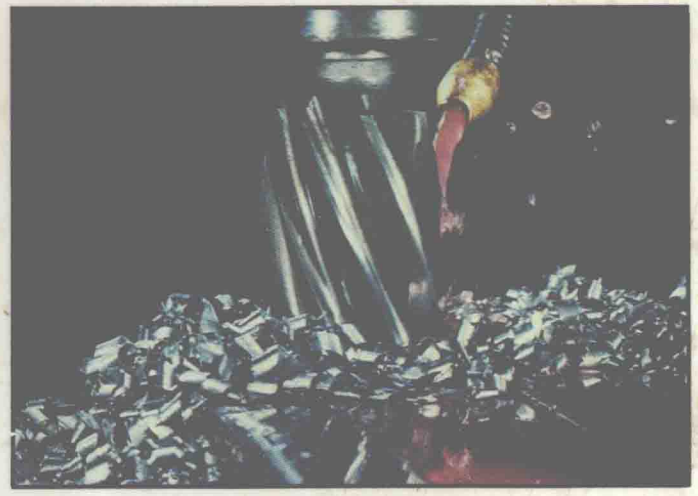
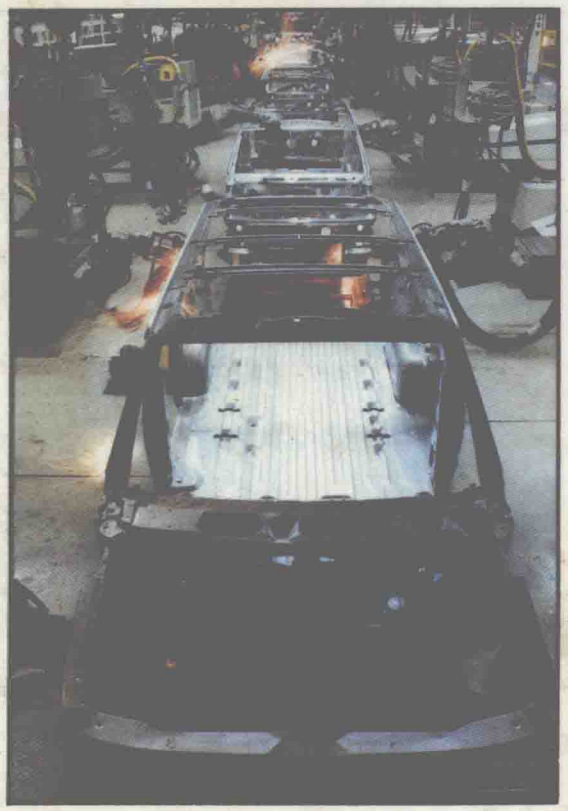
Modern Metalworking

John R. Walker





Modern Metalworking

by

JOHN R. WALKER

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INTRODUCTION

MODERN METALWORKING emphasizes the important place metals occupy in our everyday lives; it explores the numerous metalworking career opportunities. It is designed to provide a broad experience in metalworking through the use of tools, machines, and materials that are basic to this important area.

MODERN METALWORKING supplies basic information on tools, materials, and procedures used in metalworking occupations. It covers both hand and machine-tool operations, and supplies background knowledge on industrial equipment and processes.

Metal is used for many different purposes. It is used to manufacture such items as jet and rocket engines, where the material must withstand terrific heat. It is used to make buckets for mammoth earth movers, where toughness is a must. And it is used to make modern aircraft, where light weight and great strength are required.

Metals are used to make things of beauty such as jewelry, tableware, furniture, and works of art. Fuel that powers nuclear submarines is a metal. It needs only a few pounds to generate enough power to propel a submarine around the world. Still another combination of metals has the unique ability to convert sunlight to electrical energy. A thin layer of metal only a microinch (1/1,000,000 in.) thick makes it possible for a computer to make split-second computations.

Metal has been used in some way during the production of almost everything we eat, see, feel, hear, smell, and touch.

With so much of our daily living depending upon metals, it is essential that we learn something about them, how they are worked, and the industry that uses them. The following paragraphs may answer your question, "Why study about metals?"

1. The metalworking industries in the United States employ more workers than any other industries. There is a great possibility that you will be employed in this area of our economy. This course will increase your understanding of the occupational requirements and opportunities in this field.

2. By studying and participating in the metalworking areas, you have the opportunity to develop and practice basic skills necessary for vocation competence. These basic skills will also enable

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you to plan and complete the operations necessary to turn out high quality, and professional-looking metal products.

3. If you are a potential engineering student, you will have the opportunity to acquire information and develop skills that are considered basic to many engineering programs. These same skills may enable you to secure a better than average paying job during your summer vacation.

4. The technical knowledge you acquire may help you to advance more rapidly in the Armed Forces, should you decide to make this your career.

5. The basic metalworking skills you learn are applicable to many areas of industrial endeavor. You will be able to readily adapt to new technologies when they are introduced to industry in the future.

6. Many of the major items you will purchase during your lifetime (automobiles, hand and power tools, appliances, etc.) will be made from metal. This course will help you develop an appreciation for well-designed products. It will also help you expand your ability to select, care for, and use home and industrial quality products wisely.

7. You will learn and practice safe work habits.

8. The problem-solving situations you encounter will give you opportunities to make practical applications of the math and science you have studied.

9. Metalworking is a very interesting and challenging area of study. You will find many opportunities to develop leadership skills.

10. Perhaps you just like to work with your hands. If so, this will give you a chance to satisfy this desire.

John R. Walker

IMPORTANT SAFETY NOTICE

Work procedures and shop practices described in this book are effective methods of performing given operations. Use special tools and equipment as recommended. Carefully follow all safety warnings and cautions. Note that these warnings are not exhaustive. Proceed with care and under proper supervision to minimize the risk of personal injury or injury to others.

This book contains the most complete and accurate information that could be obtained from various authoritative sources at the time of publication. The Goodheart-Willcox Co., Inc. cannot assume responsibility for any changes, errors, or omissions.

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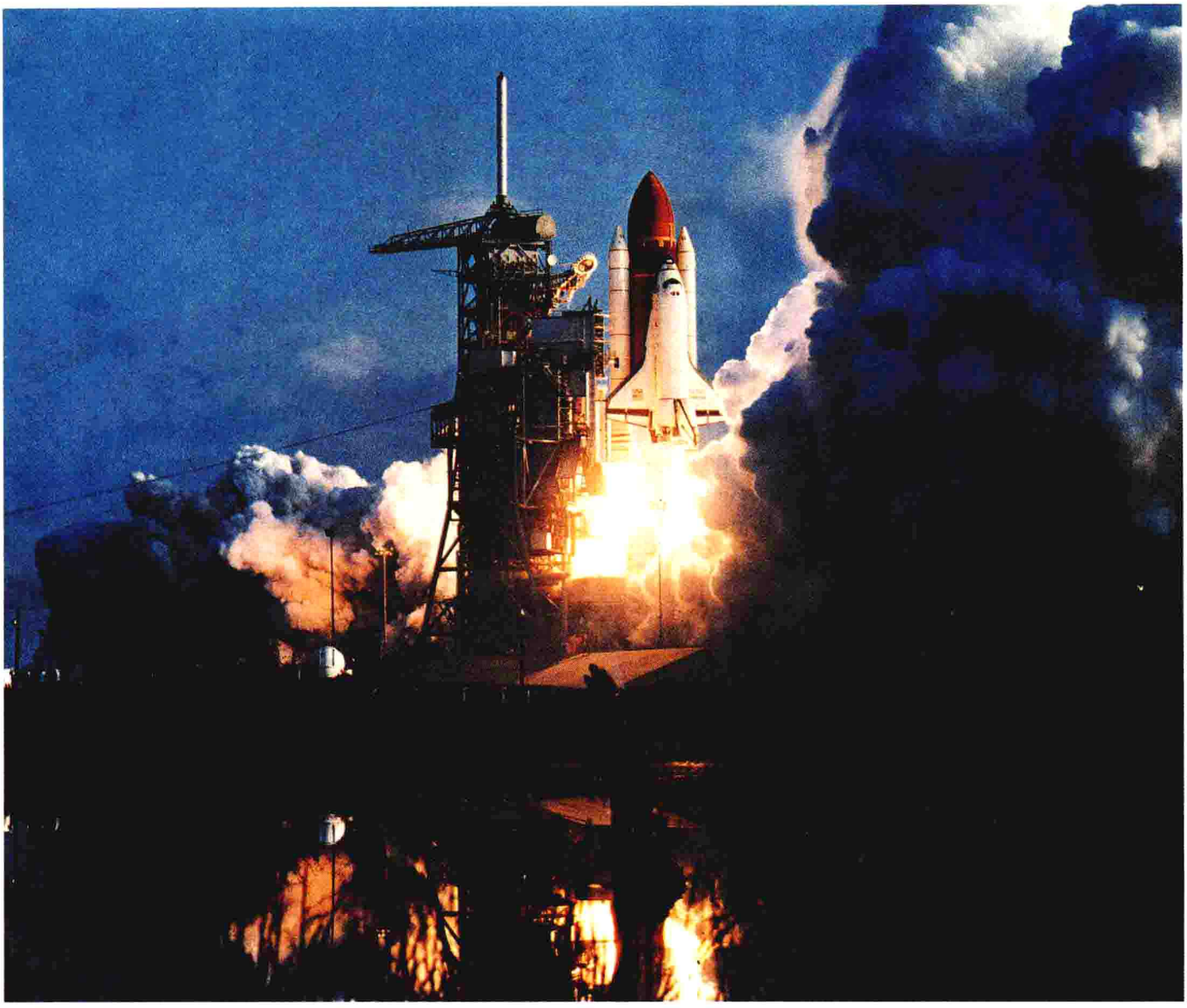

The launch of the Space Shuttle is a direct result of constant and rapid technological growth.

Unit 1

TECHNOLOGY AND CAREERS

Technology has done more to shape the world we live in than all other forces. As technical advances continue at an ever increasing tempo, Fig. 1-1, "technology" has become the catchphrase of an era. And because of these continued advances, careers in technological fields are constantly growing.

In this chapter, the evolution, current status, and types of technology will be discussed, along with careers made possible by advances in technology.

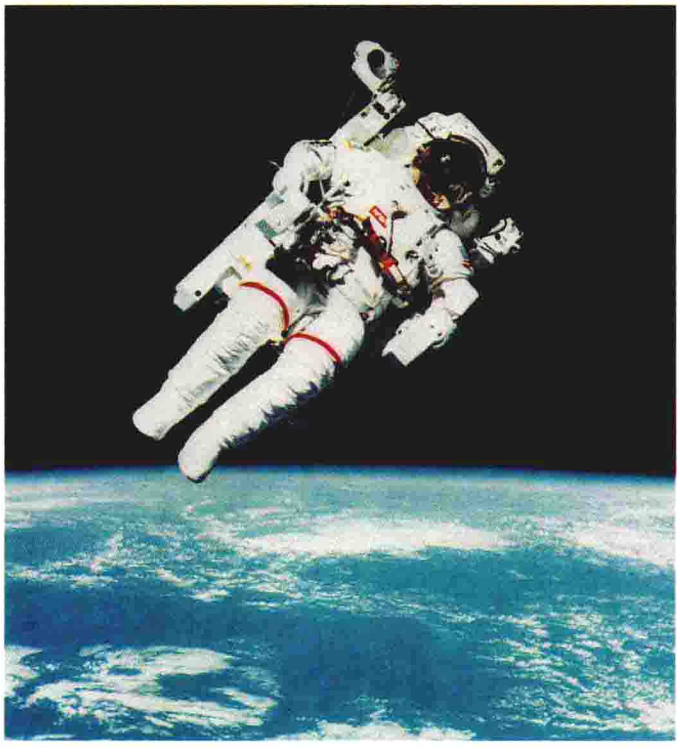

Fig. 1-1. Astronaut Bruce McCandless II on an extravehicular activity (EVA) using a nitrogen propelled, hand controlled device called the Manned Maneuvering Unit (MMU). This device will make possible the construction of a large space station. This photo was taken from the Space Shuttle Challenger. (NASA)

AN INTRODUCTION TO TECHNOLOGY

Technology started more than a million years ago when people first learned to make and use tools. The first tools, Fig. 1-2, crude though they were, made human survival possible.

From the stone age until about two hundred years ago, technical advances such as hollowing a log to make a boat, weaving, printing, making sails, wheels, and plows, were important contributions to the growth of civilization. However, farming was the most important occupation of almost all people. Unless a town or city was nearby, only enough food was grown to meet the needs of the immediate family. Most other necessities—cloth, and clothing, furniture, tools—were made from wool, leather, and wood from the farm.

Slightly more than two hundred years ago, changes started to occur that completely altered the way people lived. It eventually became known as the INDUSTRIAL REVOLUTION (1760s to 1790s). Industry was taken out of the home and handwork was replaced by machinery. Mechanical power sources (the water wheel then the steam engine)

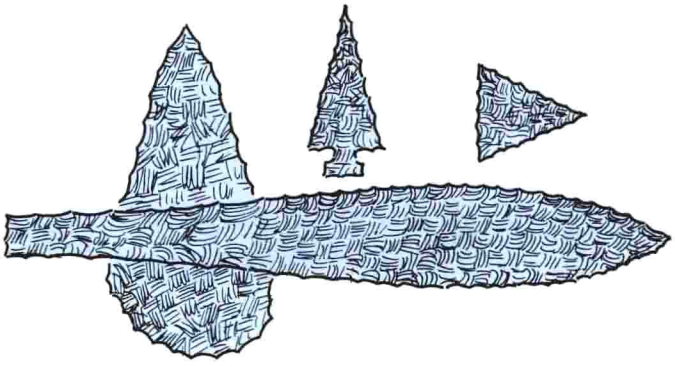

Fig. 1-2. Technology started more than a million years ago when people first learned to make and use tools of stone.

started to be used in manufacturing and transportation.

Industrialization spread rapidly, Fig. 1-3. Scientific knowledge was applied to problems of production. Automatic machinery was invented and perfected. Mass-production techniques were developed and put into use.

Since the Industrial Revolution, technological development has become even more influential in our lives. It would require many hours to list the technical advances of the past two hundred years and how they affect what we do every day. One basic effect is that technology enables people to do more work in less time, thus increasing leisure time. Technology has also provided people with objects and gadgets to use and enjoy in their free time.

THE TECHNOLOGICAL REVOLUTION

There is every indication that we are experiencing a technological revolution. Consider these recently developed and developing innovations:

1. Landing on the moon and returning safely was the first step to the stars.
2. Space shuttle flights are now routine, Fig. 1-4.
3. Research continues into artificial intelligence (AI) which enables computers to simulate certain human thought processes.
4. Computer aided processes that speed and improve engineering and design are being used with increased frequency in automated manufacturing (the latest techniques used are called flexible manufacturing systems, FMS), Fig. 1-5. FMS can be programmed to produce several different parts simultaneously, or can be quickly reprogrammed to accommodate design changes.

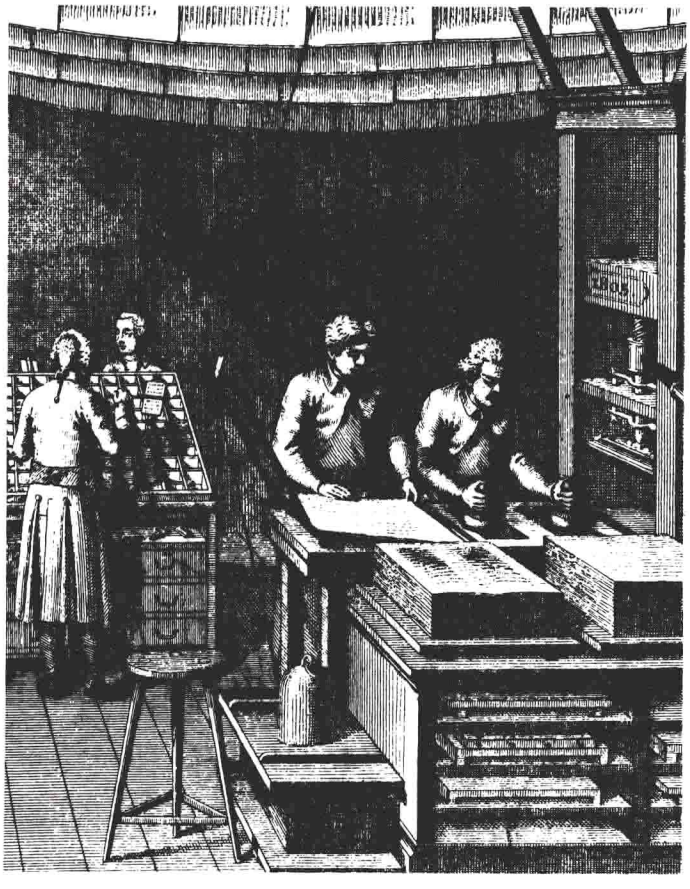

Fig. 1-3. The invention of printing from movable type made printed matter, and the ideas it contained, available to everyone. Until this time, only a few people could read because there were few books. Those that were available had been laboriously lettered by hand.
(Gutenberg Museum, Mainz, W. Germany)

Fig. 1-4. Space shuttle flights are now routine. With experience gained by these flights, humans will land on Mars in your lifetime. Just think, the Wright Brothers first flew in 1903! (NASA)

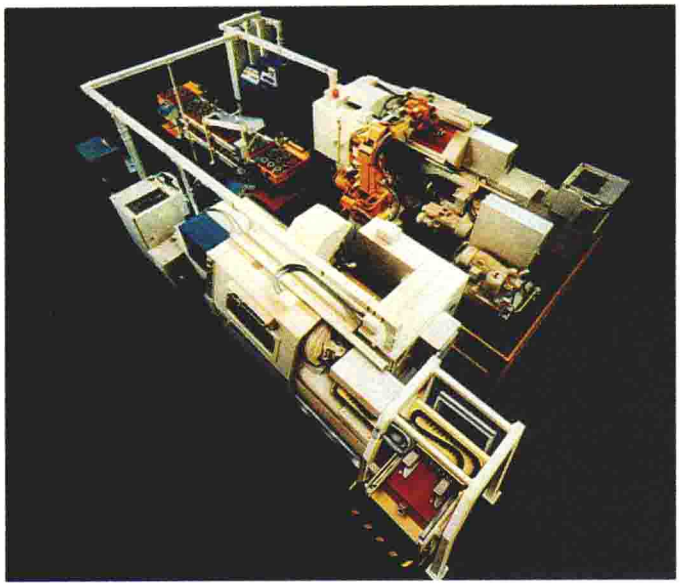

Fig. 1-5. A flexible manufacturing system, the latest in automated manufacturing. Computer controlled, it manufacturers quality parts while virtually unattended. However, highly skilled and educated technicians are required for its manufacture and maintenance. (Cincinnati Milacron)

5. New metals and materials that are superior to existing substances are being developed continually, Fig. 1-6.
6. Robotics research is producing robots capable of performing complex tasks to ever more demanding specifications, Fig. 1-7. They can work in environments that would be unsafe for humans.

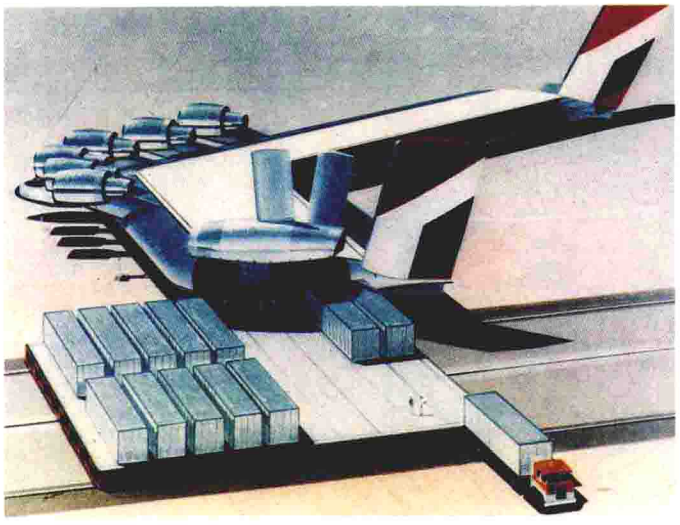

Fig. 1-6. New metals and materials are available today to build this gigantic flying wing freight aircraft. You can get some idea of its size from the people and trailer truck in the foreground. (NASA)

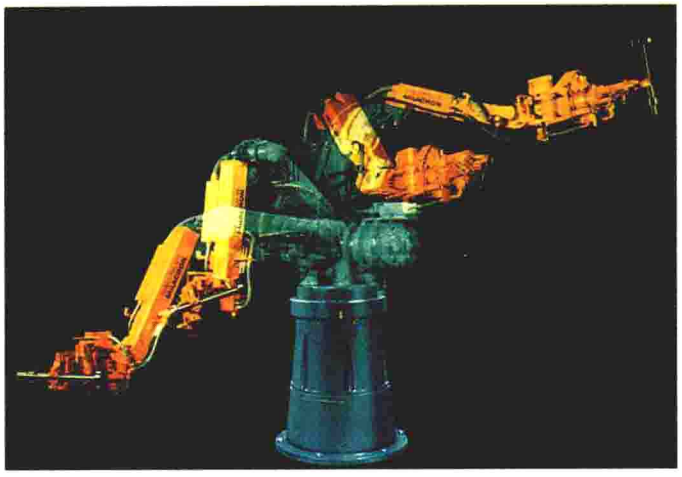

Fig. 1-7. Robots are capable of performing work in environments that would be unsafe for humans. (Cincinnati Milacron)

While the preceding are some positive effects of technology, technology also has many negative effects. For example, with advanced technology, Fig. 1-8, there will be little need for uneducated and unskilled workers.

The careless use of technology has also caused environmental problems and damage. For example, acid rain is destroying our lakes and forests.

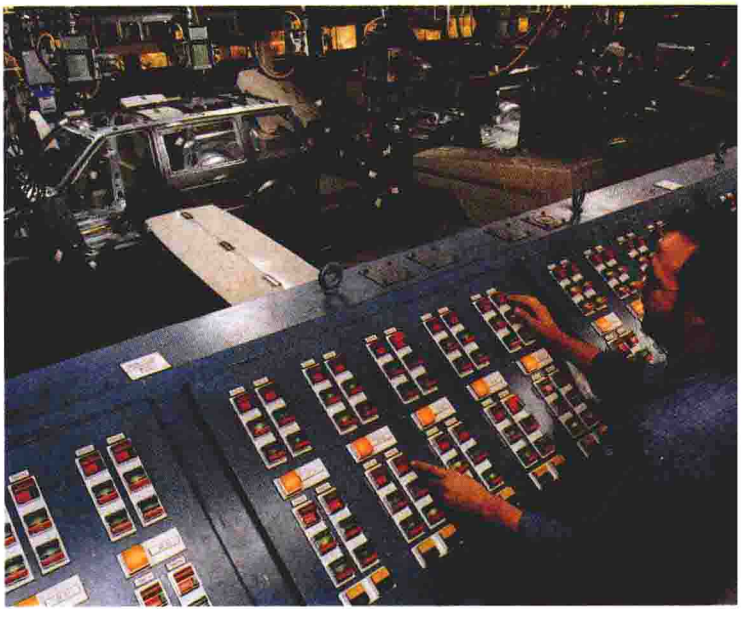

Fig. 1-8. This master computer control station continually monitors 58 robots on the robogate welding line at this Chrysler assembly plant. The high technology system applied spot welds to 97 percent of the weld locations on each van. Plants like this have little need for uneducated and unskilled workers. (Chrysler Corporation)

Highly radioactive spent fuel elements from atomic generating plants are a constant source of environmental problems. Likewise, generating plants that have exceeded their usefulness (most are designed with an operating life of 25 years) cause great concern.

Toxic wastes from some manufacturing processes are difficult to dispose of, and the affect of dangerous chemicals and substances already stored in special dumps is difficult to determine.

Automobiles are responsible for the death and injury of thousands of people each year.

Ironically, only innovative technology (new ideas and approaches to problems) can solve and/or correct the problems that have been created, Fig. 1-9.

TYPES OF TECHNOLOGY

TECHNOLOGY is the know-how linking science and the industrial arts. Its purpose is to solve problems and enhance (improve in value and/or quality) the natural and human-made environment. In the process of doing this, creativity (inventiveness), human skills, tools, machines, and resources are employed, Fig. 1-10.

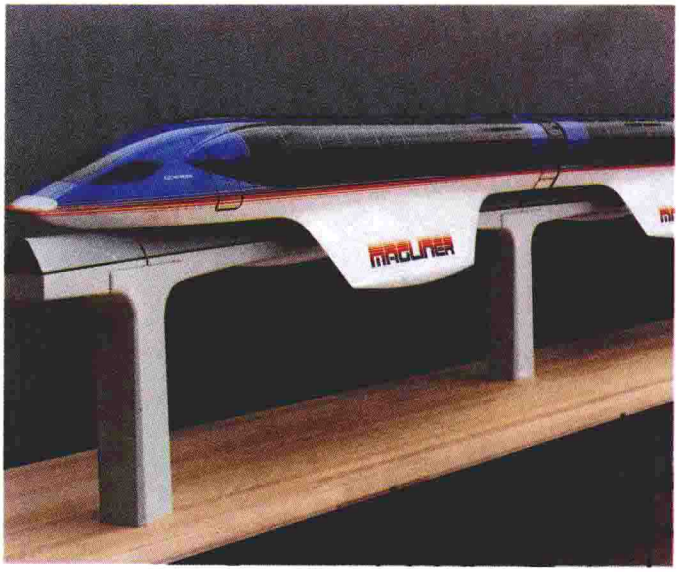

Fig. 1-10. Model of a proposed train of the future called Mag-Lev. Fast, quiet and resistant to derailing, the magnetically levitated train will travel at over 300 miles per hour. It will use super-conductors (transmits huge currents without electrical resistance, and thus sustains intense, steady magnetic fields) to levitate, guide, and propel the train. (Electromotive Division, General Motors Corp.)

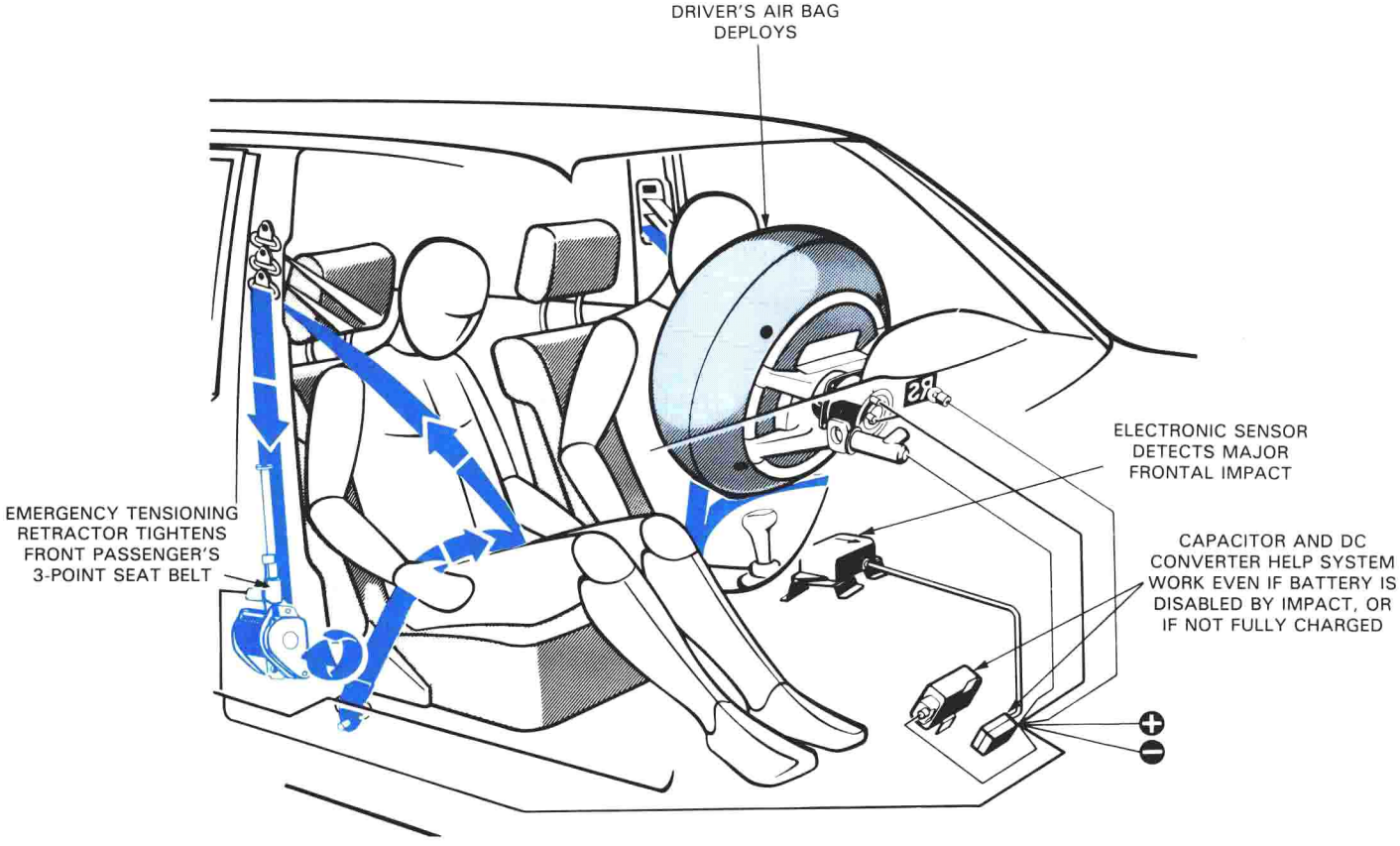

Fig. 1-9. Innovative technology like this automatic air bag system would save thousands of lives yearly if placed in each car. (Mercedes-Benz of North America, Inc.)

HIGH TECHNOLOGY and STATE-OF-THE-ART TECHNOLOGY are terms mentioned often in the media. They simply are areas of technology that employ the very latest ideas, techniques, research, tools, and machines available, Fig. 1-11.

There are many facets (sides) to technology. When applied to special areas, they receive designations such as AGRICULTURAL TECHNOLOGY, MEDICAL TECHNOLOGY, INDUSTRIAL TECHNOLOGY, and METALWORKING TECHNOLOGY.

AGRICULTURAL TECHNOLOGY pertains to our food and related products. MEDICAL TECHNOLOGY is concerned with our health and well-being. INDUSTRIAL TECHNOLOGY deals with the design, research, development, and production techniques that convert raw materials into finished products. METALWORKING TECHNOLOGY is an area of industrial technology that is involved with the fields of machining, forging, casting, and the like.

This book will be concerned with the many aspects of metalworking technology and related areas.

Can YOU name any other areas of technology?

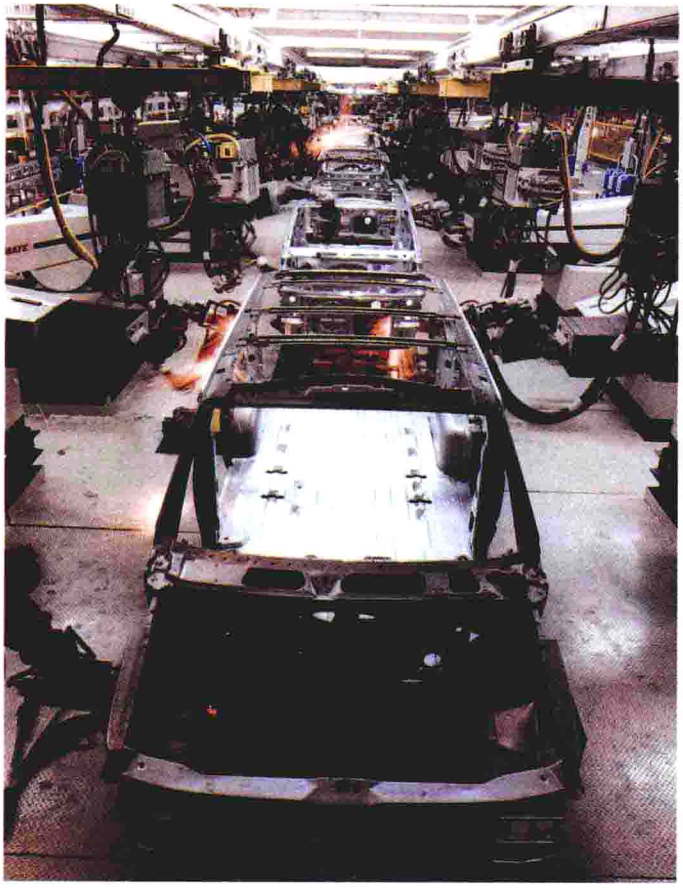

Fig. 1-11. Another view of a computer controlled robotic welding system. Lasers are employed to gauge position and fit of body panels. (Chrysler Corporation)

METALWORKING TECHNOLOGY

Through metalworking technology, it is possible to process raw materials into finished products, Fig. 1-12. This, however, is not always an easy task—financially or technically.

Fig. 1-12. This die for molding plastic model cars started as a block of metal. Metalworking technology, along with human skills and creativity, have converted the metal block into a precisely made tool to produce a product for the hobbyist. (MRC/Tamiya)

Technically, metalworking is the process of shaping things out of metal. This requires a vast amount of time and people, working toward a finished product.

Financially, a PROFIT must be made if the company is to remain in business. Profit is the income of a business AFTER all expenses—salaries, raw material purchases, utilities—have been paid. Furthermore, a profit is necessary if people are to risk their time, ability, and money in a business venture.

Profit can be a long time coming. Large projects like aircraft, cars, computers, and robots, for example, take several years from the original concept to the first finished product, Fig. 1-13. Many millions (often billions) of dollars will be invested in tools, machines, raw materials, and plants before anything is produced. In addition, the talents of thousands of highly skilled people contribute to the design, development, and manufacture of a product and they subsequently must be paid.

Many of the people have spent several years getting advanced training and/or education to perform their jobs. They oftentimes possess highly technical skills, which are necessary for successful completion of a job. A great deal of thought and effort have gone into their career decisions.

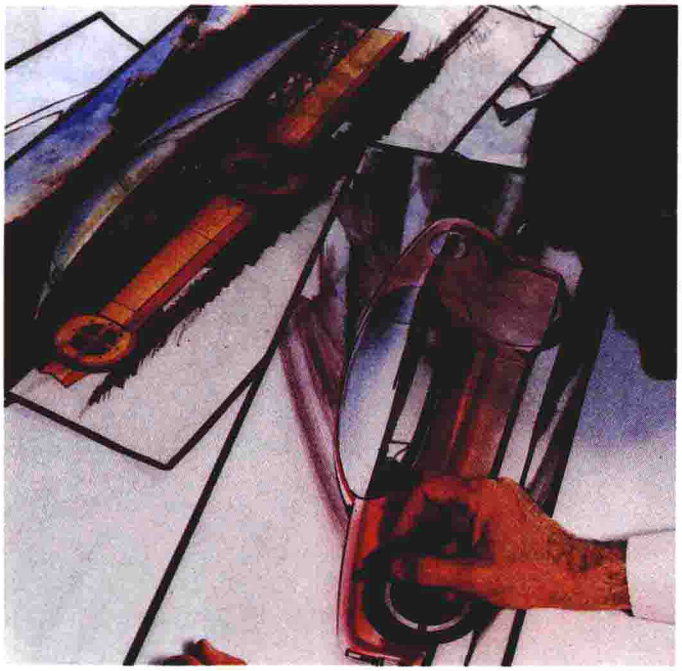

Fig. 1-13. It takes many years from the original concept of a car until the first production model is ready for sale. The talents of thousands of skilled people contribute to the design, development, and production of such a product. Many millions (often billions) of dollars will be invested in tools, machines, materials, and plants before the first dollar of profit is made. (General Motors Corp.)

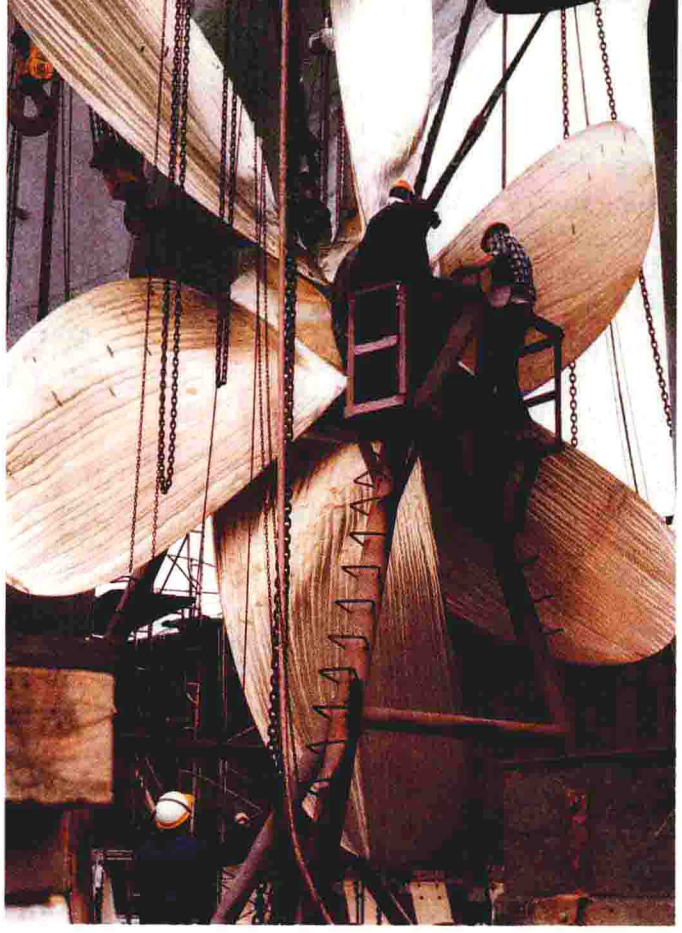

Fig. 1-14. Shipbuilding is a direct use of metals. The 31 ft. diameter bronze propeller of this 265,000 dwt tanker dwarfs a shipyard employee as the ship is ready to be floated out of the basin at Bethlehem Steel Corporation's Sparrows Point, Maryland shipyard. The rudder behind the propeller has the cubic capacity of a normal, modern house. (Bethlehem Steel Corp.)

Have you ever given any thought to the choice of a career? Like the people mentioned in the previous paragraph, your choice may be one of the most important you can make. Your choice will affect the quality of your life for many years to come.

CAREERS IN THE METALWORKING INDUSTRIES

Many people want a career with challenges and activities they enjoy. Their philosophy is, "You only work when you dislike what you are doing." Others are satisfied with whatever job comes along. In which category are YOU?

If you are looking for a career that is both interesting and challenging, the field of metalworking might be your choice. It can provide many opportunities. You may not realize it, but chances are you will be employed in an occupation that is made possible, either directly, Fig. 1-14, or indirectly, Fig. 1-15, by the metalworking industries. The scope of the industries is that great.

Your choice of employment in metalworking may be classed as SEMISKILLED, SKILLED, TECHNICAL, or PROFESSIONAL. One of the basic requirements, if you want to advance in your chosen field, is a continuing educational program. As jobs become more competitive and complex, persons

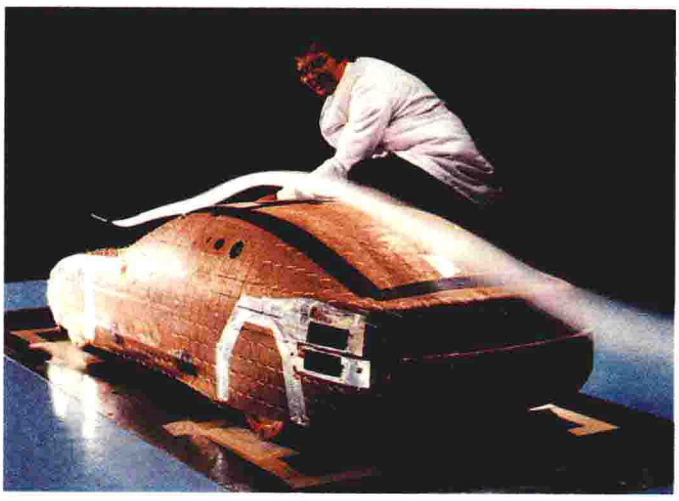

Fig. 1-15. Even though metal is not used directly in developing the aerodynamic shape of this new car model, the designers must know metal characteristics—how it can be formed, welded, etc. Otherwise, the vehicle might never get into production. (Ford Motor Company)

with a higher level of education and up-to-date specialized training will have a better opportunity for securing and retaining employment, Fig. 1-16.

There is little need for unskilled workers (those people in jobs that require little or no training) in a modern technical world, Fig. 1-17. The school dropout, and those students who do not plan their continuing educational program carefully, find it very difficult to locate satisfying employment with any sort of future. Employers prefer workers who have completed high school and acquired salable skills.

Fig. 1-16. As jobs become more competitive and complex, men and women with a higher level of education and up-to-date specialized training will have a better opportunity for securing and retaining employment. These specialists are modifying the design of a part, using a computer-aided design (CAD) system. (Information Displays, Inc.)

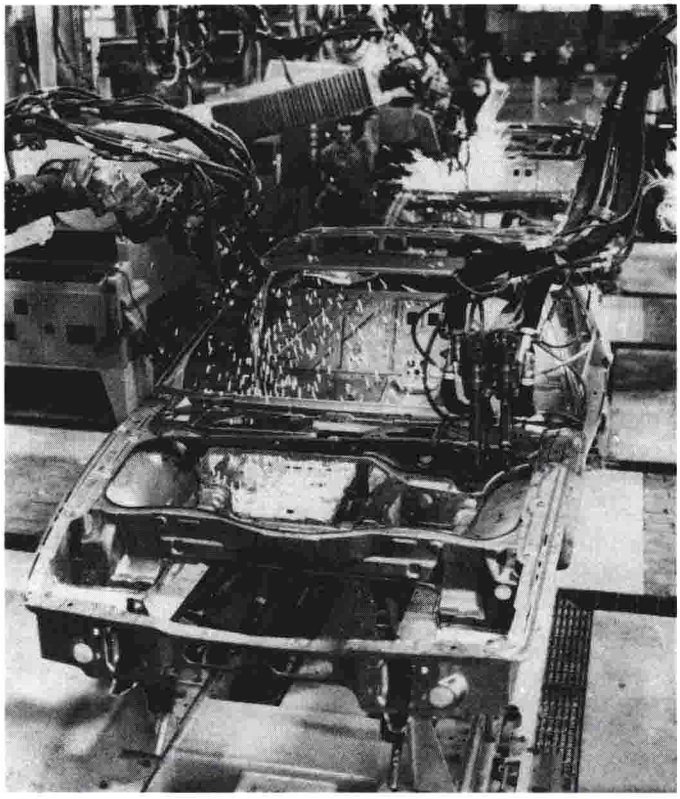

Fig. 1-17. Modern technology, like these robot welders, is eliminating many unskilled and semiskilled jobs. They do the job faster and better, and are not affected by the welding fumes. (Pontiac Motor Division, GMC)

Jobs in metalworking industries fall into the four general categories previously mentioned:

1. SEMISKILLED.
2. SKILLED.
3. TECHNICAL.
4. PROFESSIONAL.

SEMISKILLED WORKERS

SEMISKILLED WORKERS are those who perform operations that do not require a high degree of skill or training. Most of the work is routine and may be classified as follows:

1. Those who serve as helpers to skilled workers.
2. Machine tenders who perform simple, repetitive operations that can be learned relatively quickly.
3. Those who do a limited number of assembly operations in manufacturing a product, Fig. 1-18.

Fig. 1-18. Semiskilled workers perform a limited number of assembly or forming operations, such as shaping aluminum skin fuselage sections for the F-16. They will perform these operations over and over, as long as the aircraft is in production. (General Dynamics)

4. Those who inspect and test manufactured products to insure they are properly made and operate satisfactorily.

In general, semiskilled workers are told what and how work is to be done. There is little opportunity for advancement out of semiskilled jobs, without additional study and training. Most semiskilled work is found in production shops where there are great numbers of repeat operations.

SKILLED WORKERS

Skilled workers are found in all areas of metalworking. A few of the specialty fields are welding, Fig. 1-19, music instrument manufacturing, Fig. 1-20, shipbuilding, sheet metal work, and steel erection, Fig. 1-21, and in the manufacture of aircraft, automobiles, and other forms of transportation, Fig. 1-22.

Fig. 1-19. Welders are classified as skilled craftworkers. They must be familiar with metal characteristics and able to read and understand drawings. They work indoors and outdoors, in all kinds of weather. (Lincoln Electric Co.)

Fig. 1-20. Musical instrument makers are highly skilled artisans and usually spend several years learning their trade. (King Musical Instruments)

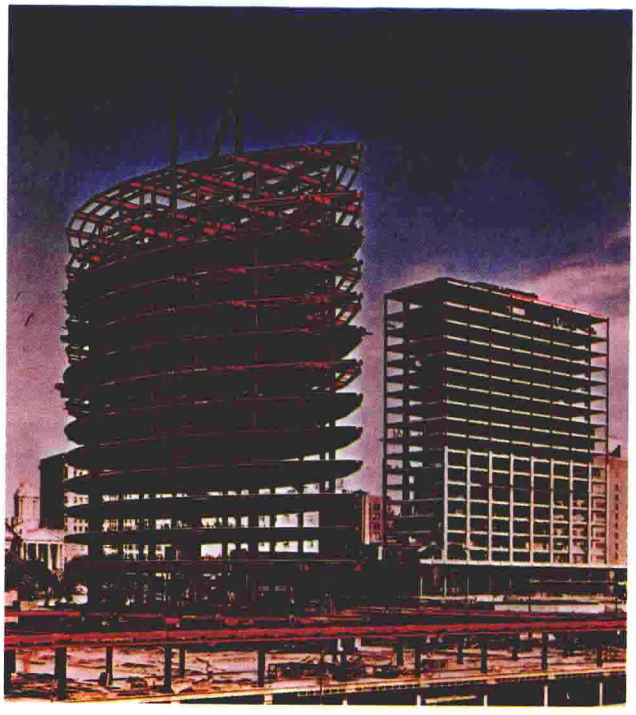

Fig. 1-21. Steel erectors fabricated these buildings. Both of the buildings are framed with steel. (Bethlehem Steel Corp.)

Many of today's skilled workers received their training in APPRENTICE PROGRAMS, Fig. 1-23. The period of instruction usually required four or more years of study with experienced craftworkers. In addition to working in the shop, an apprentice studied related subjects such as math, science, English, print reading, metallurgy, safety, and production techniques. Upon successful completion of an apprentice program, the worker was capable of performing the exacting work and skills of the trade, Fig. 1-24.

Today, however, the number of apprentice programs being offered is on the decline. Most workers

Fig. 1-22. Aircraft machinists and sheet metal workers must be skilled in their trade in order to work to the close tolerances required. A mistake can be dangerous and risky for the pilot and means the loss of a very expensive aircraft. (General Dynamics)

Fig. 1-23. An apprentice studies under an experienced craftworker in a carefully planned program. The training also includes the study of manufacturing processes, math, English, science, and other related subjects.

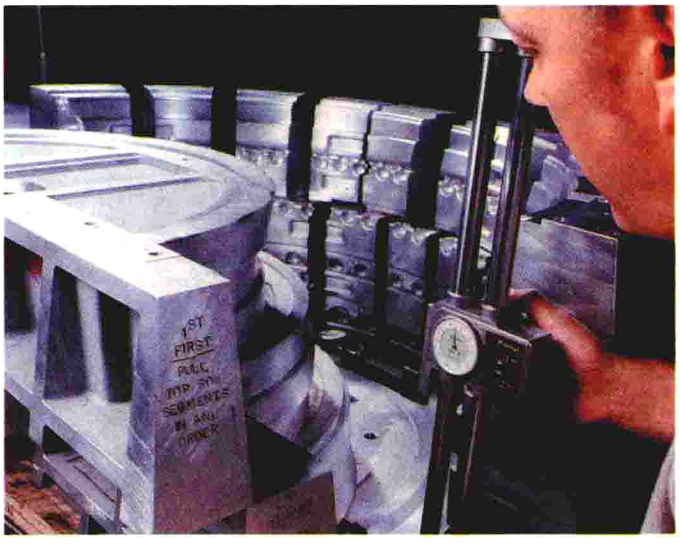

Fig. 1-24. After completing an apprentice program workers are capable of performing the exacting work and skills of their trade. This tool and die maker is checking the dies for molding a plastic pattern used to cast a complex jet engine component. This process must meet exacting quality control standards. (Precision Castparts Corp.)

now entering the metalworking trades receive their training in the ARMED FORCES, Fig. 1-25, or in vocational/technical programs offered in high schools and community colleges. Many community college programs are offered in conjunction with local industries.

TECHNICIANS

Modern technology has brought about a demand for persons capable of doing complex work of a highly technical nature. These men and women are called TECHNICIANS. Many colleges and community colleges offer two year technical programs. The course of study stresses math, science, English, computer science, manufacturing, and production techniques, Fig. 1-26.

The technician assists the engineer by constructing and testing experimental devices and equipment. He or she aids in compiling statistical information, making cost estimates, and preparing technical reports. In some manufacturing plants, the person who programs parts for production by numerical control (automatic machine control using numerical instructions coded on perforated tape, punch cards, or magnetic tape) is classified as a technician. In the same category are the specialists who repair and maintain numerically controlled machines and robotic equipment.

Fig. 1-26. New metalworking technology has brought about a demand for persons to do complex work of a highly technical nature. These men and women are called TECHNICIANS. This young woman is training in and studying machine tool operations.

Fig. 1-25. The Army, and other branches of the Armed Forces, offer excellent opportunities for learning a trade and getting paid while you study. (U.S. Army)

THE PROFESSIONS

The professions offer many excellent opportunities in the field of metalworking.

TEACHING, Fig. 1-27, is one of the most satisfying of the professions and is a field students too often overlook. The teacher of industrial arts, industrial, vocational, and technical education is in a most fortunate position. It is a challenging profession that offers freedom not found in most other professions.

Four years of training at the college level is required, and while industrial experience is not a prerequisite, it will prove helpful.

ENGINEERING is a fast growing and challenging profession. Engineers use mathematics and science to develop new products and processes in industry, Fig. 1-28.