THE HISTORY OF THE INVENTIONS LEADING TO THE DEVELOPMENT OF THE COMPUTERS AND THE RELATED EFFECTS ON EDUCATIONAL INSTRUCTION AND SOCIETY

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CHAPTER I

INTRODUCTION

> We are living in the midst of a profound revolution which most people are not even aware exists. In the last thirty to forty years we have catapulted into a time when the futures we face are changing with bewildering speed and shaking the very foundations of our way of life. Combs (1982).

It is apparent that there is an explosion of information. According to some, 90 percent of all the scientists who have ever lived are still alive today, and that technical information doubles every ten years. These scientists have given society wonderful techniques for the dispersion of information through radio, television, computers, recordings, and more. These machines are capable of placing vast amounts of information at astounding speed in the hands of almost anyone, which renders the role of instructors as information providers obsolete. Combs (1982).

Futurists explain that the speed of communication, transportation, and computation as well as the amount of power available to society since 1945 has increased by figures of ten to the seventh and eighth power over all the rest of human history. Because of this rapid change, students just out of high school today may change their occupation four or five times during their lifetime. Combs (1982). Thus preparation for the job market could be more difficult than in previous years.

Technology has already begun to affect the way in which students are preparing for classes. Bok (1985). The same is true for the teachers of those classes. For instructors to be prepared to teach in the classroom of tomorrow, they will find it necessary to be aware of what is happening in the technological world. To keep abreast of computer technology in education is to keep informed by reading the latest journals, knowing the capability and the cost of the equipment, asking companies to send brochures, visiting computer stores for the most recent software available, and checking out the equipment personally at home or in the classroom. Some companies offer incentives for educators to try their products out in the classroom at little or no cost to educational or training organizations. Locatis (1984).

With the development of science and industry, change was inevitable, and that change has produced an enormous revolution in the basic nature of the problems faced by mankind. Science has given people the knowledge necessary for solving the problems of providing food, clothing, and shelter. Industrial technology has supplied an understanding of methods used to produce goods and services in huge quantities. The crucial problems for today and tomorrow are in the area of human and social relations on a global scale. It is no longer a problem of new and better products, but problems of persons and their interactions with one another. Combs (1982). This social phenomen has necessitated a more open system of communication between the varied societies of the world. Advanced computer technology has made this a possibility through the telecommunication and video communication via satellites.

Because of increased use of telecommunication systems, the world becomes smaller, thus creating the need for an even more complex communications network. But even though the technological advances have made the world an even smaller place, "in which the power of individuals for good or evil is immensely increased," the promise for the future is that as people's basic needs are met, they will be free to explore higher levels of personal accomplishment. Therefore, education for future generations will be a life-long process. Combs (1982).

This study presents a discussion of the current impact of computers on society in the areas of employment, health, the invasion of personal privacy, and the effects of changes on the family unit. The study includes an investigation of the history of computation of numbers and the societal changes during the pre-Industrial Revolution and the Industrial Revolution. A history of the inventions leading to computer technology is studied as well as a history of the invention of the computer. The study is limited to the exploration of robotics, the automobile industry, the agricultural industry, meterorology, space programs, medicine, the textile industry, and education. It also addresses some of the effects these developments have had on society, including changes in the education of that society, and predictions for the impact of computer technologies on future societies.

A survey of a selected group of inventors who were responsible for the final invention of the computer as it is today will be presented. Since one invention is relative to another, the inventors chosen for this study were individuals who built their invention from one another's creation, one leading to the next. Calculations began early in history, but the calculator itself came much later and was considered to be the basis for the computer. A punched-card loom was an important part of some of the first computers. Other computer inventions were selected because of their importance in events through history.

The present and future changes in employment opportunities of some industries will be explored. The textile industry was chosen as one of the industries for further research because through the development of the mechanical loom, computer cards resulted. For centuries society had been weaving its own clothing through hand-made looms, and the development of the mechanical loom increased production drastically. The computer benefited from that invention and now, today, the textile industry is benefiting from the invention of the computer.

The investigation of the agricultural industry seemed necessary for this study. Anthropologists have found that man has been involved in some type of farming for centuries. Because of the rapid growth of the world population, without the agricultural industry, society would have an entirely different type of existence.

When Henry Ford developed the assembly line, the automobile industry was able to manufacture automobiles much faster and for an affordable price. The automobile industry was chosen for further research because of its use of robotics in manufacturing and the impact they made in job availability.

This study will explore three scientific areas. The medical area will be included because of the impact that the computer has made toward laser surgery. Meteorology will be included because people of Oklahoma and surrounding states have experienced the importance of the weather broadcasting. Now, because of computer technology, life saving information is provided nationwide and in less time than ever before. The last scientific area that will be discussed is space technology. Through the research done by NASA and other space programs, society will benefit from the development of a new generation of machines that could perform the task needed for finding much needed natural resources from outer space.

For a prosperous future for society, individuals must be educated in computer technology to some extent. This study will explore educational opportunities available through computer programs in schools and job-training programs. Benefits of computer devices will be explored for various age groups, the special education students, and handicapped individuals.

What does the future have in store for tomorrow's society? What will happen to the family unit? Will there be changes in the amount of personal information available through data bases? Are children going to experience excitement or frustration in planning for their future vocations? Will their education prepare them for the technological age? These are just a few of the many concerns of society today. Regardless of these concerns, there is also a sense of anticipation regarding new experiences brought about through this tehnology.

CHAPTER II

COMPUTERS: TODAY AND YESTERDAY

Impact of Computers on Society

To understand the impact of the computer on today's society, it is necessary to understand the background of the events surrounding both industrial revolutions. The first Industrial Revolution began in England in approximately1760 with rapid changes in methods of production and technology provided by mechanical and electrical power. The "second" industrial revolution, which some say had its beginnings in the middle of the nineteenth century, provided knowledge. Some writers refer to this later revolution as the "Age of Information." Newman (1972).

The Electronic computer created a revolution which has advanced the human endeavors by hundreds of years. The single-computer business has become a billion-dollar industry. By building, selling, and using computers, the industry is well on its way toward tripling its business. The technological industry has had a short growing period--perhaps the shortest of any other industry in the history of America. The computer has become one of the most important elements for world strength. Biddy (1962).

Employment

There have been major changes in the life of man in recent centuries due to the Industrial Revolution. These changes caused the "establishment" to become an economic empire. Work habits were changed drastically. The Industrial Revolution pulled paid work out of the home and placed it into factories and offices. That transformed society and altered family life. Education was also transferred out of the home. The pattern of mass commuting was created and cities were formed, reshaping lives. Companies paid for real estate, high taxes, all types of maintenance costs, and salaries, and eventually provided cafeterias, locker rooms, and parking facilities for their employees, which was costly for the employer. Toffler (1983).

Today the cost of communication, computing and office equipment is less than in previous years. Yet millions of people shift back and forth from home to office every morning and night, using millions of barrels of non-renewable fuel, causing pollution. It would cost much less, not only in terms of money, but in terms of energy spent to move information to the worker rather than the worker to information. However, People have *always* needed social contact with others, which the work environment provides. The family was a close-knit group before factories and offices existed, therefore, factory production destroyed, rather than enriched human ties. Toffler (1983). In modern society, however, in addition to improving the conditions of the workplace, the computer in some cases has brought colleagues and the family closer together.

Health

Society had shown high levels of concern with the possible health hazards for children as well as adults who spend hours every day in front of a computer. Many studies have been made and research is continually in process with each new product. Sometimes the health problems involving the Visual Display Terminals (VDT) have not shown up until an individual has been exposed to this advanced technology for many years. Pearce (1984).

Some individuals have claimed to have a facial rash because of using the VDTs but the evidence for connecting the rash with the VDT has been entirely circumstantial. From the research done concerning radiation emission, the finding proved no significant radiation from VDTs, either new or those used for a considerable length of time. The research concluded that the radiation normally emitted from VDTs did not pose a hazard to operators either on a long or short-term basis. Ionization, which produces radiation, is reduced drastically when the home or office is air-conditioned, but it is believed that sunlight could increase the amount of ionization. Pearce (1984).

Also there was some concern for computer users who were complaining about their eyes. These employees were given eye tests for cataracts, and it was found that there is no significant proof that the cataracts were caused by VDTs. Doctors, however, have found evidence of cataracts in individuals in their twenties and thirties which is a much lower age level than in the past. Many organizations have required their employees to have frequent eye tests. Doctors and insurance companies have recommended that the businesses implement meaningful health and safety procedures for the protection of the VDT users. Pearce (1984).

Because of some of the health problems, it has been recommended by insurance companies that organizations investigate the design of the equipment purchased. The VDTs should reflect clear stable images, adjustable screen angles, and detachable thin keyboards. The workplace should supply adequate space and office furniture affording good posture. Lighting engineers should be consulted to determine the best lighting for office areas where VDTs will be used. The VDT manufacturers have made adequate progress in the ergonomics of their products and research for health purposes should continue. Pearce (1984).

Privacy

Protection is not only needed for health purposes, but is also needed for individual privacy. By the early 1900s, invasion of privacy had developed into a real problem. Richard Kusserow was selected to be the master datatective for the Reagan Administration and became the inspector general for the Department of Health and Human Services in 1981. He used the agency's large IBM Computer system to examine the files of everyone on the Social Security rolls and in the process he compiled a list of every Medicare recipient known to have died. "The project uncovered 8,000 deceased recipients to whom Social Security checks were still being mailed, like clockwork, once a month." DeWitt (1987). Some of those checks were being cashed by imposters and the U. S. Treasury had been robbed.

Kusserow's search pointed out the power and the perils of computer data banks. Because of the above search, the taxpayers saved about $50 million and there were more than 500 individuals convicted for fraud. To accomplish the discovery, however, the computer records of 30 million supposedly innocent Americans were opened and examined. Civil libertarians were convinced that this is an invasion of privacy and "comes perilously close to violating the Constitution, particularly the Fourth Amendment 'right of the people to be secure in their persons, houses, papers and effects, against unreasonable searches and seizures.'" DeWitt (1987).

The U. S. Government maintains 3 billion personal computer files through which an army of bureaucrats can search and pry. Extensive records were maintained by "local governments, private credit agencies, banks, insurance companies, schools, and hospitals." DeWitt (1987). These records included home address, place of employment and salary, the number of children in the family, medical and psychiatric history, credit rating, criminal record, phone number, or the last time a person used the street-corner bank machine.

According to DeWitt, "citizens are protected from overzealous use of the Government's computer files by the Privacy Act of 1974." Some searches have been reasonable. As an example, the Internal Revenue Service withholds tax refunds from individuals who have defaulted on federal loans. But not *all* intrusions are honorable. Computer data banks are freely passed around; insurance companies exchange medical history of customers, credit bureaus sell data to employers who are screening future employees, and there are companies who have computer blacklists which help landlords and physicians investigate the people who have been involved in filing lawsuits. De Witt (1987).

In the spring of 1985, Joseph Miller quit his job at a retail store in New York to find a better job. He was in line for several potential jobs, but they never materialized. Finally in September he received a notice of his dishonorable discharge from the Army--he had never been in the service. The truth came out; his former college roommate had used his name. The roommate had gone through a data base and used Miller's Social Security number. Miller had jail records and bad credit under his name. He could not convince credit agencies to change the records and had to apply for a new Social Security number and driver's license. An individual's Social Security number --the code that third parties needed to tap into computerized information on a person--is available for at least 125 government and private agencies. Increasingly, the IRS has exchanged data with state and local tax authorities to check the accuracy of tax returns. Most banks are allowed by law to give information on customers' accounts and credit histories to state government investigators. DeWitt (1987).

Professor Arthur R. Miller from the University of Michigan has done extensive research concerning computer privacy. He feels that "the basic attribute of an effective right of privacy is the individual's ability to control the circulation of information relating to him--a power that often is essential to maintaining social relationships and personal freedom." Clark (1971). However, according to Senator William S. Cohen, without regulation in the United States, privacy could become even more threatened as technology advances. Now there is a new technique called computer profiling. It combines sophisticated software with data bases creating "profiles of people who are likely to exhibit certain characteristics. The Secret Service, for one, is reported by privacy analysts to be developing a system to help identify people with the tendencies of assassins." One private observer stated that if the data bases are allowed to be connected, it will be Big Brother, Inc. Field (1987).

Computers are necessary and can be beneficial, but depersonalization of the individual and the deprivatization of society is an abridgement of our rights. "As useful as computers are, the increasing pressure they put on personal privacy could threaten personal liberty." De Witt (1987).

Family

Families have been separated by employment in the industries and even now in the present society, there is often a lack of family ties. The computer had given the world a *home entertainment center.* With a computer and specific software, the whole family can enjoy leisure time with video games, and a game of chess or checkers. Mindscope, a software company in Northbrook, Illinois, sold 100,000 copies of Pac Man in December of 1987 alone. Schwartz (1988). Pac Man seems to be a favorite game and can be played by all members of the family.

Computer music, painting, and poetry has given creative people another outlet for leisure time. Families can visit an *Art Gallery* or create cartoons. Early in this process of graphics, the cost of a *paint* system that permitted an artist to sketch and color on a screen began at $20,000. It is now possible to purchase a graphic program for less than $100. Sculpture art can be designed on a personal computer and used as a guide for building the actual sculpture itself. Roger 1988).

Musicians, as well as families who enjoy music together can compose, perform and print music with the computer. According to Roger (1988), Californian, David Grisman, is best known for jazz and bluegrass mandolin. He also uses a Macintosh computer connected to a small synthesizer and composes music. One of Grisman's most recent accomplishments is a bluegrass-flavored string quartet. Roger

Dannenberg plays the orchestral part of "Rhapsody in Blue" on the synthesizer. At the same time an individual plays the piano. The computer "listens", slowing or speeding, to follow the beat of the real accompanist.

Michael Newman, a New York poet, sells *poetry processors* that uses color to assist the poet with rhyme, meter, and structure. The IBM PC program finds the rhymes and highlights them in different colors. Commercial songwriters makes use of the computer poet in composing their lyrics. Rogers (1988).

It is now possible, for a family to not only play together, but they can work together. When an employee is permitted to work at home, or when an individual has a private business in the home, the new technology of computers may act as a tool to bring the family together, thus strengthening or re-establishing family ties. Rogers (1988).

Historical Background of Computers

Today's society experiences computer technology equipment because of the geniuses of the past. In seeing how the computer evolved, it is necessary to begin with primitive methods of calulations. Anthropologists have concluded from their findings that long before inscribed history there were people living in groups, possibly around 9,000 B. C. These individuals were capable of creating articles and formulating ideas that solved many problems of their existence Although,"the overwhelming majority of the elements in any culture are the result of borrowing," there were rare discoveries and inventions in these primitive societies. Baldwin (1973). The pressures of an increasing population, as well as the utilization of a new invention and observing what improvements were needed, prompted still more new inventions in all societies.

In this section the origin of numbers is investigated to reveal how numbers were used in calculating, and how the need for numerical communication in a society led to new methods of "mathematical" understanding. Further, an examination of the methods of providing clothing, blankets, rugs, and other textiles necessary for the improvement of the quality of life will be explored, beginning with pre-historical times and moving to the cottage industry era before the Industrial Revolution.

Pre-Historic Numerals

In the early history of man, counting was rarely necessary; computing was irrelevant. It was as necessary to avoid one saber-toothed tiger as it was to avoid four. However, someone in society must have tried to communicate that there was one tiger. One. But something else was required; there might have been many tigers. The first counting system possibly would have been *one and many.* A few groups have never advanced beyond that point. The idealized society, regardless of its position in history, needed nothing more, as epitomized by Thoreau.

> An honest man has hardly need to count more than his ten fingers, or, in extreme cases he may add his toes and lump the rest. I say, let our affairs be as two or three, and not as a hundred or a thousand; instead of a million count half a dozen, and keep your accounts on your thumbnail.

So, communicating quantity was not difficult if the numbers were small. Pointing may have led to the use of fingers for counting. Three fingers could have given information to other members of the group and ten fingers were just as easy to handle. Shurkin (1984).

Aristotle (384-322 B.C.) was the first to note that a base-10 system, and sometimes a base-5 system of calculation, later developed in most societies, was derived from the simple fact that human beings had five fingers on each hand. Societies progressed from counting fingers to counting fingers and toes. In order for man to count more than ten, he could have called on a friend and used his ten fingers. Or a friend's fingers could count for something else, such as ten for each finger. There are societies in Africa that still compute the number 12 using one finger on a friend's hand and two on their own. When fingers and toes were no longer adequate, researchers discovered that the groups piled stones into groups of five for calculation. Babylonian culture used base-60, Mayan used base-20, and a few societies utilized a rudimentary binary system, just 1 and 2. Shurkin (1984).

A present day Sibiller tribesman in New Guinea can count to 27-- no further. He uses the fingers of his right hand to point to those of his left hand for one to five. He uses a finger on his right hand to point to his left wrist, forearm, elbow, biceps, collarbone, shoulder, ear, and eye to make up the numerals 6 to 13. The middle of the nose is 14. With his left hand he goes down the right side from eye to little finger for 15 to 27. Bergamini (1963). From generation to generation, methods of computing in some societies have remained the same.

Historians are not certain whether advances in mankind's calculation of numbers were originated because of the pressures resulting from more complicated societies or whether the advances were the motivation for the complication. In Mesopotamia around 1000 B. C., shepherds used pebbles to count their sheep. They used a bag of pebbles and a bowl. In the morning they put one pebble in the bowl for every sheep that left the enclosure. When returning in the evening, they put the pebbles back in the bag, one by one, If they had pebbles left over, they would go look for their lost sheep. Bell (1987). The word *calculus* stems from the Latin word for pebble. Shurkin (1984).

Sticks or bones were lighter in weight and were much easier to carry than pebbles, so instead of piling stones for counting, cutting notches into sticks and bones became another form of calculating. In Czechoslovakia, anthropologists found the jawbone of a young wolf containing fifty-five marks arranged in two clusters, twenty-five in the first, thirty in the second. These notches were arranged in groups of five for easier reading. Shurkin (1984).

The "quipu" was invented by the ancient Peruvian Indians. That invention was used for recording numbers in an odd arrangement of colored strings and knots by which they recorded the number of animals or sacks of potatoes they owned or wanted to sell. Baldwin (1973). One can probably assume that all inventory was calculated in the same manner. The Mexican Mayas also used these strings for calculation during the late Classic Maya period (600-900 B. C) . D'Estaing (1985).

Historians have noted that the written number is generally believed to have preceded the use of the words for numbers. Numbers were communicated either by gesture, artifact, or by the use of some form of symbol long before mathematical language developed. Religious rituals or military activities in which words for ordinal numbers were needed may have been when the language was developed. Commands such as "You go first, you go second, you third," may have preceded cardinal numbers (one, two, three) in the language. Shurkin (1984).

Instead of notches as found in Czechoslovakia, numbers were engraved on a piece of bone found in Africa dated at around 8,500 B. C. These markings contained what appeared to be the symbolization of the prime numbers 11, 13, 17, and 19, which can be divided only by themselves and by the number 1, a fairly advanced mathematical exercise for that period of time. Shurkin (1984).

Each culture had developed its own method of calculation; some were exceedingly complicated. For instance, the Egyptians had a system in which the numbers 1 to 9 were characterized by one to nine vertical lines. "A 10 was a U or a circle, 100 was a coiled rope, 1,000 was a lotus blossom, 10,000 was a pointed finger, 100,000 a tadpole, 1,000,000 was the picture of a man with his arms stretched toward heaven in astonishment." If the Egyptians needed to tran- scribe the number 2,539,425, there would be two amazed men, five tadpoles, three pointed fingers, nine lotus blossoms, four coiled ropes, two circles, and five vertical lines. Shurkin (1984). Multiplying or dividing with this system would be impossible. However, there was some evidence which indicated that the Egyptians also evolved a method of computation on papyrus using dots and lines. This was found on the back of a piece of papyrus dated around 1500 B. C. Ralston (1976).

The Greeks and the Romans did not have a convenient system of computing multiplication. It would be difficult to multiply CLXXVII by XXVI. However, with the enlargement of society came the need for an economic system and a governing system. The beginnings of architecture and geometry became necessary, bringing about changes demanding more complicated forms of mathematics. Possibly these societies had been adding and subtracting, but multiplication and division, and geometric concepts such as pi, were now becoming vital. The use of the Roman mathematical system, which lasted almost until the Renaissance in Europe (14th-16th centuries), was limited to the elite. The elite consisted of a very small group of society-- the kings and the businessmen, sometimes called knights, who were involved in trade with other countries. An abacus, history's first digital computer, was their way of computing in business transactions.

Some historians credit the Babylonians for the invention of the abacus; others credit the Oriental cultures, perhaps Chinese. Some say the date is prior to 500 B. C., Ralston (1976) and others more than 5000 years ago. Shurkin (1984). The Babylonians used the Phoenician word *abak*, designating a flat slab covered with sand on which figures were drawn. The Greeks, according to some writers, were using abacuses by 500 B. C. and the name they used came from the Greek word *abax*, which means a board, table, or calculating table. Shurkin (1984). In the Far East the abacus is still a common form of a desk calculator and is used with great dexterity and speed. Ralston (1976). At the present time in northeastern China, the oil field workers create competition between the abacus and the computer when they are measuring oil production. Allen (1982).

Another aid to the calculator was Napier's "bones" invented in 1617 by John Napier, a Scotsman. The multiplication tables were written out on strips of bone or wood. Napier also invented logarithms in 1614, which enables one to replace multiplication or division by a single addition or substraction. Lynch (1975). These inventions became the basis for slide rule operations. Ralston (1976).

During the Mayas Classic Period (300-900 A. D.), the Maya Indians developed a system of mathematics that was considered a highly intellectual achievement in the Americas, and according to some historians this system was developed without the aid of the Old World. While the Romans were still using Roman Numerals, an unknown genius in Middle America had invented a system of numbering which had all of the features of the present day arithmetical systems, according to the authors of "The Last Two Million Years." The Mayas utilized two means of representing numbers: head-variant symbols used for calendars and the more commonly used bar-and-dot for mathematical notations. See Appendix A.

> Numbers above nineteen were noted according to their placement in vertical columns, with each ascending position increasing by multiples of twenty, or a sequence of 1, 20, 400, 8,000, 160,000, 3,200,00, and 64,000,000. A numeral placed in any one of these positions automatically increased in value as determined by its corresponding multiple, and the column was then added to formulate the total. To write a number such as 827, two dots were placed in the third position, denoting two units of 400, one dot in the second position to indicate twenty, and a bar and two dots (the number seven) in the first position. A vigesimal system of this type made it relatively simple to add and subtract, and recent studies have demonstrated that it could also be adapted to multiplication, division, and square-root extractions, although to what extent the Maya understood these more complicated procedures is unknown. Gallenkamp (1985).

The principle of the zero was another notable feature of Maya mathematics and was essential to all of their calculations. It was represented in their inscriptions by a stylized shell, or an open hand. The abstract concept of the zero was invented by only two other groups of people in history, the Babylonians and the Hindus, and was not introduced into Europe until the Middle Ages. Historians are not certain whether the invention of the zero in Mesoamerica can be attributed to Olmec or Maya ingenuity. The Olmec preceded the Maya, but the two societies are closely tied to the origin of the calendar and hieroglyphic writing. Gallenkamp (1985).

The Hindus had developed a nine-digit numbering system between the first and second century A.D. The zero was added much later. Any number could now be represented in base 10 by an ordered sequence of numbers. The exact date for the zero digit discovery is unknown, but "The zero is one of the most important inventions in human history." Shurkin (1984). This discovery led to major advances in algebra. The Arabs adopted both the decimal system and the zero from the Indians. According to most historians, the Arabs tried to keep these mathematical concepts from infiltrating into Europe, but around the year 1120 A. D. a monk named Adelard of Bath translated the information and within twenty years the use of the Arabic notation had spread throughout Europe. Because of the travels of an Italian, Leonardo Fibonacci, in 1175 A. D. to the Barbary coast of North Africa and his acquaintance with the Moslem culture, the Arabic numbers were being used universally in European science by 1400 A. D. Shurkin (1984).

Ancient Textiles

During the development of a number system in ancient times, there was the development of spinning wool to make thread in order to weave cloth. To satisfy the need for clothing, a loom was developed. The invention of the loom eventually led to the binary method of computation used in the computer. The significance of this development will be explained in the "Inventions Leading to the Computer" section of this Chapter. Items found by anthropologists such as a painted dish from Egypt and a seal from Mesopotamia essentially illustrated this loom and dates back to around 3500 B. C. The warp threads were stretched between two beams which were attached to short upright posts. The Egyptian dish shows three rods lying across the warp. From these examples of looms, there may have been patterns woven into the weavings. Looms of this type are still being used in remote parts of the world.

Most of these early looms were set horizonally because the weaving was done in the open air. As the societies of the north began to use looms, they were set vertically for use inside their homes.

Looms and weaving techniques became highly developed and the people were producing some remarkable textiles of antiquity.

Clothing has been woven by processes invented in the Middle East since anicient times. Hodges (1970). A loom like today's tapestry loom was being used in Egypt during the 18th Dynasty (1567-1320 B. C.). The looms used in China between 1766 B. C. and 1122 B. C. were of a more complex design and probably had foot-controlled treadles to operate the harnesses to which the warp ends were tied. This type of loom appeared in Europe in the 13th century and was significant in the development of the Cottage Industries. Lester (1979). The textile industry, and the methodologies that developed over the years within it, would prove to be critical to the development of the computer. Further discussion of this vital element in the computer's history may be found on page 38 of this paper in a section devoted to Joseph Jacquard.

Pre-Industrial Revolution

Cottage Industries began around 1750 in Europe. Families had been accustomed to raising their own food, making their own clothes and shoes, and making their own tools. These craftsmen had produced everything from table knives to carriages; from rugs to plows, but by the late 1700's many changes were taking place. The family home now became a Cottage Industry.

Entrepreneurs developed a system among the cottage dwellers. One family would receive wool or cotton to be spun into yarn, and the entire family would sometimes be involved in the spinning process. An entrepreneur would give the spun yarn to another cottage family and the members of that family would weave the yarn into cloth. Sometimes the loom was owned by the family and sometimes by the businessman. One of the rewards for working at home, was being with the family. Wood (1979).

By that time, primitive villages and tribal economies were on the decline. The economic society in England began with the great landlords, and from the fifth to the eleventh century England experienced much violence and confusion. The society was a turbulent and agressive military organization under feudalism. It was involved in a process of concentrating land ownership into the control of a few powerful families and subjecting the masses to servile work on the land. Whether governmental institutions were associated with the crown, with the church, or with feudalism, they were dominated by the greater landlords. Wood (1979).

Wood (1979) continued to explain that by the middle of the fourteenth century, a malignant plague labeled Black Death had decimated the population in Europe and Asia. Because of the decreased population, the surviving laborers now had an economic bargaining power which the hostile, landlord-controlled government could not contradict. This enabled servile workers to become wage laborers and, in some cases, free tenants and independent yeomen.

Due to changes in power because of the Hundred Years' War with France between 1336 and 1453 B. C., and later the Wars of the Roses between 1455 to 1485 B. C. the aristocracy lost some of the adulation of the peasantry. The country was mostly self-sufficient before the sixteenth century; wants and tastes were simple and crude, and a large amount of the commodities used were produced on the farms and manors. Now, because of the wars and travel outside their own country, and knowledge of the advances made by other countries, society had become dissatisfied with the simple process of production. It was no longer sufficient for the gratification of their expanding wants and tastes and the society developed a great interest in trading with other countries. Wood (1979).

Industrial Revolution

The Industrial Revolution began in Great Britain because of the people's desire for more conveniences and material luxuries. The term Industrial Revolution in English history may be confined to the transition from commodities made by hand and the hand tool, to the techniques of manufacturing and industry and the utilization of power-operated machinery in supplying these same commodities. Bowden (1925). Revolution is also a change in the way people live. Wood (1979). For example, factories were being built on farm lands.

The farmers were now working in the factories except for a small number who consolidated their small farms into larger ones. There was destruction of the common-field system of cultivation. Toynbee (1908). Some factories were built close to water which was necessitated by the use of water-powered machinery. This forced some people to move closer to the factories where they could get a job. Wood (1979).

Men and women who had lived on the same countryside their entire lives were now living crowded together, earning their bread no longer as families or neighborhoods, but as units in the labor force of factories. Work grew to be more specialized with new forms of skill being developed, and some old forms being lost. Ashton (1970). England's imperial aim was to develop complementary economic relations between the home country and the colonies, in order to increase the "favorable balance of trade." This would be accomplished by the colonies being furnished cheap raw materials not produced in England and buying from England the more costly manufactured goods. The rich would get richer. Bowden (1925). England's classical economists were arrogant because they had a monopoly over the coal mines, cotton factories, blast furnaces, and shipyards. These factories were considered "wonders of the world."

The prevailing spirit of invention during the latter part of the eighteen century caused that period of time to be named the "Age of Invention." These inventions and discoveries would have been a revolutionary experience for previous generations. Great factories were built and almost immediately had to be rebuilt to make way for refined machinery, titanic warships were constructed and were proclaimed obsolete before they were used. Products which would have been considered miracles yesterday became commonplace. Bowden (1925).

Factory owners showed partiality among the inventors. Those with "slight claim" might be recognized, while others who were more deserving, were neglected because they had no connection with parliamentary and ministerial forces. Toynbee (1908). If factory laborers appeared to be learning too much about the operation of the factory, they were jailed. The government spread the news of their incarceration, letters of the workmen were opened, and visitors were not allowed into the factories for fear foreigners would induce the English workmen and even master manufacturers and capitalists to go abroad. Inventors and artisans would seek fortunes in other countries if possible. Chase (1932). To prevent the inventions or the knowledge of them from reaching foreigners, English businessmen established a very comprehensive system of laws. They were protective of the great textile inventions, the stocking frame and the automation needed to manufacture silk. The law prohibited any skilled worker from leaving the country and charged anyone who conspired to help them depart. Bowden (1925).

The Law of 1750 was developed to protect the woolen industry from foreign rivals. Another law, the law of 1775, prohibited the export of tools or utensils used in manufacturing cotton or cotton and linen mixed. Little did they realize that the knowledge of the machines and the methods of using them could be shared through sketches, miniature models, or specifications without the machine or the artisan ever leaving the country. Chase (1932). Samuel Slater grew up in Great Britain just as the Industrial Revolution began. He carried priceless secrets of the cotton factory from where he had worked in England to America and built the first cotton factory in America. Wood (1979).

In the autobiography of Robert Owen, the author discussed his employment as a common worker in the cotton industry, at Manchester in 1787. He was16 years old when he met a mechanic, a maker of wire frames for women's hats, and through him Owen became interested in a new spinning machine. Owen managed to get together the sum of £100 which allowed him to form a partnership with the mechanic. Owen, who eventually became one of the richest men in Great Britain, carried the title of "Cotton lord" because of his influence with the outstanding discoveries and inventions in the cotton industry. Bowden (1925).

Society's Fears and Gains

Society as a whole feared that labor-saving devices would reduce employment. A machine that combined the action of spinning and reeling cotton was destroyed in 1753 by Lawrence Earnshaw because he did not want the machine to take food away from the poor. Borden (1925). In most factories, physical endurance was tested with long and exhausting hours. Some laborers were periodically unable to find work, and still others found it necessary to shift from one job to another. The man with the greatest job security in the economic world was the jack-of-all-trades who supplied many items in a handicraft environment. Although specialization was seen as a positive move for industry, the changes were taking place at such a rapid pace that the people experienced great confusion which brought about a lack of stability in an otherwise stable world. Workers were concerned with the lack of opportunity to use their intelligence or far-sighted judgment and there was no means for them to share in the vast increase of wealth resulting from improved production. The laborers were seen as a commodity to be used when needed; when not in demand they were cast aside. Borden (1925). Depression in one industry would spread to other branches of the same trade. An example of this problem came about in Lancashire when the weavers had to work less time at lower wages because other nations were unable to purchase cotton goods. Tonybee (1908).

The organization, "Society for Bettering the Condition of the Poor" was developed to help the agricultural laborers. It was recommended that the payment would be by piece work because it inspired the father to take his son to the field with him as soon as he could handle a hook or raise a mattock. The son would earn his living and become toughened to industry and weather at an early age. Chase (1932).

Factory work was a deadening routine. Individual workers performed over and over again the same fractional act having significance only in connection with the other singular acts performed by other employees. Because of the daily routine, there was an increased need for leisure and opportunities for enjoyment. The lack of leisure time caused the worker to feel undignified and thus was injurious to his personality. In spite of this, the factories did not change much, in fact, they interposed night shifts and Sunday labor. Wholesome recreation was not available to the laborers. There were no public parks, hunting was against the game laws, music and drama were expensive, and reading was hindered either by illiteracy, by the stamp taxes, or by the prohibitive cost of books. Chase (1932).

There were some groups who conceived the introduction of machinery as an increased opportunity for finding work. There was an expansion of demand for new methods of production. A workman in a cotton mill suggested a simple change in the machinery by which the spindle was given more play at each end, thus increasing the revolution of the spindle from 4,000 to 10,000 per minute. This enormously increased the output of the mill. Laughlin (1906). The Industrial Revolution made products available at affordable prices for a million people at a time. Because of lower prices, poor people could buy products which previously were available only to the rich. Wood (1979). A desire for a higher standard of living and the opportunity for more was wide spread. The people wanted better educational systems and freedom of worship and political ideas. The middle class society posessed the means to raise an average sized family, improve their dwellings, enjoy amusements, and develop growth towards a purer and higher condition of society. Wood (1979)

Factory regulations, caused by Trade Unions, improved the conditions by limiting the hours of work which had been required for women and children, and the sanitary environment was improved. Trade Unions helped to avert social and industrial disorder and taught workmen to be organized and learn to rely on themselves. Toynbee (1908).

Sir John Sinclair worked unsuccessfully on a theory of preventing machinery from being used to exploit men in peace and to destroy them in war, or to cause technical improvements to increase the happiness of all men. He suggested that a person could work on the deep problems caused by the use of machinery, but perhaps the solution is now beyond man's grasp. Machinery, however is in control because of economic necessesities. Therefore, social forces become the master, and no statesman however noble, can reclaim control. Bowden (1925).

Inventions Leading to the Computer

Early in the 17th century adding machines began to be invented. The most famous of these machines was invented by a French Scientist, Blaise Pascal. He built numerous machines, a mechanical calculator for one, and although he had intended them for practical use, they were unreliable and were used only for scientific models. During the next two centuries, many attempts were made to develop practical calculating machines. Some of those who were involved in these inventions were Schickard (original calculator), Liebniz ("Stepped Reckoner"), and Babbage (Analytical Engine). Also involved were Hollerith (Tabulating Machine),Turing (ENIGMA/ Colossus), Mauchly, Eckert and Von Neumann (ENIAC, EDVAC and UNIVAC). Ralston (1976).

The computer was born as a result of other machinery from the past. Inventors have borrowed from other inventors throughout history, from the early calculations performed by counting on the fingers--to the calculator--to the computer--to inventions yet only in the mind of man. For the purposes of this paper, this section will begin with the inventions of the 17th century.

Schickard--Original Calculator

In 1623 a German astronomer and mathematician, Wilhelm Schickard, built a machine that could add and subtract, and with a little help from the operator could perform multiplication and division. A year later he wrote to his friend Johann Kepler, a great astronomer, telling him of his machine that computed automatically.

Schickard ordered one for Kepler, but when it was half finished, a fire broke out and the machine was destroyed. He left enough notes to assist others with sufficient knowledge to build a working model. Shurkin (1984).

Pascal--Mechanical Calculator

In 1642, at the age of nineteen, Blaise Pascal, a French mathematician, scientist, philosopher, and apparently a part-time mechanic, began work on a mechanical calculator that could add, subtract, multiply, and divide. This machine, completed in 1644, resembled a modern desk calculator consisting of a progression of number wheels whose positions could be observed through windows in the cover of a box that enclosed the mechanism. The digits used were 0 to 9, and were entered by means of dial wheels. He developed the machine for his father who was a tax collector, and went to considerable effort to build and sell them commercially. Shurkin (1984). He received a "droit de la roi," or king's rights, on the machines which gave him the legal right to build more; he built more than fifty of them. However, because they were rather expensive and fragile, the venture was not successful. Lynch (1975). Charles Thomas' machine used the Leibniz stepped wheel, but the fingers were set using numbers in slots. This machine was widely used in commerce throughout France. Shurkin (1984).

Leibniz - "Stepped Reckoner"

The German Baron Gottfried Wilhelm von Leibniz was a universal genius who won varying degrees of honor in law, religion, stonecraft, history, literature, logic, metaphysics, and speculative philosophy, and published his translation of caluclus in 1684. Sir Isaac Newton, the great Seventeenth Century mathematician, and Leibniz independently developed calculus as a way of measuring motion. This invention introduced to mathematics the principle of the motion picture. Calculus breaks the motion down into "stills" that can be observed "frame by frame." A moving object could now be treated by mathematicians as a path through space, and by "stopping the action," the object's speed and acceleration at a specific moment could be calculated. Calculus became a fundamental scientific tool. Bergamini (1963). Liebniz strongly supported the binary numbering system which became one of the important developments for the computer. His system of "stepped" wheels can be found in many of the mechanical calculators which were manufactured before the electronic era of the 1970's. Leibniz stated, "It is unworthy of excellent men to lose hours like slaves in the labor of calculation which could be safely relegated to anyone else if machines were used. Rosenberg (1969).

Leibniz invented a calculating machine in 1671 and completed it in 1694. This machine was more advanced than Pascal's adding machine. The "Stepped Reckoner" could add, multiply and divide, and extract square roots, a process accomplished by a series of repeated additions similar to that used by modern digital computers. Lynch (1975). Leibniz sent a copy of his machine to Peter the Great asking him to send it to the emperor of China. He hoped it would encourage the emperor to increase trade with Europe. Shurkin (1984).

Babbage--Analytical Engine

Charles Babbage was born in Devonshire, England, in 1791. He was born perhaps a hundred years too soon. Controversy dominated his life. The British Parliament had reorganized the rights of inheritance, causing Babbage to be denied the right to a relative's large estate. He needed money to invent the machines he visualized. However when Babbage was thirty-six years old when his father died leaving the enormous sum of about £100,000. Rosenberg (1969).

Early in his life, Charles showed an inquiring mind, desiring to delve into subjects that astonished children's minds. He, himself, was curious to the point of taking his toys apart to see what made them work. He once attempted to prove the devil existed by drawing a circle on the floor with his own blood disrespectfully spouting the Lord's Prayer backward. He overcame toothaches by reading *Don Quixote.* Rosenberg (1969).

He was an undisciplined student at Trinity College in Cambridge, and constantly puzzled his tutors. He was often annoyed because he knew more than his professors. Despite his rebellion, he was already absorbing the advanced theories of mathematics. Alfred Tennyson's couplet "The Vision of Sin" caused Babbage to challenge the words "Every minute dies a man/Every minute one is born." He wrote Tennyson a letter stating: "I need hardly point out to you that this calculation would tend to keep the sum total of the world's population in a state of perpetual equipoise, whereas it is a well-known fact that the said sum total is constantly on the increase." Babbage took the liberty to suggest in the next edition of his excellent poem, Tennyson should correct the "erroneous calculation" and write it as follows: "Every moment dies a man/And one and a sixteenth is born!" He gave him the exact figure of 1.167. All editions after 1850 were changed to: "Every moment dies a man/ Every moment one is born." Rosenberg (1969).

Babbage married Georgina when he was twenty-three. Again his life was full of grief and loss. They had eight children in thirteen years, his wife died at the age of thirty-five, and only three sons lived to adulthood. In 1816 Babbage took his first academic post as professor of mathematics at the East India College making £500 a year. This led to his becoming the head of the mathematics department at the University of Edinburgh. He also had the Lucasion Professorship at Cambridge, a Chair once held by Sir Isaac Newton. Rosenberg (1969).

Babbage was anxious to start applying his ideas for the construction of a machine for mechanizing the logarithm tables. His power of influence was helpful and so was his eagerness for success. He was presented the first gold medal award by the Astronomical Society for his paper "Observations on the Application of Machinery to the Computation of Mathematical Tables." Rosenberg (1969).

The Lords of the Treasury of the Royal Society finally granted Babbage £1,500 for the purpose of bringing his invention to completion. Babbage had studied the inventions of several predecessors and used Charles Mahon's arithmetic machine as a foundation for the development of his own calculating engine. He hired an engineer, Joseph Clement, to help him build his machine. After a period of time, it became necessary to move the equipment to a fireproof building. There was a delay in salary payments and Clement refused to continue his work, dismissing all his employees. He refused to let Babbage have access to his tools which had been specially constructed over a period of eight years at the expense of Babbage and the Government. After breaking with Clement, Babbage was never again to carry his work past the stage of drawings. Rosenberg (1969).

The work on the Difference Engine stopped, but the principle of the machine was improved a year later. The difference machine could be set with clock dials connected to a kind of typewriter which printed the number on a soft substance from which a stereotype casting was made. A formula would be placed in the machine, and it would automatically be printed, excluding all possibility of errors. Rosenberg (1969).

In shedding more information concerning Babbage and his inventions, Rosenberg (1969) stated that a year later he developed the Analytical Engine which had greater versatility and operated at a faster rate. It was designed to perform all arithmetic calculations, and combined such operations to solve any conceivable mathematical problem. Except for the speed of operation, Babbage's Analytical Engine had the flexibility that com- puters have today. This machine had four parts. One was a "store" in which the numerical data in- volved in the calculation would be reserved. It was composed of columns of wheels which were en- graved with ten digits. The second basic part of his computer was the "mill" or the desk calculator. The rotation of its gears and wheels made arithmetical calculations possible. A series of gears and levers which transferred numbers back and forth between the "store" and the "mill" was the third device. The last apparatus was used for numerical information input and output.

Babbage incorporated the punch card method used by Joseph Jacquard, the textile inventor, and was able to set up a pattern of holes which conformed to mathematical symbols. This was the fore- runner of data processing. The Analytical Engine wove algebraic patterns just as Jacquard wove patterns of leaves and flowers in silk. Rosenberg (1969).

Ada Augusta King, also known as Lady Lovelace, and the daughter of Lord Byron, had a keen mathematical mind. Her love for mathematics gave her an incentive to read papers Babbage had written. She studied his ideas and used her influence to get others interested in his invention. With her attempts to make Babbage's work more understandable for the public, she evolved the form of binary arithmetic, using ones and zeros, an idea discovered much earlier by Leibniz. Rosenberg (1969).

Babbage's difference engine was far ahead of its time, and the world was not ready to accept his gift. George Schentz borrowed the design as basis for one he constructed in Stockholm. Schentz's machine was used to calculate a number table in the 1850's but a better difference engine was built in the 1870's by the American, George B. Grant. That machine weighed 2,000 pounds, was five feet high and eight feet long, and contained more than 15,000 parts. Lynch (1975).

Jacquard--Punched-Card Loom

A discussion of the history of the punched card in the textile industry is essential to give more insight into the invention of the computer. Weaving ornamental figured silk textiles was well developed in China as early as 1000 B. C. A complex figure on the cloth appears to be a weaving process of a specified set of the warp threads being lifted to allow the passage of the transverse weft thread to form each single line of the final pattern. In a drawloom a cord is connected to each warp thread. These cords are joined in groups appropriate to the pattern to be woven. The cords are pulled in a sequence, and the weaver is able to throw the shuttle, with the weft thread attached, through the opening made by the lifted warp threads. A painted chart on squared paper with holes punched according to the pattern, one square to each thread, both warp and weft is used, and the assistant to the weaver pulls the corresponding cords. A drawboy had to pull 40 to 50 bundles at a time, in the correct sequence. This process was extremely slow according to Morrision (1961).

In the 1790's Joseph Marie Jacquard invented a fully successful automatic drawloom based on ideas from Bouchon, de Vaucauson, and Falcon. Morrison (1961). Joseph spent much of his time as a young boy in the weaving factory as a drawboy. He would daydream, causing the other workmen to think he was lazy. He observed changes in the process of weaving and his active mind was stimulated. In 1725, Basile Bouchon designed and built an amazing device for automatically selecting the cords to be raised on a loom. His machine eliminated excessive typing and looping of thread by a drawboy. In crude fashion he had introduced the concept of automatic control of machinery by means of a stored program. M. Falcon was already using the idea of cards with holes punched in specific areas for weaving. They were strung together and used on a perforated platen held in the assistant's hand with the card pressed against needles.

This method resembled the cylinder in a player piano. Falcon modified Bouchan's device and used several rows of needles instead of just one row. Morrison (1961).

Jacquard's loom became a one-man operation. Each hole represented a number, and the pattern was printed automatically. These looms were made by the "tens of thousands" in the early part of the nineteenth century. His work was woven with about 1,000 threads to the inch and resembled a line engraving in perfect detail. Portraits that appeared to be photographs were woven in silk. Morrison (1961). It can perhaps be said that Jacquard's innovations with the punched card and the automatic control of machinery by stored program led naturally to the computer.

Electronic Computers

Jacquard's punched cards were the precursors of the age of electronic computers. His weaving loom used an automatic harness controlled by punched cards linked in a roll which held the pattern. Herman Hollerith, a United States statistician, adapted Jacquard's idea for punched cards and developed a punched-card system of data processing for the 1890 United States Census. The process of obtaining the information in the 1880 census took nine years; the new method took only two years and saved the United States Government five million dollars. Bergamini (1963) Bell (1987).

According to Rosenberg (1969), Hollerith was born in Buffalo, New York in 1860 to a German immigrant couple. He had a normal childhood but had a tremendous dislike for spelling. He once leaped from a second-story window at school, then ran all the way home, rather than to face a spelling lesson. He was withdrawn from school eventually and tutored by a Lutheran minister. He posessed a gifted mind, and graduated from the School of Mines at Columbia University when he was nineteen.

Later a friend of Hollerith, General Francis Walker, accepted the presidency of the Massachusetts Institute of Technology and invited Herman to go to Boston as an instructor in mechanical engineering which he accepted. Hollerith continued to experiment with punched cards and a method of automatic feeding through a machine. Rosenberg (1969).

While on a train in Boston, he noticed the conductor hand-punching his tickets, recording a description of the passengers. Hollerith decided that this same technique could be applied to the job of recording the proper census statistics.

In 1890, Hollerith wrote a dissertation on "The Electric Tabulating System" and received his Doctorate of Philosophy from Columbia's School of Mines. The paper explained that the system of electrical tabulation could be described as the mechanical equivalent of the well-known method of compiling statistics by means of individual cards, describing the characteristics of an individual in writing. It would be difficult to invent a machine that was capable of "reading" written information, but punched cards could be read, counted, and sorted quickly. This was a step toward automated computation. Rosenberg (1969).

Hollerith's tabulating machine was composed of two parts, the press or circuit-closing device and the counters. The press consisted of a hard rubber bed plate provided with guides which kept the cards in exactly the same position so the holes would be punched in the correct place. The plate contained holes or cups corresponding in number and position with the 288 quarter-inch squares into which the cards were divided for punching. By placing perforated cards over mercury-filled trays of cups, metal pins could be made to drop through the holes to touch the mercury below, thus completing an electronic circuit. A counter was attached to the machine. In order to avoid false counts, or neglecting a card incorrectly punched, the circuits were arranged to ring a bell each time a card was registered on a counter. If the bell did not ring, the operator knew there was a problem. The cards that refused to count were laid aside for correction or investigation. Hollerith's machinery was adopted by the governments of Canada and Austria for census taking. The Tabulating Machine Company was famous around the world. A large machine-tool-building company used these machines for compiling costs, analyzing payroll, and inventorying material. Rosenberg (1969).

The Bureau of the Census had a new director, S. N. North, and he selected James Powers to seek out better equipment in the processing of masses of data for the 1910 census. Powers was smart enough to retain his patent to any machine he developed. North was so pleased with Powers' system, that he purchased three hundred pieces of machinery for the census. Powers left the bureau to form his own company, Powers Accounting Machine Company. He took over the job Hollerith had been doing. Years later Hollerith expressed his disappointment with the Census Bureau. The last involvement Hollerith had with the Census Bureau came about because of a suit brought by the Tabulating Machine Company against Dr. Durand, the Director of the Census. The Powers machines had infringed on some of Hollerith's patents. The suit was eventually disposed of without meaningful execution. Hollerith had no major dealings with the United States Bureau of Census again. Rosenberg (1969).

Rosenberg (1969) also explained that the same time Powers Accounting Machine Company was formed, Hollerith's fifteen-year-old company merged with International Time Recording Company, the Dayton Scale Company, and the Bundy Manufacturing Corporation to form the Computing-Tabulating-Recording Company. The CTR was a holding company and was renamed the International Business Machine Corporation in 1924. By 1933, IBM had become an operating corporation, using IBM punched cards for data processing.

In 1927 the Powers Accounting Machine Company became the Tabulating Machines Division of the Remington-Rand Corporation, which in 1955 merged with Sperry Gyroscope to become the Sperry-Rand Corporation. These companies are still in competition. Rosenberg (1969).

There were many other scientists who continued to work on desk-top devices to improve bookkeeping processes. Dorr E. Felt started work on a key-driven calculator in 1884. He used a wooden macaroni box, meat skewers, metal staples, and rubber bands. He built a key-driven calculating machine that was capable of adding columns of figures that required carrying from column to column. Three years later he received a patent on the machine he called the Comptometer. This machine would add, subtract, multiply, divide, do square root and cube roots, calculate interest and exchange rates, and more. Models of his machine had a monopoly on the desk-top calculator market for approximately fifteen years and was used extensively by the U. S. Treasury and the New York Weather Bureau. In the 1950s a business school for teaching Comptometer was still being utilized. Shurkin (1984).

The problem with the Comptometer was that the results of the calculations could not be recorded. This problem was solved by William S. Burroughs. Burroughs, born in 1855, worked in a New York bank as a boy. He was appalled at the inaccuracies built into the hand accounting systems. Because of ill health he moved to St. Louis where he went to work in a machine shop. He patented a working model of a printing adding machine in 1888 and then convinced a group of local businessmen to put up $100,000 to help manufacture these machines. During the time Hollerith was mechanizing the census, Burroughs had built fifty machines. He did not think they met with his standards, so he hurled them out of his second-story office window to the pavement. Within the next year, he patented and improved the first model which printed each entry and recorded the grand total. He sold 284 of the machines by 1895. His company was soon building 5,000 machines a year. Burroughs dominated the manufacturing of office equipment by 1913, and was deeply involved in calculating machines at this time. Shurkin (1984).

First Computers

By the end of the 1800's calculating machines were a standard fixture of business and commerce, but the demands of the business world created a need for more sophisticated machines.

Turing--ENIGMA/COLOSSUS

Threats of war were hanging over parts of the world in the mid-1930s. In Britain there were new demands for scientists and engineers to increase the speed of computing. Experts in electrical engineering, mathematics, and physics began gathering at Bletchley Park near London. This was one of Britain's most closely kept secrets. The Victorian estate became the headquarters of the Post Office Research Station for the Government Code and Cipher School. Shurkin (1984).

Mathematicians enjoyed their job of ciphering and were creating codes and code-making machines by the outbreak of World War II. The goal of the scientists at Bletchley park was to break the German military code. Alan Turing was the man employed for that job. Shurkin (1984).

Turing was born in England to a family of Indian Colonial civil servants. He studied mathematics at Cambridge and spent two years doing graduate work at Princeton with mathematician John von Neumann. He published a paper in the *Proceedings of the London Mathematical Society* in which he stated that there were certain types of mathematical problems that could not be solved by automatic computing machines. There were no automatic computing machines at that time, so Turing described one. His imaginary machine stored information written on paper tape and read one square at a time. The machine could solve any problem presented to it by binary digits. Shurkin (1984).

A young Polish engineer, Richard Lewinski, worked in a factory in eastern Germany, but was fired for being Jewish. He contacted a British intelligence officer and offered to sell the details he had memorized concerning an instrument he thought was a secret signaling device. Col. Stewart Menzies, of the British intelligence service, enlisted Dilwyn Knox, a cryptographer, and Turing to go to Warsaw and interrogate Lewinski. Knox and Turing were able to smuggle Lewinski and his wife out of Warsaw and hide them in Paris. Lewnski was able to reconstruct the machine he had seen in

Germany. Lewinski and Turing built an oversized version of the German ENIGMA. Shurkin (1984). The German armed forces used this device to encode and decode messages to the troops in the field. Their German machine was called Fish or *Geheimschreiber* and was three times the size of ENIGMA.

Just having a copy of ENIGMA did not mean the British could decode messages. The ENIGMA used two electric typewriters--a message in plain type was on one machine, and the coded version came from the other typewriter. The Germans changed the key three times a day, but the mathematicians at Bletchley Park had an idea of how the codes were created. Turing and fellow colleagues developed methods that enabled the machines to reduce the possibilities to a reasonable level. Once that key was found, decoding the message was easy. Shurkin (1984). Turing was considered one of the secret heroes of World War II. Hodges (1983).

By January 1943, Turing, and several other mathematicians began building an electronic decoder, and by December the machine called COLOSSUS (electronic cryptanalytic machine) was in service--perhaps the world's first electronic computer. The COLOSSUS used vacuum tubes for high-speed data processing which would prove a point for John Mauchly. Shurkin (1984).

Mauchly and Eckert

John William Mauchly was born in Cincinnati in 1907. His father was a physicist and moved the family to Maryland where he became the head of the Department of Terrestrial Magnetism for the Carnegie Institution in Washington. John was a precocious child, and at the age of five he fashioned a flashlight with a dry cell, a bulb, and a socket to explore a dark attic with a friend. The friend's mother feared this device would start a fire, so she gave the boys a candle. In grade school he installed doorbells to earn money. He loved to read in bed so he invented a trigger which he installed on the stairs. When his mother came up the stairs, his reading light would go off, and when she went back downstairs, the light would come on again. Mauchly enrolled in engineering school, but switched to physics when engineering bored him. He received his Ph.D. in physics in 1932 from Johns Hopkins University. Shurkin (1984).

When a bank failed in Philadelphia Mauchly bought a $1,000 adding machine for seventy-five dollars. Some of Mauchly's graduate students were using adding machines for statistical analysis to improve weather predictions. He believed that the cycles of the sun played a large part in terrestrial weather. Mauchly had gathered ideas from his father and from cosmic-ray research done by a friend of his father at the Bartol Foundation of the Franklin Institute. He knew that other people had proven that the sun rotated in twenty-nine-day cycles, and thought sunspots and magnetism could influence the weather. He also "acknowledged that most meteorologists considered this a crackpot notion." Many meterologists still do, but Mauchly experimented with the idea until his death. Shurkin (1984).

To make any sense out of his research and to verify his point, he needed a computer. He had no money but he knew that binary counters and vacuum tubes existed in cosmic-ray labs. If binary counters could count at something like a million per second with vacuum tubes, then it was foolish to use punch card machines, which can process a hundred cards a minute and not accomplish as much. Shurkin (1984).

When Mauchly visited the world's fair in New York, he looked at all of the machines Remington Rand and IBM had on display which used punch cards. He went home and began building electronic counting devices, certain that this was how computing would have to be done. Due to a lack of money, he used neon tubes. From information gathered in New York, he knew these would work and the tubes would emit about 200 pulses a second. They could be triggered by radio signals and could be attached to relays. He bought some OA46 tubes and "borrowed" some from students' radios that were in his shop for repair. He took an ordinary desk calculator and replaced the mechanical parts with electronics. It needed to be a decimal machine because it would be easier for the students to use, but converting it to the binary system would be convenient for the machine, not the user. Shurkin (1984).

He built several small devices, one of which he called his railroad signal. The tubes were placed in wooden blocks and were set up as "flip- flops." He designed a binary counter; if a signal was sent into the circuits, one side of the model lit; if the current was interrupted, the other side lit. Mauchly had much difficulty developing the digital computer he needed due to a lack of money and material. He continued searching observed Shurkin (1984).

John Mauchly drove east from Iowa in June of 1941, to attend a summer defense-training course at the Moore School of Electrical Engineering which was an independent organization within the University of Pennsylvania. Because of research he was doing for the government, he met the laboratory instructor, a twenty-two-year-old graduate student named J. Presper Eckert, Jr. The two men, twelve years apart in age, formed a partnership. Eckert seemed to be a born engineer, as is true of many individuals in the story of the computer. By the age of twelve, he had traveled100,000 miles and had visited every state in the union. At this same age he was visiting Luna Park in Paris where he noticed a little boat which could be steered around the pond by turning a wheel, controlled with a magnet underneath. He went home, took his Erector Set parts, balsa wood and glass, some pieces of old trains and motors, and other odds and ends, and built a boat for himself. This boat which had cables and switches and wires, he entered it in a hobby fair, winning first prize. The prize was a rowing machine which he still has in the basement of his home. By the age of eight or nine, Eckert built a crystal set on the eraser end of a lead pencil. He built radios with tubes in them by the time he was twelve. From that he progressed to amplifiers and hi-fi for the music department at Penn Charter, an expensive private school. By the time he graduated he was building sound systems for cemetaries. Eckert placed speakers in the stone of a building so the music would distract the mourners from hearing the roar of the crematorium next door. Outdoors he built a system which played chimes, making it sound as though a cathedral were nearby. Shurkin (1984).

Eckert was drawn to electrical engineering, and Philadelphia was the center of the American electrical business before World War II. The Radio Corporation of America (RCA), the Columbia Broadcasting System (CBS), and Philco were located in Philadelphia, and Atwater Kent was near Eckert's residence. One mile from his home, lived a slightly mad genius, Philo T. Farnsworth, who was an inventor of television and had a laboratory to which Eckert had access. Farnsworth ran the first television station in the country. Just before World War II, RCA had built some experimental television sets and Eckert had one. He hooked it up for sixty dollars and got it to work. There were not a lot of shows at that time, so Eckert and his friends would go to Farnsworth's station and put on shows for their friends to watch.

Surkin (1984) continued explaining that Eckert was considered the brightest student ever to graduate from the Moore School. He and Mauchly became friends and colleagues. Mauchly wanted to use an electronic computer and Eckert was interested in building one. The differential analyzer was the first serious attempt at automatic computing at the Moore School. Professor Irven Travis, a faculty member at Moore School, dabbled for years with the idea. He even tried to offer courses in computing technology at night, but there were not enough interested students. In 1938 General Electric, in conjunction with research they were doing for the U. S. Army, asked Travis to look into the possibility of building a computer by "ganging" a group of conventional desk calculators with magnets and wire. This was a bad idea which meant the Moore School and the army would have to be satisfied with the differential analyzer for the time being. Shurkin (1984).

Travis was a navy reservist and was pulled into active duty, leaving his teaching position open. Mauchly applied for the job, and was hired by Dean Harold Pender. The army wanted to know more about exterior ballistics. Gilbert A. Bliss had developed the mathematics to divide the effects of small perturbations on the flight of a shell, from his work at Aberdeen during World War I. Herman Goldstine, a mathematician had studied under Bliss at the University of Chicago. Goldstine was given the rank of first lieutenant and placed under Gillon, who was responsible for ballistic computation. Information involving the path of a bullet from the time it left the muzzle of the gun until it reached the ground was necessary. There were many things which could affect the path of the bullet, such as the speed at which it shoots out of a gun, the angle at which it shoots out of the gun, and the size of the bullet. The mathematician called this a ballistic coefficient. There were other problems which had to be considered, such as the pressure of gravity, the temperature, then the calculations had to be done according to the bullet's highest point as well as where it hit the ground. This work was done by the differential analyzer and hand computers, then printed out on a printer. Shurkin (1984).

Eckert was called to help speed up the machine. He and other technicians replaced some of the winchlike mechanical amplifiers with photoelectric cells--an idea borrowed from GE. They added servo-motors taken from extra aircraft gun turrets, and vacuum tubes to sense the photocells--used to follow plotted curves. They did succeed in speeding up the old mechanical analog machine to ten times faster. Shurkin (1984).

An American, Le De Forest, borrowed the invention of the vacuum tube from Thomas Edison and the diode (a tube with two elements) which was invented by John Ambrose Fleming. By adding a third element, a control grid made up of either a crooked metal wire or a metal plate full of holes, Le De Forest developed the triode or audion tube which amplified the signal. De Forest patented his tube in 1907 and set himself up in business, but like many others, the business was a failure. Shurkin (1984).

DeForest moved from New York to Palo Alto, California to work for the Federal Telegraph Company. He and his technicians attached some of the tubes to one of Edison's mechanical phonographs and discovered that they could hear the amplified sound two blocks away, and they could even hear the footsteps of a fly walking on a piece of paper. Shurkin (1984).

The triode was needed for a repeater in order for telephone conversations to carry over long distances. The American Telephone & Telegraph Company (AT&T) patented the tube immediately. Tubes burned out, and they were not consistent in quality. Mauchly decided that if this were the case, a very large machine would not be made reliable with vacuum tubes. Shurkin (1984).

Eckert, who was an expert on theater organs, disagreed. According to Eckert, a man named Thaddeus Cahill invented the first electric organ in 1898. Cahill was so excited about his instrument that he attached it to the telephone lines so his neighbors could hear it. People all around him could hear the music. Some did not appreciate the disturbance and the telephone company ordered him off the line. Shurkin (1984).

The Novachord built in 1930 by Hammond, contained seventy-two notes, with two tubes for each note. One tube was used as a frequency divider producing the tone; the other tube modulated the size of the signal. The Hammond organ also had ninety-one small tubes which acted as miniature generators that never seemed to wear out. Shurkin (1984).

In August of 1942 Mauchly wrote a paper, "The Use of High-Speed Vacuum Tube Devices for Calculating", explaining his proposal for improving both speed and accuracy of the differential analyzer.

He sent it to John Grist Brainerd at the Moore School. Somehow the paper was lost until the next year. Calculating machines were not to be had at this time because the office-machine companies were turning out war material instead. Shurkin (1984).

> The ballistics situation was intolerable. The Allies had invaded North Africa, and the gunners found that their firing tables were off. The ground in North Africa was softer than the ground in Maryland, and the guns were recoiling in unpredictable ways. Ordnance would have listened to any reasonable suggestion for speeding up the ballistics. Surkin (1984).

Eckert and Mauchly worked on a twenty-four-hour basis for several days gathering the information from the 1942 paper and experiences. They knew the machine could be built, but they needed money and approval. They finally gave the proposal to Brainerd. He presented it to Colonel Simon, T. H. Johnson, and Oswald Veblen. Goldstine was there to outline what the Moore School proposed to do. Veblen had tilted back his chair, and when he had heard enough, he "crashed his chair forward, stood up, and said, 'Simon, give Goldstine the money!' and left the room." Shurkin (1984) Officially the contract went through May 17, 1943 with expected expenses being $61,700 for the first six months. Brainerd was named as project supervisor, Eckert as chief engineer, Mauchly as principal consultant, and Goldstine as technical liason. Rosenberg (1969).

Mauchly, Eckert, and their team worked thirty months--100,000 man-hours--and the project was finished. The name was suggested by Col. Gillon and was christened ENIAC, which stands for Electronic Numerical Integrator and Calculator. ENIAC was classified. No one outside the school or ordnance was to know what was being built at the Moore School. Workers referred to it as the PX project. The machine weighed thirty tons and needed fifteen hundred square feet of floor space. There were forty panels, nine feet high, which "contained 18,000 vacuum tubes, 500,000 joints soldered to con- nect all the circuits, in addition to 70,000 resistors and 10,000 capacitators." Rosenberg (1969). The ENIAC required three times as much electricity as a 150-kilowatt broadcasting station. Eckert and Mauchly designed their computer to accomplish the same task as the Harvard-IBM Mark I developed by Aiken, but in a fraction of the time by about one-millionth of a second. This was achieved by doing away with telephone relays and other electromechanical components. "There's no reason technically why this job couldn't have been done ten years sooner." stated J. Presper Eckert.

"ENIAC was installed at the Aberdeen, Maryland, Proving Ground in 1947." It not only worked on turning out ballistic tables for the Army and the Air Force, but worked on problems in weather forecasting, wind tunnel design, and the study of cosmic rays. It could supply an answer to a problem in one half minute that usually re- quired twenty hours with an average desk calculator. "ENIAC was so advanced that it could do the work of twenty thousand people." A button was pressed to multiply 97,367 by itself 5,000 times, the answer came in less than a second. This machine was built for war purposes, but actually was completed two months after the surrender of Japan. Shurkin (1984).

The ENIAC had certain problems. It could not retain enough material in the memory unit, there were barriers at the input and output points because of the high speed operations, and "the complex circuitry necessitated rewriting and replugging for each new task." Shurkin (1984).

Von Neumann

A new model, incorporating new advances was needed. Professor von Neumann, a scientist new to the project, joined with Mauchly and Eckert in building the EDVAC, Electronic Discrete Variable Automatic Computer. Rosenberg (1969).

In 1944, Goldstine met von Neuman. According to some historians, von Neumann was the genius who moved the world into the computer age. John von Neumann, born in 1903 in Hungary, had a photographic memory. He could recall material and also translate it into Latin, Greek, French, English, or German without using a dictionary, paper, or pencil. His ability in mathematics was even greater than his language capability. He could compute in his head what his colleagues would have to spend many hours figuring on calculators and he had memorized all twenty-one volumes of the *Cambridge Ancient History* and the *Cambridge Medieval History.* Green (1985). Von Neuman displayed idiosyncracies just as his colleagues did. He was sometimes described as emotionally undeveloped. He was married twice. Once when his second wife was ill and in bed, she asked von Neumann for a glass of water. He went downstairs, and fifteen minutes later went back upstairs and asked her where they kept the glasses; they had lived in that house seventeen years. One of his friends said he could not "even change a tire on his automobile and that he was a complete idiot, mechanically." Shurkin (1984).

Von Newmann became a United States Citizen and one of the first permanent members of the Institute for Advanced Study at Princeton. His second wife was one of the first coders of mathematical problems for electronic computers. In 1955 he became president of the United States Atomic Energy Commission in Washington, D. C. He and his staff designed machines that functioned well most of the time and minimized the need to rewire a computer each time a new set of problems was introduced. Green (1985).

The fluorescent screen, probably Von Neumann's idea, ultimately would lead to the VDT (Video Display Terminal) CRT (Cathode Ray Tube), or simply a monitor. Green (1985).

Together, Von Neumann, Mauchly and Eckert launched the EDVAC project utilizing binary digits, but they left the project and a new team took over. Von Neumann left with Goldstine to go to Princeton. At the Institute for Advanced Study, Von Neumann continued to work with the RAND Corporation where they built the JOHNNIAC Computer. Dr. Goldstine took a position as director of mathematical research at the IBM Thomas J. Watson Research Center in Yorktown Heights, New York. Metropolis (1980).

Mauchly and Eckert formed their own company. Using their experience at the Moore School and the experience they received through developing the ENIAC and EDVAC, they invented BINAC in 1948. The new unit was cheaper and faster than ENIAC and EDVAC, and was built to handle magnetic tapes instead of punched cards. Dr. Grace Hopper, now a Navy Admiral, was a computer expert in her own right. She and her programming group at UNIVAC had developed an algebraic language in 1955. Metropolis (1980). Hopper told the story of entering Mauchly's laboratory early one morning and finding "the BINAC surrounded by Coke bottles, and sitting in front of it, slightly unshaven, John Mauchly; and both John Mauchly and BINAC singing 'Merrily We Roll Along.'" It was evident that the Eckert-Mauchly Computer Corporation was struggling. Rosenberg (1969).

Computer - First Generation

By 1927 Remington Rand, Inc. had been formed from Remington Typewriter Company and Rand Kardex Corporation and a number of other companies. Remington Rand introduced the first electromechanical visible records unit in 1946, and by 1951 they had completed an electronic version of the old Powers tabulating machine, which brought automation to office records. Rosenberg (1969).

Mr. Rand realized computers which offered speed and absolute reliability were needed for office management. He had his engineers check into the E-M laboratories. He found that Eckert and Mauchly's thinking was the same as his, and to solve their business problems, he bought E-M for a modest figure and made Eckert vice-president of the computer division. Mauchly and Eckert became the inventors of the first commercially feasible computer called UNIVAC I. This machine could check itself for errors and could handle both numbers and descriptive data and store the program. This computer was installed in the U. S. Bureau of the Census in 1951. UNIVAC or Universal Automatic Computer was used "continuously twenty four hours a day, seven days a week for more than twelve years." Rosenberg (1969). In October, 1963, UNIVAC was retired and placed in the Smithsonian Institution after it had operated for 73,000 hours.

In 1952, a presidential election year, Dwight David Eisenhower was running for president against Adlai Stevenson. Remington Rand Corporation offered CBS free use of UNIVAC in order to predict and tally votes as they came in on election night. This was the first time a computer had been used in this way. The prediction was for Eisenhower to win by a landslide. The computer was correct.

Because of UNIVAC, sales of the Remington Rand Corporation far exceeded those of IBM. In a short time, however, the lead would return to IBM and stay there. Thomas Watson, owner of IBM, used unique selling techniques, outstanding treatment of employees, and quality of product and service to make his company successful.

Computer - The Second Generation

In 1948 the transistor was invented by AT&T's Bell Laboratories and the benefits of the transistors over vacuum tubes for computer applications were recognized immediately. There were many production and technological problems to be worked out which caused a delay in the manufacture of transistorized computers until 1959. All second-generation computers replaced the vacuum tubes with transistors and were using magnetic core storage systems for main memory. For auxiliary storage, some computers used magnetic drums and disks in addition to magnetic tapes. Green (1985).

Data Processing Computers were made on a medium scale. Second-generation technology built small character-oriented processors at low cost. IBM's 1401 was the first of a very successful series of such computers, first delivered in 1960. Ralston (1976). The Bell Telephone Company used the transistor to select routes for long-distance telephone calls. Green (1985).

Computer - Third Generation

The transistor had improved computers extensively, but the smaller companies and businesses needed computers. Researchers had experimented with several possibilities of reducing the size and cost of computers. An engineering professor at Stanford University, Fredrick Terman, the son of the developer of the Stanford-Binet Intelligence Quotient Test, had been impressed with two young men, William Hewlett and David Packard. Terman recommended that they go into business together. They began constructing electronic devices in a garage in Palo Alto, California. They developed an oscillator which was purchased in 1938 to be used in Walt Disney's film *Fantasia* The young men's company, Hewlett-Packard, was in business. Several groups started businesses and became a part of the Stanford Industrial Park. Two of those companies were Fairchild Semi-conductor and Texas Instruments. A race began between these companies to see who could produce "chips" of semiconductor material made of silicon instead of germanium. These chips would replace the hand-wired transistors. The two men from Fairchild were Robert Noyce and Gordon Moore. Jack Kilby was working on the problem for Texas Instruments. Shurkin (1984).

Kilby came in first with a patent filed in 1959. His idea was to manufacture a system that permitted the miniturization of electronic circuits on semiconductor chips, called integrated circuits, or ICs.

"Kilby had reduced the transistor to the size of a match head" and Texas Instruments could sell them for $450 each. Shurkin (1984).

Those first ICs were difficult to manufacture and still had to be wired together. However, at Fairchild, Noyce used a system called "planar" manufacturing. With this method all the transistors and resistors were structured on silicon, with the metal wiring embedded in the silicon, essentially all in one piece. He filed for a patent five months after Texas Instruments. Naturally a lawsuit followed, as Texas Instruments claimed infringement from Fairchild. "A court eventually found for Fairchild, but any company wishing to produce ICs needed licenses from both companies." Shurkin (1984).

"The planar IC became the basic component for the electronics industry." As manufacturing techniques improved, the chips became smaller and smaller. Moore soon developed the Moore's law, which holds that the amount of information storable on a chip doubles every year and the price of the chip remains the same. It was now possible to store more information on a chip smaller than a fingernail, than Eckert would have been able to get into a room full of mercury delay lines. The chips were soon selling for dimes. Simple ICs were replaced with Large Scale Integrated Circuits (LSIS). The laboratories of universities and the computer industry are now working on Very Large Scale Integrated Circuits (VLSIs), which cram millions of components onto a chip. Shurkin (1984).

Noyce, a physicist, suddenly found himself a wealthy man. Each member of the team at Fairchild had earned $250,000 for the patent, and the money continued to come. Noyce became general manager of Fairchild Semiconductor and the firm quickly became a $150-million-a-year firm. Shurkin (1984).

A large number of engineers and physicists began "spinning off" from their jobs and going into business for themselves. Noyce, Moore, and Andrew Grove left in 1968 and formed their own company, Intel. Shurkin (1984).

In 1970 Intel announced a new memory chip, the 1103, containing more than 1,000 bits of information. (In computer language, 1,000 bits of information is called a "K"; a chip containing 1,000 bits is thus a 1K chip.) "The 1103 was classified as a RAM, random-access-memory. This meant that the user could write instructions into the memory. The opposite of the RAM was the ROM, read-only memory, in which the information is placed on the chip by the manufacturer and cannot be altered. With RAM, computers were smaller than ever before. Shurkin (1984).

Ted Hoff, a Stanford graduate, worked on a project for Intel to reduce the "brains" of the computer. They called it a "computer on a chip." The proper name was microprocessor. Hoff had figured out a way to get all of the circuitry onto one silicon chip, and when it was connected to the memory chips and in-put and out-put devices, it really was the "brain." Shurkin (1984).

The impact of the microprocessor on society by the mid-1970s was astounding; it was possible to buy a "hand-held calculator that could run circles around ENIAC or UNIVAC" and cost under $1,000.

By1971 engineers at IBM's Palo Alto lab had produced table-model microcomputers. The computer had gone from room size to table size, then even small enough to be held in the hand. Suddenly there were names like Tandy and Commodore. Two bright young men in their twenties, Steven Jobs and Stephen Wozniak produced small computers in a garage. This enterprise, Apple, came to be one of the fastest growing companies in American history. One of the pioneers in the industry, Nolan Bushnell, founded Atari and developed three different companies. Shurkin (1984).

The impact of the computer on society touches the lives of people in many ways. Employment used to involve working in the fields using hand crafted tools, but modern day tools have become electronic time savers. Where previous generations were unconcerned with such things as polution and radiation, those who work with new technology must be aware of these dangers.

The primitive societies learned to protect themselves from intrusion by building shelters, but the homes of modern man no longer protect society from invasion of privacy. The new technology makes it possible for information to be made available to those who sometimes have no right to such information. The family of previous generations was usually a close-knit group consisting of the extended family, working together for a livelihood. Today's family normally would consist of parents and children only, with the members of the family usually working and going to school in seperate locations. These changes have come about through the process of inventions from prehistoric numerals to innovations in the textile industry, to present day computer technology. From the discussion of the history of the development of the computer, the opportunities for use of the computer through several industries and the computer technology used for training employees has been detailed.

CHAPTER III

COMPUTER INROADS INTO THE VARIOUS FIELDS OF INDUSTRY AND SCIENCE

Through the invention of the computer the production processes in industry and science has advanced very rapidly. In this chapter several areas of industry and science will be investigated regarding how the computer has enhanced their programs and how the computer has helped in the training of employees in those areas. The specific areas to be discussed are the uses of robotics in many of these fields, the automobile industry, the agricultural industry, meteorology, NASA and the space program, medical and laser, and the textile industry. Information gained through individual interviews is included. See Appendix B.

The invention of the supercomputer has opened the door to improved product performance and to major savings in the design and development phases of industrial products. The supercomputer makes it possible to process large quantities of arithmetic operations very quickly, and provides design engineers in industry with new insight into computational analysis. However, there are still certain problems relevant to industry that are too complex for even today's advanced computers to solve. The existing software needs improvement and the transition from computational analysis on the supercomputer to the full integration of computer-aided design (CAD) with computer-aided manufacturing (CAM) is still an unsolved problem. Erisman (1987). Even with problems, the use of this technology will continue to improve and expand all industrial production.

Robotics

The advancement of robotics has been of tremendous value to industry and science. For better understanding of the robot, it is necessary to explain some of the history of automation. Historians explain that the Egyptians centuries ago, were creating "automata" objects. Egyptians built water-powered timepieces and jointed statues that moved when the owner started the mechanical operation. Eventually other countries began inventing various types of automation, also. There were tea dolls for the wealthy Japanese. The host would start the mechanism inside the doll and then place a cup of tea on the doll's tray. The doll bowed, then walked toward the guest. When the guest lifted the teacup from the tray, the doll would stop. Artificial birds that chirped, drank water, and flew were built by Hero of Alexandria in the first century Greece. Leonardo da Vinci was also active in automata. He created a mechanical lion that "walked" to greet Louis XII of France when the king visited Milan. The lion stopped, opened its breast with a claw to display the French coat-of-arms. Lee (1984).

The "automatons" were made up of springs, cogs, and gears. They were mechanical, not true robots, but led to the invention of robots. Robots descended from the automatons, combined with the industrial machinery. Lee (1984).

> If every instrument could accomplish its own work, obeying or anticipating the will of others . . . If the shuttle could weave, and the pick touch the lyre, without a hand to guide them, chief workmen would not need servants, nor masters slaves. ---Aristotle.

Even though Aristotle wrote these words over two thousand years ago, what he described were intelligent, self-controlled machines, as a robot--the automated servants. In the 1920s, a Czechoslovakian playwright, Karel Capek, coined the word *Robot* from a word in his language meaning "forced labor." Lee (1984). Robot then came to mean a machine that works on human command, without a human operator. However, practical robots only became possible through computer technology, basically in the 1950s. D'Ignazio (1982).

A robot must have a program to tell it what to do; it must have an element that takes some action, such as lifting or turning something; it requires a sensor, which can select the object of its action; there must be a decision maker, to decide whether conditions are suitable for the action--"Is this the right object?" for instance; and it must have a controller, to oversee the other parts. Thro (1987). Industrial, scientific, and educational robots are good examples of this innovative technology. D'Ignazio (1982).

All of the industrial robots have armlike projections and grippers (hands or pincers) and are computer-controlled and operate on their own once they are programmed. There are many types of these robots. Some move objects from one place to another, others have minicomputers or microcomputers onboard for flexible programming, and still others, are welding and assembly robots. Robots have now been invented for lighter work and can pick up and manipulate only light items. These will be used for clerical robots and "gopher" robots and would be useful in offices. D'Ignazio (1982). The automobile industry has not always used robots or computers in the manufacture of their products. From 1908 to 1927, Henry Ford developed the mass-produced "Model T" automobile. This elaborate way of automobile manufacturing which was done by the assembly-line method astounded the business world at that time. D'Estaing (1985).

Today, all major automobile manufacturers are turning to the robots and supercomputer for help in the design of aeordynamic cars. The Ford Motor Company relied heavily on the supercomputer for the design of its 1986 Taurus car. The consumer has benefited from the use of this computer in the area of fuel savings, and it has been estimated to have saved Ford several million dollars in design costs, primarily because it eliminated the need for multiple prototypes. All car manufacturers are now using supercomputers extensively in crash simulations. Vast amounts of money are being saved by modeling collision damage on a computer screen rather than spending money on the destruction of costly prototypes. Erisman (1987).

Mr. Rick Tipton is the Hazardous Material Coordinator with the GM-CPC Group in Oklahoma City, Oklahoma. In an interview with Mr. Tipton, the writer asked how the automobile industry has used computers and robots for the enhancement of production in the last twenty years. He explained that in the past several years they have used robotics extensively in the Body Operations department of the Oklahoma City plant. That department is responsible for the assembly of the metal "body" of the automobile. They utilize several types of welding, brazing, fitting and grinding processes. The computer-aided robot has proven a very valuable tool particularly in the welding processes. In the Trim department, the robots are used in the application of various sealers and adhesives prior to installation on the car.

As advancement continues in the technological fields associated with these processes, further mechanization will result. There are several advantages to this mechanization, among them a cost reduction associated with the elimination of wages and benefits associated with human involvement. Tipton stated that automation provides certain quality improvements through high repeatability of processes.

In addition to the use of robotics, the computer is also being used extensively in the area of safety and training for automobile industrial employees. Tipton said that in August of 1986, they were introduced to the "Interactive Laser Disk System" (ILDS). This system is composed of a CRT, CPU, and Laser Disk Player. The CRT screen is "touch-sensitive", enabling the user to ask qestions or enter responses without the use of a keyboard. The video-disk gives much greater picture quality and is quite durable.

The original use for these systems was in conjunction with a massive training program which they conducted in the area of chemical hazards and their recognition. Tipton's primary responsibility is training, and there have been 15,000 hours of training conducted, much of it on the ILDS. This type of system allows each trainee to move at their own pace and to review sections of the material they may have difficulty understanding. It also has the advantage of providing a "one-on-one" training experience, without the need for additional trainers. This program has been so successful that it is now the preferred method for most of the safety-related training. The Maintenance and Engineering departments are also utilizing this program to introduce new procedures and for training purposes. Just as the computer has brought many improvements to the automobile industry, other industries have been impacted by the use of the computer as well.

Agricultural Industry

Ancient man supplied the basic needs of his family by hunting and fishing. The nomadic family would live in one area, eating the plants that were available and then move to another area for survial. Eventually, man began using stone tools to plant and cultivate fields. With those crude tools available, the family could now settle down in permanent dwellings. As time progressed, farming became a way of life. Man domesticated animals and used oxen to pull plows and carts. They learned to reorganize watercourses for irrigation channels and to build huts where they formed villages. Improvements in farming continued for generations and spread across the continents of the world. The last two million years. (1974).

Scientific farming and farm machinery were developed around the eighteen century, and the countryside in western Europe began showing signs of agricultural revolution. Waste lands were brought under cultivation, new tools, such as the seed-drill and more efficient plows were introduced, crops were rotated and scientifically selected, and the land was fertilized artificially. The last two million years. (1974).

Tractors with kerosene engines were invented in the 1870s, but after World War I, the all-purpose tractors which used gasoline engines were developed. Today, by the use of the computer, farming equipment has progressed to being electronically powered, the farms are much larger with fewer people to help in the agricultral production. Farmers are required to handle vast amounts of paper work for their accounting purposes as well as for the government.

Dr. J. E. Osborn, head of the Agricultural Economics Department at Oklahoma State University, explained that the computer has been used extensively in Agricultural Economics since the late 1950s. The mainframe computer has been used for routine activities such as linear programming, statistical analysis, and accounting as well as special software for modeling work. Also, with microcomputers, numerous desktop applications are available for producers to use. Agribusinesses has provided information to decision makers for improving the knowledge base. Most information that Dr. Osborn has seen would concur that the mainframe and microcomputers have strengthened agricultural industries.

In the discussion concerning the training for future farmers, Dr. Osborn explained that the microcomputer is used to demonstrate how management can be assisted with computer-generated information. This information may be simply a historical data base or projections about the future. The data base may include expenses, revenue, profit, loans, assets, liabilities, yields of crops, acres of crops, production of livestock, and debts. The projections could include cash flow, yields, costs, revenue, prices, and market condition. The students have access to all of these applications, according to Osborn.

Today much farming equipment is built with an enclosed cover over the driver, which enables the farmer to be out of the weather when plowing the fields. There are times when it is necessary for the farmer to have an updated weather report. The weather reporting which is so crucial to his business is also computerized.

Meteorology

The writer visited with two men involved with Meteorology to obtain an explanation of the latest computerized weather equipment. Kevin Kelleher, the Research Associate with the Scientific Support Division at the National Severe Storms Laboratory was asked to share the advantages of the use of the computer during the last twenty years. He explained that the computers have allowed researchers to develop and test numerical models which simulate the atmosphere and its behavior. Cause and effect relationships have been established through the use of models, which, when passed on from the researcher to the operational forecaster, has provided the forecaster with an extensive set of "clues" to look for in order to predict the weather. These atmospheric models require the resources of the largest computers in existence today and these models will get even larger as the computers get larger. There are very few fields of study that make use of computers as extensively as Meteorology. Kelleher also pointed out that all National Weather Services forecast offices use computers to store worldwide weather conditions (temperature, winds, precipitation, etc.) which can be brought up instantly.

Gary Lezak, the Staff Meteorologist at KWTV Channel 9, in Oklahoma City, Oklahoma, gave his opinion of the use of computer in areas of Meteorology. He stated that the computer has been a major factor in the advancement of weather forecasting during the past twenty years. The collection of data from around the world is now quick and processed constantly throughout the day. This data is fed into computer forecast models. The models used in the United States are the LFM, NGM (Nested Grid Model), and the Spectral (AVN or Aviation Model). The LFM and NGM are processed out to 48 hours, while the AVN goes out to 10 days. The LFM was invented in the early 1970s and the NGM which uses a higher number of grid points was developed in 1982 and released for operational use in 1986. These computer forecasts, which are generated twice daily, are the main guidance to forecasting the weather whereas twenty years ago there was little support from computers.

The training of a TV weatherman does not involve the use of the computer to any great extent. Over fifty percent of the weathermen in television are not meteorologists, but most do use the computer for making forecasts and checking temperatures across the country, according to Lezak. For the meteorologist working in the private field or National Weather Services (NWS) the computer plays a more significant part in the training.

The weather office in Washington, D. C. uses one of the largest computers in the world to compile all of the current data from all over the United States and the world to produce forecasts, explains Kelleher. It will run models predicting short and long range outlooks, transmit current weather condition maps, etc. These weather maps are broadcast continually to all forecasting offices (public and private) and universities which subscribe to this service. The maps are used as a basis for forecasting. Usually a meteorologist will blend the information provided by the maps received from Washington, with his personal knowledge and experience of the local area from which he is forecasting, in order to arrive at a final forecast.

If it were not for the accurate weather reporting made possible through the use of computer technology, there would be many more people killed during severe weather in all areas of the world. Also, it is extremely important for space flights to have near perfect weather conditions for launching a flight or for recovery of the space craft.

NASA and Space

The space program as we know it today would not exist if it were not for computer technology. Tens of thousands of technical and administrative tasks are accomplished every day with the assistance of computers just for the space program. At NASA, computers and computer applications vary from small microcomputers used for word processing, planning, and data management by clerical, professional and management personnel, to mainframe computers for sophisticated management information and control systems. Minicomputers make programs possible in Computer Aided Drafting, Computer Aided Design and Engineering, and Computer Graphics and Word Processing. There are special applications that involve Electronic Printing, Electronic Publishing, Photographic Process Monitoring, Modeling or Design, Simulation, Instrumentation and Data Logging, and Telemetry. Information Summaries. (1987).

A good example of the technology used by NASA is shown by two computer-aided engineering graphics software packages. One of these software packages is called PLAID and the other is TEMPUS. They model objects like Space Station modules and the position of the astronauts within the module. This allows them to simulate their work in the Space Station environment. Specialists can study the graphic models and find ways to ensure that the people in space interact efficiently and safely with the machines. Designs that are unusable, can be modified quickly and easily before scale models are ever built. PLAID is useful for Space Shuttle mission planning and spacewalk simulation. Information Summaries. (1987).

Astronauts, engineers, and technicians who operate the Space Shuttle rely on the launch processing system, onboard systems, and the Shuttle Data Processing Complex. All of these programs are highly automated systems with programs using billions of calculations. The computer is also used in all areas of future planning. In addition to these few computer techniques listed, the world's most powerful supercomputer, capable of crunching out a quarter of a billion calculations a second, operates at the NASA Ames Research Center in Mountain View, California. Information Summaries. (1987).

Freda Deskin, one of the two Oklahoma Teacher in Space Finalists, has been trained by NASA as a Space Ambassador and has worked as Coordinator of Special Projects for the Oklahoma State Department of Education promoting "Space Literacy." Deskin is co-founder and president of Aerospace Foundation of America and Creator and manager of Space Academy of America. In an interview with Deskin, she was asked from what she observed during her training to explain how the computer enhanced the space program. She said that the computer has allowed more rapid progress in all areas of the space program. She said that, of course, the safety of the shuttle and all the simulators are improved with the sensors that send messages to the computers and the lift-off and mission are monitored by and integrated with computers. Computer Assisted graphics save many years of development and money. Ideas can be tried on the computer and computer run simulators that eliminate the cost of actual lives in experiments.

Robotics used in the space program as well as the ability to program probes to do things that would be too dangerous for man, have allowed the scientist to do much exploration that would have taken years to do otherwise. Satellites of all kinds bring information from around the world to the fingertips of scientists and engineers via computerization. Deskin received a seventeen-page application to the Teacher in Space Program. She used a computer to organize, change, edit and compress the necessary information that had to be included. She used the computer for the research needed to decide on the experiment she wanted to do while on the shuttle. Her training at NASA, in preparation for the spaceflight was all done by computers. Computers were also used in communication, and as simulators. Scientists and engineers working in computer technology for the space program have developed equipment used in many other areas as well.

By the 1970s, the Stanford Arm, a small, electrically-powered robot manipulator and Viking 1 and Viking 2 robot landers from NASA were used to retrieve rock samples from Mars. Lee (1984). The outer-space probes were developed by NASA and are being used today as sophisticated sensory systems. They are advanced remote-controlled vehicles, but can also be computer-controlled. D'Ignazio (1982).

At the present, the top national priority is to industrialize space rather than explore it. Outer-space is an ideal environment for manufacturing many products. A vacuum found in space, extreme cold, the absense of dust particles, bacteria, or other airborne impurities, and the lack of gravity makes it possible to produce excellent crystals, magnets, and lenses. Space is filled with hazards and enormous risks to people's lives and well-being. The development of a new generation of machines that could perform the tasks needed for finding natural resources to provide the needs for the growing population, modern societies, and scarce natural resources on earth is under way. D'Ignazio (1982).

Medical and Laser

Whether at the doctor's office or in the hospital, records and information concerning a person's background and other information are available to the doctor concerning a diagnosis for that person's illness, all on a computer. Medicine is another scientific field that is using mass amounts of computer technology. One of these areas is Laser surgery and therapy.

In 1916, Albert Einstein "predicted that electrons in an atom, if properly stimulated, could emit light energy (photons) of a particular wavelength." He was proven right in 1960 when Theodore Maiman built the first working laser. *Laser* is an acronym for "light amplification by stimulated emission of radiation." Galton (1985).

Gynecologists, dermatologists, and podiatrists are using laser treatment for conditions ranging from infertility to ingrown warts. There is little bleeding with laser surgery; it is now considered a miracle cure for the chronic pain of arthritis, and a needle-less form of acupuncture. One example of its use in delicate surgery in the operation performed by James Koufman, a surgeon at Wake Forest University's Bowman Gray School of Medicine, in Winston-Salem.

There was a benign tumor that threatened to block a child's breathing which kept growing back and would have to be removed again and again. He knew another operation would be difficult because of the location of the tumor in the throat. Koufman took the patient into a special operating room next to a large apparatus which looked very much like a dentist's drill. He reached for the arm of the machine, focused it on the tumor, zapped the infrared beam of light onto the tumor, and the tumor no longer existed. Teresi (1987).

A new research lab for lasers has been built at Massachusetts Institute of Technology costing $1.6 million. Many other laser research labs are now being built. The results from this research may show the use of laser to repair torn nerves and blood vessels, unclog human arteries that have been packed with plaque, and hopefully destroy cancer cells. Teresi (1987).

A diabetic patient could go blind from a gradual obstruction of sight called diabetic retinopathy. This occurs when abnormally weak blood vessels grow on the surfaces of the retina. These fragile vessels can block light from the retina or can cause a leakage of blood to the normally clear fluid found inside the eye, blurring the diabetics vision. Argon lasers (Argon is an inert gas found in the air) fortunately, can be used to reach inside a diseased eye and try to repair the damage. For treatment, the patient sits in the ophthalmologist's examination chair, looks through a set of lenses as though it was an ordinary eye checkup. The ophthalmologist looks through the other end of the lenses, takes aim, and taps a foot switch, the painless light bursts into the eye (the brightness of the laser beam is less than a watt) the light strikes the back of the patient's eye, destroying the abnormal blood vessels. The patient may return home immediately, suffering no lengthy recovery. Teresi (1987).

Francis L'Esperance a New York City ophthalmologist developed a treatment called *laser photocoagulation*. Around 20 million eyes threatened by diabetic retinopathy have been treated with laser with a 75 to 80 percent success rate. This treatment, however, can occasionally cause damage to the retina. Teresi (1987).

Years ago a German physician, Gerd Meyer-Schwickerath examined a number of patients whose retinas had been burned from looking into a solar eclipse. There were scars on the patients' retinas. From the information Meyer-Schwickerath noted, researchers of today have found that by using laser to repair a torn retina, a scar is formed which keeps the retina from tearing further. Teresi (1987).

Glaucoma causes blindness from a buildup of excess fluid inside the eyeball. The fluid exerts too much pressure and damages the eye. Holes can be punched into the eyeball by a laser beam, releasing the excess fluid, thus reducing the pressure. Teresi (1987).

Cataracts form when the lens of the eye grows cloudy and opaque. Surgeons can replace the diseased lens with a plastic lens leaving the rear membrane that holds the fluid inside the eye. The membrane is transparent, but sometimes after surgery, it becomes cloudy like waxed paper. A possible solution is found when an ophthalmologist uses a set of optics to see into the patient's eye, focuses on the membrane, and fires a switch. A beam of laser light travels through the optics and into the patient's eye. For billionths or trillionths of a second, the invisible laser beam has been focused on a point just one or two thousandths of an inch across. The intensity is so great it makes a spark and a little pop, puncturing the membrane without affecting the rest of the eye, or the implanted plastic lens. In ten minutes time, an ophthalmologist can punch a series of holes in the membrane and the patient can see again. Teresi (1987).

A surgery called *radial keratotomy* was first used in the Soviet Union. This procedure helps to solve the problem of nearsightedness and farsightedness, which occur when the eye cannot focus light on the retina. Some ophthalmologists now use the traditional surgical techniques to adjust the eye, so the patient no longer needs glasses. There are questions about the success of this type of surgery, but there is hope that in the future lasers may do the job better and without much risk. Teresi (1987).

A birthmark which gets its color from many large blood vessels close to the skin is labelled a portwine stain and becomes darker with age. With laser dermatology this abnormal birthmark can be removed with about a 70 percent success rate. Teresi (1987).

For microsurgery, the most common type of laser used is the carbon dioxide gas laser, which generate only 100 watts of infrared light. The light is absorbed by water which makes up about 90 percent of the soft tissue. The carbon dioxide gas laser has the ability to cut tissue without causing bleeding which is ideal for surgery on the larynx. The laser beam can be passed down a tube in the throat to remove small cancers or small wart-like growths. The tightly focused laser beam can vaporize growths twenty-fifth of an inch across without damaging the larynx. Teresi (1987).

Lasers can be used for the treatment of life-threatening bleeding ulcers which would be much safer than open surgery. Also, laser is being tested for blocked arteries, but Dr. Robert Ginsburg at the Stanford Medical Center found the newly developed technique called *ballon angioplasty* inserted into a blocked artery, then inflated, was a better technique at the moment; besides some laser surgeries are costing around $20,000 to $30,000. Teresi (1987). There are still a many in the medical field who are skeptical about more severe surgery than has been discussed in this paper. Much more research is needed before FDA will give their complete approval.

An interview with Dr. Royice B. Everett, Ophthamologist at Baptist Medical Center, revealed the fact that he uses the computer as a resource for reviewing new literature in his field. He feels that in the future there will be further developments in computer technology that will help with diagnosis.

Dr. James B. Wise, Chairman of Ophthalmology, at Baptist Medical Center did his residency at John Hopkins and received a Fellowship in Ophthalmology at the University of London. He stated in an interview that the most important use of computers in the last 20 years has been a revolution in diagnostic techniques, including computerized x-ray tonography and magnetic resonance imaging, computerized selectric cardiography, computerized medical laboratory tests, and computerized examination instrumentation of all kinds. He said that in the field of ophthalmology examination for glasses, visual fields for glaucoma and brain tumors, measurement of the dimensions of the eye for calculation of implant lens power in cataract surgery have all been computerized.

As has been stated before, Dr. Wise also mentioned that the field of ophthalmology has benefited most from the use of lasers in the last 20 years, as the laser has revolutionized the treatment of diabetic retinopathy (abnormal blood vessels on the eye from diabetes) and the various kinds of glaucoma. Another kind of laser is used to remove cloudy sheets occurring in the eye after cataract surgery, improving the safety and efficacy of this operation. Wise presently uses his own personal computer which is a Macintosh with a laser printer for writing scientific papers and preparing tables and graphs for those papers. For his continued training he finds computerized medical library searches are also extremely useful.

Laser surgery is just one of the many advancements in the medical field as a result of computer technology. Through this technology, there will be many patients who will not have to suffer from the recovery of having open surgery. The expense of this type of surgery is unattractive at this time, but through more research hopefully there will be a way to cut the cost, making Laser surgery available to more people.

There is openness and sharing of computer technology in the medical field. Such openness, however, is not experienced in the textile industry because of fierce competition.

Textile Industry

The International Headquarters of the Textile Institute in Manchester, United Kingdom was contacted for information concerning the use of the computer in the textile industry today and the possibilities of computer use in the future. They did not respond. The writer then contacted several textile mills in the United States. The administrators in charge of the computer technology of these industries were hesitant to share much information and asked to remain anonymous. It seems this industry is highly competitive and each separate factory maintains strict protection of their technological advances.

However, an administrator from a mill in South Carolina and a mill in Virginia did explain their standard use of computers within their individual factories. The uses of the computer which were discussed were similar in both factories. Using computers in the management and financial department, allows the industry to stay competitive with the foreign textile industries. Microcomputers are used to tie the plant floor computers into the loom monitoring system for greater efficiency and down-time reporting.

There is no computer training in this industry for the employees who work on the loom. The weaving process has been automated with microcomputers on board and monitoring of the looms is accomplished through a much larger computer.

The use of computers in the modern mills has not made inroads into all areas of the textile industry. For reason of noninfringement of copyright, the protection of native markets, or quality control on trademark items, the incorporation of the computer in the manufacturing process is out of the question. For instance, the crofts (tenant farmers) of the Outer Hebrides of Scotland, must manufacture Harris Tweed in their homes. Though they have electricity and gas for cooking in their homes, pure Scottish Virgin wool is spun, finished, and then handwoven in the crofts home. The looms are primeval. If they have no other chores, three tweeds can be made in one week. In 1983, four million yards of tweed were made on a Hattersley loom, in the Outer Hebrides. Tourtellot (1985). It is still to be determined whether or not developing computer technology can completely replace the skills that these craftsmen employ in the manufacturing of wool textiles.

In this chapter it has been demonstrated that the computer has advanced greatly the production processes of industry and science including robotics. Several areas of industry and science were investigated and data were given to show how the computer has enhanced the program in the automobile industry, the agricultural industry, meterorology, NASA and the space program, medical and laser, and the textile industry. Consideration now will be given to the impact of computer technology in educational instruction.

CHAPTER IV

IMPACT OF COMPUTER IN EDUCATIONAL INSTRUCTION

Through the centuries, drastic changes in employment have taken place due to developing technologies in various industries. In the previous chapter, the impact of developing computer technology in selective industries was discussed. To keep pace with the job skills required by those industries, prospective employees need to be educated in the computer technology peculiar to the employer within the job market. The major burden for accrediting the job applicant in computer techniques becomes the responsibity of the educational institutions. Thus, the computer curricula must be incorporated into the academic process, teachers must be qualified to teach computer literacy, and sufficient computers must be in the classroom for student learning.

Computers were introduced to the American schools, not by teachers, not by administrators, not even by computer manufacturers, but by middle-class, mainly suburban, parents. These parents had visited a computer store, purchased computers and equipment, and had used them enough to realize the need for their children to have computer training. The parents even raised 27 percent of the money in 1981-82 for purchase of the computers and delivered some of the computers themselves. The parents had no idea what it might mean for students to be able to use these machines, but they felt that the students who learned how to use computers would have more advantages in life than those who did not. Tucker (1985).

The administrators did not have anyone qualified to teach the computer at that time, and the teachers were skeptical and even hostile about having the computers available to the students. Software was available for drill-and-practice and was nearly self-explanatory and very close to paper-and-pencil drills, making it possible for a classroom teacher to disengage from the computer lab, leaving the untrained lab teacher to supervise students while they taught themselves. Tucker (1985). Even today in some schools and private homes computers are being used as a "teaching machine" programmed to "teach by rote". Papert (1980).

Eventually improvement of the computer program was necessary. In the 1970s there were approximately 35,000 computers in the schools. By the fall of 1985, the number had been increased to one million--still only about one computer to every 45 students in the nation. Tucker (1985).

In the 1980s, precocious intellectual feats were being performed at the computer keyboard by children who at one time hated school, but computers made the difference. Newspaper articles credited a computer program, "Rocky's Boots," which teaches college level mathematical concepts, for being successful with seven year olds. The "Writing to Read" program by International Business Machines Corporation (IBM) had succeeded in helping students to read above grade level, and high school students in rural Minnesota helped to make their family farms more profitable by using financial spreadsheet programs. Ryan (1988).

Classroom teachers have used micro-computers to assist them in maintaining grades, management of instructional material and keeping track of many types of learning data. Some teachers have written programs to be used by members of their class and incorporated a variety of tests and study guides for slower students into their curriculum. Armstrong (1985). However, many teachers are not qualified to use or to teach their students how to use the computer. It is for that reason that a number of teachers are now returning to college for computer instruction.

Fifth-year programs have been introduced by some states as requirements for teacher certification in computer education. As an example, beginning July 1, 1988, all pre-service teachers in California were required to complete a fifth year of course work in computer education before they could receive a teaching credential. All future teachers in that state would be required to have these credentials regardless of their discipline. The law did not affect teachers already in service. The course work required provided teachers with a comprehensive understanding of computer-based technology as an implement to intensify student development through applications in regular foundation, curriculum, and methods courses. Bruder (1988).

The new law was a 1985 assembly bill which was added to the California state education code. The bill stated that "California's public school pupils need instruction and support in the areas of computer education. . . for entry into an increasingly technological society." The extra course work required by the bill not only involved the knowledge of the computer, but included the various applications of sophisticated software available for classroom use. The requirement for the teachers had placed a burden on the colleges. Funding the technology from a one-time grant program was not enough, and yet the California colleges expected to train a staff to teach the fifth year students, and assured the fifth year students that through their training they would be able to adapt to the inevitable changes in technology. They also promoted solid research and development of new theories for purposes of adding technology to a curriculum that was integrated with other areas. Bruder (1988.)

Computer Learning

Children's ability to learn and create has been investigated by a number of psychologists. Jean Piaget, a Swiss psychologist, who studied children's behavior at varying ages by asking them questions, began probing the children for their reasons for answering the way they did. In order to categorize the children he established specific standards for their responses. This research led Piaget to his basic theory for learning--the stages of intellectual or cognitive learning. He placed the children in four main stages: the sensorimotor stage (infancy or birth to two years), the preoperational stage (age two to six), the period of concrete operations (age seven to eleven), and the period of formal operations (age eleven through adulthood). Each individual demonstrated a predictable method of the way they thought about things. One stage led into the next. Ryan (1988).

Piaget's theory was that a child is "a stimulated-seeking being for whom action is directly linked to thought." Ryan (1988). The first time a child sees a skunk, he or she may call it a kitty. Piaget believes that is *assimilation.* This involves understanding something new by fitting it into what is already known. Woolfolk(1987). "Maria Montessori stated that 'play is a child's' work." In play the child is practicing the various actions that will eventually be internalized as thought." Rippa (1988).

Seymour Papert, Professor of Mathematics at Massachusetts Institute of Technology was a student of Piaget. He agreed with the "Piagetian learning" or the concept of the children learning without being taught. Young children learn to speak, they learn the intuitive geometry needed for them to move around in space, and they learn the logic and language to manipulate their parents. No one teaches them, they just seem to know. The disagreement Papert had with Piaget comes from the fact that Papert attributes the mental growth of children to the surrounding cultures as a source of building material. His vision would be to allow children to program the computer thereby "mastering a powerful technology." He feels that if children are "thinking" about thinking they turn into epistemologists--an experience not shared by most adults. According to some learning theorists, children are capable of learning more than they are given credit for. The computer age has been beneficial in allowing not only school age children but also the very young to develop intellectually at their own pace. Papert (1980).

> In my vision, space age objects, in the form of the small computer, will cross these cultural barriers to enter the private worlds of children everywhere. They will do so not as mere physical objects...(*the child programs the computer*) and, in doing so, both acquires a sense of mastery over a piece of the most modern and powerful technology and establishes an intimate contact with some of the deepest ideas from science, from mathematics, and from the art of intellectual model building. Papert (1980).

Computers can be designed so that learning to communicate with them can be a natural process, such as learning French by living in France. Also, learning to communicate with a computer may change the way other learning takes place. If they learn to imitate mechanical thinking they learn to express what mechanical thinking is and what it is not. Charischak (1988).

Papert strongly encourages the use of the LOGO computer program for children. The Council for LOGO in Mathematics Education, or CLIME is an organization formed by math educators. These educators were from all parts of the United States and Canada and had taught math at all levels. Their belief was that LOGO could make a significant difference in the quality of mathematics education. Papert's philosophy is "that children seem to be innately gifted learners who acquire a vast quantity of knowledge long before they go to school." He feels that one reason math seems so difficult to learn is because the cultural background of most children does not provide material or experiences to supply a foundation in mathematics. Charischak (1988).

The purpose of LOGO is to simulate an environment which will supply the experiences of using mathematics in a natural way. Children need concrete concepts to understand the abstract. In LOGO the child has control of the "turtle" which appears on the computer screen and draws lines as it moves. Turtle Geometry can be accomplished by very young children. They type FORWARD 50, and the turtle moves up 50 "turtle steps"; a command RIGHT 90 turns the turtle 90 degrees to the right and another command FORWARD 50 gives a display of a right angle on the screen. These commands can be continued to form a square. LOGO knows the word "square". Again a command REPEAT 7 [SQUARE RT 45] will display another square over the other at a 45 degree angle. The turtle can be put in orbit by using commands EARTH which draws the earth, BLASTOFF followed by a distance sending the turtle out in orbit; and ORBIT followed by a number causes the turtle to follow a circular orbit with that number as the circumference. The student will understand π (pi) and the circumference of a circle. If the numbers given are wrong, the turtle will crash into the earth. The student learns by trial and error how to get the turtle to orbit the earth. Seymour Papert hopes for a society which will be more mathematically literate. To make this happen, math must be taught in a creative, logical method such as LOGO. Charischak (1988).

Many people regarded an article published in 1954 in *Harvard Education Review* as the beginning of a new movement in education The author challenged educators to change from traditional ways to teaching the new principles of learning that were emerging from studies in experimental psychology. The author of that article was B. F. Skinner, a behaviorist, who earned his doctorate in psychology from Harvard in 1931. He de-emphasized psychological theories and stressed reinforcement as a major factor in the learning process. He developed the "Skinner Box" which he used in experiments with pigeons and rats. He trained them to perform certain tasks; when the task was accomplished successfully they were rewarded (reinforced) by receiving food. Rippa (1988). This method of learning was also called "stimulus-response (S-R) psychology, the principles required for human instruction. Knirk (1988).

Skinner also developed a process for stabilizing the required level of performance through reinforcement "schedules." Linear-programmed instructional materials were built so that a student would nearly always provide the correct answer to questions. Knirk (1988). Skinner's work focused on techniques to increase learning just as programs designed for computer programs do today. Heinich (1985). Skinner developed a teaching machine that he used to control the logistics of the process. This was "A mechanical device consisting of a small box having on its top surface a window through which information printed on a paper roll could be read. The learner responded to a question or blank to be filled by selecting a multiple choice answer. If the right one was chosen, the paper roll would advance to the next question when the knob was turned. Other early devices required written responses." Heinich (1985). Programmed instruction has proven to be very effective in remedial instruction and also in tutorial instruction.

"A reinforcer is any event or thing that increases the likelihood of a preceding behavior's being repeated: learned." Heinich (1985). The teaching method could give hints to move the student in the right direction, called *PROMPT.* An example of this theory would be a PROMPT (a math problem), the RESPONSE (correct answer), and the REINFORCEMENT (knowledge of correct response and/or praise). Heinich (1985).

There have been many programs developed since the "Skinner Box." The main characteristic of all of these programs was *reinforcement* for the student. The results of these programs evolved into the computer-assisted instruction application. The computer has unmatched ability to *manage information* with speed and accuracy causing teaching and learning interaction to be handled with much greater efficiency and effectiveness. Heinich (1985).

The computer is a tool that can be used to present programmed instruction, programmed tutoring, simulation/gaming, and other instructional formats on demand to individual learners without the necessity of the presence of a human helper.

Computer-Assisted Instruction

John Goodlad wrote in his article "Computers and the Schools in Modern Society," that education should be a direct interface between student and stimulus with the teacher only a guide. Computers would be the stimulus. The computer is capable of presenting a response sequence of learning opportunities without the annoyance of speech or by varying mannerism characteristics of a human teacher. The computer has the capability of correcting errors and allows students to work at their own rate of speed. Individualized instruction and scheduling can permit students to be themselves and eliminates a number of pupil-teacher contacts which are unnecessary. Golub (1976).

The teaching day at both elementary and secondary schools should probably resemble the kind of teaching day in institutions of higher learning. Computer technology will change the schools from the way they have operated in the past, but first, changes have to be made in the attitudes of the human factors. Golub (1976).

It is, therefore, important that students become familiar with computer equipment in order to alleviate any anxiety. A computer system can present instruction directly to the students by which they can interact with the lessons programmed. This is known as Computer-Assisted Instruction (CAI). There are various instructional modes that can be utilized. Heinich (1985).

The Drill-and-Practice Mode leads the learner through a sequence of examples of concepts, rules, or procedures that have already been taught. The purpose of the program is to increase dexterity and fluency in useage of the skill, by inforcing constantly all correct responses. The computer can be extremely patient and only moves ahead when success has been shown. This mode is basically used for math drills, foreign language translating practice, vocabulary building exercises, and other basics. Several levels of difficulty are available. Heinick (1985).

Information is given in small units followed by a question in the Tutorial Mode. The student's response is analyzed by the computer and gives an appropriate feedback. The computer acts as a teacher and all of the interaction is between the computer and the learner. Heinick (1985).

The Game Mode uses games which may or may not be instructional, depending upon whether or not the skill to be learned is academic or a training one related to an instructional objective. Games can be a way of teaching computer literacy in a nonthreatening manner as a reward for work accomplished, or for repetitious drills. In management training students can make decisions regarding a mythical corporation in which the winning team would reap the highest corporate profits. Heinick (1985).

A well-known computer simulation, *Hammurabi*, is an example of the Simulation Mode. This game puts the player in charge of an economic decision regarding a small agrarian country in pre-Biblical times. The problems can vary from laboratory experiments, physical science or mathematical problems or even control of a nuclear power plant. Weather forcasting, civil and military occupations and aircraft are some other possible subjects. The Navy reduced the cost of pilot training from $4,000 per hour to $400 per hour through the use of computer-based simulation. Heinick (1985).

The Discovery Mode presents problems while the student solves them through trial and error, aiming at a deeper understanding which results from grappling with puzzling problems. Because of the data storage capabilities of the computer, more students will be exposed to "laboratory" learning in math, social sciences as well as many other areas of science. These students also learn how to get information concerning possible competitors from a database and should be able to draw conclusions about their products. Heinick (1985).

The CAI mode, Problem-Solving, falls into two categories. One program is written by the learner and the other has been written by someone else in which the learner must solve the problem. This program helps the learner attain problem-solving skills for the first program, and the other program gives the student the experience of manipulating one or more variable. One program combines simulation, instructional gaming, and problem-solving strategies by representing plant and animal life in a lake in the Cascade Mountains of Oregon. The student learns ecological relationships by role playing one of six fish and by making survival decisions. Heinick (1985).

Students have used the remarkable software and computer modes to gain a higher level of education since the 1960s. These programs can be used both in elementary and secondary classrooms. Many teachers are now excited about word processors, computer graphics, programming, and interactive videodiscs, just to name a few. The students seem motivated to use the equipment, but there is not enough equipment to satisfy the need. Ryan (1988).

Elementary and Secondary Education

Computers should be used in mathematics, social studies, or science classes and especially in vocational education courses. The students in vocational classes should leave school understanding the "workplace", but they must gain computer literacy in high school in order to be better prepared for the technological age. Curriculum is lacking in many areas, however. Several schools were visited by a group of educators and what they saw was rather bleak. Goodlad (1984).

The computer is merely an enhancement of that "most significant of all tools, the human mind." In the elementary schools nearly 100 percent of the classes are teacher dominated with respect to seating, grouping, content, materials, use of space, time utilization and learning activities. The situation was slightly improved with 90 percent in junior high, 80 percent of the senior classes in high school teacher dominated. Most of the instruction being done was "talk" --usually teacher to students. For children and youth to become functionally literate in understanding computers their computer education must be recognized as a necessity, not a frill. Goodlad (1984).

The computer may be used in many ways in the classroom. When used as an aid to teaching, tracking the progress of individual students in each given lesson becomes essential. The computer may be a motivational tool for the student to investigate new material. Conducting opinion polls or elections may be an outstanding way of acquainting students with the computer as an analytical tool. The class might proceed in the following manner:

1. Have the students enter their names into the computer.
2. Ask the computer to generate a random list of names to be polled.
3. Design a questionnaire and distribute it to the students selected for this random sample.

4. Have the students who are being polled enter their responses to the questionnaire into the computer.
5. Let the computer use a statistical package to analyze the data and produce a report on selected criteria.
6. Generalize the process and compare your project to popular opinion polls with which the students are familiar (e.g., Nielson ratings, presidential preference polls.) Wright (1985).

Computers and software are so versatile that they could and should be used with all subjects. In the science classroom the students should gain a total understanding and knowledge of the environment. The use of statistics, math, social studies, art, language arts, and music can and should be integrated in the learning process. An innovative teacher can use the unique capabilities of the computer to accomplish a broader learning experience for the students. Wright (1985).

In the introduction, LOGO was discussed for use by young math learners. LOGO could also be very effective for high school students who are lacking in concepts of geometry. Much of the material available for algebra is of the drill and practice type, but some of the packages teach the concepts of numbers, operations of numbers, and problem solving. Wright (1985).

The computer can be used to help the students develop graph programs that do graph functions commercially, and those from software exchange groups will enhance the learning for problems dealing with positive and negative numbers as well. Wright (1985).

Social Studies can be explored through many channels with computer technology. Everything from family life, community, and neighbors, to world cultures, values, and wars can be compared. Maps and time lines can be drawn; graphs and charts can measure progress--"The computer is a powerful means of exposing students to social studies as a dynamic science." Wright (1985).

Language is related to all areas of life. It can be expressed through prose, poetry, humor, drama, and journalism. Stories and newspapers could be developed on the computer by all age levels. The microcomputer is a natural medium for students to develop writing skills. They can erase words, insert words, correct mis-spellings, and learn how to do the layout of a paper, all with the aid of a computer. Wright (1985).

In an art class, students are able to erase, enlarge, reduce, copy, repeat, and store all types of computer-generated graphics. A program in graphics gives students enjoyment and can challenge students to explore, experiment, develop and express new ideas. Wright (1985).

Creating music and sounds is another way of expression for students. Music theory and terminology can be shown and heard through computer application. Wright (1985). Research has shown that every academic subject taught has some type of computer-curriculum that could be of benefit to students in the classroom. Teachers could make the difference if computers are available. However, computer coordinators and users will be required to become more knowledgeable about learning theory and pedagogy and adopt totally different planning and implementation techniques.

As an example of what one instructor has done with computer technology in high school for the students, Kjell-Jon Rye, an instructor at Bellevue High School in Bellevue, Washington, and also an advisor on educational technology issues for the United State Congress Office of Technology Assessment, developed a Technology Education Program at Bellevue High School for the purpose of motivating students to study technology. Mr. Rye intended to make each of his classes look and operate like a fiercely competitive company in the real world. The beginning classes had about 25 students each divided into groups of two, three, or four. Each group worked with robots, lasers, plotters, or computers, and up-to-the-minute tools to solve real scientific and social problems. Technology Learning Activities consisted of one to two work assignments. The groups were required to design, manufacture, test, and market a product that would solve a given problem. One project split the class into competing toy companies. They had two weeks in which to design and construct safe toys for preschool children, and the finished toys were tested by preschool children in the district. The home economics students taking a class called Exploring Childhood, along with a child psychologist, decided on the winning toys. Businesses in town helped with the advertisements in newspapers, radio and television. These high school students worked from 6 o'clock in the morning until 10 o'clock at night because they enjoyed what they were doing. Students from this program have built real cars for $60 made from aluminum, mylar, and scraps. Their car won second place in fuel-economy competition with Western Washington University because the best gas mileage it could get was 170.45 miles per gallon; the winning car cost $600 to build getting 180.8 miles per gallon. These students, through science technology, have redesigned parking lots, repaired robots that were supposed to be unrepairable, built a laser laboratory, and much more because they were given the opportunity. Rye (1988).

According to Rye, one of the most successful projects was a four-person team that included a convicted burglar, a learning-disabled student, one who couldn't speak English, and an introvert. They experienced true success and all of them became outstanding university students. Rye (1988.)

Vocational Education

Mr. Rye and his students had the advantage of computer technology. Although William Penn saw the need for "trade training" for the poor children in Pennsylvania, he did not have the equipment or facilities which are provided today. Vocational education was more important in the Middle Colonies than anywhere else in colonial America. The English poor laws of 1562 and 1601 proposed working schools and forced apprenticeship for the poor. At that time practical subjects such as merchandising, navigation, trade, and mechanics were taught. By1820 a few mechanics' institutes or technical institutions had been founded in the eastern cities. With the exception of some labor leaders who feared these schools would develop a surplus of cheap trained laborers, labor generally approved industrial and vocational training. Vocational skills and scientific information was also demanded by the farmers of America. Farmers institutes began to be developed in 1854 and led to an outstanding agricultural education, at both the high school and college level. The Morrill Acts of 1862 and 1890 gave these colleges status in agriculture and mechanical arts. The Smith-Hughes Act was passed in 1917 which provided federal aid for the states to pay industrial and vocational teachers' salaries in high schools and to aid teacher training institutions in the education of such teachers. Pulliam (1987).

A Federal Board of Vocational Education was created in 1917, and after 1919 vocational schools were training the handicapped. Congress gave increasing attention to vocational education which improved the economy, kept children in school longer, faught poverty, and created new jobs for the unemployed. Pulliam (1987).

Since early in the twentieth century, American society and the educational system have been transformed by the impact of urbanization, industrialization, and immigration. The population of America shifted from rural to urban areas, and large factories and business organization dominated the economic system. From a country that had been predominantly agricultural and centered in rural areas and small towns, there emerged a nation learning to adjust to the entangled methods of living required by urban life, large corporate organizations, and unions. To complicate an already complex situation, large numbers of immigrants from southern and eastern Europe worked as cheap labor for the new industrial plants and moved into the ghettos in the expanding urban areas. Spring (1986).

The American educational system changed by expanding their social and economic functions. Educators wanted to change the school curriculum to solve possible social problems caused by the loss of values which had been found in rural society. Also, educators were concerned with improving human capital as a means of economic growth. This was seen as a means of solving problems in the labor market. Spring (1986).

As a result of their efforts vocational guidance and vocational education programs were developed. The guidance program helped students in the selection of courses of study for future job preparation. Vocational education brought about the development of human capital through job training--an important part of the educational system. Both programs promoted industrial efficiency through suitable selection of class work and training of labor power. Spring (1986). Factory schools which came about because of the apprenticeship system, did not provide the necessary number of trained people for the factories. By increasing job specialization, workers did not need to be highly skilled at many tasks, they only had to know a single operation. Little general education was needed; training tailored to a specific tasks to be accomplished was all that was needed. Knirk (1986).

After the Civil War a clamor arose for the public schools to offer vocational training for the production of a labor force for the rapidly industrializing society of the later nineteenth and early twentieth centuries. Vocational education for the "industrial classes" became a prime target of educational reformers of the 1890s, with the organization of the National Society for the Promotion of Industrial Education in 1906. Ryan (1988).

Today the vocational schools (Vo-Tech) are offering many more vocations and incorporating computerized instruction into most classes. Brenda Nixon is an administrator in Instructional Technical Support for the Foster Estes Vo-Tech Center in Oklahoma City, Oklahoma. In an interview with the writer, Nixon shared areas in which they are incorporating instruction and computers.

Nixon also stated the autobody repair shop has used a spread-sheet computer package to estimate car repairs. They are now in the process of purchasing a new estimating and management program. With this program, the students key in, for example, a front fender, and the computer will access all the parts needed to repair the fender--the cost, the make of the car, etc. The instructor uses a crossword puzzle package to make tests using automotive terms.

They have an animated auto package for the automechanic programs. The package demonstrates different makes of cars by year and shows the internal parts as well. The software has been developed to show the motor running, the exhaust system, and how they all tie together plus other items related to the internal working of a car. Software packages are being developed which will provide assignment sheets for recording the student's progress. That program contains reading assignments with moving illustrations and tests all related to the automotive industry. The LN program requires computer literacy as a part of its curriculum. The students are required to work a minimum of fifteen hours on the computer. They learn the basics including handling software, load, and basic operations of the com- puter. They view demonstrations concerning medical needs such as nutrition, pregnancy, etc. Foster Estes has a Fashion Merchandising program that uses software for entrepreneurship, bookkeeping needs, and basic word processing to help the students prepare job manuals for DECA conferences according to Nixon.

Education is available for nearly everyone. The reasons for going to school vary; some attend vocational schools for job training and others for a new hobby. Still others are very special people who need special help. There are now more advantages for these special people through computer technology.

Special Education

During the nineteenth century, handicapped children were taken from their homes and neighborhoods and segregated fulltime in state and private schools. These children were visually handicapped, hard of hearing or deaf, speech impaired, orthopedically impaired, seriously emotionally disturbed or mentally retarded. The education for these children became known as *special education* Walker (1984). Around the turn of the century, a move had been developed to establish special classes in the public schools for those children who were mildly handicapped. These children were not mainstreamed but placed in segregated classes for instruction. Federal and state legislatures saw the need for these children to attend school with normal children in order for them to learn to adjust to social circumstances, play and work with all types of people, and gain self-confidence. Many people believed that exposure to handicapped children would benefit normal children by teaching them to show humanity to handicapped children and would aid in reducing prejudices toward children who were different from themselves. In 1975, President Ford signed the Federal Education for All Handicapped Children Act (Public Law 94-142) which guaranteed the handicapped the right to free and appropriate public education. By 1991, services are supposed to be available to children from ages three to five, with incentives to encourage states to offer services to children from birth to age two. Ryan (1988).

Some disabilities require teachers to plan their instruction to meet the needs of individual children. The federal law PL 94-142 requires that the instruction be based on an *individualized education program (IEP).* This program includes a written IEP for every handicapped child in the state, developed jointly with parents or guardian and teachers. The IEP is to be reviewed annually and revised if necessary. Ryan (1988).

Teaching Special Education students by computer has been extremely advantageous for both student and teacher. Some special students learn at a slow rate, some need constant reinforcement, still others learn from repetition and/or drill and practice activities, and almost all special education students need continuous encouragement with mastering the material to be learned. Teachers who teach special education students need relief from management activities related to diagnostic testing and individualized instruction such as record keeping processes related to grading and specific follow-up assignments. Campbell (1986).

The computer can be considered a "neutral" teaching medium when working with emotionally disturbed children. Researchers have found that hyperactive children have stayed with computer instruction longer than conventional instruction. The previously mentioned program, LOGO, has been used extensively with autistic children as CAI. Seymour Papert also recommends LOGO for children who have serious language, intellectual, and/or physical problems. Walker (1984).

Home-based curricula which is designed to help parents work with their severely handicapped youngsters is also available. A small computer and a telecommunications linkup may provide instruction for these preschoolers and their parents. Investigators have used the immediate feedback capability of the computer to teach or condition high risk infants to react systematically to computer-controlled stimuli. The main purpose for this training is to train the baby to gain control over their immediate environment. Success with this program depends upon the development of sensing devides and interface between the computer and the baby crib or toys. Walker (1984).

Many programs have been developed for the hearing impaired child. One of the most outstanding programs is known as PLATO. This system has features which involve pictorial displays, teacher-designed assignments, response analysis, error trapping, and supplies programs with variable lesson difficulty. Walker (1984).

Modern technology has brought significant enhancements to educational programs for the handicapped. Communication and response systems will improve, giving greater access to all areas of general education programs for all handicapped children. Remmes (1984). Using certain software and computer extensions allows those persons without transportantion to work at home. There are speech synthesizers and visual displays made for people with visual impairments, speech problems and severe hearing impairments. By using computers the handicapped person can conserve energy and accomplish far more in a given amount of time. For those who live alone and require assistance, the computer can effectively modify or alter the environment by controlling appliances by computer. Computer games can be used for entertainment as well as for sharpening the mind. For the creative homebound person, there are writing and drawing programs available. Remmes (1984).

One of the major hindrances of computers and word processing machines is the present need to use both hands for multiple keystroke operations. Those individuals with limited hand or arm movement must have the computer programmed so that only one keystroke is necessary to perform many different functions. Special guards have been designed which allow a person lacking fine motor control to be able to select one key at a time without accidentally depressing several at the same time. The user must insert a pencil or a finger into a hole for a particular keystroke. The surface of the keyguard is firm and the user may rest his hands on the board without hitting the keys, yet allowing the user to type with dexterity and confidence. Remmes (1984).

Educational possibilities are greatly enhanced by the computer's methods of teaching. A computer-controlled robot helps a person explore spatial relations. With a video screen, one could write, draw or design for pleasure and profit in spite of motor coordination problems. For the visually impaired, the latest technology is providing enlarged displays on keyboards and larger screens with a control for adjusting the brightness of the monitor for greater comfort. Communications systems are merging the computer and the telephone to provide those with hearing loss a chance to interact with others in a less expensive way. Remmes (1984).

Programs have been devised for even the most severely handicapped. If a person is unable to hold a pencil, they can write letters or entire books with a special keyboard. There are word processing programs which simplify such tasks as editing, erasing, deleting and moving copy. Books can be written and sent to a publisher by telephone with a *modem*, (a device that carries computer information over telephone lines) just like a phone transmits conversation. A person could certainly increase earnings for himself with a profitable home-based business made possible through the use of a computer. Remmes (1984).

The new innovations developed for the computer are supplying new life for handicapped individuals in our society. These individuals can experience more independence than they have had in the past. A person can now attend school, write letters or books, make a living for themselves, and in the process experience the excitement of success. Handicapped individuals are now able to benefit from telecommunications.

Telecommunications

Socrates (470-399 B. C.) conducted dialogues with students in ancient Athens and the knowledge was stored basically in the memory of the teachers, then passed on to the next generation. The development of written material by the monastic tradition allowed information to be shared with future generations. The printing press invented in 1455 by Johann Gutenberg accentuated the tradition and the library became essential for education.

Two other major sources of data have developed since World War II to aid learning, encourage research, and store information. Computers now rival libraries in usage and furnish another tool for learning. In addition to the library, computer technology is accessible for quality education. Now a college education can come to society through telecommunication. Brown (1986). For future success of both the individual and society, there is a need to have quick access to information. That need is being supplied by the new technology of computer telecommunications and information utilities. Information utilities and Database Services are storehouses which supply large amounts of information and data. In the past, those areas for information were encyclopaedias, dictionaries, texts, magazines, and libraries; now the new information sources are computers. Levinson (1985).

Various companies are providing information services ranging from every type of research journal to shop-by-computer services. Levinson (1985). "When two or more computers are connected in such a way that they can communicate directly with each other, they are said to be networked." There may be any number of connecting paths between computers. At least three things are essential for the network to produce. First, there must be a way for the information to flow between computers. This could be a wire in a building, a telephone wire, a commercial cable, a fiber-optic cable, electro-magnetic radiation, or some other mechanism. Second, there must be a hardware component in each computer which handles the transmission between the machines. Third, there must be software which instructs the hardware how to function and explains in detail the transmission information. Bork (1987).

"Electronic mail is the exchange of messages via computers between individuals or groups of individuals." Bork (1987). Videotex is an electronic two-way transmission of information. It is easy to use, convenient, controlled by the user, and has the potential for net-working, plus the ability for updating. This service provides several advantages to education. Videotex has the ability for effective instruction and can deliver materials that combine the advantages of interactivity with color graphic visuals. A user's request is sent upstream via coaxial cable or telephone to a large computer; the requested material is, in turn, sent downstream to the user. There, the digital data can be fed into a special terminal that translates the information into a television picture or proceeded via software decoders for display on a personal computer. Nugent (1987).

Telecomputing is a computer associated field that is growing at a phenomenal rate of speed. In France, a company has embarked on a 10-year plan to place 30 million free computer terminals in homes at a cost that is less than the $230 million a year now used to print telephone directories. The terminal is in mass production and is designed for use with "Videotex." Wright (1985).

Before the year 2,000, more than two million homes will be hooked into some type of information utility based on direct broadcast, satellite feed, cable, or telephone lines. At present, QUBE cable in Columbus, Ohio, offers 29,000 subscribers shop-at-home services, talk-back polls, and the ability to hook up a home alarm system. In San Diego, Omaha, and New Orleans, Cox Cable Company is offering that same type of service to owners of personal computers. The nation's largest cable TV company, Sammon, is offering various types of data bases containing news, consumer information, financial services, banking, and games for a low monthly fee. Subscribers can hook up their own equipment, terminals or microcomputers, and have access to data bases. Wright (1985).

Telecommunications programs comprise telelecture and teleconferencing. Both programs are usually created and implemented by an instructor. Telecommunications programs use live audio presentations for teaching. Normally these presentations are done by experts in a certain field who may be located hundreds of miles from the classroom. Telecommunication systems use telephone lines and communication satellites to carry audio messages over vast distances. This telephone system allows for two-way communication. Locatis (1984).

A simple telephone speaker can be heard by several learners at the same time, or a more complex system involving the use of speakers can be used to amplify the voice so it can be heard by a group. People in the audience can use special telephone and/or microphones to communicate with an individual or a group on the other end. A broad variety of visual material may be used in a presentation if copies are at each location. Locatis (1984).

Education in the Information Age has progressed a long way from the one-room schoolhouse. The high-tech complement of chalkboard, lecture halls, and libraries are known now as interactive videotex, modems and online databases. School could be thought of in such terms as "electronic classroom", "online education," and "telelearning." Meeks (1988).

Oklahoma State University began working with the Educational Television Services in 1967. This program was organized in the beginning to utilize television in the instructional process; however, in 1980, President L. L. Boger selected a special committee headed by the Director of University Extension to evaluate the telecommunication capabilities on campus. A report given by the committee recommended that Oklahoma State University establish a centralized telecommunication capability with emphasis on expansion of audio and video capability. The report also stressed the importance of this type of medium reaching adult and part-time students both on and off-campus. Oklahoma State Regents for Higher Education (1988).

Oklahoma State University began experimenting with audio and video teleconferencing in 1981 which initially involved a professional update of veterinarians within the state of Oklahoma. This successful broadcast was followed by other satellite videoconferences. The Educational Television Services moved to the newly constructed Telecommunication Center in the early part of 1983. Sixty-seven major universities and colleges joined Oklahoma State University to form the National University Teleconference Network which is located on the OSU campus. There are now over six hundred colleges and universities involved in a variety of telecommunication-related activities. The programs originate through the network and are shared with the rest of the country. Programs established by other major academic institutions can be borrowed and rebroadcast for use within the state. There are fifty-eight county sites in Oklahoma that have been equipped with satellite receive capability. These capabilities enhance the instructional, research, and extension missions of the university. Oklahoma State University has experienced success and acceptance of its programming nationwide. Oklahoma State Regents for Higher Education. (1988).

Three years ago, Ron Gordon, formerly a chief executive officer of Atari, founded Telelearning Systems of San Francisco. This system now offers hundreds of online courses via its "Electronic University." In order to be able to enroll in this "university" one must have a modem (300/1200 baud) and the communications software provided by Telelearning. The courses, offered from 200 colleges and universities, are developed by the originating institution and not by Telelearning. Credits are received and evaluated by the professors at the university and the students receive transcripts as though they had taken the class on campus. Credits may be transferred to more than 1,700 schools that presently accept College Level Examination Program level courses. Meeks (1988).

All "classwork" is done through modem. When the student has finished an assignment, it is uploaded to the Telelearning network, and graded by a professor who comments on the work. Students can arrange to "talk" with the professor via an online real-time conference. Meeks (1988).

Many programs are available from several networks. Some offer executive business courses, and other international programs consisting of students from Japan, Israel, Mexico, and the United States taking part in an online electronic network, sharing different cultures as well as online in home independent study courses. Meeks (1988).

Enrollment is not limited and can be accomplished with a simple telephone call. According to the director of Connected Educations, Paul Levinson, their goal is to be a university for the world. He feels education should not tie a student to a classroom or geographic location. Meeks (1988).

Control Data Corporation's program is a computer-based education system known as PLATO and is the oldest of all online education systems. In 1976 PLATO was moved into the "public domain" via its "Homelink" network, and CDC has made it possible for home computer users to take advantage of what PLATO has to offer. PLATO is available through local universities with such courses as astronomy, aviation, chemistry, English and math being offered. The handicapped community, single parents, and professionals have taken advantage of the educational benefits. Tests show it is possible to achieve more and retain more with correspondence courses than with regular classes, and with these programs a student gets far more interaction with professors on a private level--something that is rare at a large university. Meeks (1988).

North Carolina State University has introduced the ScholarNET network. Dr. David Garson and Dr. Michael Vasu developed this network and actually divided it into two systems. PoliNET focuses on the social sciences, specifically political science, criminal justice, and public administration. HumaNET offers history, philosophy, religion, and English. Heisler (1988).

In summary, a discussion of learning theories and computer programs used for creating interest in mathematics and giving assistance to special individuals has been presented. Also discussed were the computerized programs for vocational training and the telecommunication systems available for education and training programs.

CHAPTER V

FUTURE PROJECTIONS FOR INDUSTRY, SCIENCE, AND EDUCATION IN COMPUTER TECHNOLOGY

People have been afraid of new advances due to fear of losing their jobs. Some traditional jobs have already disappeared because of automation and robots. One robot may do the work of 1.5 to 6 employees. One estimate suggested that one-third of the entire production work force in industries may be replaced with robots. Hopefully, it is expected that 85 to 90 percent of these displaced workers will find another job within a year. There are new jobs being created but not as rapidly as the number being eliminated. The automobile industry has felt the greatest job loss. Thro (1987).

A robot costs less per hour than a human employee and can work twenty-four hours a day. The robot is not late to work and has no personal problems. They take no coffee breaks and rarely are they ill. A robot can be reprogrammed to do an entirely different job without job training. However, robotization of a factory may cost as much as ten times the cost of the robots themselves. Some economist say robots will be used more because of the rising labor costs, the declining productivity, and that there may be 200,000 robots in use by 1990--just in the United States alone. These "steel-collar workers" are efficient, fast, and reliable and have taken over some of the worst jobs in the factory such as those that are dangerous, repetitive, and boring. Some of the remote-controlled machines have important jobs such as conducting experiments with chemicals that are toxic or emit dangerous radiation. These can be operated by a person behind a protective shield. D'Ignazio (1982).

Employees will be retrained for job replacements as robot technicians. It is expected that dull, assembly-line tasks will be replaced by work in quality control, robot repair, programming, and as yet unforeseen service industries. Technological advancement has created new opportunities in the past and will continue to do so in the future. Someone has to build the "new technological advancements." An unpublished study, quoted in *Economics Today Newsletter*, predicts that by 1995 factory employment will rise from the present 19.2 million to 22.7 million. Lee (1984).

Industry, science, and education will continue to benefit from robotics. Robots of the future will be more "intelligent" in three ways. They will be using *artificial intelligence* (AI) to make decisions like humans would make; they will have more humanlike vision and "tactile sense" which will help the robot know how much pressure to apply to pick up something small and fragile or large and heavy; and they will seem more human because they will act as an "educated co-worker." Thro (1987). As of now, most robots cannot "see," which means there is need for a human supervisor looking over the robot's shoulder. But, the new robots will have the senses--vision, touch, and sometimes hearing, which implies there will not be a need for a supervisor. D'Ignazio (1982).

Robots can perform simple, repetitive tasks leaving future societies to discover and develop new industries, new products and other profitable things to do. To replace a ditch digger with a machine requires an engineer to design and manufacture it, skilled mechanics to see that it runs, a petroleum industry to make it work, and a skilled operator to manipulate the machinery. All of these occupations require more education, skill, and experience than the occupations they replace. Microcomputers and robots are far more complex, more difficult to design, build, and operate. People will be required to have more education for these jobs and there must be teachers qualified to teach them. The automobile manufacturers do offer job-training in new technologies for their employees.

The Automobile Industry has advanced tremendously since the opening of Henry Ford's automobile factory. In 1962, the first robots were installed on the automobile assembly line by Genreal Motors Corporation. Lee (1984). Today, most working robots in the United States are employed in the automobile industry. These robots weld car frames, spray-paint car bodies, inspect, assemble, and stack car parts. D'Ignazio (1982). Robots will be used even more extensively in the future.

In an interview with Rick Tipton who works for the Oklahoma City GM Plant, he predicted what computer technology will do for some areas of automobile manufacturing. He believes that there will inevitably be further advancements in the assembly of the automobile in the welding, brazing, fitting, and grinding processes. In the production of automobiles, he believes that greater automation using robotices in the field of paint application will be the next step. Training will, no doubt, be accomplished through a greater use of "talk-back" television. Tipton also stated that coumputers will definitely play a tremendous role in the future of the automobile industry in this country from the signal their plant received when Roger Smith, GM Chairman of the Board, decided to purchase EDS (Electronic Data Systems) and Hughes Electronics.

There are fewer farmers in America today than there has been in the past. In the agricultural industry, according to Oklahoma State University's, Agricultural Economics Professor, Dr. J. E. Osborn, microcomputer applications are being used and projected for use in: developing livestock feed rations, the amount of feed per day for livestock, determining speed and fuel mixtures for farm tractors at work, helping the farmer to keep accurate financial records including balance sheet, profit-loss statement, ledgers, debt statement and cash flow, least cost transportation routes, production enterprise combinations, tax planning, estate planning, and irrigation scheduling.

Computer techniques are also being used in the textile industry in management and production. It has been predicted that the new

Rapier looms will be the conventional looms of the future. They are tremendously flexible in fabric design and range of styles. There is almost an unlimited range of yarn sizes, type and fabric weights available with this loom. There have been considerable strides made in the last twenty years in the Rapier loom design. For instance, they now have a multicolor selection, greater speed in manufacturing, weaving multiple insertions, and the ability to increase width fabric at a rate of weft insertion in excess of 850m/min and width up to 280 cm (110 inches). Mohamed (1983).

Administrators from the textile industry did predict that in the near future there would be additional bi-directional communication with microcomputers which shuts off the loom automatically. There is also the prediction of a "partnership" to be formed between the apparel and textile industries creating an online computer design system. The apparel designs would then be better coordinated with the textile design of fabric.

Meteorologist, Gary Lezak, predicts that during the next ten to twenty years, the NWS will continue improvements on the forecast models, on computerizing satelite pictures to detail the clouds and moisture fields. The main impact from computers will be with the NEXRAD (Next Generation Radar) system. Processing radar data for the detection of severe weather events such as tornadoes and downbursts will be one of the main advancements in computer technology concerning the weather.

Kevin Kelleher from the National Severe Storms Laboratory, feels there will be larger models that will ingest more detailed weather data. The resolution or degree of accuracy on smaller scales of motion is directly related to the ability of the computer to quickly accept the data, compute the model output, and distribute the results. Larger and faster computers will allow more data to be imput, therefore more information will be used in the forecast models, so that someday meteorologists hope to be able to predict more accurately the finer scales of weather phenomenon, such as severe thunderstorms and tornadoes.

Freda Deskin, while training for the NASA space flight, had an interest in the concept of "tele-presense" and feels that this concept will become more sophisticated in the future. Tele-presense is where a human being is attached to a computer on earth and can see the probe on a monitor. If the person wants the robot to pick up something with its right hand, he or she simply makes the move and the robot makes the identical move. Since, robots and probes can not be programmed to make on-the-spot decisions and discoveries, tele-presense would combine the best of the human and the robot.

Also, robots can work without an atmosphere and in an unhealthy environment. It is predicted that robots could mine ore on planets. The ore would be processed in robot smelters and then robot-assembled into satellites, spacecraft, or even used for the improvement of the robots themselves. Rover robots will be guided by laser, motivated by sensors and probes, they can build canals, and grow plants on the surface of Mars.

In the area of medicine Dr. Wise, an ophthamologist, feels there will be more use with the microprocessors. He sees the computer being used even more for gathering and supplying data to help the doctors determine the efficacy of various operations and treatments. The computer is aiding in the use of electrical current to help thousands of people to overcome paralysis, pain, bone fractures, bedsores, drug abuse, and many other disorders. Teresi (1987).

Dr. Andrew Bassett of Columbia Presbyterian Hospital predicts that "Electricity will become as ubiquitous in medical practice as surgery and drugs; in many instances, it will supplant them." Doctors in the Roman Empire knew about electricity's therapeutic power when they pressed electric eels to the temples of people stricken with severe headaches. Doctors are now saying humans have a "body electric" which is an internal communication network which transmits messages in a language that is made up of electrical signals. Walt Whitman, the poet, professed what he did to avert pain--"sing the body electric." Teresi (1987). Each special signal determines whether or not a cell will grow, proliferate, or repair themselves. By tapping into the internal communication system with external currents, scientists have found they can alter the messages to the cells. It may be possible some day to regenerate severed spinal cords and weakened heart muscle, or stop runaway cancer cells. Teresi (1987).

Dr. Robert O. Becker, an orthopedic surgeon since 1956 at the Veteran's Administration Hospital in Syracuse, New York stated, "The concept that human beings respond to magnetic fields, is I think, going to revolutionize biology. It will revolutionize medicine." Every person may experience the results of this research. Electrical currents are now being used to heal stubborn fractures. Doctors believe electricity may cure afflictions of the bones, including osteraporosis, the brittle-bones disease which has caused 1.3 million fractures yearly in American women over forty-five. Teresi (1987).

Technology for the Medical Schools has been developed to simulate patients with a variety of diseases. These program are arranged where the students can ask the "patient" questions. Students can order medical tests, and the test results will appear instantly on the screen. By working in this fashion, medical students will eventually be able to make a diagnosis and have it confirmed by the computer or ask the computer to show them where they went wrong. Bok (1985). Doctors will be able to draw on the entire sum of medical knowledge and receive all they need to know about the patient's symptoms by use of a computer. Newman (1972).

Handicapped individuals may have access to more improved robots. In 1982, Hero 1, was invented. The American firm Heathkit specialized in technical education. Young people learned about the jobs Hero could perform. By use of the computerized equipment, Hero could do household chores, walk, grasp objects, and speak. Susumu Tachi, a Japanese inventor, took the techniques used by the Mark I computer, and by 1983, had developed the MELDOG MARK IV, capable of performing most of the functions of guide dogs. For the future, scientists and engineers are working on the Spartacus Robot for the handicapped. It is being designed to respond to a voice and even to whistling. It can take care of various tasks, such as giving a drink to the patient, turning the television on or off, opening a door or a window, turning on the heat, and many more activities. D'Estaing (1985).

The newest computer advancement for education may be the Hypertext program. This program is an electronic text processing which is being hailed as the path to the future--an efficient way to have access to information that is related to the subject a person needs or a method of linking related documents. Chiang (1988).

When a student needs to do research for a class on a specific subject, he or she begans reading magazine articles, business reports, or maybe a section of a software manual. That individual must read report after report, starting at the beginning and reading through to the end. If more information is needed, the research continues from one resource to another. Skimming past long passages that seem useless in order to find what is useful, is now a necessary part of the research process. That is "text." Chiang (1988).

Now, the student considers reading just a section of a document, covering just the part he or she is interested in, skipping to another section farther down in the document, jumping to another passage in the middle of another document, or looking at a footnote covering the same exact subject area. That is "hypertext." Some individuals believe hypertext will change the way people use computers. Chiang (1988).

There will be three basic types of links through the hypertext implementations. The first is the *note link*. This link contains parenthetical information or a footnote, a detailed definition of a term, a little graphic of what something looks like, or a context-related note to another reader. Another type of link in the *expansion link*. An extended passage of text replaces the original text of the link, with the expansion link. This would be rather like expanding one level on an outline processor and the material within an expansion should make sense in the context. The *reference link* is the heart of hypertext. This link moves to another place in the same document or inside another one. Chiang (1988).

Hypertext is a promising program now, but there are greater things in store in the near future. These systems will become more powerful and will utilize mass storage devices, such as CD-ROM. They will become more useful when optical WORM (Write Once, Read Many) devices are available. "And with greater storage, a more general concept will become practical to implement: 'hypermedia,'" according to Chiang. This program will include text and graphics, plus animation, sound, and motion video. Eventually, this program could change the views concerning publishing, royalties, and rights to reproduce text. Chiang (1988).

HyperCard was developed by Bill Atkinson, the developer of the MacPaint program for Apple. The user organizes information in his mind and then by association and context, using as a metaphor the index card. The index cards appear on the screen, referred to as stacks. Any of these cards can contain *buttons* and *fields*. Buttons perform a number of different tasks. They could send the user to another card, to another stack, play music, make invisible fields visible, activate spoken text, dial a telephone, print a report, operate a video-disc player, and much more. Fields contain text in a variety of fonts and styles, execute a formula, and can be visible or invisible. Olivieri (1987). *Card* is information displayed on the screen in the form of a card and more than one appears to be a "stack" of cards. HyperCard has the ability to link many pieces of information on one card to another piece of information on another card. Camp (1988).

This program is going to be helpful to teachers as well as students. A gradebook database consists of two stacks: an address book stack and a student marking book stack. The address book has all of the personal information about each student and that is linked to another stack showing class and achievement information. The user can program lesson plan information in full details or graphic lessons in connection with MacPaint which could include information about a painting, the biographical information about the artist, the location of the painting, and much more. Camp (1988).

New robots will have specialized vision, a sense of touch, understanding of spoken commands, and wheels to move around--

excellent for helping a teacher in an overcrowed classroom. It is predicted that robots will be used to teach advanced math, physics, art, and design in the classroom and that robots will someday appear at a mobile computer that will roll around the room and act as an "intelligent assistant" for the teacher. D'Ignazio (1982).

CHAPTER VI

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The objective of this study was to record an abbreviated history of the inventions leading to the development of the computer and to note its related effects on society--more specifically, various fields of industry, science, and education.

In chapter II, a discussion was given on the current impact of computers on society in the areas of employment, health problems connected with the use of the computer, the problems involved with the invasion of personal privacy, and the effects of changes on the family unit. The historical background of computer science was presented, showing that man was consistently searching for a more efficient method of communication, computation, and information storage. The earliest antecedents of computer technology were seen in prehistoric numerals, ancient textile patterns, and the looms of the cottage industries of the pre-industrial revolution.

The study next described the mechanical inventions that enabled the industries of the seventeenth and eighteenth centuries to revolutionize the manufacturing of commodities. As for those who built upon the inventions of the Industrial Revolution, the study presented a sketch of key individuals whose inventions were considered primal in the development of computer technology. The refinement process from the first generation of computers (UNIVAC), to the second (Data Processing), and to the third generation (Micro-processors) was described.

Chapter three detailed the creative changes that computer technology have initiated in various fields of industry and science. Other than the general use of computers in all of these industries in management and accounting, each was shown to have incorporated the computer in a special manner. The automobile industry's extensive use of robotics in body welding and assembly was examined, while the widespread use of microcomputers in desk-top applications in the agricultural industry was described. As for meterology, it was noted that the availability of extensive computerized data from weather satellites made accessible to regional areas insures a more reliable weather forecast. Tele-presence, among the latest developments in space technology at NASA, was described. This technique enables a programmer at a computer console to think and perform for a robot located elsewhere and will be used in search for obtainable natural resources on other planets. The impact of computer technology on various schools of medicine was examined, with particular attention given to the use of the laser in surgery. In the textile industry, it was noted that the computer has the potential of combining the apparel and design elements of the manufacturing process.

The impact of the computer in education is outlined in chapter IV. Listed and discussed were the contributions of Papert with the LOGO program for mathematics, computer assisted instruction for the reinforcement of learning typified by "Skinner's Box", and the visual and auditory assistance given by computers to handicapped students. Also noted were the innovations in elementary education, especially the extensive use of microcomputers and learning programs. On the secondary level and vocational technology training centers, the discussion featured how students benefited from computer technology. Computer-assisted instruction being utilized in special education to provide the individualized instruction required for those students followed. The discussion centered on various learning methods of telecommunication such as electronic mail, television classes, and international teleconferences.

In summary, the projected uses of computer technology discussed in chapter V were the talk-back television in the training of the workers for automobile assembly, wider use of microcomputers in the agricultural industry, and the possiblity of the online system for uniting apparel and textile industries. The new technologies also projected a more accurate reporting on current weather conditions, more experiments with tele-presence in the NASA program, and wider application of the use of electrical current as well as computerized diagnoses of patients in the medical field. And finally, the projection was that education will experience electronic text processing similar to the Hypertext and HyperCard computer programs.

Conclusions

There is no question that the world will be different because of the invention of the computer. Changes due to computer technology will affect work environments, job descriptions, job training programs, and the continued concerns of health related problems possibly connected with the use of the computer. Society is displeased with the invasion of personal privacy through data bases and will pursue possible methods to prevent unnecessary disclosures of personal information. Through job opportunities, computer games, and computer programs family relationships maybe improved. It is noted that these improvements should continue.

Computers have become an extremely important invention for industry. Two immediate benefits are the automobile industry experiencing reduced cost for manufacturing due to the incorportation of computer technology, and consumers benefiting from reduced fuel expenses for their computerized automobiles. Robots are being used for dangerous jobs on the automobile assembly lines to complete the work faster and more accurately. True, some individuals lose their jobs because of robots and are required to retrain for a different jobs. In response to this, classes or on-the-job training have been developed and must be continued in the future.

Computer inventions led to the development of medical techniques necessary for laser surgery. Ophthalmologists, dermatologists, and podiatrists were able to perform successful surgery on their patients. More individuals will benefit from this surgery as the cost becomes less expensive. Providing the astounding advantages of laser surgery at lower cost for patients should be a major reason for continued research and development.

Students are using various computer programs for learning. Due to future job market requirements, students will need earlier experiences with computers and at least a basic computer knowledge in their educational training. Educators must be prepared to counsel their students in the many opportunities available in computer-related occupations. The demands placed on society will require better educated, better qualified, and better informed people in computer techniques. There will be unlimited possibilities in the future job market for students who are competent in areas of computer technology.

Recommendations

It is recommended that further research be done in the many fields of computer technology. One such field which could not be covered in this paper is the use of computer graphics. In the educational area one could examine the possibilities of how games are being used to teach children with learning problems and what needs to be done to improve the material now available. Also, investigation into the possible improvements in math skills, map skills, art history, and social studies through computer graphics should be undertaken. In business, research should be done regarding the use of graphs and charts in the financial world. Computer graphics have increased communication through international teleconferences by eliminating the language barrier between countries. However, one could inquire into even better ways communication could be enhanced through computer graphics.

A field which causes concern is how the computer has affected personal privacy and made it difficult to enforce copyright laws. There is a certain amount of information that cannot be private, but if the United States can pry into personal records, a foreign country could gain access to that same information. This could be classified as spying. Copyright laws should be written and enforced to really protect society from unlawful use of private information. With the present banking system and the current credit card processes, it is difficult to have privacy. The research into these ideas would be beneficial to future generations.

There are many more areas in the medical field that could be investigated such as information about the uses of the ultrasound or Positron Emission Tomography (PET) scanners, a variety of simulators, the computer technogical uses in neonatal care, robotics used in surgery and dentistry, the use of laser in surgery and dentistry, and also the technology which is being used for medical research. These are only a few areas in medicine which could be investigated further.

Today computers provide many opportunities for family recreation including advanced computer games. Computer programs need to be available that will help the family design their own games. "Robots" could become family members in the future. Possibly families could purchase materials with which to build their own robots. This study could be extremely helpful to innovative families and could encourage closer family relationships.

Finally, more research should be done to explore the impact of computers on the K-12 education curriculum as well as nursery and pre-school age children. By the time this paper is in print, some of the technology will already be outdated. Information will be needed concerning the future educational uses of the robot; about advanced computer software and hardware and their cost and availability to the schools for all grade levels, and about computer-related curricula that are available through libraries and telecommunication. Planning should be done for purchasing hardware and software as it becomes available rather than having to wait and risk the necessity of using obsolete equipment.

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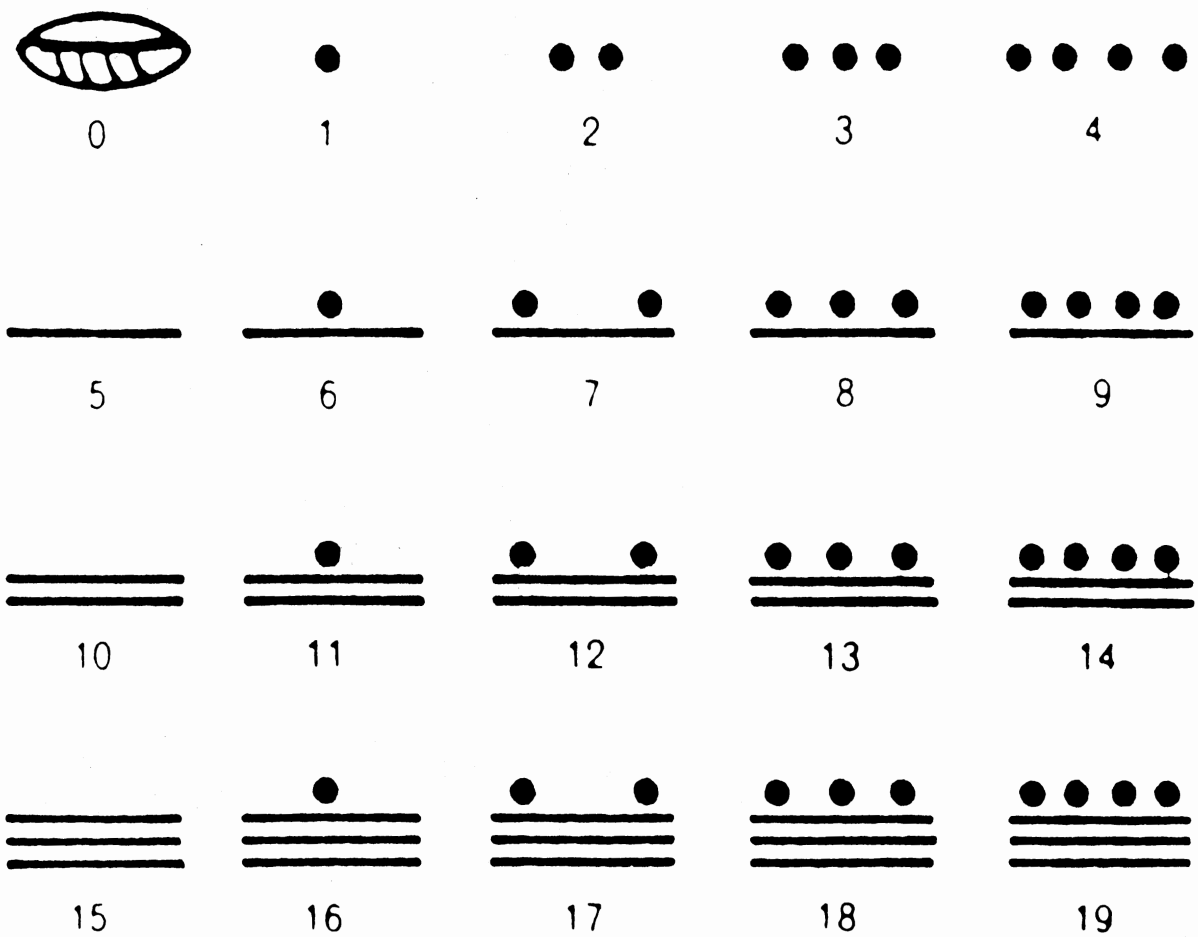
APPENDIXES

APPENDIX A

MAYA INDIAN NUMBERING SYSTEM

MAYA INDIAN NUMBERING SYSTEM



APPENDIX B

INTERVIEWS

616 S. W. 68th Street
Oklahoma City, Oklahoma 73139
May 13, 1988

Mr. Rick Tipton
General Motors Plant
Attn: Safety Department
CPC P. O. Box 26527
Oklahoma City, Oklahoma 73126

Dear Mr. Tipton:

I am working on a doctoral degree in Curriculum and Instruction with emphasis on Instructional Technology at Oklahoma State University and hope to graduate in July. The subject of my dissertation is the history of the computer and its effect on society. I am gathering information from several industries and the medical field. I need input from professional individuals concerning the use of computer in your area. Also, I will need information in regard to your title and your background for authenticity.

I shall greatly appreciate your help in answering three questions. The "Interview" needs to be returned to me by May 23, 1988, or sooner if possible. Enclosed is the "Interview" form and a self-addressed stamped envelope.

Thank you very much!

Norma Scudder

Enclosures

INTERVIEW

Your complete title:

Your background:

1. How has the computer/robot enhanced automobile production in the last twenty years?

2. How has the computer been used in the training/safety process for automobile production?

3. What future computer applications do you predict in the automobile industry?

616 S. W. 68th Street
Oklahoma City, Oklahoma 73139
May 12, 1988

Dr. J. E. Osborn
Agricultural Economics
OKLAHOMA STATE UNIVERSITY
308 Agriculture Hall
Stillwater, Oklahoma 74078

Dear Dr. Osborn

I am working on a doctoral degree in Curriculum and Instruction with emphasis on Instructional Technology and had hoped to graduate this July. The subject of my dissertation is the history of the computer and its effect on society. I am gathering information from several industries and I wanted one of them to be in agriculture.

I shall greatly appreciate your help in answering three questions concerning your area. The questions need to be returned to me by May 20, 1988, or sooner if possible. The "Interview" form is enclosed with a self-addressed stamped envelope.

Thank you very much!

Norma Scudder

Enclosures

INTERVIEW

Your title:
Your background:

1. How has the computer strengthened the agricultural industry in the last twenty years.?

2. How has the computer been used in agricultural training for future farmers?

3. What computer applications do you foresee in the future for the agricultural industry?

616 S. W. 68th Street
Oklahoma City, Oklahoma 73139
May 13, 1988

Mr. Kevin Kelleher
Naitona Severe Storms Laboratory
1313 Halley Circle
Norman, Oklahoma 73069

Dear Mr. Kelleher:

I am working on a doctoral degree in Curriculum and Instruction with emphasis on Instructional Technology at Oklahoma State University and hope to graduate in July. The subject of my dissertation is the history of the computer and its effect on society. I am gathering information from several industries and a few government departments. I need input from professional individuals concerning the use of computer in your area. Also, I will need information in regard to your title and your background for authenticity.

As per our telephone conversation, I shall greatly appreciate your help in answering three questions. The "Interview" needs to be returned to me by May 23, 1988, or sooner if possible. I have enclosed the interview form and a self-addressed stamped envelope.

Thank you very much!

Norma Scudder

Enclosures

616 S. W. 68th Street
Oklahoma City, Oklahoma 73139
May 13, 1988

Mr. Gary Lezak
Staff Meteorologist
KWTV 9
7401 N. Kelley Avenue
Oklahoma City, Oklahoma 73113

Dear Mr. Lezak:

I am working on a doctoral degree in Curriculum and Instruction with emphasis on Instructional Technology at Oklahoma State University and hope to graduate in July. The subject of my dissertation is the history of the computer and its effect on society. I am gathering information from several industries and a few government departments. I need input from professional individuals concerning the use of computer in your area. Also, I will need information in regard to your title and your background for authenticity.

As per out telephone conversation, I shall greatly appreciate your help in answering three questions. The "Interview" needs to be returned to me by May 23, 1988, or sooner if possible. I have enclosed the interview form and a self-addressed stamped envelope.

Thank you very much!

Norma Scudder

Enclosures

INTERVIEW

Your complete title:
Your background:

1. How has the weather forecasting been strengthened by the use of the computer in the past twenty years?

2. How has the computer been used in the training of weathermen?

3. What future computer applications do you predict for the National Weather Department?

616 S. W. 68th Street
Oklahoma City, Oklahoma 73139
May 6, 1988

Mrs. Freda Deskin
Aerospace Foundation of America
Norman, Oklahoma

Dear Freda,

I really appreciate the fact that you agreed to answer some questions concerning the computer and its affect on society. Only with people such as you will I be able to complete my dissertation moving in the direction by which I have started. Besides the questions, I need your background, your title, how you have accomplished the title you have now, and how the computer may have helped make those changes. Feel free to answer the following questions briefly and to the point or answer them at length. I shall be happy with any information from NASA that will show the computer relationship to society as a whole. THANKS AGAIN! Have a GREAT trip to New Zealand.

Sincerely,

Norma Scudder

INTERVIEW

Your title:
Your background:

1. How has the computer enhanced the SPACE program over the last twenty years?

2. How did you use the computer for your training period for traveling in outer space?

3. What future computer applications do you predict for the SPACE program?

616 S. W. 68th Street
Oklahoma City, Oklahoma 73139
May 13, 1988

Dr. James B. Wise, Chairman of Ophthalmology
Baptist Medical Center
3435 N. W. 56th Street
Oklahoma City, Oklahoma 73112

Dear Dr. Wise:

I am working on a doctoral degree in Curriculum and Instruction with emphasis on Instructional Technology at Oklahoma State University and hope to graduate in July. The subject of my dissertation is the history of the computer and its effect on society. I am gathering information from several industries and the medical field. I need input from professional individuals concerning the use of computer in your area. Also, I will need information in regard to your title and your background for authenticity.

I shall geatly appreciate your help in answering three questions. The "Interview" needs to be returned to me by May 23, 1988, or sooner if possible. I have inclosed the interview form and a self-addressed stamped envelope.

Thank you very much!

Norma Scudder

Enclosures

616 S. W. 68th Steet
Oklahoma City, Oklahoma 73139
May 13, 1988

Dr. Royice B. Everett, Ophthamologist
Baptist Medical Center
3433 N. W. 56th Street
Oklahoma City, Oklahoma 73112

Dear Dr. Everett:

I am working on a doctoral degree in Curriculum and Instruction with emphasis on Instructional Technology at Oklahoma State University and hope to graduate in July. The subject of my dissertation is the history of the computer and its effect on society. I am gathering information from seveal industries and the medical field. I need input from professional individuals concerning the use of computer in your area. Also, I will need information in regard to your title and your background for authenticity.

I shall greatly appreciate your help in answering three questions. The "Interview" needs to be returned to me by May 23, 1988, or sooner if possible. I have enclosed the interview form and a self-addressed stamped envelope.

Thank you very much!

Norma Scudder

Enclosures

INTERVIEW

Your complete title:
Your background:

1. How has the computer/laser enhanced the medical field in the last twenty years? (Name the most important.)

2. How are you presently using the computer for training in the area of medicine?

3. What computer application do you foresee for the future in the medical profession?

616 S. W. 68th Street
Oklahoma City, Oklahoma 73139
United States of America
May 9, 1988

The Textile Institute
International Headquarters
10 Blackfriars Street
Manchester, M3 5DR, United Kingdom

To Whom It May Concern:

In doing research concerning textile industry and computers, I found your advertisement in the Textile Horizons journal, giving details pertaining to the Institute's 1984 Annual Conference, which was held in Hong Kong. I was impressed with the topics to be discussed at that conference.

I am working on a dissertation using information regarding the history of computers and the way they effect society. Throughout the paper the history of the loom and the textile industry are interwoven with computers. One chapter will be about the present computer experiences in various industries. It is extremely important to me to find out first-hand information about what is taking place in the textile industry today and what is being predicted for the future.

If it would be possible for you to send copies of some of the papers given at that conference and/or if someone with your Institute could answer the enclosed "Interview," I would be extremely grateful. It is imperative that I receive this information by May 31, 1988, if not sooner.

Please let me know if there would be a charge for this service.

Sincerely,

Norma Scudder

Enclosures

INTERVIEW

1. How has the computer enhanced the Textile manufacturing and process control and textile design in the last twenty years?

2. How have you used the computer for textile education or job training and when did the computer training begin?

3. What computer applications do you predict in the near future for the textile industry?

VITA ν

Norma Irene Scudder

Candidate for the Degree of

Doctor of Education

Thesis: THE HISTORY OF THE INVENTIONS LEADING TO THE DEVELOPMENT OF THE COMPUTERS AND THE RELATED EFFECTS ON EDUCATIONAL INSTRUCTION AND SOCIETY

Major Field: Curriculum and Instruction

Biographical:

Personal Data: Born in Oklahoma City, Oklahoma, October 8, 1936, the daughter of Laurence A. and Bertha Mary Scudder.

Education: Graduated from Capitol Hill High School, Oklahoma City, Oklahoma, May 1954; received Bachelor of Arts degree from Oklahoma City University, Oklahoma City, Oklahoma, with a major in Elementary Education, May 1966; received a Master of Arts in Teaching degree from Oklahoma City University with a major in Elementary Education, May, 1969; received a Master of Arts in Teaching degree from Oklahoma City University with a major in Art Education, May, 1973; completed requirements for the Doctor of Education degree at Oklahoma State University in July 1988.

Professional Experience: Taught in Pilot Program for Pre-Schools, Riverside Elementary, Oklahoma City, Oklahoma, Summer, 1964; Fourth, Fifth, Sixth grade teacher, University Heights Elementary, Oklahoma City, Oklahoma, January 1966-1969; Sixth grade teacher, Lafayette Elementary, Oklahoma City, Oklahoma, 1969-1972; Seventh grade Science teacher, Jefferson Middle School, Oklahoma City, Oklahoma, 1972-1973; Humanities Instructor, Oklahoma City Southwestern College, Oklahoma City, Oklahoma, Summer, 1979; Art teacher, Mustang Middle School, Mustang, Oklahoma, 1973-1986; Art and Education instructor, Mid-America Bible College, Oklahoma City, Oklahoma, 1986-1987; Education, Assistant Professor, Director of Teacher Education, Mid-America Bible College, Oklahoma City, Oklahoma, 1987-1988.

Professional Organizations: Oklahoma Education Association, National Education Association, Oklahoma Association of Colleges for Teacher Education, Oklahoma Watercolor Association, Central Art Association, National Academy of Western Art, Oklahoma Artists Association, Delta Kappa Gamma.