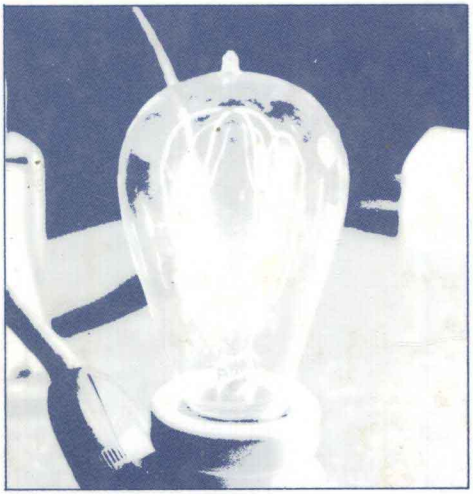
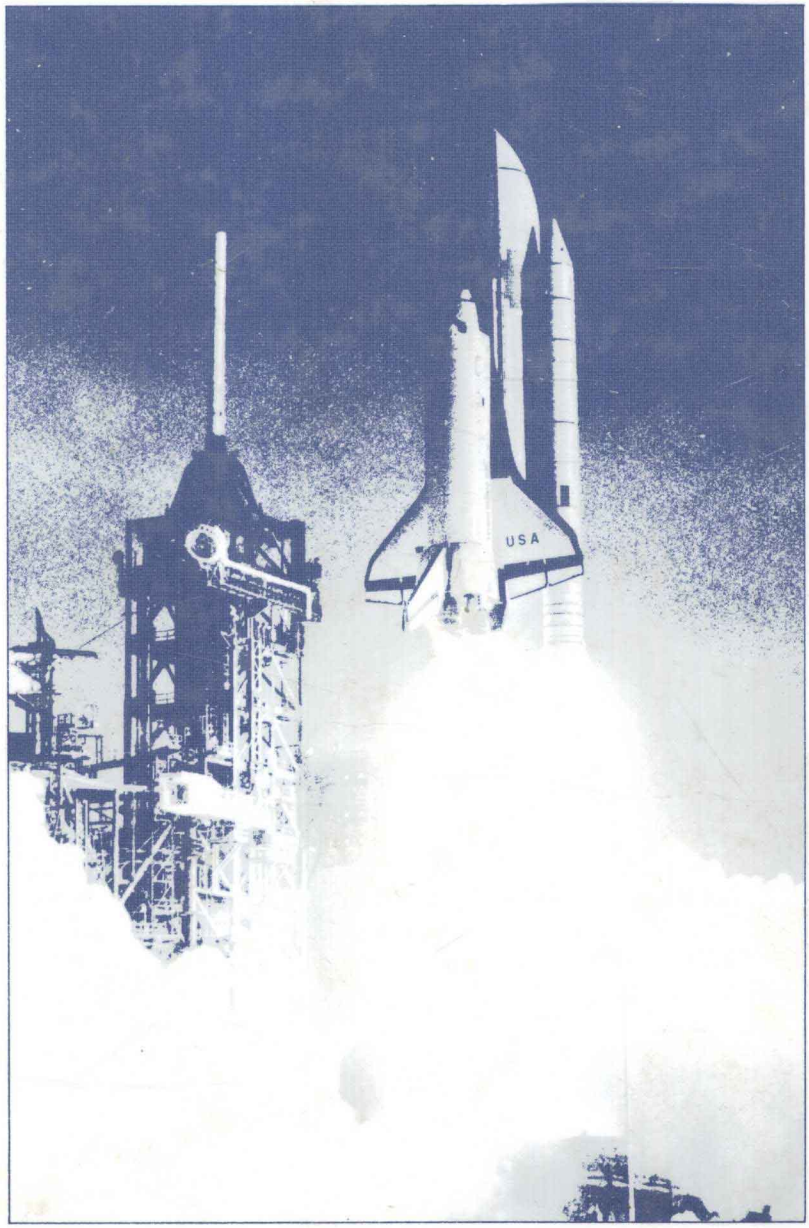
Electronics

Concepts, Applications, and History

Roger J. Houglum





ELECTRONICS:
Concepts, Applications, and History Second Edition

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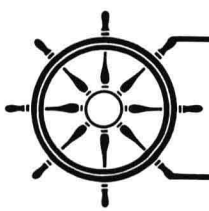

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I would like to dedicate this book to the staff members of the Electronics Department of Lane Community College for their constant support and encouragement during the long period required for its research and writing.

Preface

Today electronics touches the life of nearly every American in some manner scores of times in the course of a single day. In the 1980s, the problem of keeping everyone fully informed of new developments in the ever-widening and ever-changing field of electronics can no longer be met entirely by trade journals and technical publications.

For example, computer specialists know little about medical electronics, yet the use of computers and microprocessors has revolutionized the medical profession's approach to patient diagnosis and treatment. And to compound the problem, trained electronics personnel working in the field of medical electronics frequently have little or no understanding of computer and microprocessor operation. What is needed is a book that will serve as a clearinghouse of information for those with a professional, an avocational, or a casual interest in new developments in the field of electronics and the technology of its applications. We hope that this book, with its innovative and unique approach and content, will meet the needs of all three audiences.

The overall plan for the book is both simple and logical. The first part of the opening chapter provides a thorough and updated overview of today's Electronics Industry: how the industry is organized, recent trends affecting job opportunities, and job qualifications and rewards for production workers, supervisors, equipment servicers, and field engineers. The second part of the same chapter focuses on the history of electronics from its earliest beginnings to the present, including the major contributions of great pioneers in the field and important breakthroughs such as the vacuum tube, the transistor, and the integrated circuit.

This introductory material is followed by a series of chapters dealing with electronics theory. These ''concept chapters'' provide a detailed and well-balanced background upon which a further knowledge of electronics theory may be built. A middle-ground approach is taken in these chapters so that the occupation-oriented readers may find real substance while avocationally oriented readers remain interested. That is, electronics theory and concepts have been stated clearly, simply, and logically so that even a novice in this field can readily grasp and understand them. At the same time, concepts have been carefully related to practical examples so that future electronics technicians gain substantial background information on electromagnetism, DC and AC theory, and basic instrumentation and storage devices.

The most compelling chapters of the book deal with the wide variety of applications in electronics, including electronics in medicine and health occupations, in space and world exploration, in telecommunications, in recording and audio systems, in video systems and music, and in computers and other electronic devices used in the home, business, and industry. These ''applications chapters'' reinforce the theme of continuing change in both the technologies and the products described.

For example, in the field of medicine, the recent development of the nuclear magnetic resonance scanner is considered to be the greatest breakthrough in diagnostic medicine in the last century. Mean-

while, NASA's whole approach to space exploration has been changed by its successful series of reusable space shuttle vehicles—an accomplishment that now makes practical a manned space station. In the field of telecommunications, cable television, providing a variety of programs from distant production centers, is aggressively competing with standard television stations for its share of the viewing audience. Geosynchronous communications satellites that link these cable systems to their program sources also bring a variety of programming to private homes that are equipped with receiving dishes to intercept the microwave transmissions. Video cassette recorders are selling much more briskly than originally predicted, especially since Japanese imports forced sharp reductions in retail prices. Video discs are also selling well, having been handicapped at first by high equipment costs and limited program offerings. In the field of audio, the most exciting development has been the digital audio disc with its great dynamic range and extended frequency response. Read by a laser beam and sealed in plastic, the disc should provide flawless reproduction for many years. In the home, the best-selling electronic equipment items have been video games and personal computers. In business and industry, two important electronic technologies are emerging. The first is optoelectronics—the technology of data transmission over a modulated beam of light and then over an optical fiber to its terminal. The second is robotics—the use of a microprocessor-controlled arm to perform simple, repetitive tasks such as assembling modules or welding and spray-painting automobiles. Thus, the second edition of *Electronics: Concepts, Applications, and History* correctly reflects electronics as it is today—exciting and expanding.

Particular mention should be made of the high level of public participation and active support received in the preparation of the applications chapters. One of the largest regional hospitals in the Pacific Northwest arranged for its own staff photographer to take many new photos to illustrate the chapter on electronics in medicine. At the same time, local medical doctors provided charts, pictures, and data in their specialty fields.

Similarly, a 50 kilowatt clear-channel broadcast station and a local full-power commercial television station assigned staff members to plan and then take the many black-and-white photos needed to illustrate the chapter on electronics in telecommunications. And finally, such prestigious national firms as General Electric, Heathkit, Hewlett-Packard, IBM, RCA, and Xerox, to name a few, searched their files for both printed materials and photographs that would be helpful in the writing of the text for other applications chapters and providing suitable illustrations.

The author also wishes to acknowledge the full support of Sacred Heart General Hospital of Eugene, OR, which assigned Jay Rymeski, their director of audio-visual instruction, to the taking of several dozen photographs needed to illustrate the chapter on medical electronics. Also appreciated is the assistance of Dr. John N. Mundall, who provided examples of normal electroencephalograms, and that of Dr. Stanley M. Richmond, also of Eugene, who supplied information on the technology of acupuncture. Because of the highly specialized nature of the subject matter of Chapter 8, the author wishes to acknowledge the contributions of the following people: Ruth McCarroll, Radiologist-Technician at Eugene Hospital and Clinic, Eugene, Oregon; Tom Lawry, Director of Community Relations and the Medical-Electronics Staff at Sacred Heart General Hospital, Eugene, Oregon; and David Kelch of the Medical Products Division of Hewlett-Packard—all of whom read the original chapter and supplied suggestions and photos of new equipment. Special thanks to Dr. Daniel Robinhold, Cardiologist, for supplying several types of heart pacer to Alan Yordy, Media Coordinator of Sacred Heart General Hospital, who took the photos of these units that appear in the text.

ELECTRONICS:
Concepts, Applications, and History

Contents

1 Electronics Today and Yesterday

This woman is working in electronics drafting. Women readily find employment with electronics firms in many job assignments. (Photo courtesy of Tektronix)

The purpose of this chapter is to provide some insight into the importance and scope of electronics in terms of both its economic impact and its far-reaching effects on our lives. Electronics is an industry of great vigor and promise, and each step forward in its technology will lead to further important applications. These applications, in turn, will result in new jobs in the design, construction, and sale of new products.

Perhaps the most remarkable characteristic of the Electronics Industry is its tremendous expansion. Since 1920, annual gross income has risen from just a few million dollars for a handful of products to many billions of dollars for an enormous variety of products and services. Moreover, this growth has taken place over a period of less than sixty years—a record of expansion that other fields of industry have seldom equaled.

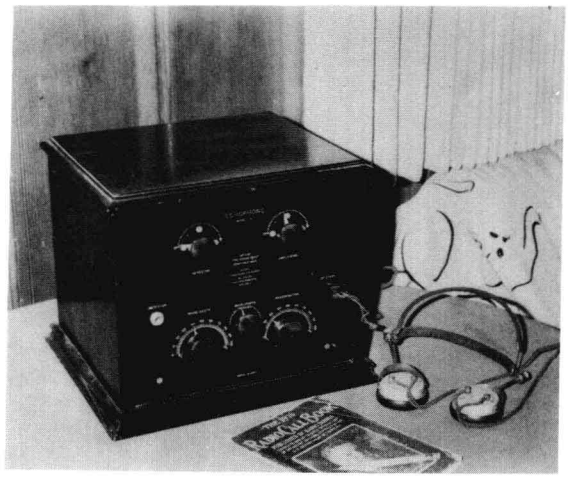

Figure 1.1 A Mid-1920s Home "Listening Post" It consisted of a battery-powered broadcast receiver connected to headphones. The 1926 *Radio Call-book* was necessary because stations operated on irregular schedules and often changed frequencies.

THE FIELD IN PERSPECTIVE

Many people can recall the almost complete lack of electronics and its applications in American life in 1920. For example, the longest distance a telephone call could travel was from New York to Denver, and connections were uncertain. What little radio broadcasting took place did so with low power and on an erratic schedule. The focal point for home entertainment was the windup acoustic phonograph with its cumbersome shellac records and rapidly wearing steel stylus. Motion pictures were of the silent type, with the dialogue projected on the screen between scenes. Hospitals had little or no electronic equipment for diagnosis, therapy, or monitoring.

The sudden upsurge of radio broadcasting in 1922 sparked rapid development in the Electronics Industry. That year marked the first large-scale use of the three-element vacuum tube (triode) invented earlier by Lee De Forest. During the period from 1920 to 1923, the number of broadcast stations leaped from 3 to more than 500, and sales of radio receivers (Figure 1.1) skyrocketed from $2 million to $136 million. General Electric, RCA, and Westinghouse, anxious to keep their receiver production lines operating at full capacity, constructed, operated, and programmed their own broadcast stations. Their top-quality programs stimulated additional set purchases. With a ready supply of mass-produced radio components, including vacuum tubes, resourceful technicians and experimenters were soon developing innovative circuitry for entirely new applications. Electronics was off to a whirlwind start, and the pace of development has never slackened.

TODAY'S ELECTRONICS INDUSTRY

Characteristic of today's Electronics Industry are steady and rapid growth; widespread automation, particularly in the production of integrated circuits; high worker productivity; and a comparatively small but highly trained work force. How big is the in-

dustry in terms of dollar volume and in terms of the number of persons employed? The *U.S. Industrial Outlook for 1982*, published by the Department of Commerce, estimated the total value of industry shipments by American manufacturers of Electronic Equipment and Electronic Components (they are considered separate divisions) at $42.4 billion—an increase of 8.9% from the 1981 figure of $38.9 billion. Much of this increase can be attributed to greatly expanded purchasing by the Department of Defense, which uses an enormous spectrum of electronic systems.

Current information from the Department of Commerce indicates that the Electronics Industry is relatively depression free. For example, during the downturn years of 1981–1982, workers in many major industries received wage cuts or even termination notices; in electronics, however, the number of workers actually expanded slightly, and many of them received wage increases averaging slightly under 10% per year.

In preparing for employment in electronics, you need to keep in mind the importance of choosing a rapidly growing segment of the industry. Choosing an area that is static or is in decline may result in a dead-end job without a future. The following sections examine the more promising areas of electronics employment.

How the Industry Is Organized

The Department of Commerce divides the Electronics Industry into two major categories and, at the same time, identifies perhaps half a dozen smaller divisions. The first major division is Electronic Equipment, which comprises a large number of electronic assemblies produced from such components as transistors, resistors, and capacitors. The second major division, Electronic Components, represents the manufacturing plants that produce the parts used in equipment fabrication.

The category of Electronic Equipment contains two subdivisions that indicate the eventual user of the product. Electronic Systems (Government Equipment), the larger of the two divisions, includes purchases made by the Department of Defense, NASA, NOAA, FAA, and other government agencies. Consumer Electronics includes equipment destined for use in the home or by individual consumers—for example, microwave ovens, video cassette recorders, TV receivers, and personal computers.

Between 1978 and 1983, sales of electronic equipment have grown from about $14 billion to $18 billion. During these years, the number of skilled workers in the field has increased from 300,000 to 325,000, and each year the field has shown a substantial increase in the value of its shipments. Over the same five-year period, sales of electronic components have increased from $10 billion to $27 billion, and employment figures have increased from 309,000 to 504,000. Also, shipments of repair parts to workers who service electronic equipment have been steadily increasing.

Recent Trends Affecting Job Opportunities

Certain developments that began in mid-1983 and carried over into 1984 may have a far-reaching effect on Electronics Industry employment. Late in the spring of 1983, video games and video game machines, which had been selling so briskly that it was difficult for retailers to keep them in stock, suddenly encountered great sales resistance. Prices tumbled overnight, but sales remained abnormally low. Major firms such as Atari and Mattel, which had specialized in video games, suffered severe financial losses. Atari sought to reduce production costs by closing a number of its U.S. plants and moving manufacture of its game machines to the Far East—a decision that cost hundreds of American workers their jobs. Were other American manufacturers to follow the same course, the effects on employment in the Electronics Industry would be very unsettling.

In the early summer of 1983, a similarly abrupt drop in personal computer sales caught retailers in a bind worsened because factory shipments of com-

puters were increasing each month. Within a few weeks retail prices of well-known PCs tumbled—in some cases to less than half their previous level. A number of smaller computer firms declared bankruptcy. Others cut back their work force drastically, and thousands of skilled workers lost their jobs. Today the demand for PCs can be described only as fair, despite the bargains available at computer stores. Manufacturers claim they are losing money on every sale, and some companies may eventually go bankrupt. These developments have made it inadvisable to look for employment in the video games or personal computer segments of the Electronics Industry.

Job Qualifications for Production Workers

Production workers account for approximately 80% of an electronic assembly plant's employees. They are usually described as hi-tech workers. Most employers expect potential employees to have a high school diploma or its equivalent, but few applicants will be turned down if they seem bright and eager. Previous experience in electronics is usually not required, although some previous training in the field may be helpful when the number of job applicants exceeds the number of vacancies.

In a typical assembly line, workers sit at a bench equipped with hand tools and bins of small electronic parts. A completed model of the circuit board on which they are working is prominently displayed in front of them. The worker must bend leads on small parts and then insert the leads into predrilled holes in the circuit board. After clipping off the excess lead length, the worker solders the component in place on the circuit board. An excellent job of soldering is required. Besides soldering and hand-tool skills, workers need only be familiar with the resistor and diode color codes.

Job Qualifications for Supervisors

The educational background and the skills needed by upper-echelon workers in electronic systems or electronic components plants are different from the requirements established for production workers. In general, production-line supervisors and department heads need a minimum of two years of electronics training, both theory and shop skills, and some successful supervisory experience. Chief engineers and their assistants should hold a degree either in electrical or in electronic engineering from an accredited college. They must also be able to design sophisticated electronic equipment.

Job Qualifications for Equipment Servicers

The armed forces train selected personnel for electronic equipment repair, but civilian repairers are far more numerous. Personnel engaged in electronic equipment repair number about four or five times

Hewlett-Packard engineers ponder changes in a circuit board and its supporting structure, an essential module of the professional oscilloscopes shown in the foreground. Engineers are always alert to changes that will improve equipment performance and reliability. (Photo courtesy of Hewlett-Packard)