between the two hot wires, a reading of 240-volts was obtained. The simple flipping of the toggle switch tested the fluorescent fixture. A triumphant yell erupted from Edward when the light came on. The incandescent fixture was checked out by Edward climbing a ladder and placing one probe in the center of the socket and the other probe on the ***base***. With the light switch on, the tester gave a reading of 120 volts.

Edward was so excited to have everything check out positively that he could hardly contain himself! He commented,

"This has been like running a mile race and winning. It took a while to finish the wiring, but it all works now!"

On the way back to Dealers Electric, Edward knew his dad was pleased. Mr. Estrada confirmed that impression by turning to Edward and saying, "Son, you did a great job on this first wiring assignment, and I'm really proud of you. You have the potential to become a good electrician. But right now, I have something else on my mind that you might approve. What do you say about us doing another favorite project—fishing?" "Sounds great to me, Dad!" Edward exclaimed.

They soon checked in the truck at Dealers Electric and reported that they had finished that particular work order. The secretary stated there were no other jobs scheduled and the men could take off the rest of the day.

Mr. Estrada laughed and replied, "As a matter of fact, that's just what we were discussing!"

As Edward and his dad cruised around the lake looking for the perfect fishing spot, Edward could see pride in his dad's face. Edward hoped that his dad knew how much he was respected and admired, too. This fishing trip would be an excellent opportunity to tell his dad how much he was appreciated.

LIFE PRINCIPLE



"Love and a cough cannot be hid."

—George Herbert