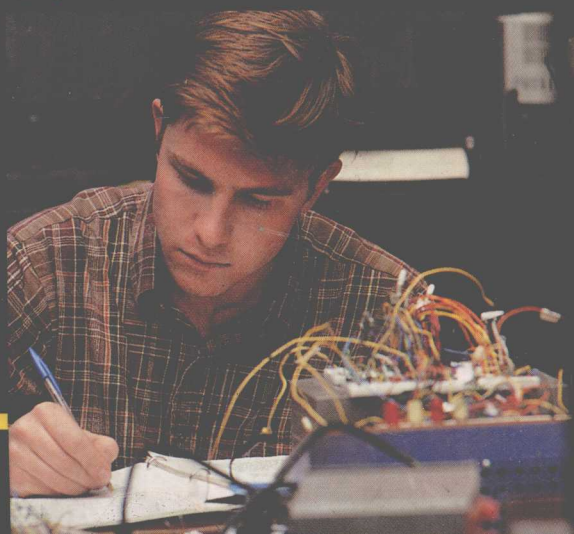
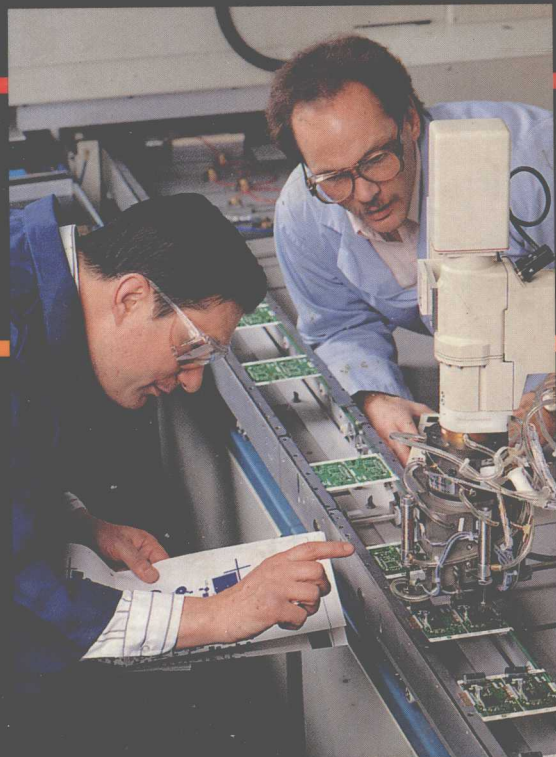
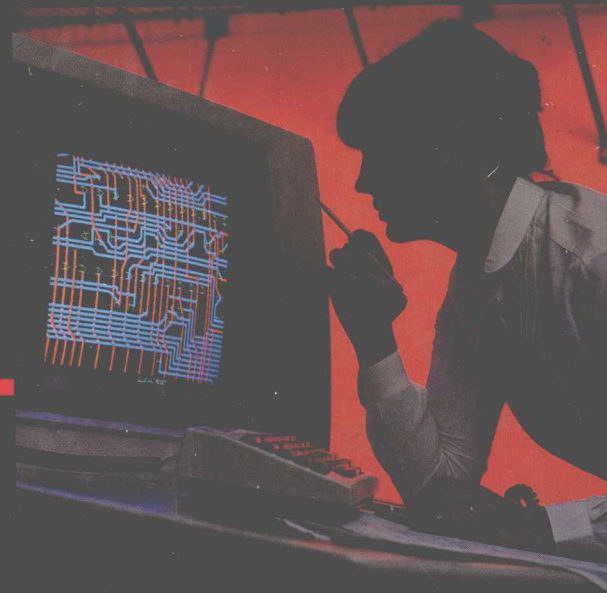
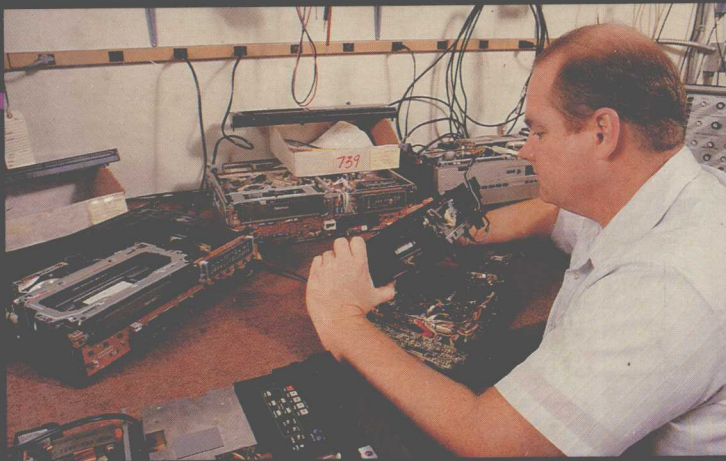
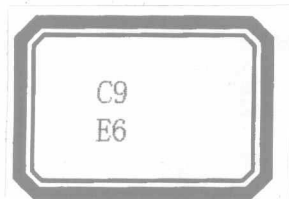


ESSENTIALS OF ELECTRONICS

A Survey

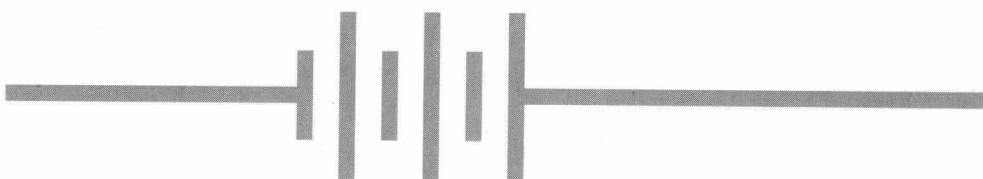
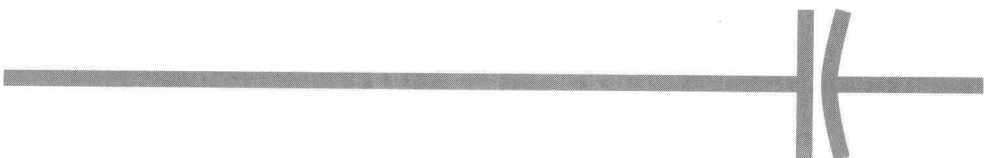
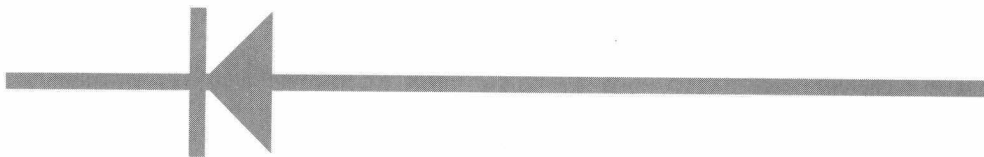
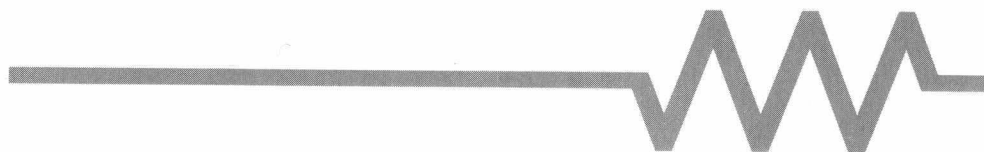


FRANK D. PETRUZELLA



ESSENTIALS ELECTRONICS

— A Survey



FRANK D. PETRUZELLA

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PREFACE

Essentials of Electronics: A Survey is a comprehensive introduction to one of the most exciting and challenging fields of modern technology. It is broad-based in its approach. The book is structured to serve the needs of all students by contributing to their general education, and then by providing them with opportunities to test their interest and aptitude for the many different types of career opportunities associated with electronics.

Two companion pieces, *Activities Manual for Essentials of Electronics* and *Instructor's Resource Guide for Essentials of Electronics* are available for use with the text. The student *Activities Manual* contains multiple choice, true/false, completion, and matching-type questions for each chapter and serves as an excellent review of the material presented. In addition, the *Activities Manual* contains practical lab activities for each chapter. These practical assignments outline suggested experiments and practical testing applications that are designed to maintain student interest and enthusiasm, as well as to provide *hands-on* learning. Special attention has been given to the use of readily available and relatively low-cost components for these experiments. The *Instructor's Resource Guide* contains answers to all the textbook review questions and *Activities Manual* objective questions and practical assignments.

The textbook is organized so selected chapters or topics can be studied individually, making it highly adaptable to many different curricula. It focuses on those principles that will provide a solid foundation to the entry-level student. The numerous illustrations in the text help students understand the theory and visualize its practical applications.

Objectives are listed at the beginning of each chapter to give students an outline of what they will learn. The subject material is written in a language that is easy to read and understand.

Mathematics is used only where I feel that an adequate grasp of the concept demands a mathematical treatment.

Review questions are included at the end of each chapter to help students evaluate their understanding of the chapter. These questions are related very closely to the chapter objectives.

Frank D. Petruzella

CONTENTS

PREFACE IX

CHAPTER 1 SAFETY 1

1-1	Safety in the Home	1
1-2	Safety Outdoors	3
1-3	Safety in the School Shop	3
1-4	Occupational Safety	4
1-5	Electric Shock	5
1-6	First Aid	9
1-7	Artificial Respiration	10
1-8	Fire Prevention	10
1-9	Safety Color Codes	12

CHAPTER 2 TOOLS OF THE TRADE 13

2-1	Measuring Devices	13
2-2	Common Tools	15
2-3	Organization and Use of Tools	19

CHAPTER 3 CONDUCTORS, SEMICONDUCTORS, AND INSULATORS 22

3-1	Electron Theory of Matter	22
3-2	Bohr Model of Atomic Structure	23
3-3	Ions	24
3-4	Electricity Defined	25
3-5	Electric Conductors, Insulators, and Semiconductors	25
3-6	The Continuity Tester	26

CHAPTER 4 SOURCES AND CHARACTERISTICS OF ELECTRICITY 29

4-1	Static Electricity	29
4-2	Charged Bodies	31
4-3	Testing for a Static Charge	31
4-4	Producing a Static Charge	32
4-5	Current Electricity	33
4-6	Sources of Electromotive Force (emf)	34

CHAPTER 5 BASIC ELECTRICAL UNITS 40

5-1	Electric Charge	40
5-2	Current	41
5-3	Voltage	41
5-4	Resistance	42
5-5	Power	44
5-6	Energy	44
5-7	Basic Electric Circuit	45
5-8	Relationship Among Current, Voltage, and Resistance	46
5-9	Direction of Current Flow	47

CHAPTER 6 ELECTRIC CONNECTIONS 48

6-1	The Necessity for Proper Electric Connections	48
6-2	Preparing Wire for Connection	49
6-3	Terminal-Screw Connections	49
6-4	Crimp Terminals, Splices, and Mechanical Connectors	50

6-5	Insulating Repairs	52
6-6	Soldered Connections	54
6-7	Electronic Data Communication Interconnection Systems	56

CHAPTER 7 --- **SIMPLE, SERIES, AND PARALLEL CIRCUITS 59**

7-1	Circuit Components	59
7-2	Circuit Symbols	61
7-3	Circuit Diagrams	61
7-4	Simple Circuit	64
7-5	Series Circuit	64
7-6	Parallel Circuit	66
7-7	Constructing Wiring Projects Using Schematic Diagrams	68
7-8	Breadboarding Circuits	70
7-9	Computer-Simulated Circuits	71

CHAPTER 8 --- **MEASURING VOLTAGE, CURRENT, AND RESISTANCE 73**

8-1	Analog and Digital Meters	73
8-2	Multimeter	74
8-3	Reading Meters	75
8-4	Measuring Voltage	77
8-5	Measuring Current	80
8-6	Measuring Resistance	83
8-7	Meter Safety	86
8-8	Multimeter Specifications and Special Features	87

CHAPTER 9 --- **CIRCUIT CONDUCTORS AND WIRE SIZES 90**

9-1	Conductor Forms	91
9-2	Conductor Insulation	93
9-3	Wire Sizes	94
9-4	Conductor Ampacity	94
9-5	Conductor Resistance	96
9-6	Voltage Drop and Power Loss	97

CHAPTER 10 --- **RESISTORS 100**

10-1	Resistance Wire	100
10-2	Resistors	101
10-3	Types of Resistors	101
10-4	Rheostats and Potentiometers	103
10-5	Resistor Identification	105
10-6	Series Connection of Resistors	106
10-7	Parallel Connection of Resistors	108
10-8	Series-Parallel Connection of Resistors	109

CHAPTER 11 --- **OHM'S LAW 112**

11-1	Electrical Units and Prefixes	112
11-2	Ohm's Law	114
11-3	Applying Ohm's Law to Calculate Current	116
11-4	Applying Ohm's Law to Calculate Voltage	117
11-5	Applying Ohm's Law to Calculate Resistance	117
11-6	Ohm's Law Triangle	118
11-7	Power Formulas	118

CHAPTER 12 --- **SOLVING THE SERIES CIRCUIT 121**

12-1	Series Circuit Connection	121
12-2	Identifying Circuit Quantities	121
12-3	Series Circuit Current, Voltage, Resistance, and Power Characteristics	122
12-4	Solving Series Circuits	124
12-5	Polarity	128
12-6	Series-Aiding and Series-Opposing Voltages	129

CHAPTER 13 --- **SOLVING THE PARALLEL CIRCUIT 132**

13-1	Parallel Circuit Connection	132
13-2	Parallel Circuit Current, Voltage, Resistance, and Power Characteristics	132

13-3	Solving Parallel Circuits	134
13-4	Troubleshooting a Parallel Circuit	138

CHAPTER 14

SOLVING THE SERIES-PARALLEL CIRCUIT 141

14-1	Kirchhoff's Voltage Law	141
14-2	Kirchhoff's Current Law	142
14-3	Solving Series-Parallel Circuits	143
14-4	Troubleshooting Series-Parallel Circuits	151

CHAPTER 15

MAGNETISM 154

15-1	Properties of Magnets	154
15-2	Types of Magnets	155
15-3	Law of Magnetic Poles	156
15-4	Magnetic Polarity	157
15-5	The Magnetic Field	158
15-6	Magnetic Shielding	159
15-7	Theories of Magnetism	159
15-8	Uses for Permanent Magnets	160

CHAPTER 16

ELECTROMAGNETISM 163

16-1	Magnetic Field Around a Current-Carrying Conductor	163
16-2	Left-Hand Conductor Rule	165
16-3	Magnetic Field About Parallel Conductors	165
16-4	Magnetic Field About a Coil	166
16-5	Left-Hand Coil Rule	167
16-6	The Electromagnet	167
16-7	The Magnetic Circuit	168
16-8	Uses for Electromagnets	170

CHAPTER 17

BATTERIES 174

17-1	The Voltaic Cell	174
17-2	Battery Terminology and Ratings	175
17-3	Primary Dry Cells	176
17-4	Series and Parallel Cell Connections	177

17-5	Testing Primary Cells and Batteries	180
17-6	Lead-Acid Rechargeable Battery	181
17-7	Testing a Lead-Acid Battery	182
17-8	Nickel-Cadmium Rechargeable Battery	184
17-9	Battery Chargers	184

CHAPTER 18

CIRCUIT PROTECTION DEVICES 187

18-1	Undesirable Circuit Conditions	187
18-2	Fuse and Circuit Breaker Ratings	189
18-3	Types of Fuses	190
18-4	Testing Fuses	194
18-5	Circuit Breakers	194
18-6	Thermal Overload Protection	197
18-7	Lightning Rods and Arresters	197

CHAPTER 19

ELECTRIC POWER 199

19-1	Electric Generating Stations	199
19-2	Alternate Ways of Generating Electricity	201
19-3	Transmitting Electricity	202
19-4	Electric Power	203
19-5	Calculating Electric Power	204
19-6	Measuring Electric Power	205

CHAPTER 20

ELECTRIC ENERGY 207

20-1	Energy	207
20-2	Calculating Electric Energy	208
20-3	The Energy Meter	208
20-4	Energy Costs	210
20-5	Energy Management	211

CHAPTER 21

DIRECT CURRENT AND ALTERNATING CURRENT 215

21-1	Direct Current (DC)	215
21-2	Alternating Current (AC)	216

21-3	AC Generation	217
21-4	The AC Sine Wave	218
21-5	AC Sine Wave Voltage and Current Values	220
21-6	Three-Phase AC	221
21-7	DC Generation	222
21-8	Types of DC Generators	224
21-9	Generator Prime Movers	225

CHAPTER 22 --- **LOW-VOLTAGE SIGNAL SYSTEMS 228**

22-1	Low-Voltage Signal System	228
22-2	Door-Chime Circuit	229
22-3	Annunciator Circuit	230
22-4	Electric Door-Lock Circuit	232
22-5	Telephone Circuits	233
22-6	Alarm Systems	237

CHAPTER 23 --- **RESIDENTIAL WIRING REQUIREMENTS AND DEVICES 244**

23-1	Approval of Equipment and Wiring	244
23-2	The Incoming Service	245
23-3	The Three-Wire Distribution System	246
23-4	General Wiring Requirements	247
23-5	Installing Nonmetallic Sheathed Cable	252
23-6	Electric-Outlet Boxes	254
23-7	Electrical Receptacles	257
23-8	Lampholders	258
23-9	Switches and Dimmers	259
23-10	Grounding System	262
23-11	Overcurrent Protection	264

CHAPTER 24 --- **RESIDENTIAL BRANCH CIRCUIT WIRING 266**

24-1	National Electrical Code Branch Circuit Requirements	266
24-2	Pull-Chain Lampholder and Duplex Receptacle Circuit	269
24-3	Switch and Lampholder Circuit	271

24-4	Two Lamps and One Switch Circuit	271
24-5	Duplex Receptacle, Switch, and Lamp Circuit	273
24-6	Switched Split-Duplex Receptacle Circuit	274
24-7	Three-Way Switch Circuit	278
24-8	Four-Way Switch Circuit	279
24-9	Planning Your Electrical System	279

CHAPTER 25 --- **APPLIANCE CORDS AND CONNECTIONS 284**

25-1	Types of Electric Cords	284
25-2	Cord Connectors	286
25-3	Grounding Appliances	288
25-4	Ground-Fault Circuit Interrupter (GFCI)	291
25-5	Weatherproof Fixtures	292

CHAPTER 26 --- **LIGHTING EQUIPMENT 294**

26-1	Incandescent Lamps	294
26-2	Repairing a Table Lamp	297
26-3	Installing Light Fixtures	298
26-4	Fluorescent Lighting	302
26-5	Fluorescent Light Fixture Circuits	302
26-6	High-Intensity Discharge (HID) Lamps	308
26-7	Security Lighting	309

CHAPTER 27 --- **ELECTRIC MOTORS 312**

27-1	Motor Principle	312
27-2	Direct Current (DC) Motors	314
27-3	Universal Motors	316
27-4	Alternating Current (AC) Motors	317
27-5	Motor Power and Torque	323
27-6	Troubleshooting Motors	294

CHAPTER 28
RELAYS 326

28-1	Electromechanical Relay	326
28-2	Magnetic-Reed Relay	330
28-3	Solid-State Relays	331
28-4	Timing Relays	332

CHAPTER 29
MOTOR CONTROLS 336

29-1	Motor Protection	336
29-2	Motor Starting	339
29-3	Motor Reversing and Jogging	345
29-4	Motor Stopping	346
29-5	Motor Drive	348
29-6	Motor Pilot Devices	351

CHAPTER 30
INDUCTANCE AND CAPACITANCE 359

30-1	Types of Inductors	359
30-2	Inductance	360
30-3	Inductive Reactance	361
30-4	Phase Shift in Inductance	364
30-5	Capacitance	365
30-6	Capacitor Ratings	366
30-7	Types of Capacitors	368
30-8	<i>RC</i> -Time Constant	368
30-9	Capacitive Reactance	370
30-10	Phase Shift in Capacitance	371
30-11	Impedance	372
30-12	Power in AC Circuits	374

CHAPTER 31
TRANSFORMERS 378

31-1	Transformer Action	378
31-2	Transformer Voltages, Current, and Power Relationships	380
31-3	Ignition Coil	384
31-4	Types of Transformers	385
31-5	Testing Transformers	386
31-6	Three-Phase Transformer Systems	387

CHAPTER 32
SIGNAL SOURCES 390

32-1	Transducers	390
32-2	Loudspeakers	391
32-3	Microphones	391
32-4	Phonograph Cartridges	393
32-5	Record/Play Tape Head	393
32-6	Computer Disk Head	394
32-7	Compact Disc Player	396
32-8	Sensors and Detectors	396

CHAPTER 33
PRINTED CIRCUITS 402

33-1	PC Board Construction	402
33-2	Planning and Layout	404
33-3	Printing the PC Board	405
33-4	Component Assembly and PC Board Soldering	407
33-5	Servicing Printed Circuit Boards	410

CHAPTER 34
ELECTRONIC TEST INSTRUMENTS 414

34-1	The Oscilloscope	414
34-2	Oscilloscope Front-Panel Controls	415
34-3	Oscilloscope Measurements	416
34-4	Signal Generators	420
34-5	DC Voltage Supplies	422
34-6	Bridge Measuring Circuits	423

CHAPTER 35
SEMICONDUCTOR DIODES 426

35-1	Semiconductors	426
35-2	N-Type and P-Type Material	427
35-3	PN-Junction Diode	428
35-4	Diode Operating Characteristics	430
35-5	Diode Packages and Ratings	430
35-6	Testing Diodes	431
35-7	Practical Applications of Diodes	432
35-8	Special Purpose Diodes	435

CHAPTER 36	
POWER SUPPLIES 439	
36-1	Power Supplies 439
36-2	Power Transformer Circuits 440
36-3	Rectifier Circuits 441
36-4	Three-Phase Rectifier 446
36-5	Filter Circuits 448
36-6	Voltage Regulation 449
36-7	Voltage Multipliers 451
CHAPTER 37	
TRANSISTORS 453	
37-1	Bipolar-Junction Transistors (BJTs) 453
37-2	Field-Effect Transistors (FETs) 457
37-3	Unijunction Transistors (UJTs) 463
37-4	Phototransistors 486
CHAPTER 38	
TRANSISTOR SWITCHING, AMPLIFICATION, AND OSCILLATION CIRCUITS 469	
38-1	Transistor-Switching Circuits 469
38-2	Transistor Amplifiers 474
38-3	Transistor Oscillators 486
CHAPTER 39	
THYRISTORS: THE SCR AND TRIAC 491	
39-1	Thyristors 491
39-2	Principles of SCR Operation 492
39-3	DC-Operated SCR Circuits 493
39-4	AC-Operated SCR Circuits 495
39-5	Testing the SCR 499
39-6	The triac 500
39-7	Triac Circuit Applications 501
CHAPTER 40	
INTEGRATED CIRCUITS (ICs) 505	
40-1	Integrated Circuit (IC) Construction 505

40-2	Advantages and Limitations of ICs 506
40-3	IC Symbols and Packages 507
40-4	Analog and Digital ICs 509
40-5	Operational Amplifier ICs 509
40-6	Op-Amp Voltage Amplifiers 511
40-7	Op-Amp Voltage Comparator 513
40-8	Linear-Power Amplifier 514
40-9	The 555 Timer 516
40-10	Sourcing and Sinking IC Outputs 519

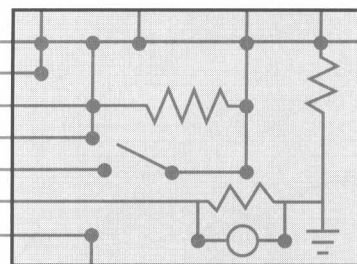
CHAPTER 41	
DIGITAL FUNDAMENTALS 521	
41-1	Digital Electronics 521
41-2	Binary Number System 521
41-3	Logic Gates 524
41-4	Combinational Logic 530
41-5	Binary Arithmetic 535
41-6	Encoders and Decoders 538
41-7	Multiplexers and Demultiplexers 541
41-8	Sequential Logic 543
41-9	Registers 547
41-10	Binary Counters 548
41-11	Connecting with Analog Devices 553
41-12	Digital Logic Probe 555

CHAPTER 42	
THE MICROCOMPUTER 559	
42-1	Microcomputers 599
42-2	Memory Units 561
42-3	Input and Output 561
42-4	Computer Communications 565
42-5	Computer Software 568
42-6	Processing Information 569
42-7	Microprocessor-Based Control Systems 670

GLOSSARY	577
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INDEX	585
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1



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.

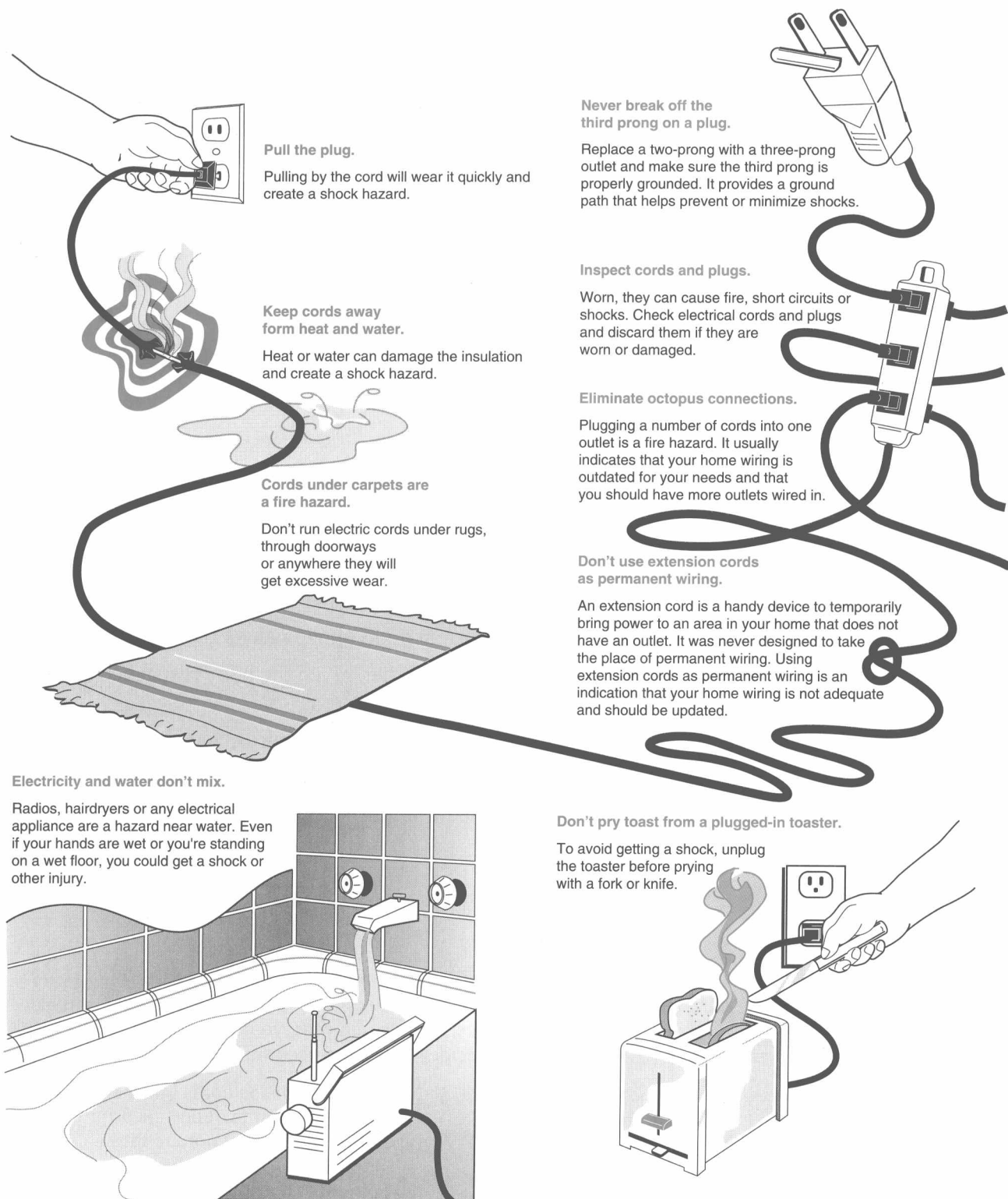


FIGURE 1-1 Know the potential hazards and take the necessary precautions to eliminate them. (Courtesy Ontario Hydro.)

- 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:

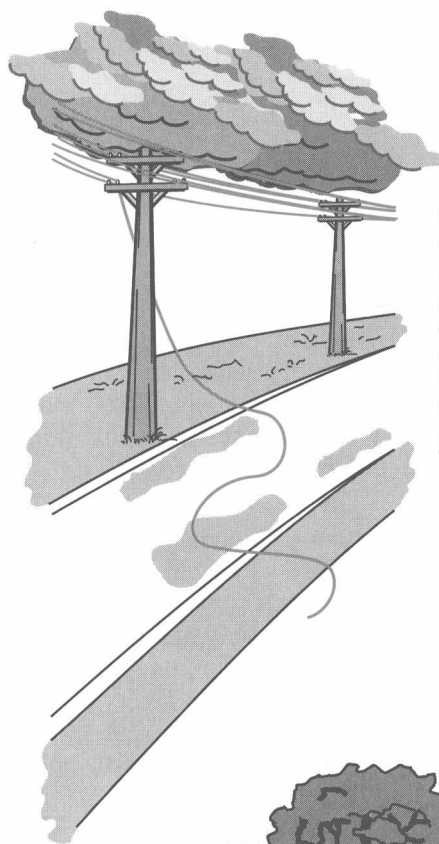
- Never touch a downed wire.
- Stay clear of power lines.
- Do not bring appliances near swimming pools.
- Never use power tools on wet grass or other wet surfaces.
- All outdoor electrical outlets should be supplied from circuits equipped with *ground-fault circuit interrupters* to provide extra protection. 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.

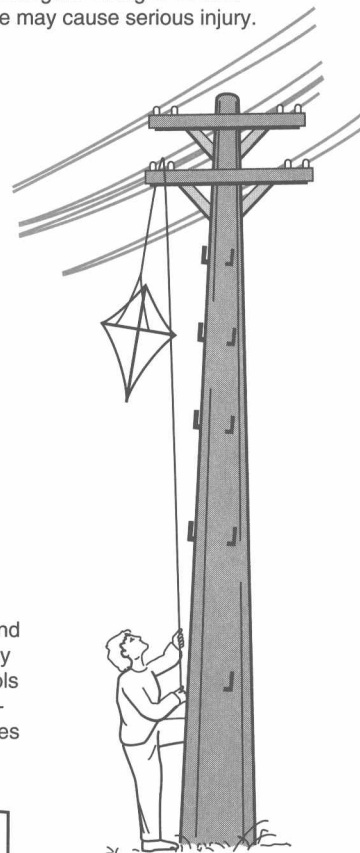


Never touch a downed wire.

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.

Stay clear of power lines.

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



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.

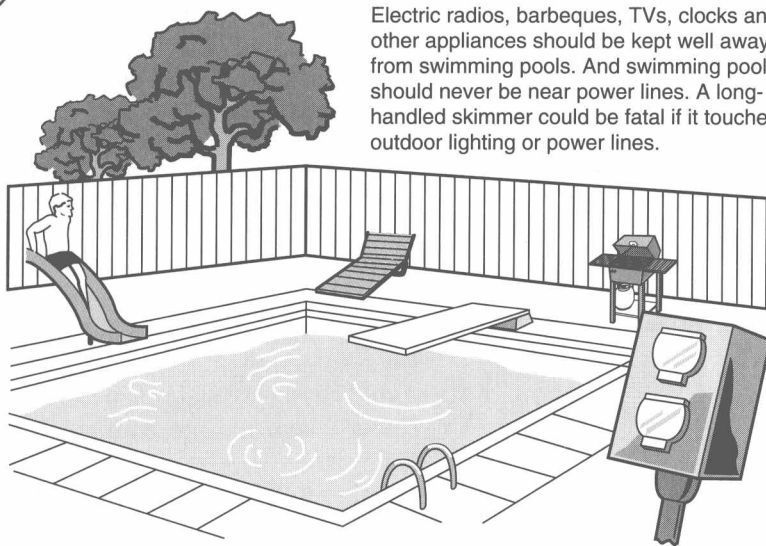


FIGURE 1-2 Safety outdoors. (Courtesy Ontario Hydro.)

1-4

OCCUPATIONAL SAFETY

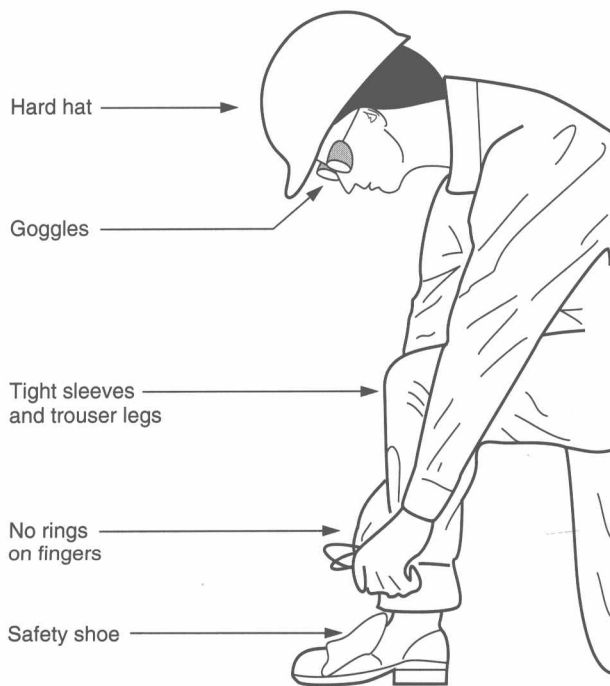
Safety has become an increasingly large factor in the working environment. The electrical industry, in particular, regards safety to be unquestionably the single most important priority due to the haz-

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:

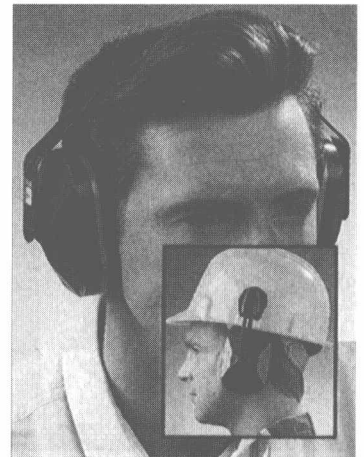


FIGURE 1-3 Typical accident prevention signs. (Courtesy Safety Supply Canada.)



A. Clothing and personal safety

B. Hearing protection



C. Breathing protection

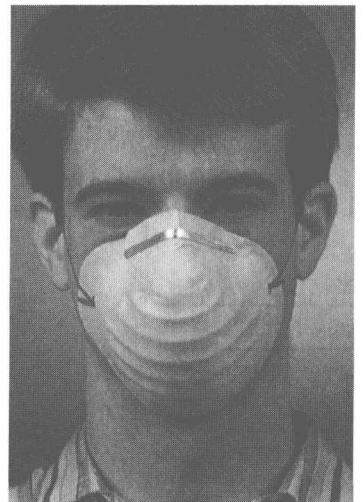


FIGURE 1-4 Clothing and equipment used for personal safety. (Courtesy Safety Supply Canada.)

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).

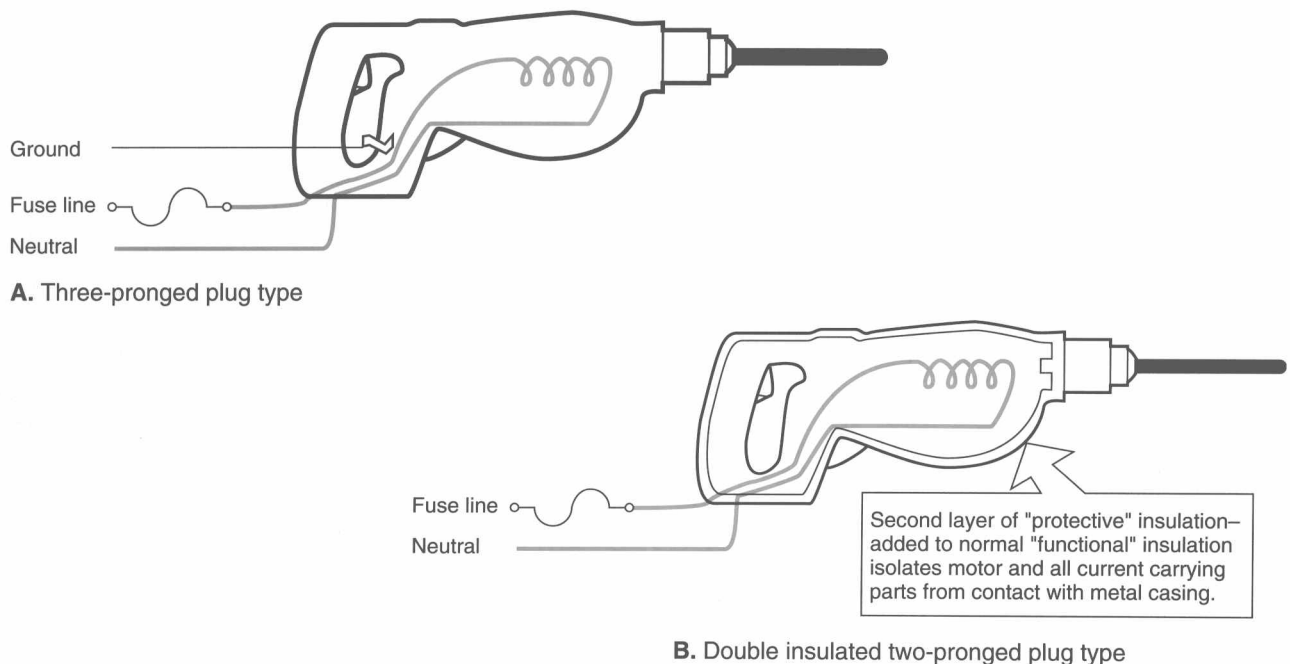
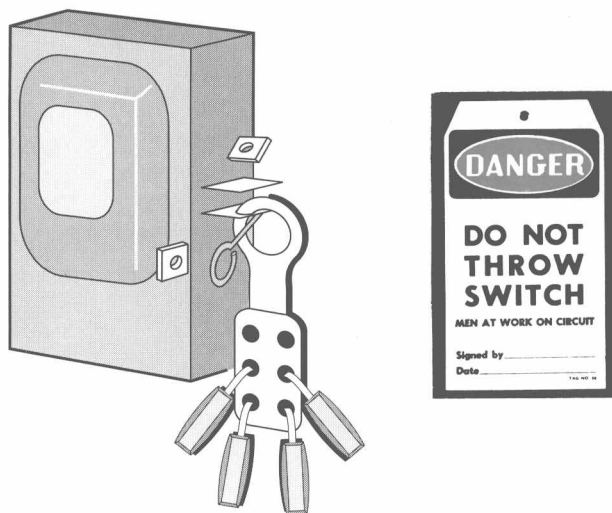


FIGURE 1-5 Use properly grounded tools.



(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

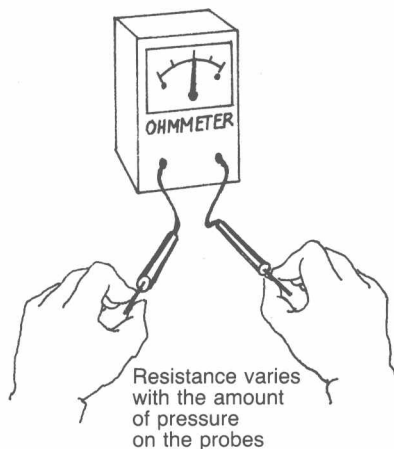


FIGURE 1-7 Measuring body resistance.

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.