ELECTRONIC ASSEMBLY

CONCEPTS AND EXPERIMENTATION

FREDRICK W. HUGHES

THE FUNDAMENTALS SERIES FOR ELECTRONIC TECHNOLOGY

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Concepts and Experimentation

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Dedication

This book is dedicated to Mr. Robert Roberts whose persistence in the field of education and the training of Electronics Assembly workers has earned him a well deserved retirement. His invaluable assistance and cooperation was most appreciated. Good luck BOB!

Also special recognition is given to Mr. Gil Patterson for the cover photo and his assistance in photography and the moral support he provided. Okay Gil, it's time for you to publish!

Special thanks to my wife Roberta and son Jeffery for their assistance in making the photographs.

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Preface

The electronics industry has changed considerably in the past decade. Many manufacturing techniques have changed and automation has taken over most of the jobs originally performed by workers. However, there is wide diversity among manufacturing facilities. Some plants may be totally automated, whereas others combine automatic machines and manually operated procedures in their production process.

Fabrication of electronic devices involves efforts of a technical team composed of engineers, electronic assemblers, and technicians. The original ideas for an electronic product are developed by the engineer, who may also plan how the device is to be fabricated. The electronics assembler manufacturers the product following the plans of the engineer. Testing the finished product to see that it meets specifications and functions properly is the job of the electronics technician. The technician is also responsible for the maintenance and repair of the equipment for its continued operation.

Jobs in electronics are suited to men and women of all nationalities, and many persons have achieved a high degree of success in all phases of the industry. Regardless of the new methods and techniques of manufacturing that appear nearly every day, a person desiring to enter the electronics industry must have the necessary basic understanding of electronic components and skills in the use of hand tools and soldering.

This book was written for those persons working with or planning to work with the production, repair, or maintenance of electrical and electronic equipment and devices. A list of such persons would include production assembly persons, component repair persons, technicians, field engineers, and systems engineers. Persons entering the electronics field as assemblers, testers, or technicians cannot merely go to work and pick up knowledge of the trade on the job; they must be trained. Even job-entry positions require that a person have some basic knowledge and skills in electronics. In addition, a person with knowledge and skills advances more rapidly in the electronics industry.

BOOK OBJECTIVES

When you have completed this book, you will be able to:

1. Explain a basic electrical circuit.
2. List safety practices associated with electrical/electronic devices and circuits.
3. Identify the schematic symbols of passive and active electronic components.
4. Recognize and use basic hand tools.
5. Prepare a soldering iron properly for soldering components.
6. Use correct soldering techniques for various soldering joints.
7. Define the process of creating a printed circuit board.
8. Assemble insertion-type components and surface mount components into printed circuit boards.
9. Produce cables and attach connectors to wires.
10. Repair basic component problems associated with electronic devices and printed circuit boards.
11. Show how assembly persons can upgrade themselves to meet the challenge of automation.
12. Explain the various terms used in fabricating and manufacturing electronic devices and equipment.

BOOK FORMAT

Each unit in this book follows a standard format consisting of six sections. In Section 1 the reader is introduced to the theory or information of basic topics. Section 2 consists of definition exercises that enable the reader to begin to understand and use the language of electronics assembly. Exercises and problems are given in Section 3 to develop in the reader a working knowledge of electronic devices and assembly procedures. These exercises include drawings, matching symbols, and various other methods to motivate and maintain the interest of the reader. In Section 4 we show how to perform simple tests on electronic devices, mechanical assembly, soldering procedures, and related methods of manufacturing. An instant review of basic terms is presented in Section 5 to reinforce the reader's knowledge. A self-checking quiz is given in Section 6 to provide the reader with instant feedback of what was learned from the unit. Answers are provided at the end of each unit.

FOR THE STUDENT

Manipulative skills such as mechanical assembly and the use of proper soldering procedures are essential for any electronics assembler and technician. However, the same person attempting this type of work must have knowledge of the terms used, be able to recognize schematic symbols, be aware of safety precautions for the protection of personnel, equipment, and tools, and be familiar with other manufacturing methods used in the industry.

This book is designed to be used in conjunction with a classroom setting, but is written as a self-study method. The material is presented in an easy-to-read, straightforward manner that will provide the readwer with a solid foundation for further study in electronics. The important thing to remember is to be serious about learning electronic assem-

bly procedures and to spend time studying those topics that are most difficult for you.

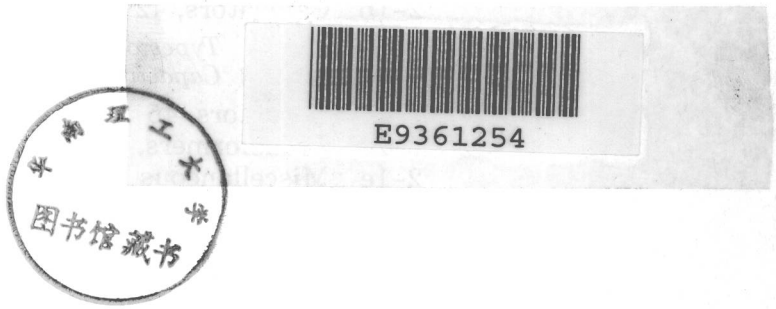
FOR THE INSTRUCTOR

This book uses an individualized learning approach, which involves the reader in the activities of learning. This provides the instructor with student-centered instruction that does not require preparation. In a lock-step type of course, students still have some capability to learn at their own rate with the use of this book. A student is able to perform other sections of a unit while waiting for personal instruction from the instructor. By placing more responsibility on students for their learning, schools are able to graduate better-prepared persons to enter the work force.

I wish you good luck and success in the electronics industry.

Fredrick W. Hughes

Contents



Unit 1

Basic Electrical Circuit Components

INTRODUCTION

Anyone working with the construction and assembly of electrical/electronic devices must be able to identify basic components and have a knowledge of basic circuit operation. This not only enhances a person's skills, but provides a foundation for understanding safety when working with tools and the prevention of electrical shock.

UNIT OBJECTIVES

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

1. Define the terms *voltage, resistance, current, volt, ohm,* and *ampere.*
2. Describe a basic electrical circuit.
3. Identify types of wire, switches, lamps, and safety devices.
4. State what constitutes a good electrical conductor.
5. List materials that make good conductors.
6. State what constitutes a good electrical insulator.
7. List materials that make good insulators.
8. Define basic wire and cable connectors.
9. Describe a multimeter.
10. Use an ohmmeter to test a lamp and a switch.
11. Define *open circuit, closed circuit,* and *shorted circuit.*
12. Explain how an electrical shock occurs.
13. Show what is meant by *grounding* a circuit.
14. List good safety practices when working with electrical/electronic equipment and devices.

SECTION 1–1
FUNDAMENTAL CONCEPTS

1–1a THE BASIC ELECTRICAL CIRCUIT

The basic electrical circuit is easily illustrated with the common battery-operated flashlight, shown in Figure 1–1. To produce light you must have a power source, such as batteries; a lamp; electrical conductors to connect the lamp to the batteries; and a switch to provide on/off control. Usually, these components are placed in an insulating plastic case with a reflector, which increases the light's brightness. The bottom part of the switch has a metal portion that contacts the conductor with a forward movement and allows electrical current to flow through the lamp, producing light.

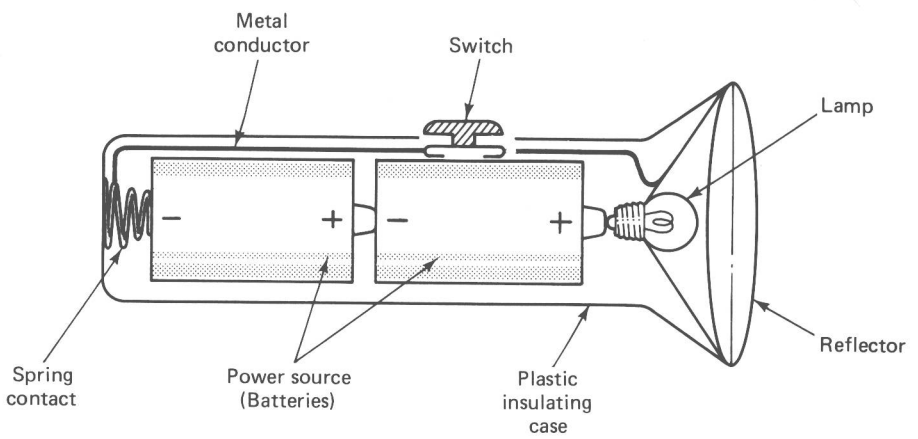


Figure 1–1 Simple flashlight (cross-sectional view).

An *electrical circuit* can be defined as an electrical path between two or more devices for the purpose of carrying electrical current to produce a useful function. There are three important terms associated with an electrical circuit:

1. *Voltage:* the force that causes electrical current to flow in a circuit. Voltage is the difference between two charges, such as a battery. The negative end of the battery has a large number of negatively charged particles, referred to as *electrons.* The positive end of the battery has many fewer electrons and, therefore, is referred to as a *positive charge.* When a conductor is placed across the terminals of a battery, the electrons will flow from the negative terminal through the conductor to the positive terminal of the battery. The *volt* (V), the unit of voltage, helps to identify various forms of voltage, such as a 6-, 9-, or 12-V battery. A battery operates on dc (direct current) voltage since the electrons always flow in one direction, from negative to positive. Typical house voltage changes polarity at a specified frequency of 60 cycles per second and the electrons flow first in one direction, then in the other. This type of voltage is referred to as ac (alternating current) voltage.
2. *Current:* the flow of electrons through the circuit caused by the force of voltage. The *ampere* (A), the unit of current, aids in showing amounts of current, such as 20 A, 10 A, or very small amounts such as 0.1 A [100 milliamperes (mA)].
3. *Resistance:* the opposition to current flow of the components and conductors in a circuit. The *ohm* [Ω (Greek capital letter omega)] the unit of resistance, helps to identify various values, such as 10 Ω, 100 Ω, 1000 Ω, and 1,000,000 Ω.

A flashlight can be represented by a basic electrical circuit, as shown in Figure 1–2. The power source is a 1.5-V battery, the load, which is an electrical device that performs a useful function; in this case, a lamp and the conductors are connecting wires. A switch is also used to control the flow of electrical current in the circuit.

In Figure 1–2 a, when the switch lever is placed to the left, the switch is open and no current flows in the circuit. When the switch lever is placed to the right, the switch is closed and electrons leave the negative terminal of the battery and flow through the switch, then through the lamp to the positive terminal of the battery. The electrons flowing through the resistance of the lamp create heat and produce light—hence, a typical flashlight circuit.

Figure 1–2b and c show a *schematic diagram* (electrical drawing). Notice the symbols for battery, switch, and lamp. As a technician, you should be able to draw these symbols from memory. In Figure 1–2b the switch is open and the resistance of the circuit from the viewpoint of the battery is infinite. Therefore, no current flows in the circuit and the lamp is off or not glowing. This condition is referred to as an *open circuit.* In Figure 1–2c the switch is closed and current flows through the circuit, as indicated by the arrows, which in turn causes the lamp to glow. The battery now "sees" a lower resistance, which depends on the resistance of the lamp. The closed switch is assumed to have no or zero resistance. This condition is referred to as a *closed circuit.*

The circuit in Figure 1–2 is a *series circuit,* because electrons leaving the negative terminal of the battery flow through the switch and then through the lamp to reach the positive terminal of the battery. Since the

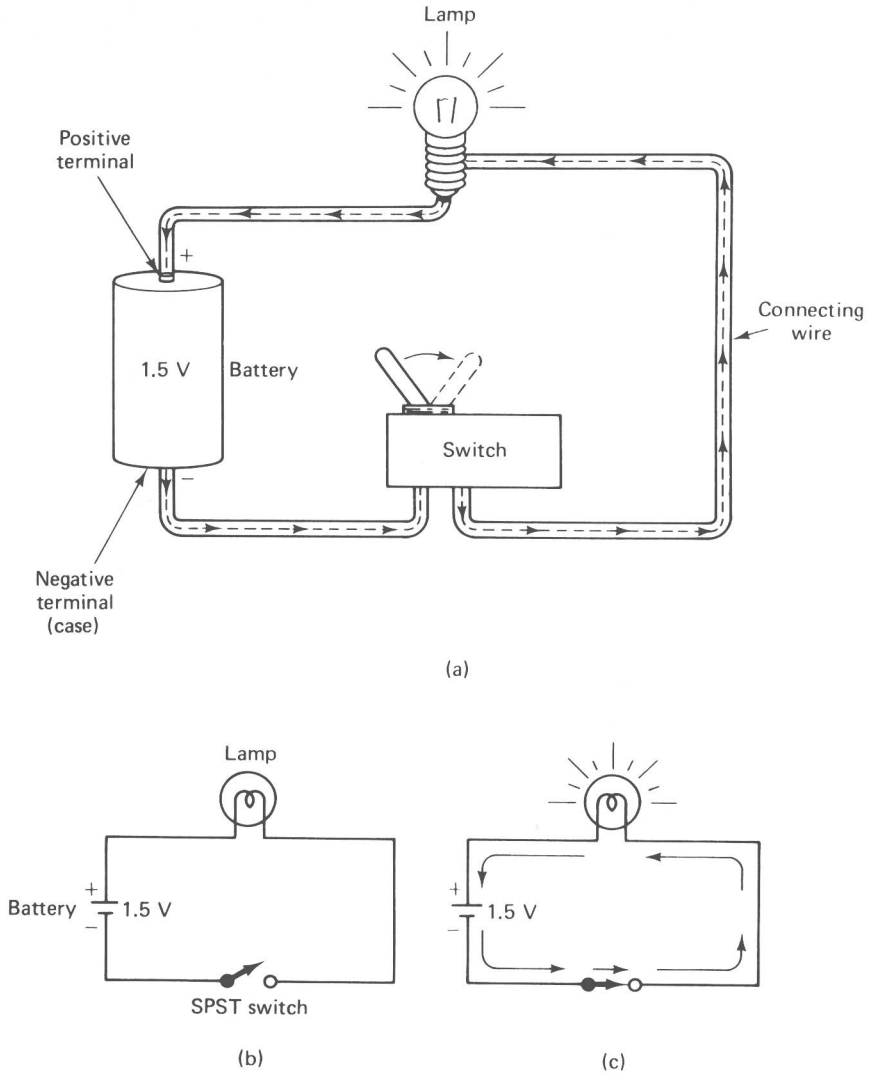


Figure 1–2 Basic electrical circuit: (a) pictorial diagram; (b) schematic diagram, open circuit; (c) schematic diagram, closed circuit.

same current flows through the switch and then the lamp, it is said that the switch and lamp are in series.

1–b CONDUCTORS

An *electrical conductor* is a material that has a large number of electrons capable of flowing through the material. These electrons are often referred to as *free electrons.* Most good conductors are metallic in substance. Silver is the best known practical electrical conductor. Table 1–1 shows a comparison of some conductive materials with a diameter of 0.001 in. (1 mil) and a length of 1 ft at a constant temperature of 20°C.

TABLE 1–1
Comparison of Conductor Materials

Material	*Ohms/mil, foot*	*Relative Conductivity*
Silver	9.8	1 (high)
Copper	10.4	2
Gold	14.7	3
Aluminum	17.0	4
Tungsten	33.2	5
Nichrome	660.0	6 (low)