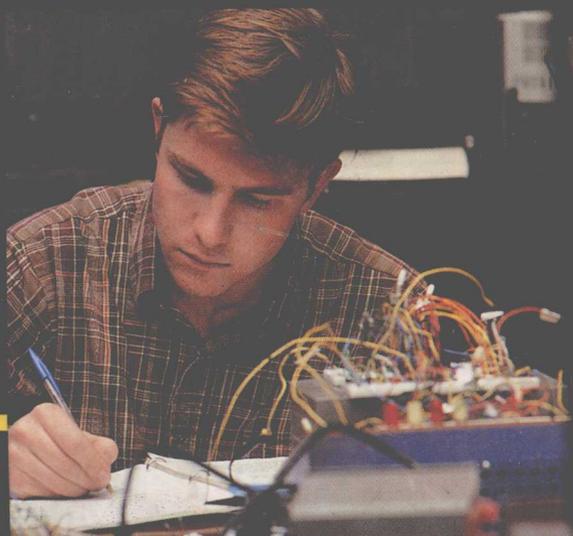
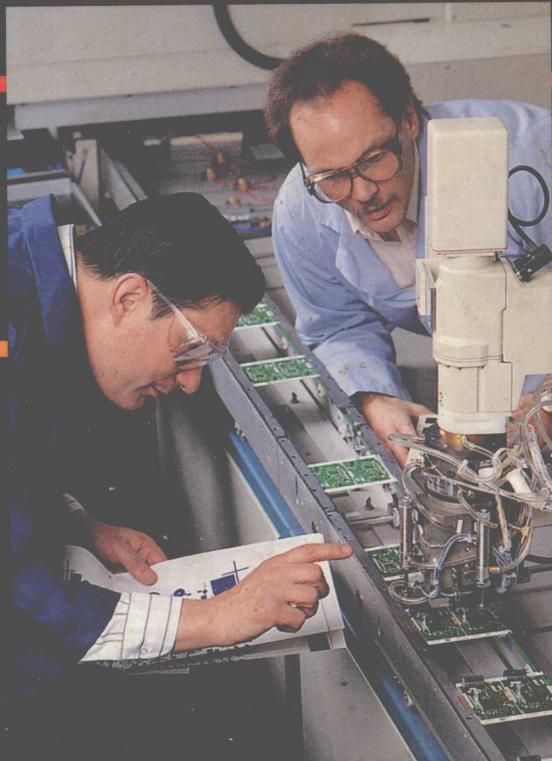
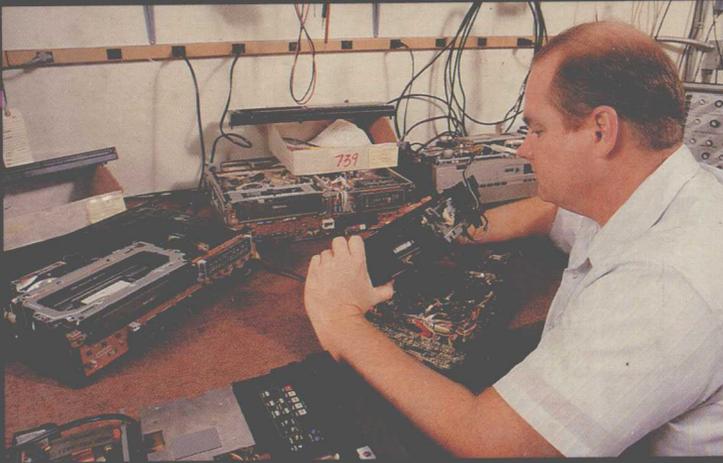
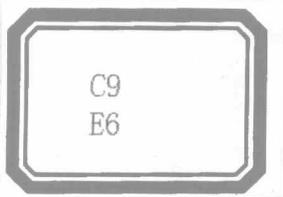


ESSENTIALS OF ELECTRONICS

A Survey

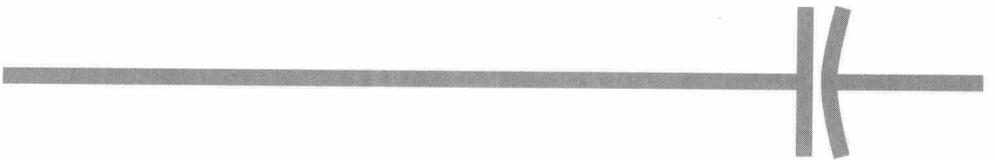


FRANK D. PETRUZELLA



ESSENTIALS ELECTRONICS

A Survey



FRANK D. PETRUZELLA

GLENCOE

Macmillan/McGraw-Hill

New York, New York Columbus, Ohio Mission Hills, California Peoria, Illinois

Library of Congress Cataloging-in-Publication Data

Petruzella, Frank D.

Essentials of electronics: a survey / Frank D. Petruzella.

p. cm.

Includes index.

ISBN 0-02-800893-6

1. Electronics. I. Title.

TK7816.P48 1993

621.381—dc20

92-32921

CIP

Cover color photography

Top left, © Michael Salas/The Image Bank;

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Imprint 1994

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Send all inquiries to:

GLENCOE DIVISION
Macmillan/McGraw-Hill
936 Eastwind Drive
Westerville, OH 43081

ISBN 0-02-800893-6

Printed in the United States of America.

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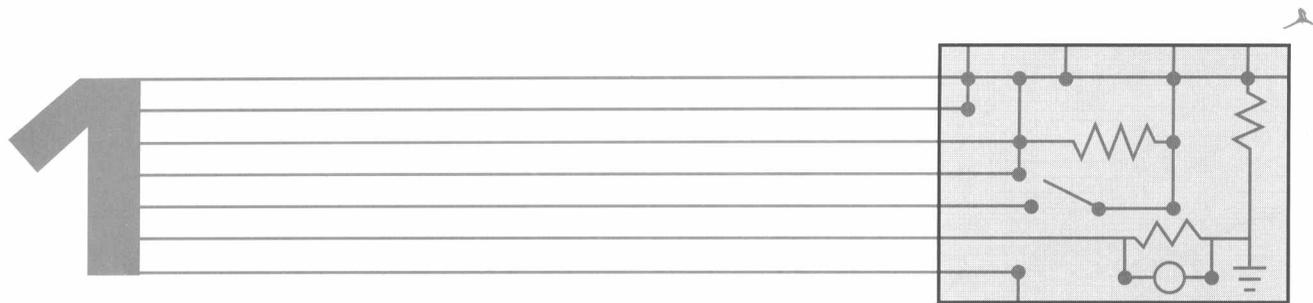
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SAFETY

OBJECTIVES

Upon completion of this unit, you will be able to:

- Outline electrical safety rules that apply to conditions in the home, outdoors, school shop, and on the job.
- Describe the electrical factors that determine the severity of an electric shock.
- State the maximum safe current and voltage values.
- Calculate the body current flow when given the body resistance and applied voltage.
- Outline the first-aid procedure for bleeding, burns, and electric shock.
- Outline the mouth-to-mouth method of artificial respiration.
- Outline the procedure to be followed in case of an electrical fire.

1-1

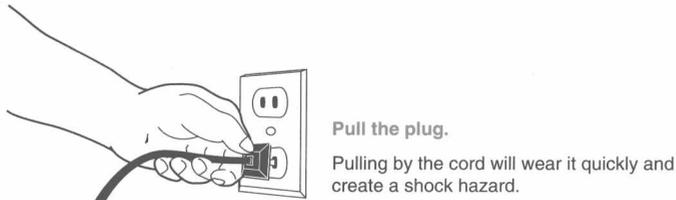
SAFETY IN THE HOME

Electrical equipment used in homes today is safe when properly installed, maintained, and used. However, hazards are created when this equipment is improperly used or when suitable safety measures are not employed.

Second only to motor vehicles, the home is the site of most fatal accidents each year in the United States. The best way to reduce accidents at home is to know the potential hazards and take the neces-

sary precautions to eliminate them (Figure 1-1). The following list of electrical safety suggestions is designed to increase your awareness of electrical accidents that can occur in the home:

- Never run extension cords under rugs. Extension cords are not designed for this type of rough service, nor are they a substitute for permanent wiring.
- Do not jerk extension cords from electrical outlets.
- Cover unused electrical outlets so that children cannot poke pins and the like into them.



Pull the plug.

Pulling by the cord will wear it quickly and create a shock hazard.



Keep cords away from heat and water.

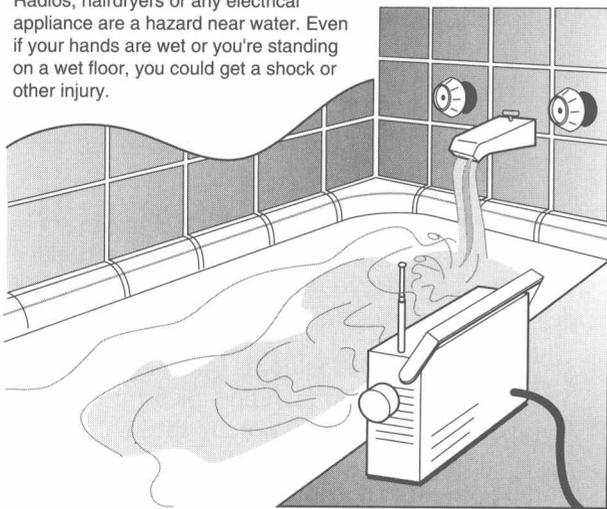
Heat or water can damage the insulation and create a shock hazard.

Cords under carpets are a fire hazard.

Don't run electric cords under rugs, through doorways or anywhere they will get excessive wear.

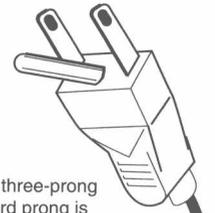
Electricity and water don't mix.

Radios, hairdryers or any electrical appliance are a hazard near water. Even if your hands are wet or you're standing on a wet floor, you could get a shock or other injury.



Never break off the third prong on a plug.

Replace a two-prong with a three-prong outlet and make sure the third prong is properly grounded. It provides a ground path that helps prevent or minimize shocks.



Inspect cords and plugs.

Worn, they can cause fire, short circuits or shocks. Check electrical cords and plugs and discard them if they are worn or damaged.

Eliminate octopus connections.

Plugging a number of cords into one outlet is a fire hazard. It usually indicates that your home wiring is outdated for your needs and that you should have more outlets wired in.

Don't use extension cords as permanent wiring.

An extension cord is a handy device to temporarily bring power to an area in your home that does not have an outlet. It was never designed to take the place of permanent wiring. Using extension cords as permanent wiring is an indication that your home wiring is not adequate and should be updated.

Don't pry toast from a plugged-in toaster.

To avoid getting a shock, unplug the toaster before prying with a fork or knife.

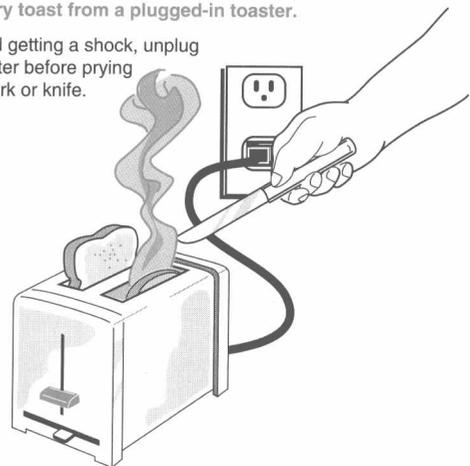


FIGURE 1-1 Know the potential hazards and take the necessary precautions to eliminate them. (Courtesy Ontario Hydro.)

- Do not over-fuse a circuit. Never use a penny to make a fuse connection.
- Always turn off the main electrical switch before replacing a blown fuse.
- Keep basement floors around washtubs and machines dry to help eliminate falls and to reduce the hazards of electric shock.
- Replace frayed appliance cords or defective wiring on all appliances as soon as they are discovered.
- Discover the problem's cause if fuses blow often.
- Do not overload electrical outlets by use of multiple tap-off (octopus) devices.
- Do not use electric space heaters, radios, or appliances in the bathroom, laundry room, or near the kitchen sink.
- Turn off the main electrical switch when checking or replacing switches and outlets.
- Do not pry bread from a plugged-in toaster.

1-2

SAFETY OUTDOORS

Unfortunately, the human body will conduct electricity. Dry skin offers some insulation, but if the voltage is great enough, the electricity will pass through. When the skin is wet, its resistance is much lower. This means more current can pass through the body, causing more damage. A few safety tips (Figure 1-2) to keep in mind outdoors include:

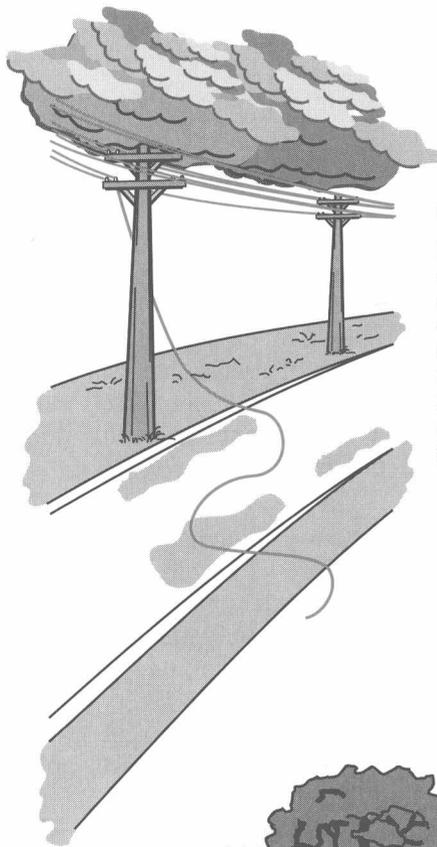
- Never touch a downed wire.
- Stay clear of power lines.
- Do not bring appliances near swimming pools.
- Never use power tools on wet grass or other wet surfaces.
- All outdoor electrical outlets should be supplied from circuits equipped with *ground-fault circuit interrupters* to provide extra protection. This is especially important in damp locations where electrical shocks are usually more severe and where a normal fuse or circuit breaker does not provide enough protection.

1-3

SAFETY IN THE SCHOOL SHOP

Most school shop accidents are caused because safety rules are not observed. The school must ensure safe working conditions for the students. However, you must learn how to protect yourself and others working near you. Use your common sense! The school shop, in particular, is not the place for horseplay or carelessness. You should be aware of the following *general* school safety rules, and your instructor will point out the *specific* safety rules that apply to the shop you are working in:

1. Inform your instructor immediately when you become aware of a safety hazard.
2. Always notify your instructor when you are injured in the shop. Have proper first aid applied.
3. Do not underestimate the potential danger of a 120-V circuit.
4. Work on live circuits **ONLY** when absolutely necessary and while under supervision of the instructor.
5. Stand on dry, nonconductive surfaces when working on live circuits.
6. Never bypass an electrical protective device.
7. Arrange your work so that you never have to reach over a hot soldering iron that is on your bench.
8. Keep your work area clean.
9. Always wear safety glasses or goggles when you are operating any kind of power tool or when soldering.
10. Avoid horseplay and practical jokes.
11. Know where the fire extinguisher is and how to use it.
12. Check all "dead" circuits before you touch them.
13. Never take a shock on purpose.
14. Do not touch two pieces of plugged-in equipment at the same time; an equipment defect could cause a shock.
15. Do not open or close any main switch without permission from the instructor.
16. If *ever* in doubt, ASK your teacher.
17. Make sure all electrical connections are secure before applying a voltage.

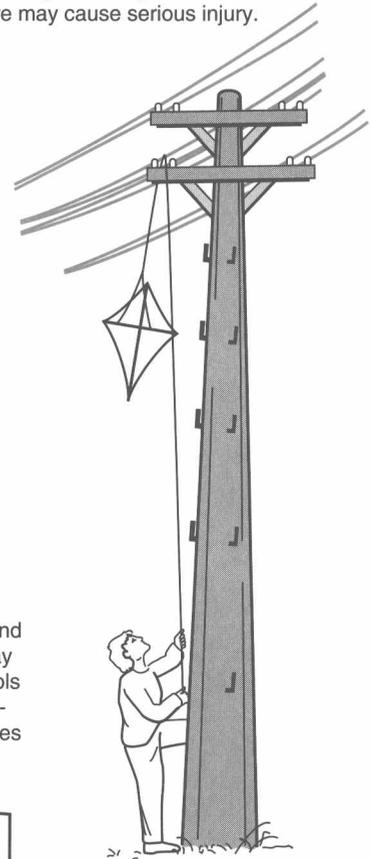


Stay clear of power lines.

If kites or model airplanes touch overhead lines, even touching the string or control wire may cause serious injury.

Never touch a downed wire.

Even if the wire appears dead, touching it could be fatal. If your car hits a hydro pole and dislodges wires, stay inside until a hydro crew removes the wire. If you must get out because of fire, jump free with both feet together and without touching the car and the ground at the same time. Shuffle away using small steps. Do not return to the car for any reason and warn others to keep away.



Don't bring appliances near water.

Electric radios, barbecues, TVs, clocks and other appliances should be kept well away from swimming pools. And swimming pools should never be near power lines. A long-handled skimmer could be fatal if it touches outdoor lighting or power lines.

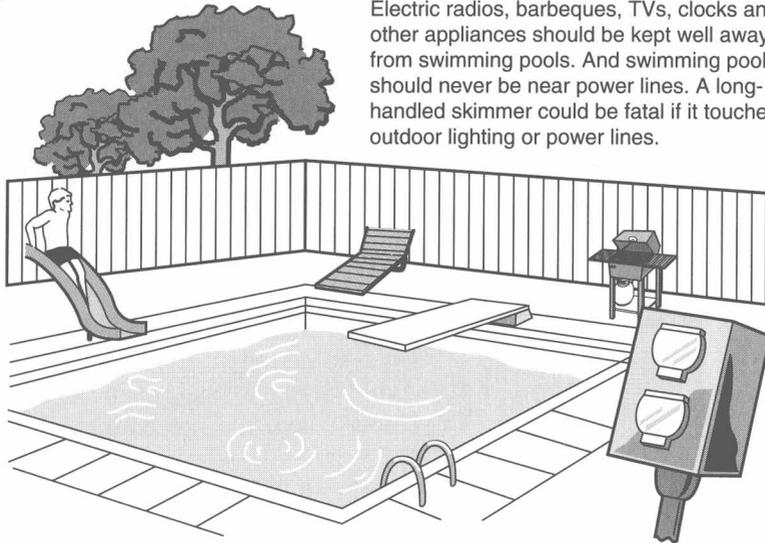


FIGURE 1-2 Safety outdoors. (Courtesy Ontario Hydro.)

1-4

OCCUPATIONAL SAFETY

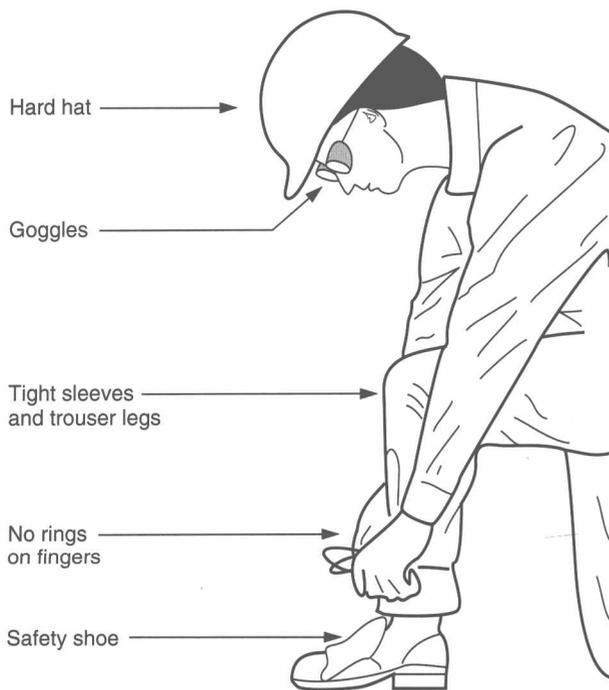
Safety has become an increasingly large factor in the working environment. The electrical industry, in particular, regards safety to be unquestionably the single most important priority due to the haz-

ardous nature of the business. *Obey all accident prevention signs!* (See Figure 1-3.)

Personal Safety Attire The clothing worn at work is important for personal safety. Appropriate attire should be worn for each particular job site and work activity (Figure 1-4). The following points should be observed:

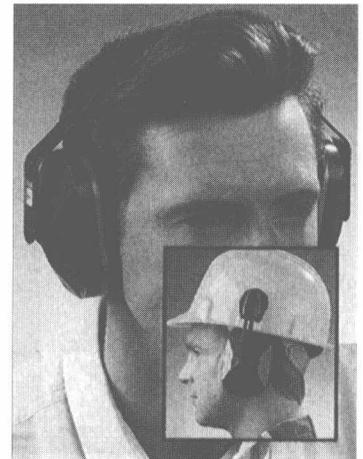


FIGURE 1-3 Typical accident prevention signs. (Courtesy Safety Supply Canada.)



A. Clothing and personal safety

B. Hearing protection



C. Breathing protection

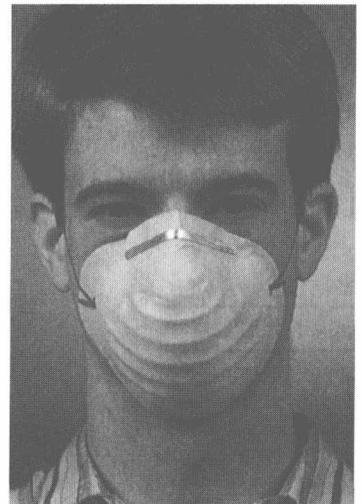


FIGURE 1-4 Clothing and equipment used for personal safety. (Courtesy Safety Supply Canada.)

1. Hard hats, safety shoes, and goggles must be worn in areas where they are specified.
2. Safety earmuffs must be worn in noisy areas.
3. Clothing should fit snugly to avoid the danger of becoming entangled in moving machinery.
4. Remove all metal jewelry when working on energized circuits; gold and silver are excellent conductors of electricity.
5. Confine long hair or keep hair trimmed when working around machinery.

Equipment Safety An ungrounded power tool can kill you! Always use properly grounded power tools. Use only those power tools with three-pronged plugs or double insulated tools with two-pronged plugs (Figure 1-5). Inspect cords and equipment often to make sure ground pins are in safe condition.

Electrical *lockout* and *tagout* (Figure 1-6) refers to the process of padlocking the power source in the OFF position and indicating, on an appropriate card, the procedure that is taking place. This procedure is necessary so that someone will not inadvertently turn the equipment to the ON position while it is being worked on. Lockout and tagout should be carried out **BEFORE** any repair is started. When in doubt about this or any other procedure, ask your supervisor! Also, report any un-

safe condition, equipment, or work practices as soon as possible.

1-5

ELECTRIC SHOCK

Often we think that serious electric shock can only take place from high-voltage circuits. This is not so! More people are injured or killed by 120-V household voltage every year than in all other electrical-related accidents. If you walked away from your last electric shock, consider yourself lucky. Do not depend on luck. Work safely with electricity and live!

Electric shock occurs when a person's body becomes part of the electric circuit. The three electrical factors involved in an electric shock are: resistance, voltage, and current.

Resistance Electrical *resistance* (R) is defined as the opposition to the flow of current in a circuit and is measured in ohms (Ω). *The lower the body resistance, the greater the potential electric shock hazard.* Body resistance varies with the condition of the skin and the area in contact. Typical body resistance values are listed in Table 1-1. Body resistance can be measured with an instrument called an *ohmmeter* (Figure 1-7).

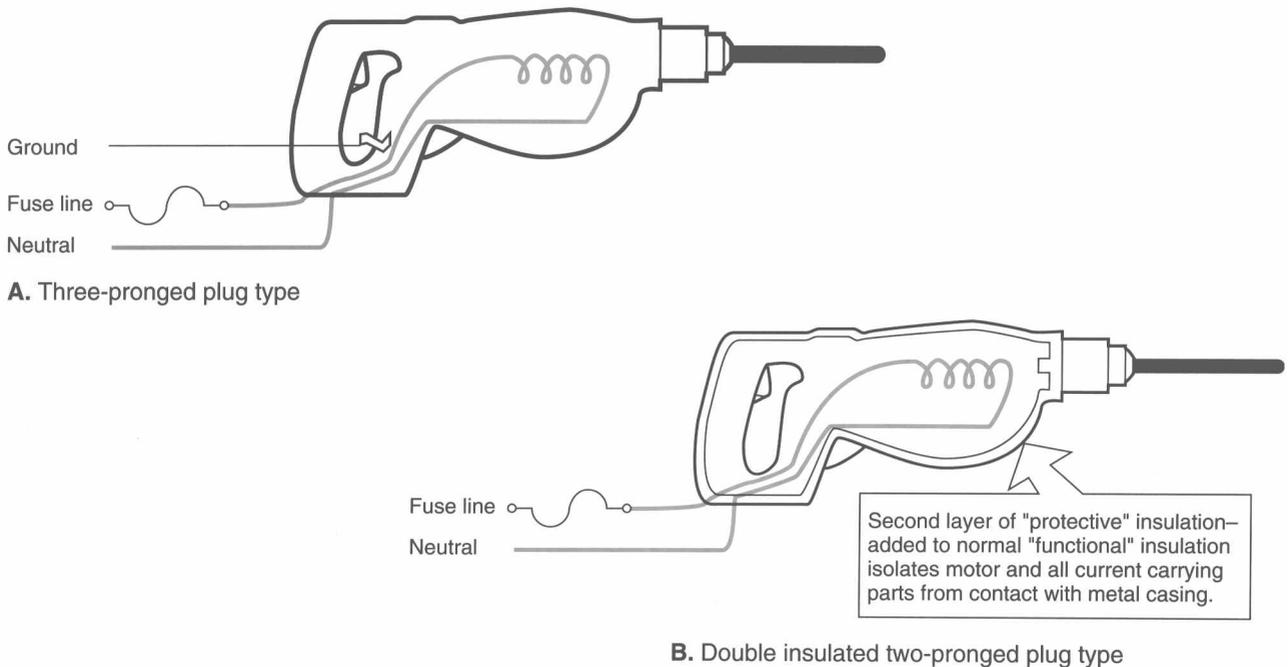
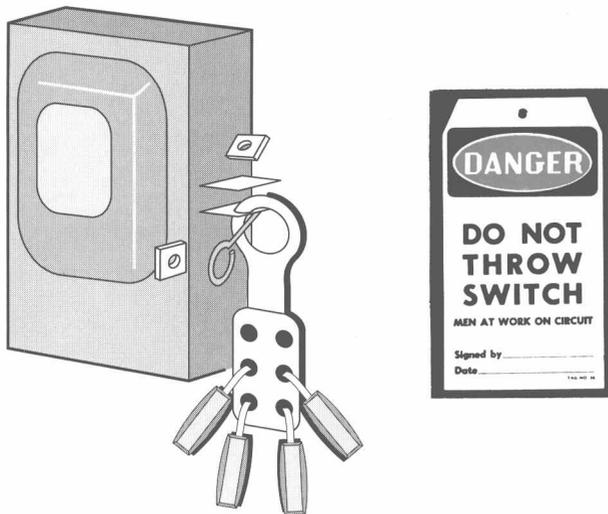


FIGURE 1-5 Use properly grounded tools.



(Courtesy Safety Supply Canada.)

FIGURE 1-6 Electrical lockout and tagout.

TABLE 1-1 Skin Condition or Area and Its Resistance

Skin Condition of Area	Resistance Value
Dry skin	100,000 to 600,000 Ω
Wet skin	1,000 Ω
Internal body—hand to foot	400 to 600 Ω
Ear to ear	about 100 Ω

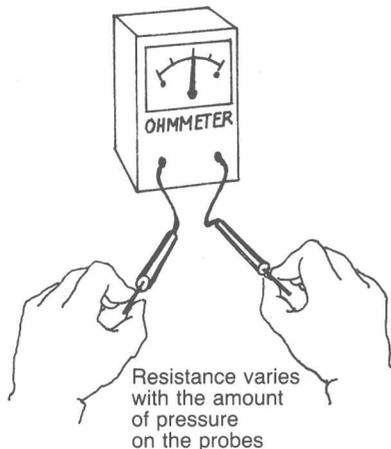


FIGURE 1-7 Measuring body resistance.

Voltage *Voltage (V)* is defined as the pressure that causes the flow of electric current in a circuit and is measured in units called volts. The amount of voltage that is dangerous to life varies with each individual due to differences in body resistance and heart conditions. **Generally, any voltage above 30 V is considered dangerous.**

Current *Electric current (I)* is defined as the rate of flow of electrons in a circuit and is measured in amperes. The amount of current flowing through a person's body depends on the voltage and resistance. Body current can be calculated using the following formula:

$$\text{Current through body} = \frac{\text{Voltage applied to body}}{\text{Resistance of body}}$$

$$I (\text{amperes}) = \frac{V (\text{volts})}{R (\text{ohms})}$$

or

$$I (\text{milliamperes}) = \frac{V (\text{volts})}{R (\text{kilohms})}$$

$$1 \text{ ampere} = 1000 \text{ milliamperes}$$

$$1 \text{ kilohm} = 1000 \text{ ohms}$$

It doesn't take much current to cause a painful or even fatal shock. A severe shock can cause the heart and lungs to stop functioning. Also, severe burns may occur where current enters and exits the body. Figure 1-8 illustrates the relative magnitude and effect of electric current.

GENERALLY, ANY CURRENT FLOW ABOVE 0.005 A (AMPERES) OR 5 mA (MILLIAMPERES) IS CONSIDERED DANGEROUS.

A flashlight cell can deliver more than enough current to kill a human being, yet it is safe to handle. This is because the resistance of human skin is high enough to limit greatly the flow of electric current. In lower voltage circuits, resistance restricts current flow to very low values. Therefore, there is little danger of an electric shock. Higher voltages, on the other hand, can force enough current through the skin to produce a shock.

THE DANGER OF HARMFUL SHOCK INCREASES AS THE VOLTAGE INCREASES.