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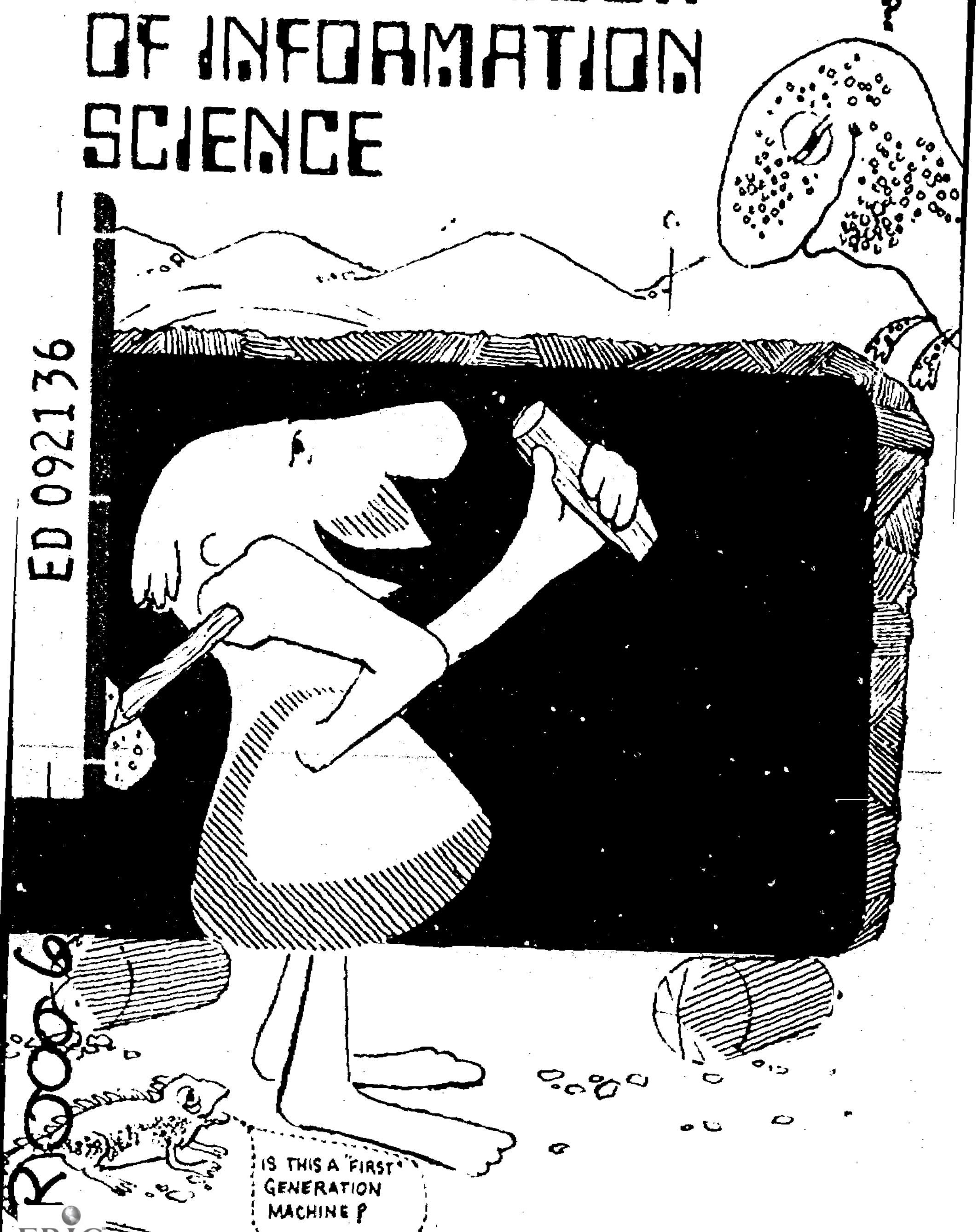
ABSTRACT

A primer on information science introduces the study of how information is transmitted to the person who needs it and how it is later stored and retrieved. Beginning with the history of information as it was used by early man, the booklet summarizes the rapid development of new information technologies, with illustrations and in terms that can be easily understood by the average layman. Some of the technologies reviewed include: computer systems--punched cards, magnetic tapes, and computer languages and programs; communications systems--telephone, cable, microwave, and satellite; and microforms--types of microfilms, holography, viewing and copying, and computer-microform systems. Finally, there is a glossary of terms and a list of additional readings in the area. (WDR)

THE FIRST BOOK OF INFORMATION SCIENCE

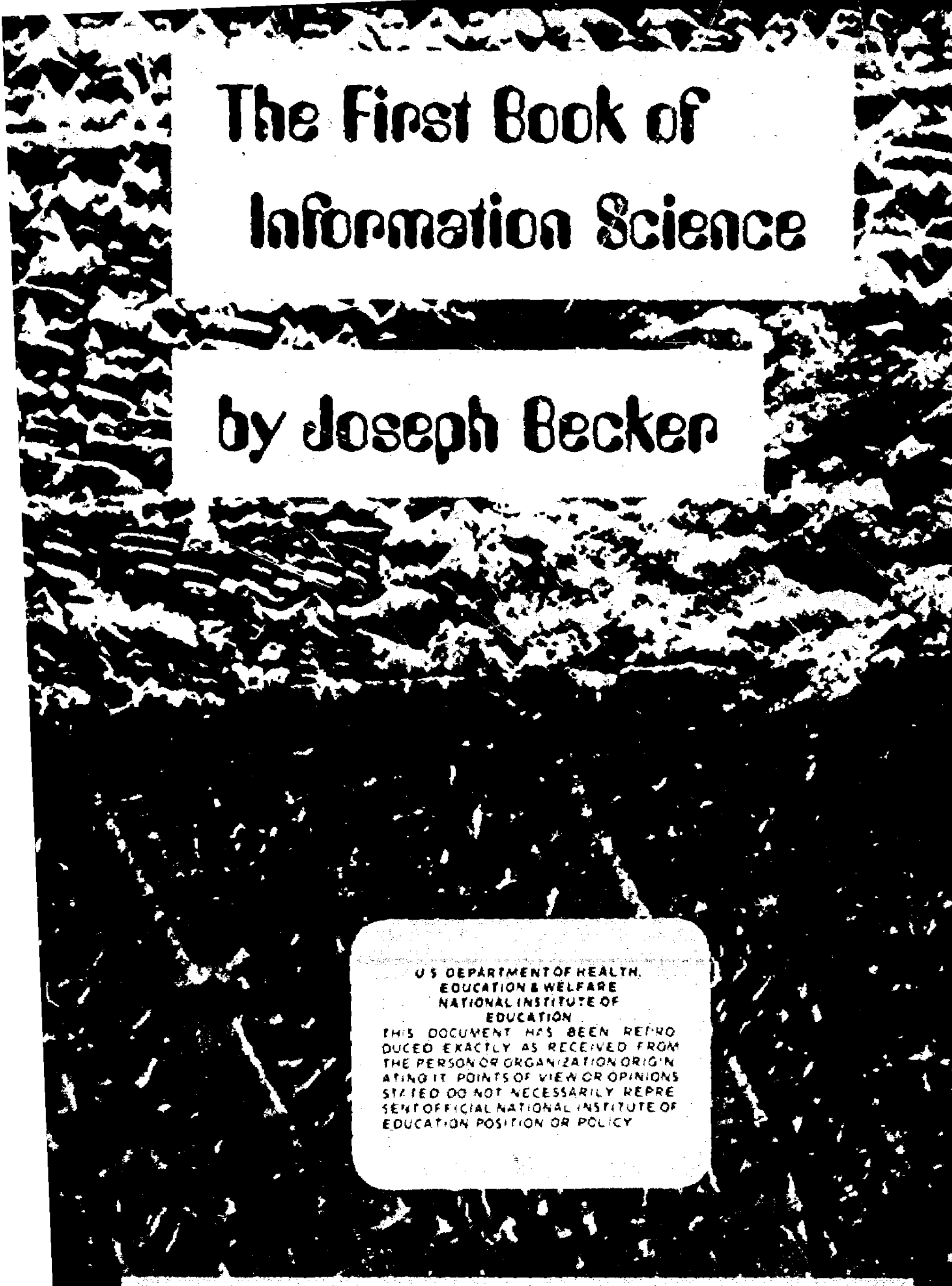


Information science is the study of how man communicates with man. It is concerned with discovering better ways to get the right information quickly to the person who needs it, and with finding information later, once it is stored in libraries and other centers of information.

This booklet is a primer on information science.

Joseph Becker, President of Becker and Hayes, Inc., a subsidiary of John Wiley & Sons, has an extensive background in education, computer management, federal library administration, telecommunications research, and library automation. He was the Director of a National Conference on Inter-Library Communications and Information Networks and was a professor in the School of Library Science at Catholic University. In 1968 he became President of the Information Science and Automation Division of the American Library Association and in 1969 he was elected president of the American Society for Information Science. He received a B.S. in aeronautical engineering from Brooklyn Polytechnic Institute and an M.L.S. from Catholic University. He is co-author with Dr. Robert M. Hayes of *Information Storage and Retrieval* (Wiley, 1963) and *Handbook of Data Processing for Libraries* (Wiley, 1970).

In 1971 Mr. Becker was appointed by President Nixon as a member of the new National Commission on Libraries and Information Science.



The First Book of Information Science

by Joseph Becker

Portion of a clay block inscribed with a list of Sumerian kings in cuneiform. The Sumerian civilization flourished in Mesopotamia between 2025 and 25 B.C.

CONTENTS

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INTRODUCTION

A few years ago a ***computer**** in New York City "talked" for the very first time to a computer in London. Computers can't really talk the way people do, but these machines were able to exchange ***information*** about a very complicated arithmetic problem. The computers were connected to each other through the Early Bird ***satellite***. Early Bird is the name of a small radio relay station which is about the size of a refrigerator, and orbits the earth high above the Atlantic Ocean.

A powerful rocket put Early Bird into orbit several years ago and its job is to receive signals from an American radio station and send them to a radio station in Europe.

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*Italicized words are defined in the glossary beginning on page 85.

Because satellites communicate with computers and computers can process tremendous amounts of information at lightning speed, it is possible for Early Bird to send a lot of information back and forth much faster than any other way of communicating.

In addition to doing arithmetic, computers can also process letters of the alphabet, words, and sentences. We call this *language processing*, and when computers do this kind of work through satellites like Early Bird, they give us a new kind of power—"information power." This information power is going to be very important to you and to everyone else in the world during the years ahead.

The science of information is an exciting subject. Once you understand it, perhaps you too will want to become an information scientist and join others who are interested in unlocking the information secrets of the future.

WHAT IS INFORMATION?

When a child is born and opens his eyes for the first time, his brain immediately begins to receive and store impressions of the things he sees around him. These snapshots of the world recorded by the brain through sight are his first sources of information. As he grows up other senses such as sound, touch, smell, and taste also develop, and these together with sight help bring him new information. Somehow, every piece of information that reaches the brain is recorded in *memory*. Little by little, through reading and personal experience, a child begins to combine new information with the old—we call this learning.

Scientists do not yet fully understand how the human brain performs this wonderful function, but they do know that information and learning give us the power to think and to be creative. As you read this book you are receiving and recording information in an organized communications center, your brain.

You can think of your brain as a personal information center because it contains all you know and helps you put this knowledge to work in your daily life. If you were to see a picture of the inside of a human brain it would appear as a complicated bundle of tissue folds. It is a marvelous instrument, with each part having a particular job to perform and every complicated connection having some special purpose to help us to think.

The ability to remember, that is, to recall pieces of information from memory, and the skill to mix these pieces together in order to create new ideas, are very precious human qualities.

Although the brain has an enormous capacity to store information, its size is really very small when we compare it with the amount of information in the world. A person can learn only a fraction of everything there is to be known, yet the human brain in a lifetime uses only ½ of its total capacity. Furthermore, just the act of remembering a great many pieces of information does not mean that a person will automatically become knowledgeable or wise.

Knowledge and wisdom can only result from understanding and using information. A knowledgeable person is one who learns to fit pieces of information into a pattern of thought that will lead to intelligent action, and a wise person is one who learns to apply these patterns constructively to life's problems.

The History of Writing

So far we have been talking about the way in which people absorb information. However, for information to be useful it has to be passed from one person to another. Before writing was invented, the main way to pass information was for one person to speak to another. This kind of communication was fine for conversation and discussion, but it was limited to the distance the voice would carry and there was no method to record what was said.

Obviously an effective method was needed to make it possible for each new generation to build upon the thoughts and work of the past. To achieve this, man invented writing and other methods of recording knowledge.

First came picture writing, then the alphabet, then script, and then printing. Each new method was more useful than the last.

This early map of the world, inscribed on a Sumerian clay tablet about 2800 B.C., shows Babylon at the center.

Thousands of years ago, writing was recorded on clay tablets, on dried animal skins, papyrus, and on many other materials.

After the Chinese invented paper, it became the most popular surface for writing and recording information. The first books were in the form of scrolls which had to be turned and rolled in order to be read. In fact, the word volume, which means book, comes from the Latin word "volare" meaning "to turn". These early books, called manuscripts, were handwritten one at a time. It was a very slow way to record and distribute information.

The Chinese were also the first to invent moveable type, which led to commercial printing. Johannes Gutenberg in the year 1440 A.D. was the first European to use it and, thanks to him, it became possible to *publish* many copies of the same book inexpensively much the way we do today.

Books and Libraries

Keeping all the manuscripts and books in one place was the job of the librarian. At first there were very few *libraries* and those which were built were considered great treasure houses by the scholars who used them. Hundreds of years ago, very few people knew how to read, but those who did were willing and eager to travel great distances and

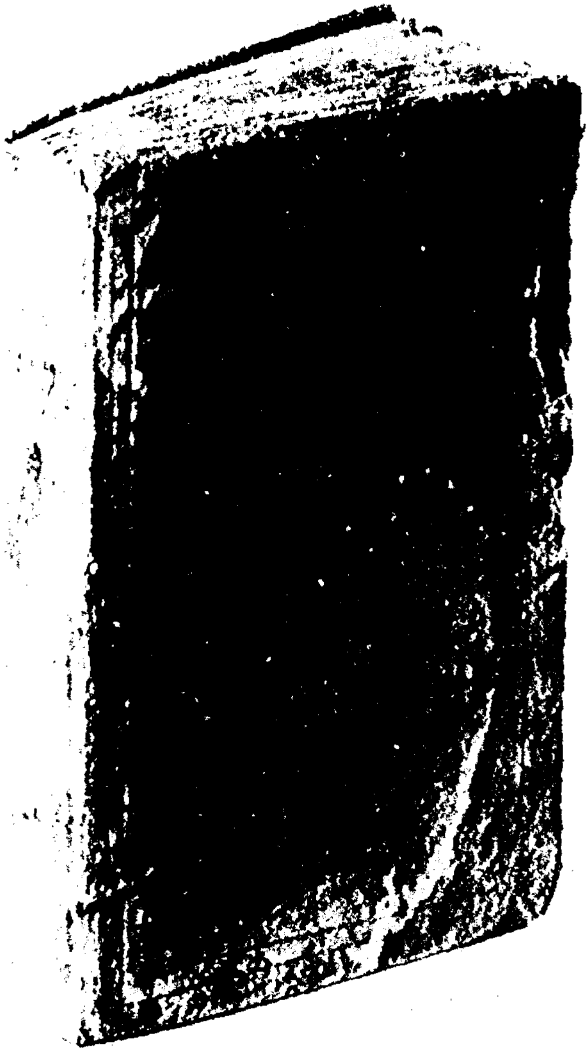
A page from the 15th century *Tres Riches Heures de Duc de Berry* (Very Rich Hours of the Duke of Berry), a small illuminated prayer book. These works of art were made for, and enjoyed by, only a few privileged persons.

undergo personal hardships just to be able to study the information and other knowledge that had been recorded in books. Books and libraries have made a remarkable contribution to civilization; without them it is doubtful that the people of the world would have made as much progress as they have.

Making Information Available

Because a printing press could make many copies of the same book, it was possible to send books to different places so that people could have a copy no matter where they lived. Mail and postal systems were started and helped to distribute books to different cities, and it didn't take long before the mails became the busiest form of communication for the exchange of information between people. When ships, trains, and airplanes began to carry mail, this greatly increased the capacity and the speed of postal service. Today, it is routine for tons and tons of information to be moved through the mails every day from place to place all over the world.

Electricity provided another method by which information could be distributed. Telephone and telegraph lines connected people to people and places to places. With the help of electricity, these new communication lines were able to carry information messages back and forth at the speed of light. Today, we have 100,000,000 telephones in the United States and millions more throughout the world. They are a very necessary part of personal communication.



The Bay Psalm Book was the first book printed in America. It was published in 1640 in Cambridge, Massachusetts. (See the figures on the next two pages.)

THE

VVHOLE

BOOKE OF PSALMES

Faithfully

TRANSLATED *into* ENGLISH

Metre.

Whereunto is prefixed a discourse declaring not only the lawfullnes, but also the necessity of the heavenly Ordinance of singing Scripture Psalmes in the Churches of God.

Coll. III.

Let the word of God dwell plenteously in you, in all wisdome, teaching and exhorting one another in Psalmes, Himnes, and spirituall Songs, singing to the Lord with grace in your hearts.

Iames V.

If any be afflicted, let him pray, and if any be merry let him sing psalmes.

Imprinted

1640

The title page (above) and a page of text (right) from the Bay Psalm Book.

2 Hee in the folds of tender-grasse,
doth cause mee downe to lie:
To waters calme me gently leads
3 Restore my soule doth hee:
he doth in paths of righteousnes:
for his names sake leade mee.
4 Yea though in valley of deaths shad
I walk, none ill I'le feare:
because thou art with mee, thy rod,
and staffe my comfort are.
5 For mee a table thou hast spread,
in presence of my foes:
thou dost anoynt my head with oyle,
my cup it over-flowes.
6 Goodnes & mercy surely shall
all my dayes follow mee:
and in the Lords house I shall dwell
so long as dayes shall bee.

Psalme 24
A psalme of david.

THe earth Iehovahs is,
and the fulnesse of it:
the habitable world, & they
that there upon doe sit.
2 Because upon the seas,
hee hath it firmly layd:
and it upon the water-floods
most sollidly hath stayd.
3 The mountaine of the Lord,
who shall thereto ascend?
and in his place of holynes,

Another way we communicate information is by radio. The telephone permits one person to talk to another person who is far away, but the radio can also be used to broadcast the same information to many people all at once. ***Television*** goes a step further. It broadcasts information just the way the radio does, but it also allows people to see as well as hear the information. Each of these technical developments had the effect of making more information widely available to more people than ever before.

STORING AND RETRIEVING INFORMATION

For many centuries, libraries have served as our major storehouses of knowledge. They accumulate books, periodicals, and newspapers, organize these materials for everyday use, and provide various services to help people find information. There are many types of libraries--school libraries, public libraries, university libraries, and special libraries. Special libraries cover one subject like law or medicine. Libraries perform several functions: They select and acquire materials for their users, they catalog and classify these materials so that users can find what they're looking for, they circulate books so that a user can take material home, and they answer questions on almost any subject. The study of these functions is called ***library science.***

Libraries are for everyone. They provide free and open access to information for recreation, education, and research. For this reason, more and more public libraries are becoming the main information center in towns and communities.

Modern libraries are also acquiring ***audio-visual*** materials to complement their collections of books and magazines. Films, filmstrips, audio cassettes, TV tapes, long playing records, slides, video cassettes, and other forms are available in many of today's libraries.

As libraries get bigger, as they acquire more audio-visual materials, and as they begin to serve the more complex information needs

of their users, they are discovering that the computer and other technology may provide new ways to strengthen their ability to store and retrieve information. The application of computers and technology to library functions is called *library automation*.

The Information Explosion

More people live on earth today than the sum of all the people who ever lived before in recorded history—we call this the population explosion. People must have information to get along in today's world and, as the world's population increases, it becomes necessary to find better ways of distributing needed information. Also, because of the population explosion, information is being produced faster by more people than in the past. And, the number of specialized subjects is increasing rapidly—we call this the *information explosion.*

No longer does the word information apply only to things that are printed. It also includes other materials like information on film, slides, television tape, and computer tape. ***Information science*** is the study of how man communicates with man. It is concerned with discovering better ways to get the right information quickly to the person who needs it, and with finding information later, once it is stored in libraries and other centers of information.

The population explosion, which has precipitated the information explosion, is well illustrated in this view of New York City's Fifth Avenue at noon.

Information Science

Information science is a young field. People everywhere are concerned with the information explosion, but don't know what to do about it. For example, a doctor needs new information to be sure he treats his patients with the most effective remedies. A lawyer needs new information to be sure his client benefits from the latest court rulings affecting his case. An engineer needs new information to be sure he doesn't spend his time inventing something that has already been built. A businessman needs new information to be sure his company is managed in a way that will make a profit. A farmer needs new information to be sure he gets the maximum harvest from his cultivated land.

And so it continues. Information science studies the way these different people use information in their jobs and provides effective methods for giving them the kind of information they need to do their job best.

Any *information system* that distributes knowledge and information to individuals must satisfy three basic requirements. First, it should be able to tell a user where to find his information; second, it should be able to deliver this information to him once he decides he wants it; and third, it must respond within the time limits the user imposes. Information science is therefore concerned with the way different people create information, index or label it, store it, find it, analyze it, send and receive it, and use it.

Information science draws on many different fields for its development. Some of these are mathematics, logic, language arts, psychology, computer technology, communications, micrographics, library science, and business management. Nevertheless, there are at least three basic tools that every information scientist must learn to use.

First, he should know about computers, because they can process information in the form of words as effectively as they compute numbers. Second, he should know about ***communications***, because this technology is capable of distributing word and picture information at great speeds to different people no matter where they live. And finally, he should know about the field of miniature photography called ***micrographics***, because film technology allows a lot of information to be condensed into a small space.

The purpose of the next few chapters is to acquaint you with these new information technologies so that you can understand how they operate and how they are going to change our information habits in the years ahead. Today's libraries and information centers are already being affected by these latest electronic discoveries.

PUTTING INFORMATION INTO A COMPUTER

Punched Cards and Paper Tape

When information appears in print, as on this page, people like you and me are able to read and understand it. However, if information is to be processed by a machine, like a computer, then other ways must be found to put these same letters and words into the machine. Computers, of course, do not have eyes like humans—but they do have electrical sensing equipment that in certain ways does almost the same thing.

For example, most of us have walked into supermarkets through doors that open by themselves. These doors are controlled by electrical sensing equipment known as photoelectric cells, which act like eyes. Each door is controlled by two photoelectric cells that shine a beam of light to each other. As you walk through the door, the light beam is broken causing the photoelectric cells or "eyes" to sense that someone is beginning to enter. The electric eye reacts in a split second by sending a burst of electrical energy to the door's mechanical hinge, and this automatically swings the door open.

The photoelectric sensing idea can also be used to detect the presence of a hole in a card or piece of paper.

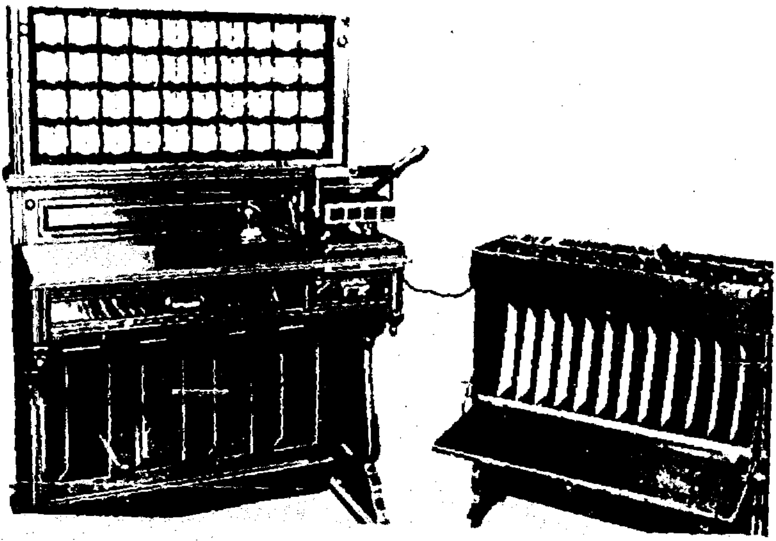
Thus, if holes are punched in paper to represent certain letters of the alphabet or words, it is possible for a machine to electrically sense or read this information.

In 1880 a man named Herman Hollerith of Buffalo, New York, invented a method for representing information as holes in a punched card. Mr. Hollerith worked for the U. S. Bureau of the Census where he dealt with population statistics from all parts of the country. His job was to add up many thousands of hand written figures, and naturally this arithmetic took a lot of time. So he developed a set of machines to do the job quicker, and he also thought of a way of punching holes in a card to record the information on population in a form that was readable by machines.

Today, ***punched cards*** and ***punched paper tape*** are two popular methods for putting information into ***machine readable*** form for processing by computers.

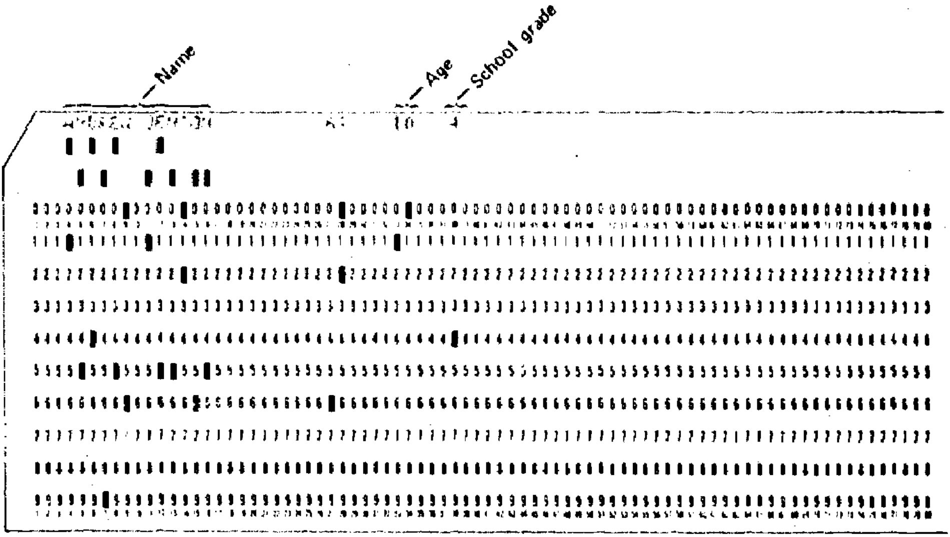
The figure at the top of page 24 shows a typical punched card. Mr. Hollerith chose to make his card the size of an American dollar bill in 1880. Although the dollar bill is smaller today, the dimensions of the Hollerith card have not changed. The punched card in the figure contains information on the name, age, and school grade of a typical student.

Each punched card is divided into columns and rows. Columns go up and down, rows go from side to side. There are 80 columns and 12 rows. A number, like 6, is represented by punching a hole in the sixth row of any column. Notice in the figure how the number 6 was punched in column 27. A letter, like S, is represented by punching two holes in the same column. Notice how the



Part of Hollerith's first complete Census Bureau tabulating system in 1890.

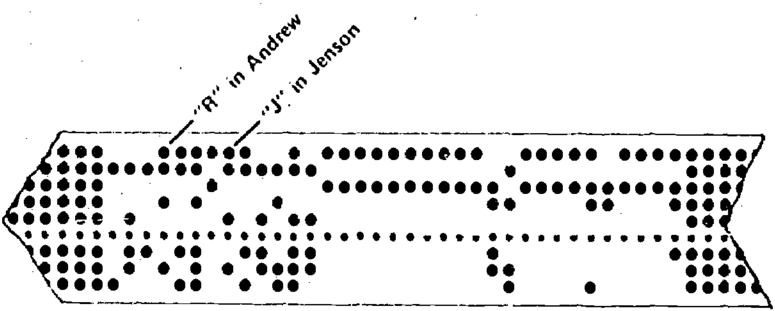
The Pantograph Punch, part of the Hollerith system, was used in the 1890 and 1900 censuses. With improvements, the U. S. Census Bureau used it for statistical tabulations through the 1920s. This picture was taken about 1918.



A typical punched card containing information on the name, age, and school grade of a 10-year-old student.

letter S was punched in row 10 and row 2 of column 28.

Similarly, the figure below illustrates how information about the same student would be punched into paper tape. Each combination



The same student information, shown in the figure above, punched into paper tape. Note how the group of holes for a "J" differs from the holes that stand for the letter "R".

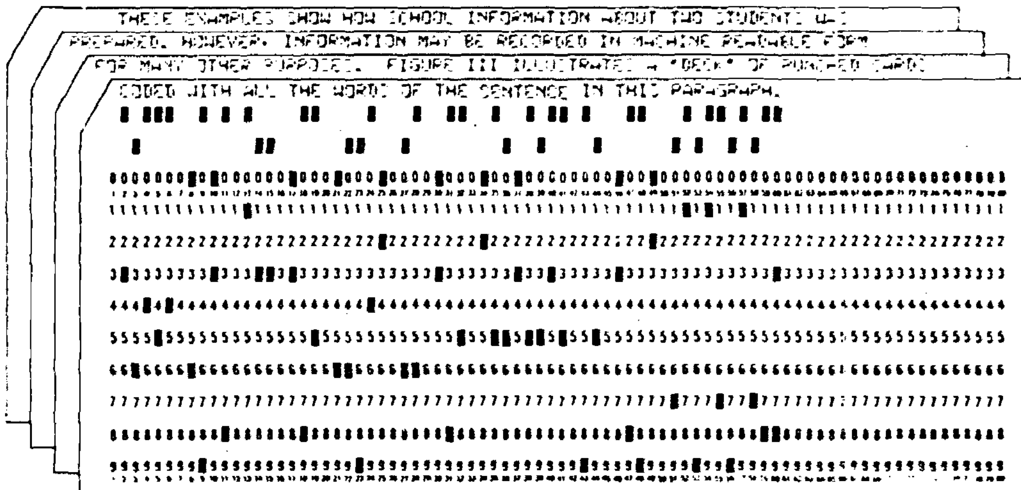
of holes across the width of the paper tape has a different meaning. Notice how the group of holes for a J differs from the holes that stand for the letter R.

These examples show how school information about two students was prepared. However, information may be recorded in machine readable form for many other purposes. The figure on page 26 illustrates a "deck" of punched cards coded with all the words of the sentences in this paragraph.

More and more these days, information is being prepared in machine readable form. Many machines, with keyboards like typewriters, automatically make punched cards and punched paper tape when a page of information is typed. People who *publish* books, magazines, and newspapers are creating machine readable information so that they can take full advantage of computers and other electronic printing machines.

The Computer's Language

Computers are basically electrical devices. Like all electrical machines they respond to electrical signals. To make these signals represent information, a code is needed to represent numbers and alphabetic letters. The code adopted by most of today's computers is based on the *binary number system*. The binary number system uses only two symbols—a "0" and a "1"—to represent numbers and letters. Each symbol is called a *bit*. By working with these two symbols we can code any number or letter.



A deck of punched cards coded with all the words of the sentence in this paragraph.

Below you can see how to represent the numerical symbols from 0 to 9 in the decimal system and in the binary number system.

Decimal	Binary
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001

The following list shows how the 26 letters of the alphabet can be represented by placing two more zeros and ones in front of the binary symbols for numbers 1 through 9.

A = 110001	J = 100001	S = 010010
B = 110010	K = 100010	T = 010011
C = 110011	L = 100011	U = 010100
D = 110100	M = 100100	V = 010101
E = 110101	N = 100101	W = 010110
F = 110110	O = 100110	X = 010111
G = 110111	P = 100111	Y = 011000
H = 111000	Q = 101000	Z = 011001
I = 111001	R = 101001	

Using the six bit binary code above, you would spell RADNOR ELEMENTARY SCHOOL as shown on the next page.

RADNOR	ELEMENTARY	SCHOOL
111111	1111110110	011111
011000	1010101101	111000
100001	0000000011	001000
001110	1011110000	000110
000010	0100001000	110111
110101	1110111110	010001

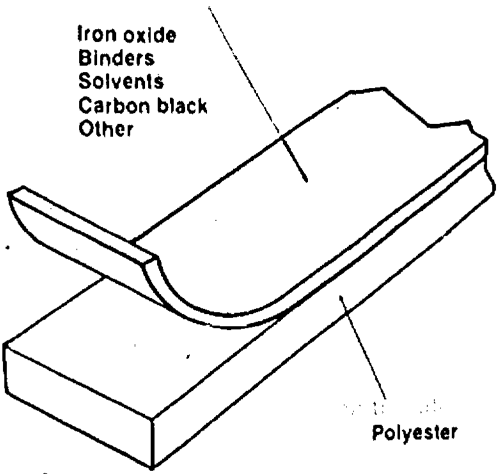
Magnetic Tapes and Disks

Another way to record information for use with computers is by putting the information directly onto *magnetic tape*. However, this is not like typing on paper. In order to understand how information can be recorded on magnetic tape, it is necessary to explain what magnetic tape is.

A cross section of magnetic tape looks like a sandwich. The bottom layer consists of a clear piece of plastic. Spread over this plastic base is a brown substance called *ferrous oxide* that forms the middle layer, and the top layer consists of another coating of clear plastic.

The figure on the opposite page shows a piece of magnetic tape. This tape is very thin; it looks and feels like a piece of ribbon because its layers are packed so tightly together.

Ferrous oxide, the brown substance in the middle of the tape sandwich, contains grains of iron that rearrange themselves and point in one direction whenever they are bombarded with a burst of electrical current. This is called magnetizing. If the electrical current is

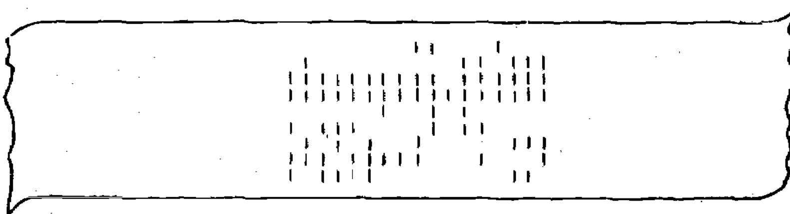


This drawing illustrates the three layers of magnetic tape—clear plastic, ferrous oxide, and clear plastic.

directed to a tiny spot, then only that spot will be magnetized. This is how information is written or recorded on magnetic tape. By reversing the electrical current in the same spot, the information can be demagnetized or erased.

Thus, electricity is used to write a message on a piece of magnetic tape or erase one from it. The interesting thing about magnetic tape, however, is that it is possible to write very tiny messages on it since you don't have to punch holes, as you do in cards, in order to represent letters and numbers. Instead, electricity is used to magnetize certain spots with electrical current. The spots are packed so tightly together that it's difficult to see any of them with the naked eye.

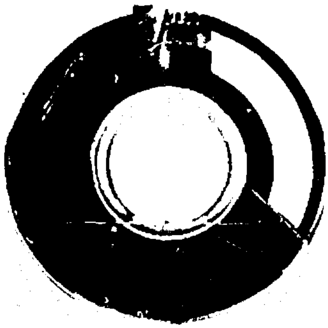
The figure below shows how combinations of eight binary symbols can be converted to magnetized spots to represent information. In this illustration, you see how the words ELEMENTARY SCHOOL would look if you saw the spots magnified under a microscope on an actual piece of IBM magnetic tape.



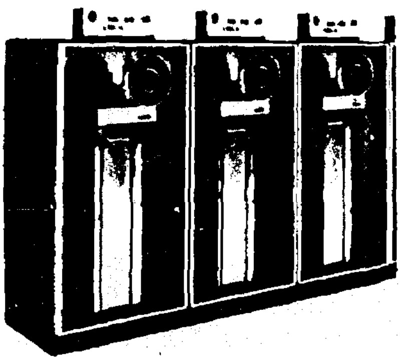
This eight bit binary code on magnetic tape spells out "Elementary School".

Because more information can be recorded on a piece of magnetic tape than on a punched card or punched paper tape, magnetic tape is by far the most efficient machine readable form for putting information into a computer. If you visit a computer center, you will generally see many spools of tape. The figure on the opposite page shows a typical 2400-foot tape spool, a computer machine for handling the tape spool, and a library of magnetic tapes.

Typing information onto a magnetic tape is done by using a special machine. Depressing the keys of the machine's keyboard as if you were typing causes the machine to magnetize certain tiny spots on the tape that represent the typed words. It does this by sending signals of electricity to the spots that are to be magnetized. These signals contain enough



A 2400-foot spool of magnetic tape.



Three tape drives.

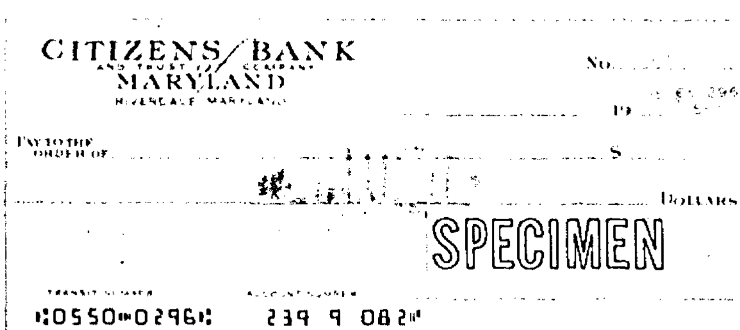
A library of magnetic tapes.

electrical current to rearrange the iron particles in the ferrous oxide and to convert them from a demagnetized to a magnetized state.

Magnetic tapes can be kept for many years and they take up very little storage space. They can be erased and used again for recording new information. They are used to send information into computers, to record output, and to store computer results.

Sometimes a computer must go through an entire 2400-foot spool of magnetic tape to find the information it seeks. To overcome this problem, information is sometimes stored on ***magnetic disks*** that permit a computer to find an existing piece of information quickly. Magnetic disks are like hi-fi records and are coated on both sides with the same ferrous oxide material used on magnetic tape.

Each side of a magnetic disk contains circular tracks for recording information. Since the segments of each track have pre-designated addresses, it is easy for a computer to go directly to a specific location on a disk



MICR characters on a bank check.

to find the particular information it needs. It is also quicker for a computer to get information from a disk rather than from a tape.

Speed of information access depends on the computer's ability to look something up directly instead of searching an entire file. Using a disk to look up information in a computer is like using a dictionary to look up a word.

Character Recognition Machines

Information scientists are also experimenting with new ways of converting printed information to machine readable form without having to type or key the information at all. Machines have already been built that look at the printed page the way our eyes do and automatically convert the printed information to spots on magnetic tape. These machines are called ***Optical Character Recognition*** (OCR) machines or ***Magnetic Ink Character Recognition*** (MICR) machines. Since the shape of each letter of the alphabet and number is different, it is possible for a machine to examine the shape of a letter or number to determine what it is.

If you will look at the account number in the lower lefthand corner of a bank check, you will see an example of some numbers that can be read by a Magnetic Ink Character Recognition machine.

In this chapter we have discussed several different methods for changing information into a machine readable form that a computer can handle. Millions of magnetic tape spools containing information already exist and are being used for computer processing. In the years ahead, more and more information will be recorded this way.

As large amounts of information become available as *input* for computer processing, what kinds of things will information scientists attempt to do? The next chapter investigates this question.

GETTING INFORMATION FROM A COMPUTER

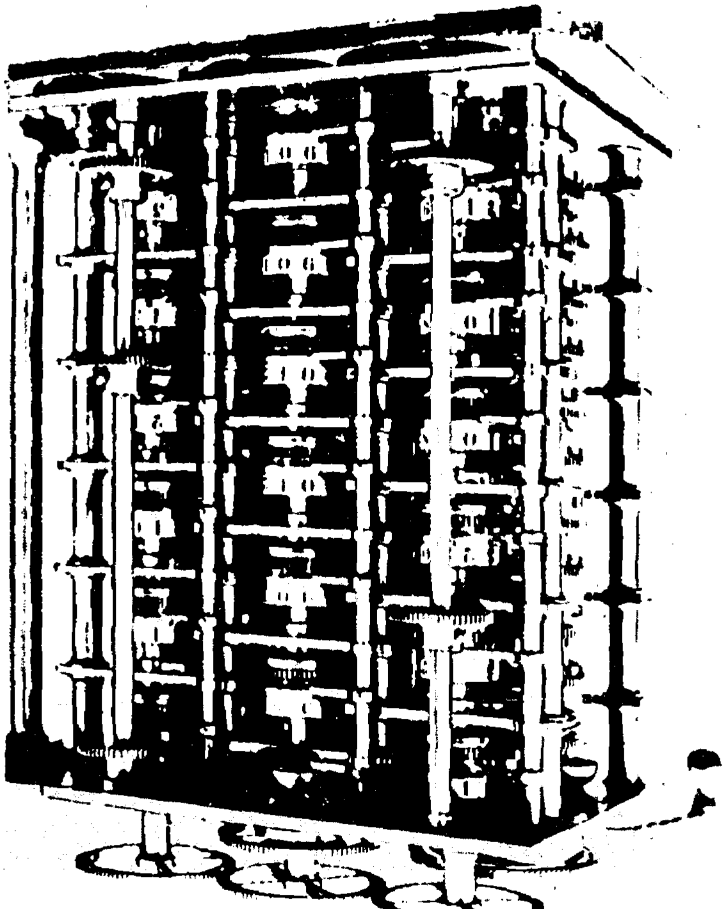
As more and more machine readable information becomes available, libraries will surely buy magnetic tapes along with books. They already collect motion picture films and sound recordings for our use and pleasure and, in time, they will become the main organization in the community that provides us with access to all kinds of information.

However, just as we need a projector to show motion picture films, and a record player to listen to stereo recordings, so a computer will be needed to help use information stored on magnetic tape.

What is a computer? How does it work? What can it do? and, How will it help us find information?

An English mathematician named Charles Babbage wrote a paper in 1822 that outlined the functions to be performed by a computer. However, it wasn't until 1944 that engineers were able to build such a machine that worked. The first computer was housed at Harvard University and its chief job was to solve complex mathematical problems.

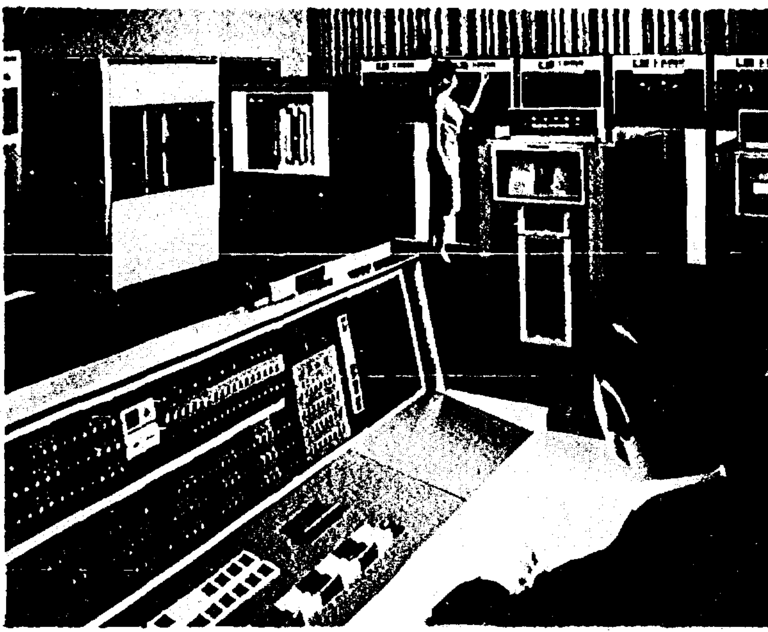
During the past 25 years, however, computers have improved considerably. They are faster, cheaper, smaller, and more efficient. In 1970, there were about 80,000 computers in the United States and they were being used for many different purposes. The word compute means to add up numbers and provide a result. Computers can also subtract, multiply, divide, and perform other arithmetic calcula-



The "Difference Engine" of Charles Babbage. This digital, decimal computer was conceived in 1820. A small model was successfully built, but manufacturing problems prohibited the construction of large machines.

tions. Early computers could only process numbers.

Today, the word "computer" has a much broader meaning. It refers to a machine that not only performs arithmetic efficiently, but also handles the letters of the alphabet. This new feature is the one that allows the computer to function as an information machine. A typical computer installation looks like the one shown below.



A modern electronic digital computer.

How to Program

Two things are needed to make a computer work as an information machine: (1) machine readable information and (2) a *computer program*. The previous chapter dis-

cussed how machine readable information is prepared, but did not explain what a computer program is.

Many companies like IBM, UNIVAC, General Electric, and Control Data manufacture computers. When you buy or rent a computer from one of these companies, they will teach you how to operate it and make it perform successfully. In doing this you will learn a new language called a ***programming language.***

The programming language is used to write programs, and programs are sets of instructions that tell the computer what you want it to do. It's much easier to learn a programming language than a spoken language like French or German. Programming languages have much smaller vocabularies and are written and learned in English. Many high schools and colleges now offer programming language courses to students who want to learn how to program a computer.

Although computers can help man a great deal, they are not able to learn and think for themselves like humans. You will remember in the first chapter we said that the ability to remember ideas and create new ones is uniquely human. A computer alone can do neither, but must be told what to do by a human. It is the programming language that enables us to tell the computer what to do.

Once you learn a programming language, you can write instructions to the computer that cause it to do exactly what you want. For example, you could tell the computer to alphabetize all the names of the students in

```
100 PRINT "THIS PROGRAM CALCULATES THE AREA OF A"
110 PRINT "CIRCLE IF YOU SUPPLY THE RADIUS."
120 PRINT "WHAT IS THE RADIUS"
130 INPUT R
140 LET A = 3.1416*R↑2
150 PRINT "THE AREA IS "; A ;" SQUARE UNITS."
160 PRINT "WOULD YOU LIKE TO GIVE THE COMPUTER"
170 PRINT "ANOTHER RADIUS (TYPE YES OR NO)"
180 INPUT X$
190 IF X$ = "YES" THEN 120
200 END
```

This computer program, written in the BASIC programming language, calculates the area of a circle for any radius given.

a school and print out a list for the teacher. If you had a file of the names in machine readable form, say on magnetic tape, and the names were all mixed up on the tape, the computer would rearrange and sort them into alphabetic order. When it finished doing this, the program would then print or output the list on an automatic typewriter.

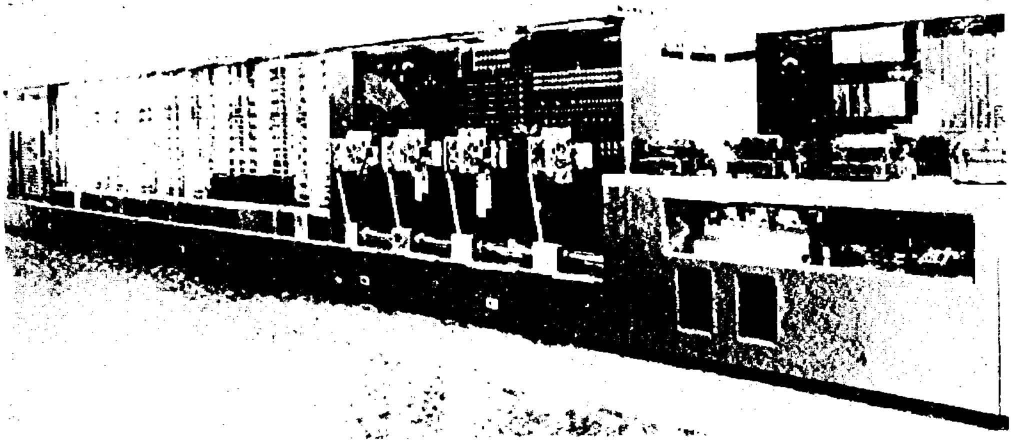
This is only one example of how a computer can be used to handle information. Using the same information, you could also write a computer program that instructed the machine to select only the names of female students in the school who were 10 years old and in the sixth grade. From just these two examples, we can see how a computer can be used as an information machine to store, rearrange, select, and print information according to instructions.

Information scientists are interested in using computers to perform many different information functions. Computer programs have been written to index documents and books, to translate from one language to another, to find books in a library, to compare poems, to compose music, to answer questions, to print dictionaries, and to distribute information to students and teachers according to their requirements.

Other programs have been written to look through insurance record files, search for information on automobiles, find the correct antidote for someone who has taken poison, choose information on chemicals, examine patient records in hospitals, and obtain legal information for lawyers.

And still other computer programs have been written to help students learn a subject, help doctors find cures for people who are sick, and give managers the information they need to run their businesses.

Some big companies, like IBM, use a computer program to examine the titles of new scientific and technical magazine articles. A computer program stores the subject words of interest to each IBM engineer and then checks automatically to see if any of these words are contained in any of the new titles. Whenever a match occurs, the program causes the computer to print out a note to the engineer telling him about the new document.



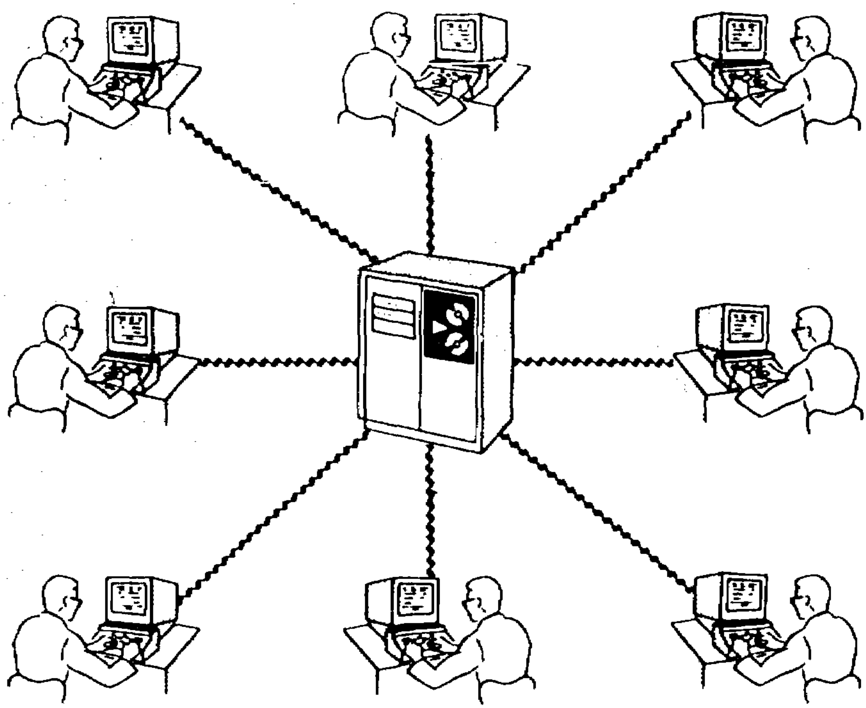
The first U. S. computer, the Automatic Sequence Controlled Calculator, which was built at IBM and presented to Harvard University.

This is called ***selective dissemination of information***.

Experimental computer programs for translating from one language to another are also available. Most ***machine translation*** research has been from Russian to English, but many other languages, including Chinese, have been attempted. Programs to perform word-for-word translation are fairly easy to write. However, it is much harder to write programs for rules of grammar that can smooth out stem endings and provide proper word order. No computer program yet exists that interprets meaning or translates idioms with any reliability. However, information scientists continue to research the field because of the enormous potential benefits they know will accrue if artificial language barriers between countries could be brought down. ***Language processing*** is the phrase information scientists use to describe computer programs that deal with words and ideas.

Telephoning the Computer

Until a few years ago, it was necessary to go to a computer center in order to use the machine, but recent improvements have made it possible to use a computer from a distance. This is done by connecting an automatic typewriter to a telephone in your home or school and then dialing the computer as you would another telephone. Once the telephone



Time sharing allows many persons to use one computer at the same time.

line connection is made, the computer is ready to receive your instructions. This is known as being *on-line* with the computer and you share its time along with others. ***Time-sharing*** allows many people to use the computer and its store of information from a distance at the same time.

The ability to communicate with a computer over a telephone line is of great importance to information science. It means that no matter where information may be located or stored, it can be made instantly available to anyone who has access to a telephone. Once information is in machine readable form, not only can it be processed by a computer, but it can also be transmitted over telephone and radio communication systems.

Telecommunications is the word used by information scientists to describe the way different types of information can be sent and received over great distances. It is a compound word. "Tele" means distance and "communications" means the sending of messages. Telecommunications means sending messages of information back and forth over great distances.

This development is sure to change the way information is used in business, government, education, and research because it will create vast ***data banks,*** thus permitting anyone to use a much greater store of information than was ever available before. It also means that information can be transferred or delivered directly to any person no matter where he lives. It is for these reasons that information science is concerned with improving the methods by which people can get information from a computer.

COMMUNICATING INFORMATION

By Telephone

One of the greatest inventions of all time is the telephone, invented by Alexander Graham Bell in 1876. Though we occasionally get a busy signal on the line, the telephone is a marvelous communications instrument. However, a telephone by itself is useless; its value lies in reaching other telephones. The more phones and other communication devices that are interconnected, the greater its value.

Each telephone is not connected to another by direct wires, but the wires do come together in many central stations throughout the country, and these stations are used to switch a call to the correct number. The telephone network in the U. S. includes about 100,000,000 telephones interconnected by more than 700,000,000 circuit miles of cable, wire, and radio relay systems crisscrossing the land. On a normal day the network handles with speed and accuracy more than 300 million calls in a variety of forms—voice, television signals called "video," and computer information.

Certainly the telephone is one of the best means we have for communicating voice information. It enables us to speak with another person anywhere in the world, and it can be used to send pictures and even machine readable computer information over the same lines. It is also used to communicate across the ocean. This is done over telephone wires that are wrapped in watertight cables

and carefully laid on the ocean's floor by a telephone cable ship.

For example, two Trans-Pacific undersea telephone cables link Hawaii with the mainland of California.

At present the information scientist uses telephone lines for communicating spoken information, for sending and receiving ***teletype*** messages, for on-line computer work, and for the transmission of picture information by ***facsimile.*** Though some of these terms may be unfamiliar to you, each is a part of the vocabulary of an information scientist.

A teletype machine works very much like a telephone, except that the information it sends and receives is typed out rather than spoken. Hundreds of libraries in the United States use teletype machines to request books or a specific piece of information from other libraries. A "yellow pages" book with only teletype telephone numbers in it is put out by the telephone company, and it is just as easy to "call up" a teletype machine as it is a telephone.

On-line use of a computer over telephone lines is becoming more popular, too. To use the computer this way you must first have a telephone and a computer ***terminal*** in your home or classroom. The computer may be located far away from the terminal, perhaps even in a different city or state.

Alexander Graham Bell speaks the first words on the new telephone connection between Chicago and New York on October 18, 1892.

The terminal is a machine that can look like a typewriter or a TV screen. Since the computer has its own telephone number, you may dial it as you would another phone. When you hear a "beep", you know you're linked on-line to the computer. Thereafter the computer is used as if it were in the same room with you.

Once you are on-line with the computer, you can do many different things. Using your programming language, you can solve a mathematical problem, learn a new subject, or find old information that you yourself may have stored in the computer.

Information scientists are studying ways to assist doctors, lawyers, engineers, and other persons to use computers on-line as part of their daily routine. The computer is such a new information instrument, however, that it will take many years before information scientists discover all of its possible uses and applications.

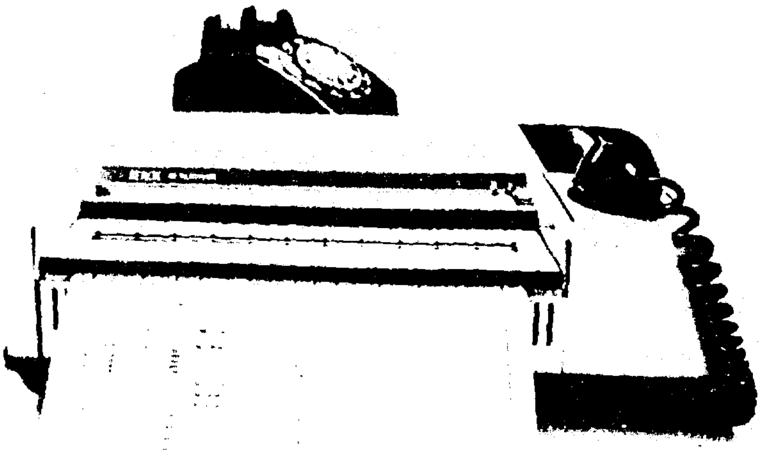
Sending computer data back and forth over telephone lines is possible because the telephone company's system is able to change the magnetic codes of the computer into tones that are carried over the telephone line and then change them into codes again at the other end in order to operate a distant computer or some other machine.

The same thing can be done with picture information. A TV camera scans a page of printed text and sends millions of bits of information as tiny black and white spots that make up each line. For example, if you examine a picture on a TV set very closely with a magnifying glass, you will see that it is really made up of these little spots. The result at the receiving station is a ***facsimile***, or duplicate print of the original page that was scanned by a TV camera or by a similar machine called a facsimile scanner. Facsimile comes from the Latin words "factum" and "simile", meaning exact duplicate.

Many libraries are interested in facsimile because it will permit them to exchange pictures and other graphic information over the telephone. To do this, of course, each library would need to have a facsimile scanner and a facsimile receiver as terminal equipment.

Information scientists are working with companies that are starting telefacsimile services to compete with the U. S. Post Office by providing a speedier wav of sending and receiving private messages over great distances. A facsimile scanner and recorder is shown on the next page.

Another device that is of special importance to the information scientist is the touch-tone telephone. In many ways the touch-tone telephone is similar to the familiar dial telephone. However, there is a major difference. Only the touch-tone telephone enables a user to transmit information directly to a computer. It does this by emitting different frequencies of sound for each number represented on the push buttons. When a touch-tone telephone is used to call a distant computer, it is able to transmit numerical information after the telephone connection is established. And when this



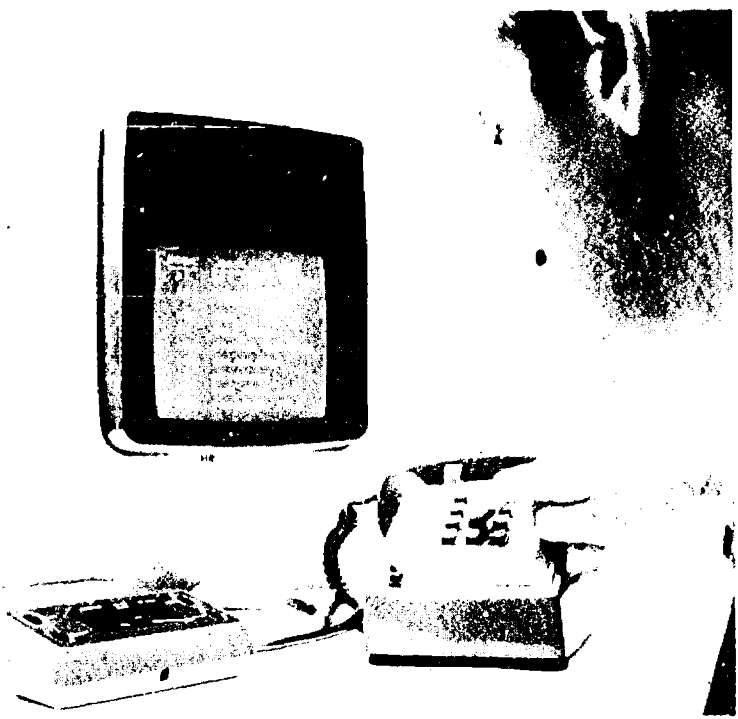
A facsimile scanner.

numerical information is received by the computer it can cause it to function by remote control. Touch-tone developments are prompting information scientists to consider new ways to connect a user in his home with a distant library or data bank.

Development work has been started on sending and receiving live television pictures of people while they are telephoning. At the New York World's Fair in 1965, the telephone company demonstrated a new instrument called a ***picture phone*** that lets you see the other person when making a telephone call. Someday these picture phones will be in every home, school, and office, and they will greatly expand the types of information we will be able to telecommunicate.

By Cable

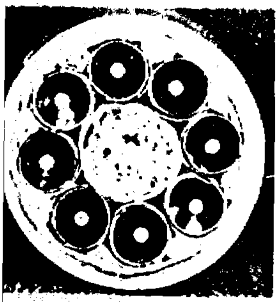
Although the telephone line is fine for carrying voice conversations, information scientists believe we will need more than telephone wires to carry the huge amounts of machine readable data that computers will handle in the future. If the tens of thousands of tiny bits that make up a computer message or a TV message had to be squeezed through a telephone line, the message would take a long time to get where it's going. However, new channels of telecommunications are being



Picture phone services include communicating with computers. The user can dial numbers to ask the computer to display specific types of information on the screen.

developed with greater capacity than the narrow telephone lines now provide, and these broader channels will permit messages to flow back and forth much faster.

Coaxial cable is one example of a new kind of wire that can carry many times the capacity of the telephone line. As you can see from the picture, a coaxial cable has a number of copper wires located inside an insulated tube. In Latin the prefix "co" means "the same" and "axial" refers to an axis.



oaxial cable showing in-rnal wires.

In a coaxial cable the wires and the tube are parallel and therefore have the same axis; this is how the cable got its name. Since each of these wires can carry as much or more information than one telephone line and there are many of them in each cable, you can see that much more information can be sent much faster through coaxial cable than by telephone.

Cable television stations (CATV) will soon send television signals into the home over coaxial cables. CATV stations have very powerful antennas that enable them to capture TV signals from many distant TV transmitters and retransmit the signals to the home through underground cables. Instead of receiving a few local stations on a home TV set, the CATV subscriber will be able to see many TV programs long distance. CATV signals will be crisp, clear, and without "ghosts".

Just as telephone lines enter the home today from the street, so will coaxial cables a few years hence. The Federal Communications Commission expects to reserve at least one or two CATV channels for educational purposes. Over these educational channels, CATV coaxial cables will someday bring picture answers to information questions directly to individual home TV sets.

By Microwave

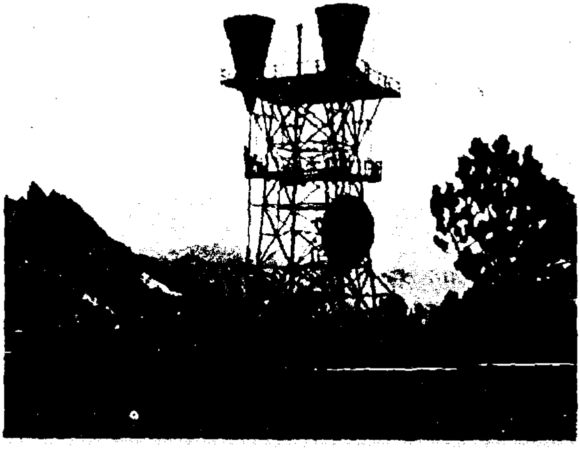
Another way to send and receive information is by microwave. Engineers refer to the word microwave when describing information systems that use high frequency bands of the radio spectrum for transmission. Normal radio broadcasts use the lower frequencies. The bands for higher frequencies are to be found way out to the right and off our home radio dial. There are many microwave sending and receiving stations in the United States and many more are being built.

You can recognize one in your own neighborhood by looking for an antenna tower with a blunt nose and some round "dishes" on top. The blunt nose shows the difference between a microwave antenna tower and a pointy TV antenna tower. The pictures you see on pages 56 and 57 show the difference in appearance between the two towers. Microwave towers are spaced about 30 miles apart and the top of one tower must be able to "see" the top of the next tower without anything coming between them. This is called line of sight.

To have line of sight, microwave towers are usually installed on top of tall buildings or high mountains. Microwave connections can be thought of as broad communication high-ways in the sky because they take the place of many thousands of coaxial cables.

By Satellite

The newest and most promising telecommunications development for sending and receiving information is the ***communications satellite.*** We probably would not need a communications satellite if it were practical to build microwave towers that would span the ocean. However, it is not practical to string microwave stations, spaced 30 miles from each other, across the ocean. And, because of the curvature of the earth, if you tried to build a microwave tower in the



A microwave tower (above) and a television tower (right).

middle of the Atlantic Ocean that would have line of sight with the Statue of Liberty in New York and the Big Ben Clock in London, it would have to be at least 475 miles high! It is this limitation that gave rise to the development of the communications satellite.

A communications satellite is an object that is placed in orbit above the earth to receive and retransmit messages from different points on earth. It can be thought of as a "switchboard in the sky". A communications satellite is launched by a rocket into a circular path around the equator at an altitude of approximately 23,000 miles. At this distance its speed keeps exact time with the rotation of the earth. The communications satellite then appears to remain fixed in space and messages can be beamed to it from the same places all the time because it is always in line of sight.

A communications satellite is not very big. A model of one is on display in the lobby of the Communications Satellite Corporation building in Washington, D. C. It stands about 10 feet high, is about 8 feet wide, and has several antennas projecting from it that look like the antennas on top of some home TV sets.

Inside there is a receiver for accepting messages from earth, an amplifier that strengthens the signals in these messages, and a transmitter that beams them to the point on earth where they're going. The outside of the communications satellite is coated with tiny solar batteries that change energy from the sun into electrical power needed to operate the satellite. A communications satellite can

Above, at the Fourth U.N. Conference on the Peaceful Uses of Atomic Energy, held in Geneva, Switzerland, in 1971, a visitor queries by satellite communications a computer data bank in Oak Ridge, Tennessee. Answers to his bibliographic inquiry are displayed on the screen in front of him. The Tennessee computer serves a number of terminals in the U. S. Below, Don Davis of the Technical Information Center in Oak Ridge queries the computer.

work well for about 6 years before being replaced.

Three satellites are all that are needed to cover the globe with communications except for the North and South Poles. Communications satellites take the place of many thousands of microwave stations that would otherwise be needed. Today, communications satellites are being used for sending TV programs from one country to another, for holding international telephone conversations, for exchanging machine-readable data between computers located in different countries, and for sending and receiving facsimiles of pictures. Communications satellites made it possible for people the world over to witness President Nixon's historic visit to China in 1972, and to follow the Olympic Games from Munich, Germany.

As we have said before, information exists in many different forms. When someone wants information he may need spoken information recorded on audio tape, written information in printed form, pictorial information on film or on TV tape, machine-readable information stored on magnetic tape, or combinations of these forms. The satellite is of special interest to the information scientist because of its ability to send and receive all forms of information over the same broad channel.

A two-way telecommunications system should provide a way to integrate, or mix, sound, digital, and video signals into a single system. The communications satellite does this.

FINDING INFORMATION IN MICROFILM

A Chinese proverb says that "one picture is worth a thousand words". Pictures contain a vast amount of information because they reveal details that are hard to describe in words. This is particularly true when information is captured on film. Film is a powerful information medium that records all the details seen in a certain situation at a certain time.

Once film is exposed, the developed picture or pictures can be looked at over and over again. A film that has small pictures of printed or graphic information is a ***microfilm.***

When Neil Armstrong and Buzz Aldrin landed on the moon, they took many pictures and they also described what they saw with words over the radio. The movie films and still photographs they brought back to earth were studied by photo-interpreters.

Each film is placed under a stereomicroscope that allows scientists to examine, measure, and evaluate the minutest part of the picture of the moon's surface. Later on, the results of what the photo-interpreter saw will be printed in books that describe the enormous amounts of information contained in the films.

Film is an especially important information medium. Not only does it capture a lot of detailed information in one snapshot, but it also records this information in a very small space. The width of a film in our home cameras is about 2 inches, yet we can record a

picture of a Boeing 747, the Empire State Building, or the U.S. Capitol in that small space.

For this reason, film is sometimes used to photograph printed or graphic information such as the pages of a book, files of business letters, collections of newspapers, magazines, and so forth. Compressing printed or graphic information into a compact film form without altering or changing the information content of the original document is called microfilming.

Microfilming permits bulky materials to be compressed into a more convenient, smaller size. For example, The New York Times regularly films the pages of each copy of its daily paper. An entire month of newspapers can be put into a single reel. Individual frames of a reel of microfilm are referred to as microphotographs or micro-images.

The History of Microphotography

In 1839 John Benjamin Dancer, an Englishman, combined photography with microscopy to produce a microphotograph. He used a microscope lens for his experiment and was thus able to reduce a page of information to a very small size. Ever since, other scientists have tried to make smaller and smaller pictures.

Buzz Aldrin walks on the moon in this photograph taken by Neil Armstrong.

A microfilm reader.

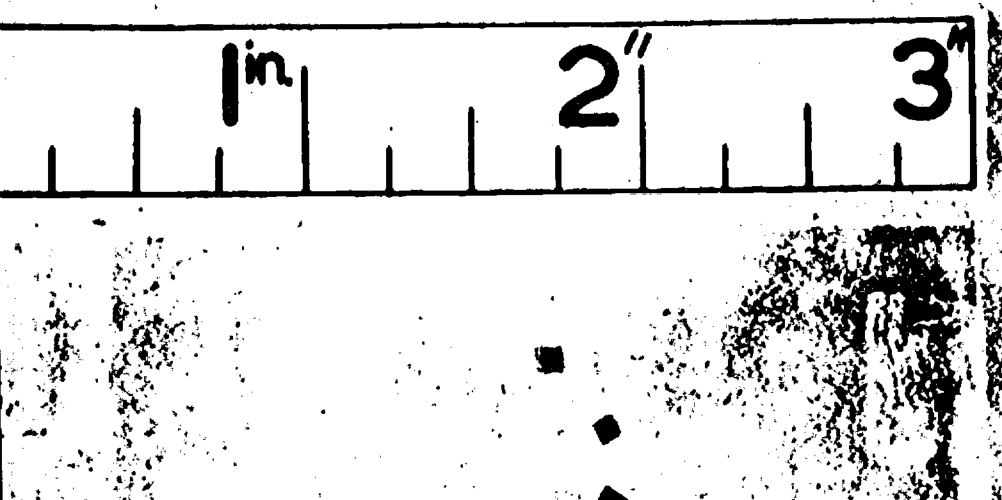
In 1860 an Englishman named Sir David Brewster wrote a scientific paper describing how he could conceal many tiny pictures of information in a space no bigger than an ink dot.

During the Franco-Prussian War, the French Government used microphotographs to communicate with its forces in Paris when the city was under siege. As many as 3000 pages of information were reduced to film just a few inches long. The lightweight film was rolled into a scroll, slipped into a small container, and attached to a pigeon's tail feather. When the homing pigeon reached Paris, the film was taken from the container, shown on a projector, and the messages were copied by hand onto paper.

The German Army in World War II developed a photographic method called "microdot" for its espionage, or spy, work. Several pages of secret information were photo-reduced to a very tiny size—so tiny, in fact, that the messages were hidden under the punctuation marks in the sentences of a printed book! Only the German spy knew which period or dot in the book covered his message. Microdot is an example of how far microphotography technology had advanced by 1940. Since that time, however, many other changes have been introduced into the field.

Types of Films

Four kinds of film are used to make microphotographs. "Silver-halide" film is the most popular. This is the same film used to take pictures at home. The surface of the film is coated with chemicals containing microscopic grains of silver. When a picture is snapped, light enters the camera and strikes the silver-halide chemical coating. This is called "exposing" the film. The chemicals are so sensitive to ordinary light that wherever



One of the microdots above is shown in an enlargement on the facing page. Extracts from this message read as follows: "9 December 1960. Hello my dear and beautiful one! I am sending you my best wishes on the festival of the 43rd anniversary of October [Russian Revolution]. Expected letters from you, but it seems that it will be possible only by the end of the month. My work is getting on all right. . . I feel lonely---lonely. . . . I understand everything about your work and your friend and what you said about his work and his excellent pro-Soviet attitude. . . . There is great emptiness in me . . . . I am always happy when holidays end and ordinary working days re-start. . . . If at all possible I ask you to give KNE 2500 roubles a month. . ." This message led Scotland Yard to investigate the identity of the sender whose alias was "Gordon Lonsdale". It established that Lonsdale was a Russian spy and that he had been reprimanded by Moscow for having broken the security rules by (1) writing to his wife and (2) writing in uncoded Russian.

the light falls on the coating it uncovers the hidden grains of silver.

The film is then taken to a darkroom where it is "developed", or bathed in other chemicals that wash away the unexposed silver. What remains is called the "negative"; it is a piece of film that has a dark or grey layer called an "emulsion" and clear white areas in other places. A negative is used to make readable prints of pictures.

"Diazo" film is a second type. This film is coated with a layer of dye that is sensitive to ultraviolet light. Ultraviolet light is unlike ordinary white light. It has a different wavelength and looks purple to the eye. When Diazo film is exposed to ultraviolet light, portions of the dye break up.

The film is developed by placing it in a chamber filled with ammonia vapor. When the ammonia vapor touches the coating, a chemical action occurs causing the remaining dye to flow into the film and the broken-up dye to dry up. The result is a piece of film that has clear and dark areas; thus, the picture becomes visible to the human eye.

A third film is called by its trade name, "Kalvar". Kalvar is coated with a plastic layer of microscopic bubbles of gas. Exposure to ultraviolet light expands the gas in the bubbles. To develop the film, it is passed between warm rollers; no wet chemicals are required. Heat causes the bubbles to burst showing the clear film underneath. The rest of the plastic coating on the film remains to provide the picture information. This "dry" developing of Kalvar makes it especially useful in commercial photography where it is sometimes very important to make a picture in a hurry.

Another process, called "photochromics", offers a different way of making microphotographs. Photochromic film coatings contain microscopic individual molecules that can alternately change their color. This happens only when the molecules are affected by ultraviolet light. Exposure to ultraviolet light changes the molecules from a colored state to a colorless state. This "switch" takes place without any heat or chemical assistance.

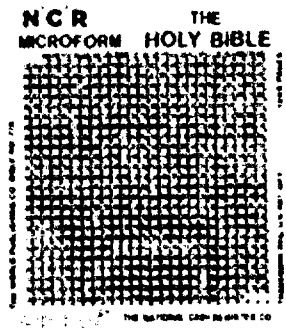
Photochromic film can also switch back to its original state by exposing the film to white light. Thus, information on photochromic film coatings can be erased just like information on magnetic tape.

All four films, of course, depend on the lens of a camera to reduce an image to its tiniest dimensions. Photochromic film, however, is the one most capable of high density storage. Shown on page 70 is a 2-by-2-inch film made from a photochromic negative containing almost 2000 ***p**hoto**c**hromic **m**icro**i**mages* (PCMI) of the King James version of the Holy Bible. Even smaller reductions than this are possible.

Holography

A part of the new technology, which is very exciting to the people interested in microfilm, is the *laser* and its ability to produce *holograms*.

The word laser stands for ***l**ight **a**mplification by **s**timulated **e**mission of **r**adiation*. In



A photochromic film of the King James version of the Bible.

1951 Charles H. Townes, an American physicist, found a way to change the natural balance of low-energy molecules into a high-energy state, making them even more active so that they gave off more energy.

The emission is in the form of a powerful, narrow beam of light that can be reduced in size so that it is no more than a hundred-thousandth of an inch wide. This is a laser.

The word "hologram" originated with Dr. Dennis Gabor, a Hungarian scientist. In the late 1940s, while experimenting with the invention of a new microscope, Dr. Gabor made a special kind of picture, using a tightly packed bundle of light rays known as coherent light. He called this a hologram; the word comes from the Greek words that mean "whole picture". In 1971 Dr. Gabor received the Nobel Prize in physics for his invention and development of holography.

This strange kind of light has some interesting properties. Waves of coherent light consistently maintain their relative spacing, which means that by shining a beam of light from one object to another and knowing the wavelength of the light, the distance between them can be measured very accurately. In part, it is this property of regular wave spacing that makes the production of holograms possible.

A normal photographic plate records dark and light spots depending on how the object being photographed is illuminated. Laser photography does the same but in addition it records information about the distances from the object as well. This is done by splitting the laser beam into two parts.

One part shines on the photographic plate as a reference; the other is projected on the object and the reflected light waves also reach the plate. The two similar sets of light waves are said to interfere because the reflected light is out of phase according to the outlines and surfaces of the object.

These differences in wavelength produce spots on the plate that record the object's third dimension. The plate is then developed like ordinary photographic film. After processing, it looks dull and gray to the naked eye. However, when viewed with a coherent light source, such as a laser, all the information on the plate becomes visible including dark, light, and distance information, and this supplies the full three-dimensional image.

Really, it's more than just a three-dimensional picture; the distance information is so completely and thoroughly recorded that the viewer can actually see around the object just as he does in the real world. This is the new technique of holography.*

The fact that three-dimensional information can be stored in microscopic form on film opens up an entirely new world of microfilm uses.

Forms of Microfilm

It is clear that microfilm provides a very useful method for storing large amounts of information. Microimages may be stored in two forms—sequentially and individually.

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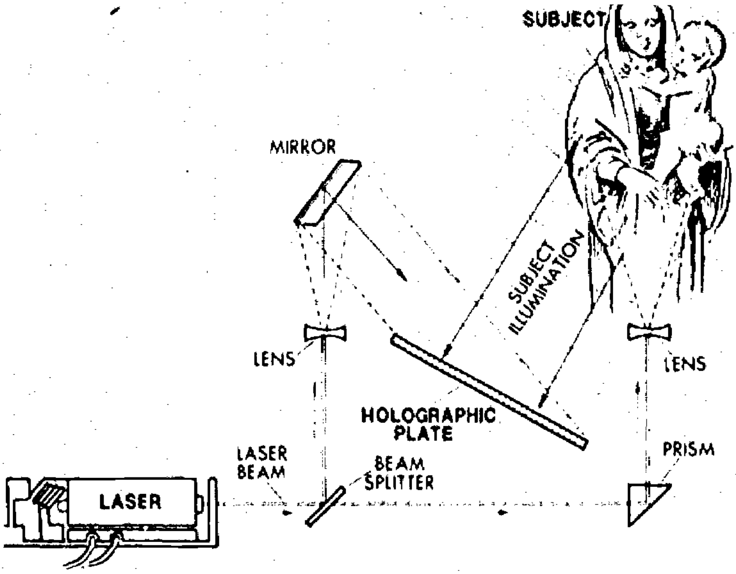
*For more information on lasers and holography, see ***Lasers***, another booklet in this series.



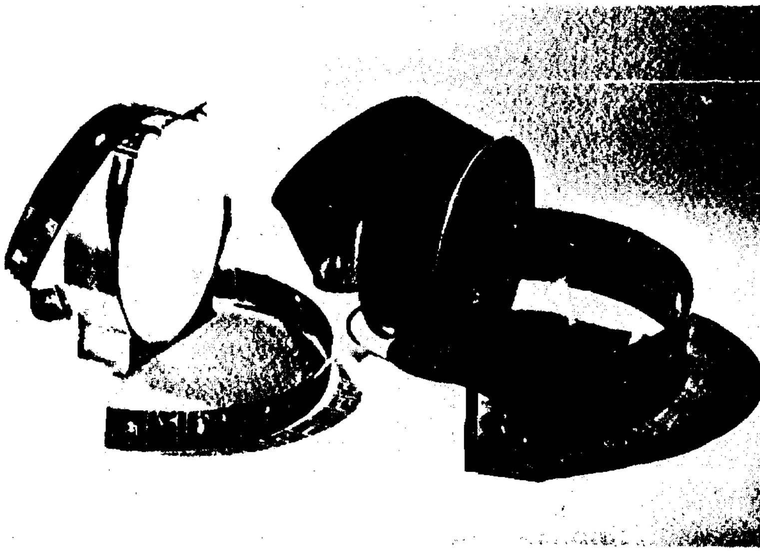
A major problem in the public display of art masterpieces is how to protect them from theft or damage. One solution would be to display a hologram of the object while the artwork itself is safely stored in a vault. Holographic copies of the same artwork could be displayed around the world without ever moving the original object. In fact, several years ago the Cincinnati Art Museum held an art show using holograms of famous sculptures. Above, a diagram shows how a laser beam is divided, directed, and reflected to capture a holographic image. Below, Dr. Ralph Wuerker, a physicist, aligns a ruby laser and a holographic plate to recreate a 3-dimensional image of a 14th century statue of a Madonna and Child by an unknown sculptor.

When stored in sequence the microimages are recorded on 100-foot spools of 35mm or 16mm microfilm. One millimeter equals 0.04 inches. Therefore, 35mm microfilm is 1.4 inches wide and 16mm microfilm is 0.64 inches wide. Spools of microfilm can be handled manually or placed in cartridges for use with automatic viewing machines. The figure on the next page shows what microfilm spools and cartridges look like.

In addition to spools, microfilm can also be stored as individual units. For example, a microfilm jacket holds strips of microfilm placed in sleeves of clear plastic; a microfilm aperture card contains one or more microimages mounted in gummed window frames in an IBM or other card; ***microfiche*** is a sheet of film with many images in rows and columns (the French word "fiche" means "sheet"); microtape consists of microimages that are printed on adhesive backed paper for cutting and pasting on file cards; and a microcard is like a microfiche except that its microimages are printed on paper cards instead of sheets of film. The figure on page 76 contains pictures of various microforms.

Viewing and Copying

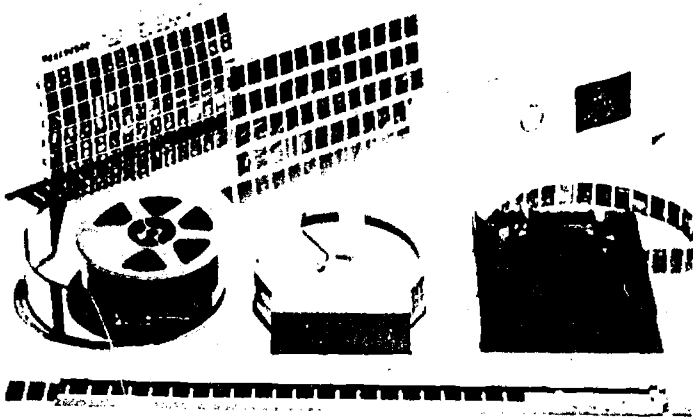
Information scientists are working with publishers to make entire libraries of books available in microfilm. This will enable libraries to concentrate thousands of books in a film container the size of a shoe box! At present, the U. S. Government is the foremost producer of microfilm.



Microfilm spools and cartridges.

In 1970, the Department of Defense, the Atomic Energy Commission, the National Aeronautics and Space Administration, and the Office of Education published their research and technical reports or microfiche and together distributed almost 20 million microfiche. Also the U. S. Government Printing Office announced in 1971 that it intended to publish all U. S. Government documents on microfilm. Thus, microfilm, in all forms, is rapidly becoming an especially important method for distributing information even though it was originally developed as a space saver.

In order for anyone to use the information in a small microphotograph it must be magnified for viewing. Equipment on the market today makes it possible not only to



Microfiche, microfilm jacket, aperture card, spool, cartridge, and strip.

view a microphotograph but also to obtain, if needed, a paper enlargement of all or part of the desired page in a matter of seconds. These machines are called reader-printers, and are illustrated on the next page.

If your local school library does not own a reader-printer, it probably has a machine in the library that will permit you to view a microphotograph life-size on a screen. Information scientists are working to produce an inexpensive, portable microfilm reader that a student may use at home or in class.

A portable microfilm reader is certain to promote increased use of all forms of microfilm in schools and in the home. Designers believe it should be lightweight, about the size of a book, possess a good internal light source, have sharp focusing, and above all be just a little "cuddly" so that people will feel as comfortable reading microfilm as they do curled up in a chair reading a book.

These are called "human-factors" considerations, and information scientists know that they must make the relationship between man and machine as natural and uncomplicated as possible. Many human factors are taken into account in the design of any information

A microfilm reader-printer.

machine and that is why numerous psychologists have entered the field of information science.

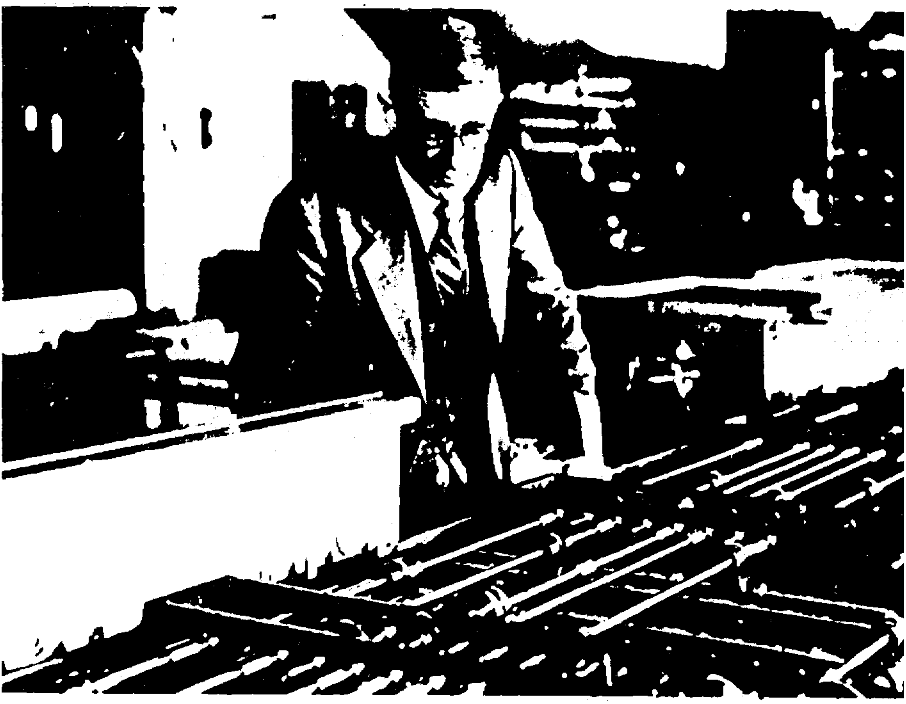
Computers and Microfilm

As more and more information is photographed on film, it becomes necessary to index the film in order to find where the information is. Dr. Vannevar Bush, an American scientist, saw this need in 1946 and suggested a machine called MEMEX that would automatically search information on a spool of microfilm. Today, computers are used to index and search the needed information and also to find and choose the microphotograph they want from a very large microfilm file.

The computer is influencing the development of microfilm in other ways too. For example, computers are used to produce microphotographs on microfilm. Instead of printing the computer's results or output on paper, it is programmed to operate a special machine that uses a sharp pencil of light—called an electron beam—to form the shapes of letters and numbers and project them on film.

The operation is so fast that hundreds of page negatives can be produced every second. These special purpose machines are called COM, which stands for *computer output microfilm.*

Computers can also be used to make-up a page for *electronic printing.* They can be programmed to use a certain type size and style, set the width and height of each page,



Dr. Vannevar Bush shown with a portion of his Differential Analyzer. Built at the Massachusetts Institute of Technology, the Differential Analyzer was the forerunner of modern analog computers.

insert headings, produce page negatives on film, and do many other things automatically. Electronic printing is a growing area of interest in information science.

These are only some of the many developments that are taking place in the world of information science. The object is to find new ways to harmonize the electronic power of the computer to the recording power of film in order to produce creative and useful applications.

It is clear that microfilm is going to play an important part in information science. It has many uses in addition to record-keeping. In the very near future, microbook libraries will be available. The hundreds of pages found in a typical book will be photographed on a single 4 x 6 inch microfiche. Thus, thousands of books will be stored in a container the size of a shoebox. Instead of circulating microfiche like books, *tomorrow's libraries will* duplicate them for you to take away and read on your own portable microfilm reader!

Microfilm technology is the start of a new era in information transfer. Together with the computer and telecommunications it will surely become a powerful force in shaping information developments in our country and the world.

THE FUTURE OF INFORMATION SCIENCE

[illegible] communications, and computer graphics. With these tools, it is possible to develop and build information systems that will serve many different people in many new ways. Libraries, for example, are working together to build ***information networks*** that will link the information, books, and audiovisual materials of many libraries into one large library system.

Using communications, it will then be possible to make the information resources of the whole network available to any single user in the country, no matter where he lives. After all, why shouldn't a student who happens to live in a rural area have the same right to use the rich knowledge resources of a big city? Networks of libraries interconnected by telecommunications will soon make this a reality.

Developing effective information systems and networks is the job of the information scientist. However, in addition to knowing all about the tools of information science, he must also understand how people "use" information. This is especially important because we all have different information needs and we all have different ways of expressing our demands for information.

It isn't enough to just make information available to people; to be useful, the information must also be relevant, timely, and of special value to the person who receives it. Therefore, many information scientists are conducting research into the information habits of various individuals like doctors, lawyers, businessmen, and others, trying to discover how they absorb information, how they use it, and what kind of information they need. These research studies are crucial to the development of better information systems.

Although information science is a new field, many universities are offering courses leading to graduate degrees in the subject. If you choose information science as a career, you can become a researcher who investigates the very basic theories underlying information science, or a practitioner who employs the tools of information science and technology to satisfy a particular information requirement, or a teacher who instructs young students in the fundamentals of this new field of work.

EPILOGUE

Many years ago, before air transportation and electrical communications were invented, the amount of information available in the world was manageable and the rate at which information was generated and used was leisurely. Since 1950, however, the picture has changed.

The pace of technological change, the population explosion, the development of audiovisual materials and TV, and the impact of communications and micrographics have combined to produce huge amounts of information at a faster rate for more people. This rate seems to be increasing alarmingly. Man today is subjected to a rate of information exchange greater than anything he previously experienced. In fact, the information pace is rising so rapidly that most of us cannot begin to comprehend its present and future impact on every aspect of our lives.

The tremendous growth of different kinds of information in modern times is evident. Less evident, however, is the fact that it is no longer possible for any one person to learn and remember everything he would like to know.

It is up to the information scientist to figure out how to save the words, sounds, pictures, and other symbols that constitute a record of man's past achievements, and to provide this along with new information whenever an individual wants it. This is the challenge that confronts the new information scientist.

If you accept the challenge and choose education science as a career, you can expect to do exciting work, with varied rewards, and reap the personal satisfaction of knowing your efforts are helping to deliver education and knowledge to those who want to learn and you are striving to build a better future for all of us.

GLOSSARY

Audio-visual Non-print materials such as films, film-strips, sound tapes, cassettes, and other media that record information by sound and sight.

Binary number system A mathematical method for representing information using only two symbols—a "0" and a "1".

Bit A contraction of the term *binary digit;* it is the smallest unit used to represent information in a binary system.

Cable television The reception of long distance television programs retransmitted to local TV sets over underground coaxial cables.

Communications Electrical systems that can send and receive information messages.

Communications satellite An earth orbiting device capable of relaying communication signals over long distances.

Computer An electronic machine capable of processing numbers and letters of the alphabet for many different purposes.

Computer output microfilm The transfer of information from a computer to microfilm through an intermediate photographic device.

Computer program A sequence of instructions that cause a computer to complete a desired task.

Data banks Large accumulated files of information in machine readable form for subsequent access by users via a computer.

Electronic printing The coupling of information stored on a magnetic tape with high-speed photocomposition machines that automatically set type for printing.

Facsimile The optical scanning of a page of printed or graphic information, its transmission over communication lines, and its faithful reproduction at a distant receiving location.

Ferrous Oxide A special substance that is coated on magnetic tapes and disks. It contains iron particles that can be magnetized or demagnetized by a computer to represent binary information.

Hologram A recording of information in three dimensions using a coherent light source.

Information Facts about any subject.

Information explosion The exponential increase in the growth and diversification of all forms of information.

Information networks The interconnection of a geographically dispersed group of libraries and information centers, through telecommunications, for the purpose of sharing their total information resources among more people.

Information science The study of how man creates, uses, and communicates information in all forms.

Information system A formal method by which information can be found, delivered, and used by those who need it.

Input The process of entering information into a computer and especially into its memory.

Language processing The use of computer programs to manipulate words and ideas for functional purposes.

Laser A tightly packed, narrow beam of light formed by the emission of high-energy molecules.

Libraries Places where information of all kinds is stored, systematically organized, and made available for use on request.

Library automation Application of computers and other technology to library operations and services.

Library science The study of the way libraries select, acquire, catalog, circulate, and make available books and other information.

Machine readable Information in a form such as punched holes or magnetic codes that can be processed directly by computers and other machines.

Machine translation The use of computer programs to translate one language into another.

Magnetic disk A ferrous oxide platter used for storing information in a way that makes it directly accessible for computer processing.

Magnetic ink character recognition The ability of a machine to electrically sense a printed letter of the alphabet and determine which one it is. Each letter on the source document is imprinted with special magnetic ink containing iron particles.

Magnetic tape A long strip of mylar plastic coated with ferrous oxide on which binary information may be stored, read, or erased.

Memory An automated device that stores information for later recall.

Microfiche A sheet of film that stores images of a reduced size in a grid pattern.

Microfilm Photographic film used for recording graphic information in a reduced size.

Micrographics The use of miniature photography to condense, store, and retrieve graphic information.

On-line The connection of a distant user terminal to a central computer through a continuing communication hook-up.

Optical Character Recognition The ability of a machine to scan a printed letter of the alphabet and discern which one it is.

Picture phone A new device that permits you to see the person you are calling when making a telephone call.

Programming language A special language supplied by a computer manufacturer for writing programs that cause the computer to function according to a programmer's instructions.

Publish Putting an author's creative work into a form that can be distributed to many people.

Punched card A stiff paper card of exact dimensions into which holes are punched to represent information. Subsequently, the information can be sensed and processed by mechanical, electrical, or optical machines.

Punched paper tape A narrow strip of paper into which holes are punched to represent information for subsequent processing by machines.

Satellite see **Communications satellite**

Selective dissemination of information Computer selection and distribution of information to specific individuals based on their prestated subject interests.

Telecommunications The sending of all types of information over great distances.

Teletype A piece of equipment capable of sending and receiving information that is typed at one location and printed at another.

Television A method of broadcasting information so that people see and hear it at the same time.

Terminal A remote communications hookup to a computer that may be used for either input or output.

Time-sharing Use of a central computer by many individuals in different locations at the same time.

READING LIST

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Page	
Contents page	Ashmolean Museum
4	Gerber Products Company
7	Ashmol[illegible]seum
9	The Metropolitan Museum of Art
11, 12, & 13	American Antiquarian Society
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54 & 56	American Telephone and Telegraph Company
57	WCDA TV-20
62	National Aeronautics and Space Administration
66 & 67	Neville Spearman
70	National Cash Register Company
73	Emmett N. Leith and Juris Upatnieks
79	Massachusetts Institute of Technology

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IB-507 Nuclear Reactors
IB-510 Nuclear Reactors for Space Power
IB-508 Radioactive Wastes
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