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The First Sheet from the Printing Press

GRADED SUPPLEMENTARY READING SERIES

GREAT INVENTIONS AND DISCOVERIES

BY

WILLIS DUFF PIERCY

NEW YORK
CHARLES E. MERRILL COMPANY

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GREAT INVENTIONS AND DISCOVERIES

CHAPTER I

INTRODUCTION

Tens of thousands of years ago, when the world was even then old, primitive man came into existence. The first men lived in the branches of trees or in their hollow trunks, and sometimes in caves. For food they chased horses or caught fish from the streams along whose shores they lived. If they had clothing, it was the skins of wild beasts. Life was simple, slow, and crude. There were no cities, books, railroads, clocks, newspapers, schools, churches, judges, teachers, automobiles, or elections. Man lived with other animals and was little superior to them. These primitive men are called cave-dwellers.

A resident of modern New York sits down to a breakfast gathered from distant parts of the earth. He spreads out before him his daily newspaper, which tells him what has happened during the last twenty-four hours all over the world. Telegraph wires and ocean cables have flashed these events across thousands of miles into the newspaper offices and there great printing presses have recorded them upon paper. After breakfast he gets into an electric street car or automobile and is carried through miles of space in a very short time to a great steel building hundreds of feet high. He steps into an electric elevator and is whirled rapidly up to his office on the twentieth floor. The postman brings a package of letters which fast-flying mail trains have brought him during the night from far-away places. He reads them and then speaks rapidly to a young woman who makes some crooked marks on paper. After running her fingers rapidly over the keyboard of a little machine, she hands him type-written replies to the letters he has received. A boy brings him a little yellow envelope. In it he finds a message from Seattle or London or Hong Kong or Buenos Ayres sent only a few moments ago. He wishes to talk with a business associate in Boston or St. Louis. Still sitting at his desk, he applies a small tube to his ear and speaks to the man as distinctly and as instantaneously as if he were in the next room. He finds it important to be in Chicago. After luncheon, he boards a train equipped with the conveniences of his own home, sleeps there comfortably, and flies through the thousand miles of distance in time to have breakfast in Chicago the next morning.

What is the difference between the life of the cave-dweller and the life of the modern New Yorker? We call it *civilization*. It is not at one bound or at one thousand that we pass from the primitive cave to New York City. Civilization is the accumulation of centuries of achievement. It is builded, in the language of Isaiah, "line upon line, line upon line; here a little, and there a little."

Different nations have accomplished different things and have scattered the seeds of these accomplishments among other nations. Certain individuals have seen farther in certain directions than their fellows and have contributed to civilization the results of their vision. Whoever has added to the safety, the happiness, the power, or the convenience of society; whoever discovers a star or a microbe; whoever paints a picture or plants a tree, builds a bridge or fights a righteous battle; whoever makes two ears of corn grow where there grew but one before; whoever lets the light shine in upon a darkened street or a darkened spirit is an agent of civilization.

The history of civilization is largely a history of man's struggle against the forces of nature and of his victory over them. Nature is always saying to man, "Thou shalt not"; and man is always replying, "I will." If diseases lurk in air and water, cures are ready in the mind of man. Nature shoves men apart with lofty mountains; but man drives his iron horse over the mountains or through them. Vast oceans roll and mighty winds blow between continents; but steam laughs at stormy seas. The moon's light is not sufficient for man's purposes and he makes a brighter one. When winter blows his icy breath, man warms himself with coal and fire. The South pours down upon him her scorching summer; but he has learned how to freeze water into ice. Time and space conspire together for human isolation; man conjures with electricity and with it destroys both. The stars seek to hide their secrets behind immeasurable distances; but an Italian gives man a glass that brings the heavens closer before his vision. History tries to conceal itself in the rubbish of ages; but with ink man preserves the past. His asylums, hospitals, churches, schools, libraries, and universities are lights along the shore guiding the human race in its voyage down the ever widening stream of growth and possibility.

The centuries do not yield to man equal advancement. Some are very fertile; others are almost, if not quite, barren. The entire period of a thousand years stretching from the fall of Rome to the discovery of America was as sterile as a heath. On the other hand, the nineteenth century was the greatest in history in point of human progress, especially in the field of inventions. It alone gave to man far more of civilization than the whole ten centuries before the discovery of America or indeed any other period of a thousand years. One hundred years ago there was not a mile of railroad, ocean cable, or telegraph wire in the world; not a telephone, automobile, electric light, or typewriter. The people were then deriding the new-born idea of the steamboat, and wireless telegraphy had not been dreamed of.

Even up to the beginning of the Revolutionary War, less than one hundred fifty years ago, no man in America had ever seen an envelope, a match, a stove, a piece of coal, a daily newspaper, a sewing machine, a reaper, a drill, a mowing machine, ether, chloroform, galvanized iron, India-rubber, or steam-driven machinery. We who are alive to-day are fortunate more than any other generation thus far in the world's population.

"We are living, we are dwelling
In a grand and awful time;
In an age on ages telling—
To be living is sublime."

The horse and the dog of to-day are not very different from the horses and the dogs of a thousand years ago. From the beginning they have done about all they can ever do. Not so with man. He is a progressive animal. He is always reaching outward and upward for broader and higher things. Tennyson sings,

"For I doubt not thro' the ages one increasing purpose runs,
And the thoughts of men are widen'd with the process of the suns."

The difference between the lives of the primitive cave-dweller and the modern American is unspeakably vast. But looking far down the vista of future ages, who shall say that the fortieth century may not as far surpass the twentieth as the twentieth does the sleepy dawn of man's existence on the earth? We are packing more of life into a day than our ancestors could put into a month. And the hours of the centuries to come hold a fuller experience than our days.

Thomas Carlyle calls man a "tool-using animal." Throughout all time man has made and used tools. These tools are the best measure of his civilization. According to the material out of which they have been made, man's progress has been divided into epochs or ages.

Primitive man made a few implements of bone, horn, and stone. They were few and crude. This period is called the Stone Age. During it men dwelt in caves or huts, dressed themselves in skins, and lived by catching fish, chasing wild animals, and gathering wild fruits. By and by man learned how to make tools out of bronze, an alloy composed of copper and tin. These bronze implements were more numerous and more efficient than the stone tools and gave man a higher degree of power and workmanship. With them he cut down trees or carved stone for his dwellings and acquired generally a higher order of life. This era is named the Bronze Age. Finally the use of iron was discovered. This metal afforded many tools that could not be made of stone or bronze—tools that were much stronger and more efficient. Man became correspondingly more powerful and his life more complex. The period during which iron was used is called the Iron Age.

Invention is the making of some new thing not previously existing. *Discovery* is the finding of something already in existence but not known before. There was no electric telegraph until Samuel Morse made or invented it; America has always existed, but was not known until Christopher Columbus found or discovered it.

Among all the builders of civilization, not the least are the inventors and discoverers. High up on the page of those who have made the world great will always stand the names of Gutenberg or Coster, Watt, Stephenson, Morse, Edison, Fulton, Galileo, Newton, Columbus, Morton, Bell, Marconi, and others who have invented new machines and discovered new processes for making life more happy, safe, and powerful.

Regarding the influence of inventions upon civilization, Lord Salisbury says: "The inventors and even the first users of the great discoveries in applied science had never realized what influence their work was to have upon industry, politics, society, and even religion. The discovery of gunpowder simply annihilated feudalism, thus effecting an entire change in the structure of government in Europe. As to the discovery of printing, it not only made religious revolutions possible, but was the basis on which modern democratic forms of government rested. The steam engine not only changed all forms of industry and the conditions under which industries were prosecuted, but it made practically contiguous the most distant parts of the world, reducing its vastness to a relatively contracted area. And now the introduction of electricity as a form of force seems destined, as its development proceeds, to bring about results quite as important in their way, though but yet dimly seen by the most far-sighted."

Secretary Seward pays this tribute to invention: "The exercise of the inventive faculty is the nearest akin to the Creator of any faculty possessed by the human mind; for while it does not create in the sense that the Creator did, yet it is the nearest approach to it of anything known to man."

And Lord Bacon tells us: "The introduction of new inventions seemeth to be the very chief of all human actions. The benefits of new inventions may extend to all mankind universally; while the good of political achievements can respect but some particular cantons of men; these latter do not endure above a few ages, the former forever. Inventions make all men happy, without injury to any one single person. Furthermore, they are, as it were, new creations, and imitations of God's own works."

CHAPTER II

THE PRINTING PRESS

> "Blessings be on the head of Cadmus, the Phœnicians, or whoever it is, that first invented books."
>
> *Thomas Carlyle.*

"Except a living man," says Charles Kingsley, "there is nothing more wonderful than a book—a message to us from the dead—from human souls whom we never saw, who lived perhaps thousands of miles away; and yet these, on those little sheets of paper, speak to us, amuse us, vivify us, teach us, comfort us, open their hearts to us as brothers. We ought to reverence books, to look at them as useful and mighty things." Milton calls a good book "the precious life blood of a master spirit, embalmed and treasured up on purpose to a life beyond life." Cicero likens a room without books to a body without a soul. Ruskin says, "Bread of flour is good; but there is bread, sweet as honey, if we would eat it, in a good book." And Thomas Carlyle exclaims: "Wondrous, indeed, is the virtue of a true book! O thou who art able to write a book, which once in two centuries or oftener there is a man gifted to do, envy not him whom they name city-builder, and inexpressibly pity him whom they name conqueror or city-burner!"

Is it not wonderful that a record of all the world has thought and said and felt and done can be deposited in a corner of my room, and that there I may sit and commune with the master spirits of all the centuries? Socrates, Plato, Homer, Cicero, Virgil, Horace, Paul, David, Moses, Buddha, Confucius, Goethe, Dante, Shakespeare, Hugo, Wordsworth, Tennyson, Carlyle, and Emerson, all in one room at the same time!

Great as books are, however, the world has not long had them. For many generations after man's advent, he had no language. He communicated with his fellows by means of gestures or gave vent to his feelings in rude grunts or cries, much as the lower animals do now. But God gave to man something He did not bestow upon the other animals—the power of articulate speech. Certain sounds came to represent certain ideas and a kind of oral language grew up. This became more and more highly developed as time went by. For centuries the traditions, stories, and songs of men were handed down orally from father to son and were preserved only in the memory. The poems of Homer, the great Greek bard, were recited by readers to large audiences, some of them numbering probably twenty thousand.

By and by men felt the need of preserving their thoughts in some more permanent way than by memory, and there grew up a rude system of writing. At first pictures or rude imitations of objects were used; a circle or a disc might represent the sun, and a crescent the moon. The idea of a tree was denoted by the picture of a tree. The early Indians of North America were among the peoples who used a system of picture writing. In process of time, as men grew in knowledge and culture, certain fixed signs began to denote certain sounds, and a phonetic system of writing was developed.

For the first phonetic alphabet it is generally supposed that we are indebted to the Phœnicians, an active, commercial people, who lived along the eastern shore of the Mediterranean Sea. They were a maritime nation and scattered their alphabet wherever they sailed, so that some kind of phonetic alphabet finally existed throughout the civilized world.

Books among the ancients were very different from the books of the present. Paper has not been known long, nor, indeed, has the art of printing. When man began to preserve his thoughts and deeds in more permanent form than in the memory, various substances were used to write upon. Josephus, an historian of the Jews, mentions two columns, one of stone and the other of brick, upon which the children of Seth wrote accounts of their inventions and astronomical discoveries. Tablets of lead containing the works of Hesiod, a Greek writer, were deposited in the temple of the Muses in Bœotia. According to the Bible, the ten commandments which the Lord gave to Moses on Mount Sinai for the children of Israel were engraved on two tablets of stone; and the laws of Solon, the great Grecian law-giver, were carved on planks of wood.

Sixty centuries ago on the banks of the Nile in northern Africa flourished the civilization of the Egyptians. There grew abundantly in Egypt a marsh reed called the papyrus. From the name of this plant is derived our word *paper*. The Egyptians made their books from the papyrus plant. With a sharp instrument they cut lengthwise strips through the stalk, put these strips together edge to edge, and on them at right angles, placed another layer of shorter strips. The two layers were then moistened with Nile water, pressed together, and left to dry. A leaf of writing material was thus produced. Any roughness on the surface of the sheet was polished away with some smooth instrument. A number of leaves were then glued together so as to form a long piece of the material. The Egyptians took reeds, dipped them in gum water colored with charcoal or with a kind of resinous soot, and wrote on the long papyrus strip. Sometimes ink was made of the cuttle fish or from lees of wine. After the papyrus had been written upon, it was rolled up and became an Egyptian book. Papyrus was used for writing material not only by the Egyptians but by the Greeks and the Romans also, and for a long time it was the chief substance used for writing throughout the civilized world. It continued in use to a greater or less extent till about the seventh century after Christ.

On the plains of Asia lived the Chaldeans, whose civilization was about as old as that of the Egyptians. But their books were very different. Men use for their purposes the things that are close at hand. In Egypt the papyrus plant was utilized for making books. In Chaldea, instead of this marsh reed, there were great stores of clay and of this material the ancient Chaldeans, and the Babylonians and the Assyrians who followed them, made their books. The Chaldeans took bricks or masses of smooth clay and, while they were yet soft, made impressions on them with a metal stiletto shaped at the end like the side of a wedge. In Latin the word for *wedge* is *cuneus*. Hence this old writing of the Chaldeans is called cuneiform or wedge-shaped. Some of these wedge-shaped impressions stood for whole words, others for syllables. After the clay tablets had been written upon, they were burned or dried hard in the sun. A Chaldean book was thus made very durable and lasted for ages. During recent years many of them have been dug up in ancient Babylonia and deciphered. They consist of grammars, dictionaries, religious books and hymns, laws, public documents, and records of private business transactions.

The early Greeks and Romans used for their books tablets of ivory or metal or, more commonly, tablets of wood taken from the beech or fir tree. The inner sides of these tablets were coated with wax. On this wax coating the letters were traced with a pointed metallic pen or stiletto called the stylus. Our English word *style*, as used in rhetoric, comes from the name of this instrument. The other end of the stylus was used for erasing. Two of these waxed tablets, joined at the edges by wire hinges, were the earliest specimens of bookbinding. Wax tablets of this kind continued in partial use in Europe through the Middle Ages. Later the leaves of the palm tree were used; then the inner bark of the lime, ash, maple, or elm.

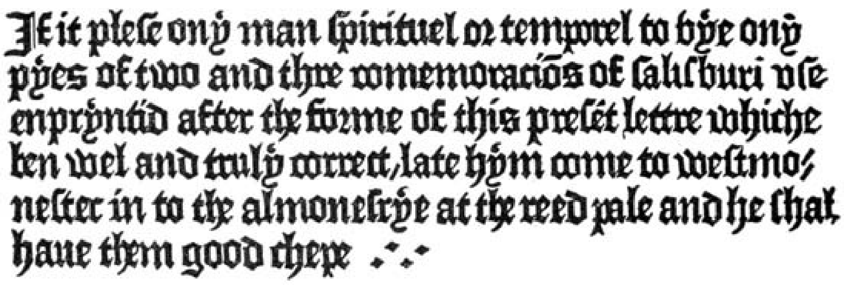
The next material that came into general use for writing purposes was parchment. This was made from the skins of animals, particularly sheep or lambs. Next came vellum, the prepared skin of the calf. Parchment and vellum were written upon with a metallic pen. As these substances were very costly, sometimes one book was written over another on the same piece of parchment or vellum. Of course this made the reading of the manuscript very difficult.

About the end of the ninth century or the beginning of the tenth, after Christ, parchment and vellum as material for books gave way to paper. At first paper was made of cotton, but during the twelfth century it was produced from linen. It is not known who invented linen paper, but its introduction gave the first great impulse to book making.

In the early Greek books the lines ran in opposite directions alternately. That is, there would be a line from left to right across the page, and then the next lower line would begin at the right and run towards the left. Among some of the Orientals the lines ran from right to left. In the old Chinese books the lines were vertical down the page, as they are still. Among Western and Northern peoples the lines ran from left to right as in our modern books.

The old civilizations of Egypt and Babylonia, in which the art of book-making originated, sprang up, flourished, and decayed, burying from the sight of men precious secrets in the arts and sciences. The beautiful flower of Greek culture budded, bloomed, and withered. Passing on from east to west, civilization knocked at the door of Rome and awakened there such military and legal genius as the world had not yet seen. Then a horde of wild barbarians poured over the mountains of northern Italy and overthrew the mighty city on the Tiber. The sun of civilization was setting, at least for a time. Night was coming on, the night of the Dark Ages, a night without a star of human thought or achievement, a night full of the noxious vapors of ignorance and superstition.

About the beginning of the fifteenth century after Christ there came over the world a great intellectual awakening. The human intellect began to awake, to stretch itself, to go forth and conquer. One of the first signs and causes of this intellectual awakening was an event that happened at Mainz in Germany or at Haarlem in Holland, or possibly in both places at the same time. Of all the events that have made for civilization and have influenced the progress of the human race, this event at Haarlem or Mainz is the most important. It is the invention of printing. Before this time, ever since man began to record his thoughts, whether on plank, stone, or papyrus, on bark of tree, skin of animal, or tablet of wax or paper, every letter was made by hand. The process was necessarily slow, books were rare and costly, and only the few could have them. But with the advent of a process that would multiply books and make them cheap, learning was made accessible to the multitude. The clang of the first printing press was the death knell of ignorance and tyranny.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nester in to the almonesrye at the reed pale and he shal
haue them good chepe

An Advertisement of Caxton, the First Printer in England

Before the invention of printing with movable, metal types, a kind of block printing was used. The words or letters were carved on a block of wood; the block was applied to paper, silk, cloth, or vellum, and thus impressions were made.

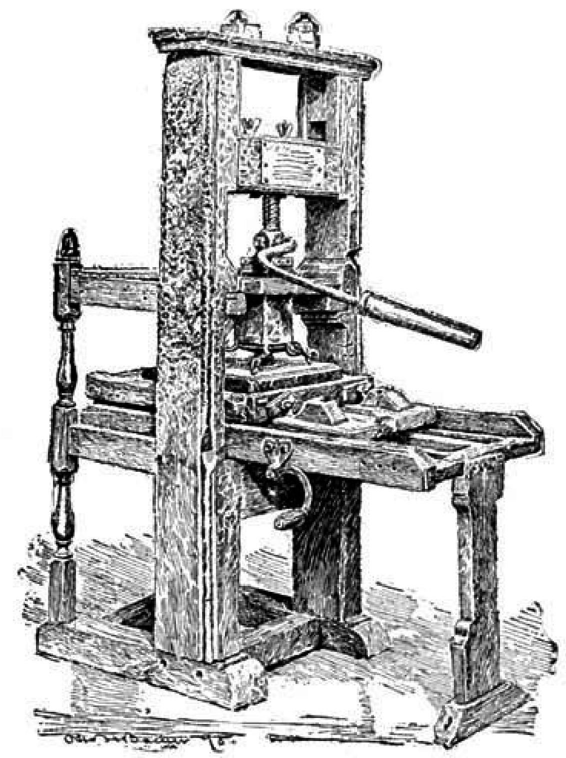
It has always been a matter of dispute as to who invented printing. It is fairly clear that printing, both with blocks and with movable types, was practised in China and Japan long before it was in Europe. There is a tradition that as far back as 175 A.D. Chinese classics were cut upon tablets of stone, that these tablets were placed outside the university, and that impressions were made from them. However, we are not indebted to China or Japan for the art of printing. The real invention of printing, so far as the civilized world is concerned, occurred in Europe in the latter part of the fifteenth century. The inventor is often said to be Johann Gutenberg, of Mainz, Germany. Another strong claimant for this honor is Lourens Janszoon Coster, who lived at Haarlem, in Holland.

Concerning the lives of Coster and Gutenberg little is known. Coster was born at Haarlem, Holland, about 1370 A.D. He was a member of the Haarlem Council, assessor and treasurer. He probably perished in the plague that visited Haarlem in 1439-40. Gutenberg was born of noble parents at Mainz, Germany, in 1410. He had an active mind and gave attention to the manufacture of money, the polishing of stones, and the making of looking-glasses, besides his efforts in printing. He died in February, 1468, poor, childless, and almost friendless.

The first printed book, so far as can be determined, was made at Mainz, Germany, and bears the date of 1454 A.D. From certain legal records it is supposed that Gutenberg was the maker of this book and the inventor of printing. On the other hand, there is a story that Coster, while walking in the woods one autumn afternoon, chanced to make for his little grandchild some letters from the bark of a tree; that these letters suggested to him the idea of metallic types; and that he, and not Gutenberg, was the inventor of printing. As the story goes, a slave stole Coster's types and ran away with them from Haarlem to Mainz; and the books which, it is supposed, were made at the latter place came really from Coster's types, not Gutenberg's. The fact cannot be known. It has hopelessly gone with the years.

This first book, which was printed in two different editions, consisted of certain letters written by Pope Nicholas V in behalf of the kingdom of Cyprus. By about 1477 A.D. printing had extended from Mainz to all the chief towns of Germany, Italy, Switzerland, France, the Netherlands, Spain, and England. By the beginning of the sixteenth century it had spread to all the principal places of Europe.

In the type of the early books the various letter forms were not fixed as they are in modern books, but the type for each book was made as much as possible like the writing of the original manuscript. As printers moved from place to place introducing their art, it seems that not one carried away the types of his master but each made his own anew. Type was originally made and set up by hand, piece by piece, so that even the production of printed books was very slow. Various mechanical devices have been invented from time to time, quickening and cheapening the making of books and other printed matter, so that to-day printers turn out books and papers in large quantities in an amazingly short time.



The Printing Press in Boston at Which Franklin Worked

The first newspaper in the world is believed to have been the *Frankfurter Journal*, published about 1615 A.D. at Frankfort-on-the-Main, in Germany. But of this there is no certainty. Newspapers, however, had their beginnings in Germany and Italy some time in the latter part of the sixteenth or the first part of the seventeenth century. It is believed that the *Weekly News*, started in London in 1622, was the first newspaper published in England. In the United States there was a printing press attached to Harvard College, at Cambridge, Massachusetts, as early as 1638, two years after the college was founded, and only six years after the settlement of Boston. With this one exception, for a long time there were no printing presses in the colonies. A newspaper called *Publick Occurrences* was started in Boston in 1690, but it was soon afterward suppressed by the British government. The first permanent newspaper in America was the *Boston News Letter*, established at Boston in 1704.

One of the greatest wonders and triumphs of civilization is the great modern daily newspaper. It occupies a giant "sky-scraper" as its home, employs a small army of workmen, spends vast sums of money in obtaining and printing the news, and is sold for a cent per copy. The head of a newspaper staff is the editor-in-chief. He is in a general way responsible to the publishers for the paper. Next in command is the managing editor who has charge of the actual work of publication. Subordinate to the managing editor are other editors who have control over various departments of the paper. The telegraph editor looks after news sent by telegraph; the city editor has charge of happenings in the city of publication; the exchange editor clips items from other papers; the religious editor attends to affairs of religion; the sporting editor collects and arranges news of sports and games; the commercial editor works with the markets and matters of commerce and business; the society editor gives attention to social functions; and the dramatic editor takes note of the theaters. The city editor commands a company of perhaps half a hundred reporters, who are sent scurrying daily throughout the city to bring in the news from its various sources. One goes to the ball game, another to a funeral, another to the courts, another to a hotel to interview some prominent person, and still another goes to a political convention. There are also photographers, illustrators, and editorial writers.

At the close of the day, special correspondents and representatives of press associations in every nook and corner of the earth send the world's news for the day by telegraph and ocean cable direct into the newspaper office. A king has died; a battle has been fought; storm, earthquake, or fire has destroyed a city; or there has been some achievement in science or art. The local reporters have brought in the news of the city. After all has been quickly written, examined, and edited, the reports are sent to the composing room to be put into type.

The foreman of the composing room distributes the manuscript, called copy, among skilled operators, who by means of type-setting machines put it into type. Impressions are then made from this type on strips of paper. These impressions are called proofs. Proof readers compare these proofs with the original copy for the purpose of correcting errors. After the correction of errors the columns of type, called galleys, are locked up in a form which is the size of a page. The form is next sent to the stereotyping room, where an exact reproduction is made in metal. The metal plates are put in place on the presses. The machinery is started. Tons of white paper are fed into the presses at one end. Out at another in an instant comes the finished newspaper, printed, cut, and folded. These papers are counted and delivered automatically to the mailing room, at the rate of about 100,000 copies in an hour, for the improved, modern press. After their arrival at the mailing room, papers that are for out-of-town subscribers are wrapped in packages, addressed, and carried in express wagons to fast mail trains, which carry this record of what man did the previous day to readers hundreds of miles away.

This afternoon at five o'clock a prominent man dies suddenly in San Francisco. To-night at midnight the newspapers of St. Louis, Chicago, and New York will come from the press with his picture and a long sketch of his life. How is this possible in so short a time? The papers have on file, arranged in alphabetical order, photographs of prominent persons and places and biographical sketches of great men, kept up to date. Whenever any noted person, place, or thing is made conspicuous by any event, the picture and sketch are taken from the files and used.

It is the electric telegraph that makes possible the modern daily newspaper. Before its invention, papers resorted to various devices for transmitting news. For some years messengers riding ponies brought news from Washington to the New York papers. These papers also utilized small, swift-sailing vessels to meet incoming ships bearing news from foreign countries.

A recent bulletin on printing and publishing issued by the Census Bureau of the United States government showed that there were in the United States 21,394 newspapers and periodicals, printed in twenty-seven different languages. Of these, 2,452 were daily; 15,046 weekly; 2,500 monthly; 353 quarterly; 58 tri-weekly; 645 semi-weekly; and 340 of all other kinds. 20,184 of these papers were English; 619 German; 158 Scandinavian; 58 Italian; 41 French; 44 Bohemian; 31 Spanish; 18 Hebrew; 21 Dutch; 7 Chinese; 9 Japanese; 5 Greek; 46 Polish; 5 Hungarian; 3 Arabic; and two each in the Welsh, Syrian and Gaelic languages. The capital invested in printing and publishing in the United States was a little more than $385,000,000. It would take one person twelve hours a day every day for six thousand years, or from the beginnings of Egyptian and Babylonian civilization to the dawn of the twentieth century, to read at an average rate all the papers published in the United States during a single year.

CHAPTER III

THE STEAM ENGINE

THE SONG OF STEAM

By George Washington Cutter

Harness me down with your iron bands;
   Be sure of your curb and rein;
For I scorn the power of your puny hands,
   As the tempest scorns a chain.
How I laughed as I lay concealed from sight
   For many a countless hour,
At the childish boast of human might,
   And the pride of human power.

When I saw an army upon the land,
   A navy upon the seas,
Creeping along, a snail-like band,
   Or waiting the wayward breeze;
When I marked the peasant faintly reel
   With the toil which he daily bore,

As he feebly turned the tardy wheel,
   Or tugged at the weary oar;

When I measured the panting courser's speed,
   The flight of the courier dove,
As they bore the law a king decreed,
   Or the lines of impatient love,—
I could not but think how the world would feel,
   As these were outstripped afar,
When I should be bound to the rushing keel,
   Or chained to the flying car;

Ha, ha! they found me out at last;
   They invited me forth at length;
And I rushed to my throne with a thunder-blast,
   And I laughed in my iron strength.
Oh, then ye saw a wondrous change
   On the earth and the ocean wide,
Where now my fiery armies range,
   Nor wait for wind and tide.

Hurrah! hurrah! the waters o'er;
   The mountain's steep decline;
Time—space—have yielded to my power;
   The world—the world is mine!
The rivers the sun hath earliest blest,
   Or those where his beams decline;
The giant streams of the queenly West,
   And the Orient floods divine.

The ocean pales where'er I sweep,
   I in my strength rejoice;
And the monsters of the briny deep
   Cower, trembling, at my voice.
I carry the wealth and the lord of earth,
   The thoughts of his god-like mind;
The wind lags after my going forth,
   The lightning is left behind.

In the darksome depths of the fathomless mine
   My tireless arm doth play,
Where the rocks never saw the sun decline,
   Or the dawn of the glorious day.
I bring earth's glittering jewels up
   From the hidden caves below,
And I make the fountain's granite cup
   With a crystal gush o'erflow.

I blow the bellows, I forge the steel,
   In all the shops of trade;
I hammer the ore, and turn the wheel,
   Where my arms of strength are made;
I manage the furnace, the mill, the mint;
   I carry, I spin, I weave;
And all my doings I put into print
   On every Saturday eve.

I've no muscle to weary, no breast to decay,
   No bones to be "laid on the shelf,"
And soon I intend you may "go and play,"
   While I manage this world myself.
But harness me down with your iron bands,
   Be sure of your curb and rein;
For I scorn the power of your puny hands,
   As the tempest scorns a chain!

The most powerful and important mass of matter on the earth is the steam engine. It is the throbbing heart of civilization, even as the printing press is its brain. It would be difficult for man to compute his debt to steam. Upon it he relies for food, clothing, and shelter, the three necessities for which the race has always striven; and without it he could have scarcely any of life's comforts and luxuries. Steam is the mistress of commerce, manufacturing, and mining, and the servant of agriculture. Steam gives employment to millions of men. It plants cities and towns in waste places. It enables man to leave the little valley or hillside where his fathers lived, and makes of him a citizen of the world. It lessens the power of time and space, and makes neighbors of ocean-divided continents.

It would not be easy for men living in the twentieth century to imagine a society uninfluenced by the use of steam; but nearly all of man's life on the earth has been passed without its help. Fire and water, the two productive factors of steam, have always existed; but it was not until a few score of years ago that man learned to put them together successfully, and to produce the greatest force known to civilization. In the few years since its discovery it has spread to every nook and corner of civilization. Suppose you could ascend to some great height whence you could see working at one time all the steam driven machinery in the world. What a sight it would be! What if the noise from all this machinery—the screech of the speeding locomotive, the hum and roar of factory and mill, the hoarse yell of ships, and the puffing of mine-engines—should reach your ear at once? What a sound it would be!

The idea of using steam for driving stationary machinery originated in the early centuries. This was the first use to which steam was put. For a long time no one seems to have thought of using it for transportation purposes. As far back as 130 B.C., we find mention of "heat engines," which employed steam as their motive power, and were used for organ blowing, the turning of spits, and like purposes. But from this early date till the seventeenth century practically no progress was made in the use of steam. Though men had experimented with steam up to this time with more or less success, the world is chiefly indebted for the developed type of the steam engine to James Watt and George Stephenson.

Watt was born in Greenock, Scotland, January 19, 1736. He was a poor boy and early in life he was thrown upon his own resources. During his youth he struggled against ill health; for days at a time he was prostrated with severe headaches. But he was bright, determined, and had a genial disposition that made him many friends. When he was twenty-one years old, he secured a position as maker of scientific instruments for the university in Glasgow. He began discussing with some scientific friends at the university the possibility of improving the steam engine, which at that time was used only for pumping water, chiefly in the drainage of mines. He entered upon a scientific study of the properties of steam and tried to devise means for making the steam engine more useful. One Sunday afternoon early in 1765, while walking in Glasgow, the idea he had studied so long to evolve suddenly flashed into his mind. Without delay Watt put his plan to the test and found that it worked.

For a long time, owing to a lack of money, he had difficulty in establishing the merits of his improvements. Finally he formed a partnership with Matthew Boulton, a wealthy and energetic man who lived at Birmingham, England. They began the manufacture of steam engines at Birmingham, under the firm name of Boulton and Watt. This partnership was very successful. Watt supplied the inventions; Boulton furnished the money and attended to the business.

Before the time of Watt, the steam engine was exclusively a steam pump—slow, cumbrous, wasteful of fuel, and very little used. Watt made it a quick, powerful, and efficient engine, requiring only a fourth as much fuel as before. Under his first patent the engine was still used only as a steam pump; but his later improvements adapted it for driving stationary machinery of all kinds and, save in a few respects, left it essentially what it is to-day. Prior to Watt's inventions, the mines of Great Britain were far from thriving. Many were even on the point of being abandoned, through the difficulty of removing the large quantities of water that collected in them. His improvements made it possible to remove this water at a moderate cost, and this gave many of the mines a new lease of life. The commercial success of his engine was soon fully established.

Watt paid practically no attention to the use of steam for purposes of transportation. In one of his patents he described a steam locomotive; but he offered little encouragement when his chief assistant, Murdoch, who was the inventor of gas lighting, made experiments with steam for locomotion. The notion then was to use a steam carriage on ordinary roads. Railroads had not been thought of. When the idea of using steam on railways began to take shape in the later days of Watt, he refused to encourage the plan. It is said that he even put a clause in a lease of his house, providing that no steam carriage should ever approach it under any pretext whatever.

Besides developing the steam engine, Watt made other inventions, including a press for copying letters. He also probably discovered the chemical composition of water. He died at Heathfield, England, on the nineteenth of August, 1819.

It is denied many men to see the magnitude of their achievements. Moses died on Pisgah, in sight of the "Promised Land," toward which for forty years he had led the children of Israel through the wilderness. Wolfe gave up his life on the plains of Quebec just as the first shouts of the routed French greeted his ears. Columbus was sent home in chains from the America he had discovered, not dreaming he had given to civilization another world. Lincoln's eyes were closed forever at the very dawn of peace, after he had watched in patience through the long and fearful night of the Civil War. It never appeared to James Watt that the idea which flashed into his mind that Sunday afternoon while he was walking in the streets of Glasgow, would transform human life; that like a mighty multiplier it would increase the product of man's power and give him dominion, not over the beasts of the field and the fowls of the air, but over tide and wind, space and time.

Victor Hugo calls locomotives "these giant draft horses of civilization." But man never harnessed these wonderful iron animals until the time of George Stephenson, less than a hundred years ago.

Stephenson was born at Wylam, near Newcastle, England, June 9, 1781. His father was a fireman of a coal-mine engine at that place. In boyhood George was a cowherd, but he spent his spare time making clay models of engines and other objects of a mechanical nature. When he was fourteen years old, he became assistant to his father in firing the engine at the colliery, and three years later he was advanced to engine driving. At this time he could not even read; but, stimulated by a strong desire to know more of the engines made by Boulton and Watt, he began in his eighteenth year to attend a night school. He learned rapidly. During most of this time he studied various experiments with a view to making a successful steam locomotive.

Modern railways had their origin in roads called tramways, which were used for hauling coal from the mines of England to the sea. At first ordinary dirt roads were used for this purpose; but as the heavy traffic wore these roads away, it become the practice to place planks or timbers at the bottoms of the ruts. Afterwards wooden rails were laid straight and parallel on the level surface. The rails were oak scantlings held together with cross timbers of the same material, fastened by means of large oak pins. Later strips of iron were nailed on the tops of the wooden rails. Over these rails, bulky, four-wheeled carts loaded with coal were pulled by horses.

Stephenson made what he called a traveling engine for the tramways leading from the mines where he worked to the sea, nine miles distant. He named his engine "My Lord." On July 25, 1814, he made a successful trial trip with it.

The successful use of steam in hauling coal from the mines led thoughtful persons to consider its use for carrying merchandise and passengers. At this time freight was transported inland by means of canals. This method was slow; thirty-six hours were required for traveling fifty miles. Passengers were conveyed by coaches drawn by horses. In 1821 a railroad for the transportation of merchandise and passengers was opened between Stockton and Darlington in England. The line, including three branches, was thirty-eight miles long. The plan was to use animal power on this road, but George Stephenson secured permission to try on it his steam locomotive.

In September, 1825, the first train passed over the road. It consisted of thirty-four cars weighing, all told, ninety tons. The train was pulled by Stephenson's engine, operated by Stephenson himself, with a signalman riding on horseback in advance. The train moved off at the rate of ten or twelve miles an hour, and on certain parts of the road it reached a speed of fifteen miles per hour. The trial was a complete success.

The road had been built chiefly for the transportation of freight, but from the first passengers insisted on being carried, and in October, 1825, the Company began to run a daily passenger coach called the "Experiment." This coach carried six persons inside and from fifteen to twenty outside. The round trip between Stockton and Darlington was made in two hours. A fare of one shilling was charged, and each passenger was allowed fourteen pounds of baggage free. The Stockton and Darlington was the first railway in the world over which passengers and freight were hauled by steam.

Stephenson was next employed to help construct a railway between Liverpool and Manchester. The most eminent engineers of the day predicted that the road could not be built. But it was built. On the fifteenth of September, 1830, Stephenson made a trial trip over the road with an improved locomotive named the "Rocket." On the trial trip the "Rocket" made twenty-nine miles an hour. This trip firmly proved the possibilities of steam as motive power on railways and started the modern era of railroad building. Other railways were quickly built and soon they radiated from London to nearly every English seaport.

An Early Railroad Train in England

Stephenson's son, Robert, assisted him in the construction of the "Rocket" and later attained considerable reputation as an engineer.

It is claimed that George Stephenson was the inventor of the safety lamp for use in mines, an invention usually accredited to Sir Humphry Davy. He was often consulted in the building of subsequent railroads, but he spent the last years of his life in farming and gardening at his home at Chesterfield, England, where he died August 12, 1848.

Before the days of railroads in America, freight was hauled on canals and passengers rode in stage coaches or on horseback. A coach made the trip from Boston to New York twice a week and the journey required six days. A trip from New York to Philadelphia took two days. From Philadelphia to Baltimore the roads were good, but south of Baltimore they were bad and even dangerous. South of the James River the traveler was compelled to make his journey on horseback. A coach from Charleston to Savannah was the only public conveyance south of the Potomac River.

In the days of the old colonial stagecoach, if a traveler wished to go from Boston to New York, he would have to be ready to begin the journey at three o'clock in the morning. The stage had no glass windows, no door or step, and passengers were obliged to climb in at the front. One pair of horses pulled the stage eighteen miles, and then they were relieved by another pair. At about ten o'clock in the evening, after a day's journey of forty miles, the stage drew up at an inn for the night. At three o'clock the next morning, after dressing by the light of a horn lantern, the traveler must resume his journey. If the roads were bad, he might have to alight from the stage and help the driver pull the wheels out of the mud. Rivers were crossed on clumsy flat-boats. When the streams were swollen with rains or filled with floating ice, the passage across was often dangerous. The trip from Boston to Philadelphia, which would have taken eight days of Washington's time, can easily be made now by train in as many hours. In these days of the modern railroad, San Francisco is nearer in time to New York than Washington was scarcely a hundred years ago.

The first railway in America was built in 1826. It connected a granite quarry at Quincy, Massachusetts, with the town of Milton in the same state. It was only two or three miles long, and was operated with horses. In May, 1829, three English locomotives—the first ever seen in America—were unloaded at New York City. On August 9 of the same year, one of these engines was tried at Honesdale, Pennsylvania. This was the first time that a locomotive ever turned a wheel on a railway in America.

A canal which the business men of Philadelphia proposed to construct from their city to Pittsburg, in order to give them access to the trade centers of the West, threatened the commercial prosperity of Baltimore. To offset the advantages which this canal would give Philadelphia, at a great public meeting in Baltimore it was decided to build a railway from Baltimore to some point on the Ohio River. The road was named the Baltimore and Ohio. In 1830 it was finished from Baltimore as far as Ellicott's Mills, a distance of fifteen miles. The Baltimore and Ohio was the first railroad in the United States built for the express purpose of carrying passengers and freight. The original intention was to pull cars over this road with horses. But Peter Cooper persuaded the railroad officials to try his engine "Tom Thumb," which he had built in 1829. The trial was successful, for "Tom Thumb" drew a car-load of passengers at the rate of fifteen to eighteen miles per hour. This engine was the first locomotive built in America, and its trial was the first trip ever made by an American locomotive.

The first railroad in the United States constructed with the original purpose of using steam as motive power was the South Carolina railroad, a line one hundred thirty-six miles long between Charleston and Hamburg. A locomotive built in New York City, called the "Best

Friend," made its first trip over this road in November, 1830. It was the first locomotive to run regularly on a railroad in the United States.

Railroad building spread rapidly in America, as it had in England. By 1835 there were twenty-two railroads in the United States, two of them being west of the Alleghenies, though no road was more than one hundred forty miles in length. There was no railroad west of the Mississippi River prior to 1853, and in that year a line only thirty-eight miles long was built. During 1906 alone, 5516 miles of railroad were constructed in the United States. At the end of that year, there was a total in the United States of 222,635 miles, or nearly enough to reach nine times around the entire globe. The United States now has thirty per cent. more miles of railway main track than all of Europe, and contains two fifths of the railroad mileage of the world. The railroads of the United States represent a value of about fifteen billion dollars, and give employment to a million and a half persons.

The Pennsylvania Railroad was originally owned by the state. Any one could use it by paying certain charges, and each person operating the road furnished his own cars, horses, and drivers. There were frequent blockades; when two cars going in opposite directions met, one had to turn back. If rival shippers came together and neither was willing to yield to the other, a fight probably settled the rights of precedence. After a time steam became the sole motive power, and the locomotives were owned by the state.

The railroad journeys of our grandfathers were very different from our own. In their day the rails were wooden beams or stringers laid on horizontal blocks of stone. Strips of iron were fastened with spikes to the tops of the wooden rails. The cars were small, each seating only a few passengers. The locomotive was crude. Its greatest speed was about fifteen miles an hour. It could not climb a hill, and when a grade was reached, the cars had to be pulled up or let down with ropes managed by a stationary engine. No cab sheltered the engineer; no brake checked the speed. Sometimes the spikes fastening the iron strips to the tops of the wooden rails worked loose, and these strips curled up and penetrated the bottoms of the cars, greatly to the annoyance and fright of the traveler. The bridges in those days were roofed. The smokestack of the locomotive, being too tall to pass under the roof, was made in two joints or sections fastened together with hinges. When the train approached a bridge, the top section of the stack was lowered. As wood only was used for fuel, the stack emitted a shower of sparks, smoke, and hot cinders. The passengers coughed and sputtered, and covered their eyes, mouths, and noses with handkerchiefs.

The trip from Chicago to New York is about a thousand miles, over prairie, river, and mountain. Should you make the journey between these cities over the Pennsylvania Railroad of to-day, there would be little danger of conflict because two rival trains might want the track at the same time. Nor would you have to wait while ropes pulled the train up a grade, for the locomotive can climb the hills. Instead of the old wooden rails with their strips of iron, there is a double track of solid steel rails all the way. The landscape would fly past you at the rate of a mile a minute, instead of fifteen miles an hour.

Let us suppose that you leave Chicago at 2.45 o'clock P.M., central time. Before the train starts you could telephone to a friend without leaving the car. You might sit down, in an elegant dining-car, to a dinner of all the delicacies the market could afford. You might occupy your own exclusive compartment in a luxuriously equipped Pullman car, lit by electric bulbs, or you could spend the evening reading the magazines, newspapers, and books provided in the train library. You might write at a comfortable desk with train stationery, or dictate letters and telegrams to the train stenographer. You are provided with hot and cold water, bathing facilities, and a barber shop. A maid could be summoned to the service of women and children; and a valet would be in attendance to sponge and press clothing over night. You would arrive in New York the next morning at 9.45 o'clock, having traveled the thousand miles in eighteen hours.

Simple as the idea of the sleeping-car is in reality, it was not introduced until 1858, when the Lake Shore Railroad ran the first crude and uncomfortable night-cars. George M. Pullman in 1859 set for himself the task of producing a palace car which should be used for continuous and comfortable travel through long distances by day and night. He remodelled into sleeping-cars two passenger coaches belonging to the Chicago and Alton Railroad. Though these cars fell far below the inventor's ideal, they were far in advance of the first make-shifts and in consequence created a demand for more and better cars of the same kind. In 1863, at his factory in Chicago, Pullman began the construction of the "Pioneer," the first of the Pullman palace cars. This car was built at a cost of $18,000. It was first used in the funeral train which conveyed the body of President Lincoln to his burial place in Springfield, Illinois.

Few inventions have been financially so remunerative to the inventors as the Pullman palace car. It brought Mr. Pullman an immense fortune. The Pullman Palace Car Company, founded by Pullman in 1867, is one of the largest and most successful manufacturing concerns in America. It employs a capital of $40,000,000, gives work to fourteen thousand persons, furnishes sleeping-car service for 120,000 miles of railway, and operates over 2,000 cars.

Mr. Pullman adopted plans for the vestibule car in 1887. He died at his home in Chicago, October 19, 1897.

The idea of the steamboat did not originate in the brain of Robert Fulton. It is claimed that, as early as 1543, Blasco de Garay propelled a boat by steam, and that in 1707, just a hundred years before the time of Fulton's *Clermont*, Papin ran a boat with steam on a river in Germany. In 1763 William Henry experimented with a steamboat on the Conistoga River in Pennsylvania.

James Rumsey, a Scotchman living in Maryland, is said to have been the first American to discover a method for running a vessel with steam against wind and tide. He conceived the idea in August, 1783. During 1785 he made his boat, and in 1786 he navigated it on the Potomac River at Shepherdstown, Virginia, in the presence of hundreds of spectators. He wrote to General Washington of his invention, and Washington wrote concerning it to Governor Johnson of Maryland. In 1839 Congress voted a gold medal to James Rumsey, Jr., son and only surviving child of the inventor, in recognition of the elder Rumsey's achievement.

In 1787 John Fitch exhibited on the Delaware River a vessel to be propelled by steam, and in 1790, from June to September, he ran a steamboat on that river between Philadelphia and Trenton. But he could not induce the public to patronize his boat, and for lack of business it had to be withdrawn.

Some British authorities claim that the first practical steamboat in the world was the tug "*Charlotte Dundas*," built by William Symmington, and tried in 1802 on the Clyde and Forth Canal in Scotland. The trial was successful, but steam towing was abandoned for fear of injuring the banks of the canal. Symmington had built a small steamboat that traveled five miles an hour in 1788.

ROBERT FULTON

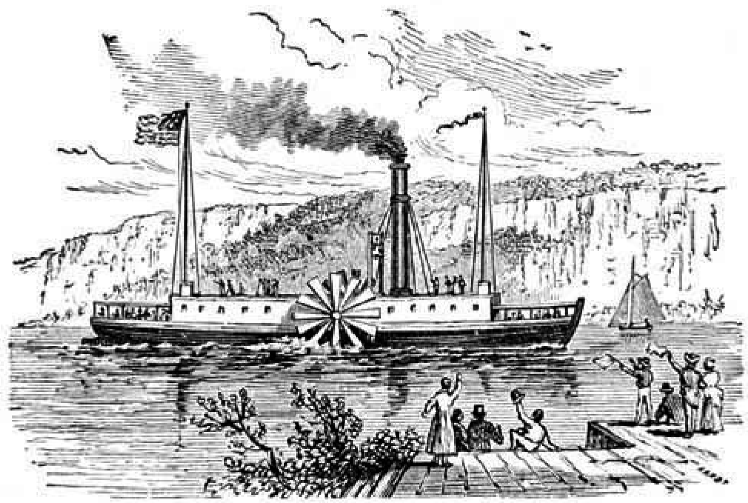
To Robert Fulton, an American, belongs the credit for placing the steamboat on a successful commercial basis. Fulton was born at Little Britain, Pennsylvania, in 1765. At the age of seventeen he adopted the profession of portrait and landscape painter. At twenty-two he went to England to study art. There he met James Watt, the inventor of the steam engine, and soon he began to give attention to mechanics. In 1793 he started to work on the idea of propelling boats by steam. He made an unsuccessful experiment with a steamboat on the Seine River in France. The vessel sank because its construction was faulty. Fulton returned to America and in New York harbor began to build another boat which he named the *Katherine of Clermont*, shortened to the *Clermont*. Her engine was procured from Boulton and Watt in England. The boat was one hundred feet long and twenty feet wide, weighed one hundred sixty tons, and was equipped with side paddle wheels and a sheet-iron boiler. As the inventor worked patiently at his task, the newspapers gave him but little notice and the public ridiculed him. The New York legislature had passed a bill granting to Fulton and to Chancellor Livingston the exclusive right to navigate with steam boats the waters of New York State. This bill was a standing subject of ridicule among the legislators at Albany.

In August, 1807, the *Clermont* was ready for her trial trip. A large crowd of spectators lined the banks of the Hudson as the boat slowly steamed out into the river. The crowd jeered and hooted and shouted at the vessel their nick-name of "Fulton's Folly." As the *Clermont* moved up the river, making slow headway against the current, the crowd changed their jeers to expressions of wonder and finally to cheers. The dry pine wood used for fuel sent out a cloud of thick, black smoke, flames, and sparks, which spread terror among the watermen of the harbor. The *Clermont* made the voyage from New York up the Hudson to Chancellor Livingston's country estate near Albany, a distance of a hundred ten miles, in twenty-four hours. The trip was without mishap and it thoroughly established the practicability of steam for purposes of navigation.

Concerning this voyage Fulton wrote to a friend in Paris: "My steamboat voyage to Albany and back has turned out rather more favorably than I had calculated. The voyage was performed wholly by power of the steam engine. I overtook many sloops and schooners beating to windward, and parted with them as if they had been at anchor. The power of propelling boats by steam is now fully proved. The morning I left New York there were not thirty persons in the city who believed that the boat would ever move a mile an hour, or be of the least utility. While we were putting off from the wharf, I heard a number of sarcastic remarks. This is the way in which ignorant men compliment what they call philosophers and projectors. I feel infinite pleasure in reflecting on the immense advantages my country will derive from the invention."

The *Clermont* was soon running as a regular packet between New York and Albany. The owners of sailing craft on the river hated her and tried to sink her. The New York legislature passed a bill declaring that any attempt to destroy or injure the *Clermont* should be a public offense punishable by fine and imprisonment. Then the enemies of the boat applied to the courts for an injunction restraining Fulton from navigating the Hudson with his steamboat. Daniel Webster appeared as Fulton's attorney. He won the case and secured for the *Clermont* the full rights of the river.

Fulton afterward built other steamboats, including a system of steam ferries for New York City. In 1814 he constructed the first United States war steamer. Before constructing the *Clermont*, Fulton was interested in canals and in the invention of machinery for spinning flax and twisting rope. He also made experiments with sub-marine explosives in England, France, and the United States; but these were considered failures. He died February 24, 1815.

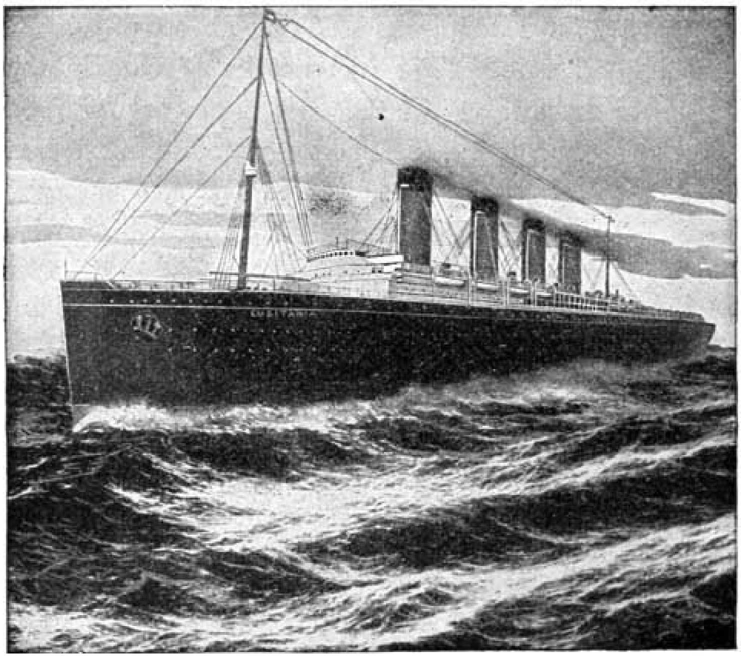


THE CLERMONT ON THE HUDSON

The first steamboat in the West was built at Pittsburg in 1811, and within a few years after the first trip of the *Clermont*, steamboats were being used on all the leading rivers of the country.

From the earliest times men had sailed the seas, but their ships were small and slow and subject to wind, tide, and current. The success of the river steamboat led to the use of steam in ocean navigation. The first steamship to cross the Atlantic was the *Savannah*, in 1818. The vessel relied almost as much upon wind as upon steam for motive power, but during the voyage of twenty-five days steam was used on eighteen days.

The wood required for fuel left little room in the vessel for freight. With the advent of coal for fuel, and better machinery, steamships grew in importance, and in 1837 two ships, the *Sirius* and the *Great Western*, crossed the Atlantic from Liverpool to New York with the use of steam alone. By 1850 the average time for a trans-Atlantic voyage had been reduced to eleven or twelve days.



The Lusitania of the Cunard Line

If the old *Savannah* could be placed beside the *Lusitania*, the giantess of the Cunard line of ocean steamers, a comparison would demonstrate the triumphs of the century in ocean navigation. If you were to cross the ocean on the *Lusitania* or her sister-ship the *Mauretania*, you would enter a vast floating mansion seven hundred ninety feet long, eighty-eight feet wide, eighty-one feet high from keel to boat deck, and weighing thirty-two thousand five hundred tons. Her height to the mastheads is two hundred sixteen feet; each of her three anchors weighs ten tons; and her funnels are so large that a trolley car could easily run through them. The *Lusitania* has accommodation for three thousand passengers, officers, and crew, and is driven by mighty turbine engines of sixty-eight thousand horse power. The steamer was built at a cost of $7,500,000. She has traveled the three thousand miles across the Atlantic in about four and a half days—the quickest trans-Atlantic voyage ever made. She moves through the great waves of the ocean with such steadiness that passengers can scarcely tell whether they are on water or land. A telephone system connects all parts of the ship; there are electric elevators, a special nursery in which children may play; a gymnasium for exercise, shower baths, and an acre and a half of upper deck. There are five thousand electric lights, requiring two hundred miles of wire. Wireless telegraphy flashes messages to the moving ship from distant parts of the world, and bears back greetings from her passengers. A daily illustrated newspaper of thirty-two pages is published on board ship.

CHAPTER IV

ELECTRICITY: THE TELEGRAPH AND THE TELEPHONE

The great miracle of the twentieth century is electricity. If the printing press is the brain of civilization and the steam engine is its heart, electric wires are its nervous system. Steam is a giant; electricity is a witch. There is something uncanny about it. Man writes volumes about electricity; calls it positive and negative and measures it in ohms and volts; gives courses to explain it in his schools and universities; kills criminals, cures the sick, and scatters darkness with it; makes it whirl him through space; compels it to bear his whisper through hundreds of miles, and can make it fly around the entire earth with his written word—and yet no man knows what electricity is. Electricity exists, and has always existed, from the back of a cat to the infinite arch of the sky.

A hundred years ago practically nothing was known of electricity. Persons now living were born into a world that had never seen an electric telegraph, a telephone, an electric car, or an electric light. We are living in the morning of electrical knowledge, and what the day may bring no one can imagine. Americans have given the world many of the greatest inventions, and in the field of electricity they have given it nearly everything of value. It is to American ingenuity that civilization is indebted for the electrical telegraph, the sub-marine cable, the telephone, the electric light, and the electric car. The names of Morse, Vail, Field, Bell, Brush, Gray, Edison, and Sprague—all American electrical inventors—will always be prominent in the list of the world's great benefactors.

If you will rub a stick of sealing wax briskly with a woolen cloth, you will find that the stick of wax will attract to itself bits of bran, small shreds of paper, and the like. This is the simplest experiment in electricity. In the same way, by rubbing amber with silk, Thales, a Greek philosopher who lived in the sixth century before Christ, is thought to have discovered electricity. The Greek word for *amber* is *elektron*. Because of the supposed discovery of electricity in amber by Thales, the English word *electricity* was "coined" and used for the first time by William Gilbert, a British physician and scientist, who lived during the reigns of Elizabeth and James.

For nearly twenty-five centuries, reaching from the time of Thales to the opening of the nineteenth century, the world learned practically nothing about electricity. The start in modern electrical knowledge was made by Galvani, an Italian scientist, born in 1737, who just before the last century dawned showed that electricity can be produced by the contact of metals with fluids. The term *galvanic*, used in connection with electricity, comes from the name of this investigator. Galvani's experiments suggested the electric battery to Volta, another Italian scientist who was born in 1745. The electrical word *voltaic* is in honor of Volta. In 1752 Benjamin Franklin flew his kite into the thunderstorm and proved that lightning is electricity. A little later Hans Christian Oersted, a Danish investigator, pointed out the relation between electricity and magnetism. In the early part of the nineteenth century, Michael Faraday, an eminent English physicist, discovered the possibility of producing electric currents through the motion of a magnet. Faraday's discovery led to the electric dynamo machine, the source of modern power over electricity.

The oldest and greatest of electrical inventions is the telegraph. *Tele* is a Greek adverb meaning "afar." *Graph* comes from the Greek verb "to write." *Telegraph* therefore means "to write afar."

The idea of telegraphic communication is more than two and a half centuries old. In 1632 Galileo referred to a secret art of communicating at great distances by means of magnetic needles. In 1753 there appeared in the *Scots Magazine* an article signed "C. M." (since ascertained to have been Charles Morrison, of Greenock in Scotland) setting forth a fairly clear idea of the electric telegraph. Joseph Henry, of Washington, D.C., in 1831 signaled through an electrical circuit a mile in length. The first commercially successful telegraph was devised in 1837 by Samuel F. B. Morse, an American.

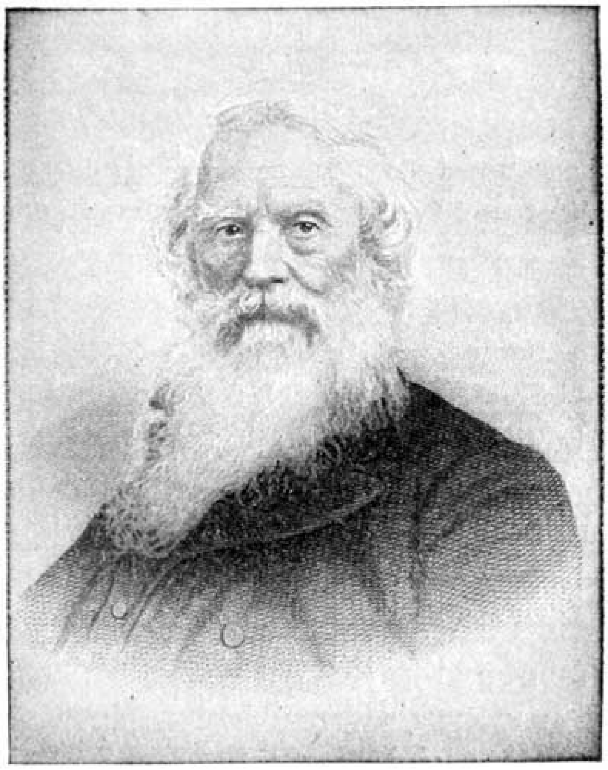
Samuel Finley Breese Morse was born in Charlestown, Massachusetts, April 27, 1791. He was educated in the common schools of his native town and in Yale University, where he was graduated in 1810. After graduation, like Fulton, the inventor of the steamboat, he went to Europe to study art, and became successful as an artist. On his return to America in 1832, one of his fellow passengers on the ship was Charles T. Jackson, who had been studying electricity in Paris. Jackson told Morse of some experiments in electricity which the French had been making, and remarked that it would be a good thing if news could be transmitted through long distances by electricity. Morse replied, "Why can't it be done?" From that hour he gave his time and energy to the invention of the electric telegraph. During the remainder of the voyage he drew plans for apparatus and tried to devise an electric alphabet. In 1837 he put two instruments at the ends of a short line through which he sent and received messages. About this time he met a man who was destined to be of great service to him in promoting his invention, and one who deserves almost as much credit for it as Morse himself. This was Alfred Vail.

Vail was born at Morristown, New Jersey, September 25, 1807. He was a son of Stephen Vail, the wealthy owner of the Speedwell iron works.

One day in September, 1837, after Morse had completed his apparatus, he was invited to exhibit it at the University of the City of New York. Alfred Vail was a student in the university at the time and was one of the spectators to whom the apparatus was exhibited. He was much impressed with it. Morse needed money, and Alfred Vail's father had it. Morse was invited to the home of the Vails in Speedwell, where the matter of the invention was talked over. The sum of two thousand dollars was necessary to get the invention started. Stephen Vail agreed to furnish the money. Alfred Vail was to construct apparatus and exhibit it to Congress. For this he was to have one-fourth of the proceeds arising from the patent.

Alfred Vail set to work to construct the apparatus. A room in his father's factory was set apart for this purpose. William Baxter, a bright mechanic employed in the iron shops, was chosen to assist him. As secrecy was required for the work, the room was kept locked. For several months Vail and Baxter occupied together the locked room, sharing each other's confidence and each other's elation or disappointment as the work went well or ill. On January 6, 1838, Baxter, without hat or coat, rushed to the elder Vail's residence to announce that the apparatus was completed.

Mr. Vail had become discouraged. However, he went to see the trial of the apparatus. He found his son at one end of the three miles of wire that was stretched around the room, and Morse at the other. After a short explanation had been made to him, he wrote on a piece of paper, "A patient waiter is no loser." He then said to his son, "If you can send this, and Mr. Morse can read it at the other end, I shall be convinced." The message was sent and read at the other end of the wire. The apparatus was taken to Washington, where it created not only wonder but excitement.



Samuel F. B. Morse

In September, 1837, Morse filed an application for a patent on his invention. In December of the same year he failed in his effort to secure from Congress an appropriation for an experimental line which he proposed to build between Washington and Baltimore. In May, 1838, he went to Europe seeking aid. The governments there refused him funds or patents. In May, 1839, he returned to the United States and began an heroic struggle for recognition. During this period he often suffered for the barest necessities of life. Sometimes he could afford but a single meal in twenty-four hours.

Finally, after repeated disappointments, when Morse himself had almost given up hope, the House of Representatives of the Twenty-seventh Congress, on the last night of its session, March 3, 1843, by a vote of ninety to eighty-two, appropriated thirty thousand dollars for building a trial line between Washington and Baltimore. After the bill had passed the House, the outlook for its passage in the Senate was not bright. One Senator who was favorable to the bill advised Morse to "give it up, return home, and think no more of it." The bill had been made the object of opposition and ridicule; one prominent official, to show his contempt for the project, proposed that half the amount asked for should be used in mesmeric experiments. Morse, believing that the Senate would defeat the appropriation, went to his lodging place to retire for the night. He found that after paying the amount he owed at the hotel, he would have less than forty cents left. Early the next morning information reached him that a little before midnight the Senate had passed the bill. Apparent failure had turned into victory; the fight was won.

"Work was begun at once. [1] On April 30 the line reached Annapolis Junction, twenty-two miles from Washington, and was operated with satisfactory results.

"May 1, 1844, was the date upon which the Whig convention was to assemble in Baltimore, to nominate the candidates of that party for President and Vice-President. It was arranged between Morse and Vail that the latter should obtain from the passengers upon the afternoon train from Baltimore to Washington, when it stopped at Annapolis Junction, information of the proceedings of the convention and transmit it at once to Morse at the Capitol in Washington.

"The train arrived at half-past three o'clock, and from the passengers, among whom were many of the delegates to the convention, Mr. Vail ascertained that the convention had assembled, nominated the candidates, and adjourned. This information he at once dispatched to Morse, with whom was gathered a number of prominent men who had been invited to be present. Morse sat awaiting the prearranged signal from Vail, when suddenly there came from the instrument the understood clicking, and as the mechanism started, unwinding the ribbon of paper upon which came the embossed dots and dashes, the complete success of the telegraph over twenty-two miles of wire was established.

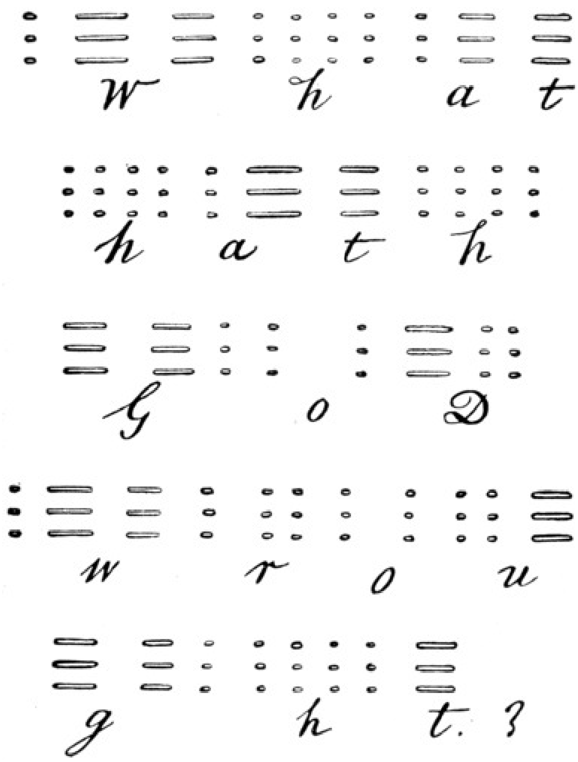
"Slowly came the message. When it had ended, Morse rose and said: 'Gentlemen, the convention has adjourned. The train bearing that information has just left Annapolis Junction for Washington, and Mr. Vail has telegraphed me the ticket nominated, and it is—' he hesitated, holding in his hand the final proof of victory over space, 'it is—it is Clay and Frelinghuysen.'

"'You are quizzing us,' was the quiet remark. 'It's easy enough for you to guess that Clay is at the head of the ticket, but Frelinghuysen—who is Frelinghuysen?'

"'I only know,' was the dignified answer, 'that it is the name Mr. Vail has sent to me from Annapolis Junction, where he had the news five minutes ago from the train bound this way bearing the delegates.'

"At that time the twenty-two miles from the Junction to Washington required an hour and a quarter for the fastest trains, and long before the train reached Washington the newsboys—enterprising even in those days—had their 'extras' upon the streets, their headings 'By Telegraph' telling the story, and being the first time that such a legend had ever appeared upon a printed sheet.

"A great and enthusiastic crowd greeted the delegates as they alighted from the train at the station. They were struck dumb with astonishment when they heard the people hurrahing for 'Clay and Frelinghuysen,' and saw in cold type before their very eyes the information which they supposed was exclusively their own, but which had preceded them 'by telegraph.' They had asked Mr. Vail at the Junction what he was doing when they saw him working the telegraph key, and when he told them, they joked about it most glibly, for no one had any belief in the success of the telegraph."



The First Message by Telegraph

By May 23 the entire line was completed from Washington to Baltimore. On the next day, May 24, 1844, Morse from Washington sent to Vail at Baltimore the first message ever sent over the completed wire, "What hath God wrought?"

This famous message was dictated by Miss Ellsworth, daughter of the commissioner of patents at that time. She had taken a keen interest in the success of the bill appropriating the thirty thousand dollars for the experiment, and was the first to convey to Morse the news that the bill had passed. Morse thereupon gave Miss Ellsworth his promise that the first message to pass over the line should be dictated by her. A bit of the original wire and the receiver that Vail used at Baltimore are now preserved in the National Museum in Washington. The transmitter used by Morse at the Washington end of the line has been lost.

Morse lived to see his system of telegraphy adopted by the United States, France, Germany, Denmark, Sweden, Russia, and Australia. Ninety-five per cent of all telegraphy is by his system. He finally received a large fortune from his invention. Unlike Columbus, Morse was honored in his lifetime for his achievement. Foreign nations bestowed upon him honors and medals, and in August, 1858, a convention of European powers called by Napoleon III at Paris gave Morse four hundred thousand francs (about $80,000) as a testimonial of his services to civilization. In October, 1842, he laid the first sub-marine telegraph line. It was across the harbor of New York. Later he assisted Peter Cooper and Cyrus W. Field in their efforts to lay the first Atlantic cable. Honored by all the civilized world, he died in New York City April 2, 1872. Thirteen years earlier Vail had died at his home in Morristown, New Jersey.

In the Morse system the alphabet is represented by combinations of dots and dashes. The dots denote short currents of electricity flowing through the wire; the dashes, longer ones. Credit for the alphabet really belongs to Vail; Morse had devised a somewhat complicated system, but Vail invented the dots and dashes. He discovered that *e* and *t* are the most frequently used letters. He denoted *e* by one dot, or one short current; *t* he indicated by one dash, or one long current. The other letters are denoted by dots and dashes, as *a*, one dot and one dash; *b*, one dash and three dots, etc.

In 1838 Steinheil, a German investigator, contributed an important element to the practical operation of the electric telegraph by discovering that the earth could take the place of the return wire, which up to that time had been deemed necessary to complete the circuit.

At first only one message could be sent over a wire at a time. Now several messages may be transmitted in opposite directions over the same wire at the same time.

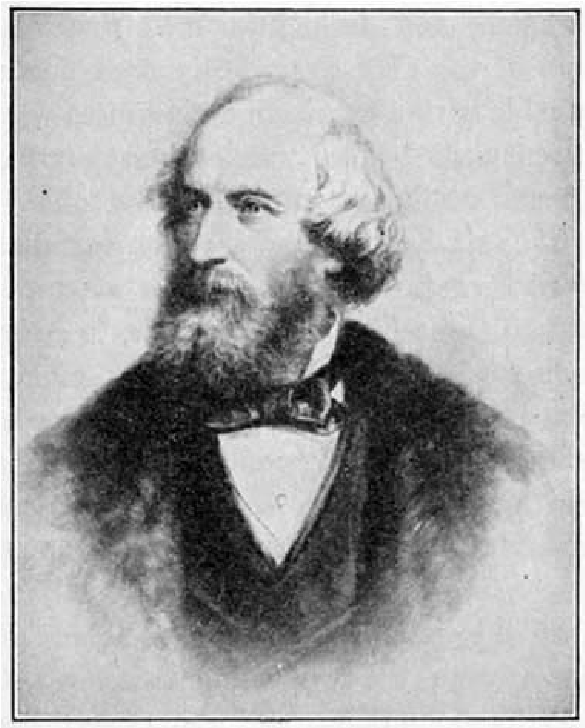
Wireless telegraphy is based on the principle discovered and announced by the English scientist Michael Faraday, that heat, light, and electricity are transmitted by ether waves, and that these ether waves permeate all space. The first to demonstrate the practical operation of wireless telegraphy was Guglielmo Marconi, an Italian. In 1890 he undertook experiments to prove his theory that the electric current readily passes through any substance, and when once started in a given direction follows a direct course without the aid of a conductor. Marconi made the first practical demonstration of wireless telegraphy in 1896. In March, 1899, he sent a wireless message across the English channel from France to England. In December, 1901, be began his first experiments in wireless telegraphy across the Atlantic. In December of the following year the first official trans-Atlantic wireless message was sent. Now wireless telegraphic messages are sent regularly to and from moving ships in mid-ocean, and across the three thousand miles of the Atlantic between Europe and America.

One of the most striking illustrations of the power of perseverance is the successful struggle of Cyrus West Field in laying the Atlantic cable. Mr. Field was born in Stockbridge, Massachusetts, November 30, 1819. His schooling, which was slight, was secured in his native town. When he was fifteen years old, he secured a position in a business house in New York City at a salary of fifty dollars a year. He subsequently founded a prosperous business in the manufacture and sale of paper. In 1854 Mr. Field's attention was directed to an attempt to lay an electric cable at Newfoundland, which had failed for want of funds. The idea of laying a cable across the Atlantic occurred to him. He laid his plans before a number of prominent citizens of New York. On four successive evenings they met at his home to study the project, and they finally decided to undertake it. On May 6, 1854, a company was organized to lay the cable, with Peter Cooper as president.

The next twelve years Field devoted exclusively to the cable. He went to England thirty times. The first cable was brought from England and was to be laid across the Gulf of St. Lawrence. Forty miles had been successfully laid, when a storm arose and the cable was cut in order to save the ship. Then came a year's delay. Meantime the bottom of the sea was being explored and a vast tableland was discovered stretching from Newfoundland to Ireland. Field went to England, where he had little difficulty in organizing a company, and work was then begun on the construction of a new cable. Next he laid his enterprise before Congress, and asked for money. An appropriation bill was finally passed in the Senate by a majority of one, and was signed by President Pierce on March 3, 1857, the day before he retired from office. Field returned to England to superintend the construction of the cable and to make preparations for laying it. At last it was ready, tested, and coiled on the ship. On August 11, 1857, the sixth day out, after three hundred and thirty-five miles had been laid, the cable parted.

Lord Clarendon, in an interview with Field, had remarked: "But, suppose you don't succeed? Suppose you make the attempt and fail—your cable is lost in the sea—then what will you do?" The reply came promptly, "Charge it to profit and loss, and go to work to lay another." Lord Clarendon was so well pleased with the reply that he pledged his aid. The loss of three hundred and thirty-five miles of cable was the loss of half a million dollars. Field came back to America and secured from the Secretary of the Navy the vessels needed for another trial. On June 10, 1858, the United States steam frigate *Niagara*, then the largest in the world, and the British ship *Agamemnon* set out from opposite shores, bound for mid-ocean. The vessels met, and the two sections of the cable were spliced; then they began laying it toward both shores at the same time. After a little more than a hundred miles had been laid, this cable parted in mid-ocean, and Field hurried to London to meet the discouraged directors.

On July 17, the ships set sail again for mid-ocean. The cable was spliced in fifteen hundred fathoms of water and again the ships started for opposite shores. Field was on the *Niagara* headed toward Newfoundland. Scarcely any one looked for success. Field was the only man who kept up courage through this trying period. On August 5, 1858, he telegraphed the safe arrival of the ship at Newfoundland. The shore ends of the cable were laid and on August 16 a message from Queen Victoria of England to President Buchanan flashed under the sea. There was great excitement everywhere. The two worlds had been tied together with a strange electric nerve.



CYRUS W. FIELD

On the evening of the first of September a great ovation was tendered Field in New York. National salutes were fired; processions were formed; there was an address by the mayor, and late at night a great banquet. While the banquet was in progress, the cable parted.

Everyone except Field was disheartened. He went to work again, and during the next five years, the long years of the Civil War, he labored unceasingly. A larger cable with a greater resisting force was made. On the twenty-third of July, 1865, the steamship *Great Eastern* began another attempt to lay the cable. When it was within six hundred miles of Newfoundland, the cable parted again. For nine days attempts were made, in two and a half miles of water, to grapple the cable, splice it, and continue the work of laying it. Three times the cable was grappled, but the apparatus on the ship was not strong enough to hoist it aboard. Still Field never faltered. Another British company was formed and another cable was constructed. The *Great Eastern* was again loaded and on July 13, a Friday, set sail westward laying the cable. After an uncertain voyage of two weeks the *Great Eastern* arrived at Newfoundland, and the undertaking had again been successfully accomplished. Field telegraphed his arrival as follows: "*Hearts Content, July 27, 1866*. We arrived here at nine o'clock this morning. All well. Thank God, the cable is laid, and is in perfect working order. CYRUS W. FIELD."

Twelve years of unfaltering perseverance had won. Honors were heaped upon Field. Congress voted him a gold medal and the thanks of the nation. The prime minister of Great Britain declared that only the fact of his being the citizen of another nation prevented his receiving the highest honors in the power of the British government to bestow. The Paris "Exposition Universelle" of 1867 honored him with the Grand Medal, the highest prize it had to give.

Mr. Field was afterward interested in the laying of cables connecting Europe, India, China, Australia, the West Indies, and South America. In 1880-81 he made a trip around the world, full of satisfaction in his own part in making a new era of the world's civilization. He died at his home in New York on July 11, 1892.

The effect of the electric telegraph on government, intelligence, and civilization in general can scarcely be overstated. Sydney Smith, writing to Earl Grey after the admission of California into the United States, said that this marked an end to the great American republic; for how could people with such diversified interests, with such natural barriers, hold together? He did not foresee how strongly a fine copper wire could bind together the two seaboards and the great plains of the interior. Without the electric telegraph, neither the great daily newspaper nor the modern operation of railroads would be possible. It wipes away the natural boundaries of nations and makes neighbors of all men.

In 1819 Sir Charles Wheatsone, an English physicist, invented an instrument popularly known as the "magic lyre," but which he called the telephone. The first part of this word is the same Greek adverb *tele* that is found in *telegraph*. The *phone* is from another Greek word meaning "to sound." To *telephone*, therefore, means "to sound afar." The use of the English word *telephone* by Wheatsone is historically the first appearance of the word in our language. His device did nothing but reproduce music by means of sounding boards. The inventor of the modern telephone is Alexander Graham Bell.

Mr. Bell was born in Edinburgh, Scotland, March 3, 1847. His father was Alexander Melville Bell, a Scotch educator, inventor of a system of visible speech, and author of some text-books on elocution. His grandfather was Alexander Bell, noted for his efforts to remove impediments of speech. Alexander Graham Bell was therefore well fitted by heredity for the invention of an instrument to transmit speech. He was educated in the Edinburgh high school and in the University of Edinburgh, and in 1867 he entered the University of London. Hard study broke down his health and he moved to Canada. Thence he moved to the United States, becoming first a teacher of deaf mutes, and afterward professor of vocal physiology in Boston University. In 1874, at the suggestion of the Boston Board of Education, he began some experiments to show to the eye the vibrations of sound, for the use of the deaf and dumb. The results of these experiments convinced Bell that articulate speech could be transmitted through space. Early in 1876 he completed the first telephone. The same year he exhibited it at the Centennial Exposition at Philadelphia, where it was pronounced the "wonder of wonders."

He filed application for a patent on his invention at the Patent Office in Washington, February 14, 1876. It is a singular fact that another application for a patent on the telephone was received at the Patent Office a few hours later on the same day from Elisha Gray, an electrical inventor of Chicago. The patent was issued to Bell, not because his invention was superior in merit to Gray's, but on the ground that his application was received first. This is a case where "the early bird catches the worm," for the profits arising from the patent have made Mr. Bell very wealthy, and high honors have come to him as the inventor of one of the world's greatest and most marvelous inventions.

The Bell Telephone Company was organized in 1877, and in 1878 the first telephone exchanges were constructed. By the following year the telephone was firmly established as a social and commercial necessity. It has grown with great rapidity. It is now found in every city of the world; hotels, large buildings, and ships have their private exchanges, and it has found its way recently into thousands of farmhouses.

Bell had to fight hard in the courts to sustain his patent. Suit after suit was brought by rival claimants, attacking his right to the patent. The litigation was bitter and protracted. One of the most noteworthy of these suits was brought by a Pennsylvania mechanic named Drawbaugh. He claimed that about 1872 he had made a working telephone out of a cigar box, a glass tumbler, a tin can, and some other crude materials; and that with the apparatus thus constructed he had talked over a wire several hundred feet long. Many persons testified that they were acquainted with Drawbaugh's apparatus, some of them having used it. Some instruments, said to be the original ones which Drawbaugh had constructed, were brought into court and exhibited. It was shown that speech could be transmitted with them in a crude way. Drawbaugh claimed that he was too poor at the time of making the apparatus to take out the necessary patent. The Court decided in favor of Bell. Elisha Gray, whose application for a patent had been received the same day that Bell's was, also brought suit against Bell. Before making his application, Gray had filed some preliminary papers looking forward to a patent on the telephone. In his suit against Bell he charged that the patent examiner had fraudulently and secretly conveyed to Bell the contents of those papers. But Bell won this suit, and he finally established over all rivals his legal title as the inventor of the telephone.

Recently a wireless system of telephoning has been in process of development, and it will not be strange if, within a few years, we shall be talking through space without wires, so boundless seem the possibilities of the age.

[1] From an account by Stephen Vail used in *Graded Literature Readers*, by permission of *Truth*.

CHAPTER V

ELECTRICITY: LIGHTING, TRANSPORTATION, AND OTHER USES

Man must have discovered artificial light as soon as he discovered fire, for the two exist together. The first light was probably produced by burning sticks or pieces of wood. In his search for more light, man learned how to make the tallow candle. Lights made in one form or other from the fats of animals persisted almost to the threshold of the present. The next step forward was to the use of oil; and the next, to the use of gas.

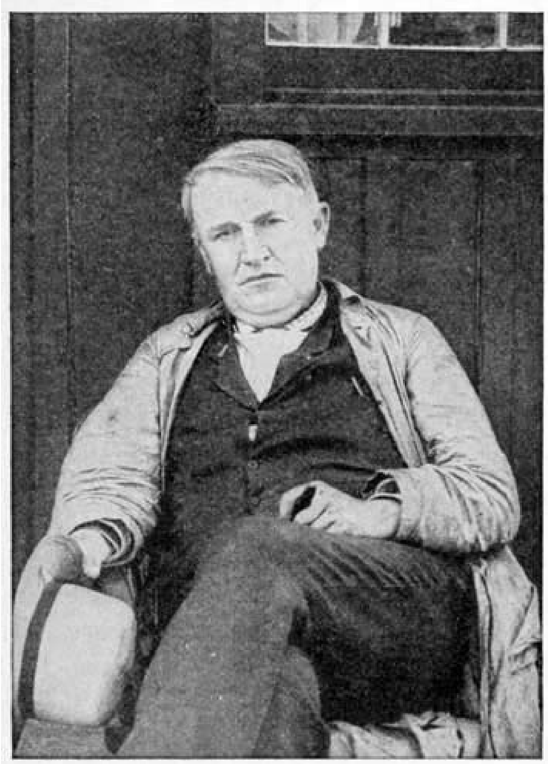
The first practical use of gas for purposes of illumination was in 1792. In that year William Murdoch, an English engineer, produced gas artificially from coal, and with it lighted his house in Cornwall, a county of England. Nine years afterward a Frenchman named Lebon illuminated his house and garden in Paris with gas produced from wood. Street lighting by gas was introduced in 1807 by an Englishman named F. A. Winzer or Windsor, in Pall Mall, one of the fine streets of London. The first gas lights in America were installed in 1806 by David Melville, of Newport, Rhode Island, in his residence and in the streets adjacent. Baltimore was the first city in the United States to adopt gas lighting for its streets. This was in 1817.

When gas was first used, there was much opposition to it, as there usually has been to improvements in general. The citizens of Philadelphia protested for more than twenty years against the introduction of gas into that city for purposes of illumination. Some of the newspapers of the time called gas a "folly and a nuisance"; and one of the professors in the University of Pennsylvania declared that even if gas were the good thing its supporters were declaring it to be, tallow candles and oil lamps were good enough for him. But gas triumphed, and to-day the world could scarcely do without it, either for illumination or for fuel.

The electric light had its beginning about 1800 in the experiments of Sir Humphry Davy, a British investigator. He discovered that if two pieces of carbon are brought into contact, completing a circuit through which an electric current flows, and if the carbon points are separated by a short distance, the points will become intensely hot and emit a brilliant light. The word *arc*, used in connection with the arc lamp or light, refers to the gap or arc between the two carbon points, across which the electric current leaps in creating the light.

Following Sir Humphry Davy's experiments, several arc lights were invented, with greater or less degree of success, and about 1860 electricity was tried successfully for lighting in some lighthouses along the British coast. The widespread usage and the usefulness of the arc electric light, however, are due to Charles Francis Brush, an electrical inventor of Cleveland, Ohio, who in 1876 simplified the arc light so as to bring it into general use for lighting streets, large rooms, halls, and outdoor spaces. Brush was also the inventor of an electric-dynamo machine that has added to his fame. After the invention of the arc light, he took out more than fifty other patents. The incandescent electric light, for lighting residences and small rooms, came a little later as the invention of Edison.

Thomas Alva Edison is one of the most remarkable men of all times and places. Alexander, Caesar, and Napoleon together did not benefit mankind as has this quiet American inventor. He was born at Milan, Ohio, February 11, 1847. His father was of Dutch descent and his mother was Scotch. The mother, who had been a teacher, gave him all the schooling he received. Early in life he showed great mental vigor and ingenuity. When he was twelve years old, he is said to have read the histories of Hume and Gibbon.



Thomas A. Edison

When Thomas was seven years old, the Edison family moved to Port Huron, Michigan. He soon became a newsboy on the Grand Trunk railway running into Detroit. He also became proprietor of a news stand, a book store, and a vegetable market, each a separate enterprise in Port Huron, employing eleven boys in all. His spare hours in Detroit, between the arrival and departure of his train, he spent reading in the Free Library. Before long he had bought a small hand printing press, some old type, and plates for "patent insides" from the proprietor of a Detroit newspaper, and using the baggage car for an office, he started the *Grand Trunk Herald*, the first and only newspaper ever published on a railway train. His inquiring mind led him one day to make some chemical experiments in the car. He overturned a bottle of phosphorus, set the car on fire, and as a result was not permitted to use it longer for a newspaper office.

One day young Edison snatched the child of the station agent at Mount Clemens, Michigan, from beneath the wheels of a locomotive. In gratitude for this act, the station agent taught him telegraphy. In a few months his ingenuity, one of the chief characteristics of the great inventor, led him to string a private telegraph wire from the depot to the town. Over this wire he forwarded messages, charging ten cents for each message. Next he went to Stratford, Canada, as night operator for the Grand Trunk railway. One night he received an order to hold a train. He stopped to reply before signaling the train, and when he reached the platform the train had passed. A collision resulted, though not a serious one, and Edison was ordered to report at the office of the general manager. Edison hastily climbed on a freight train, went to Port Huron, and probably has not yet called on the general manager.

Edison worked as telegraph operator at various places. Although he was a brilliant and rapid telegrapher, his fondness for playing pranks and making fun lost him several positions. After making his first experiments with a telegraph repeater, he left Indianapolis for Cincinnati, where he earned sixty dollars per month, besides something extra for night work. He Worked next in Louisville and Memphis. He was poor in purse, for all his money went to defray the expenses of his experiments. His fondness for Victor Hugo's great work, *Les Miserables*, gained for him the nicknames of "Victor" and "Hugo."

At Memphis he perfected his telegraph repeater and was the first to bring New Orleans into direct communication with New York. However, the manager at Memphis was jealous of him and dismissed him. Shabby and destitute, he made his way back to Louisville, walking a hundred miles of the way, and resumed his old position. After he had worked in the Louisville office for two years, his experimenting again got him into trouble. He upset some sulphuric acid, part of which trickled through the floor and spoiled the carpet in the manager's room below. For this he was discharged. He next went to New Orleans, intending to sail for Brazil; but the ship had gone and an old Spanish sailor advised him to stay in America. He went back to Cincinnati, where he made some of his first experiments in duplex telegraphy, a system whereby two messages may be sent over the same wire at the same time.

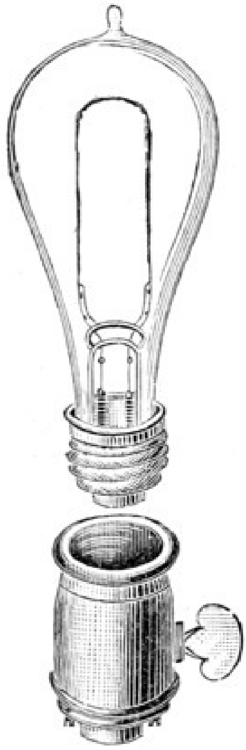
A little while afterward, as poor as ever and as unattractive in dress, he walked into the telegraph office in Boston, where he had procured work. His co-workers there, thinking they would have some fun at his expense, set him to receiving messages from the most rapid operators in New York. Instead of throwing up his hands in defeat, as his companions expected, he received the messages easily, with a good margin to spare, and asked the operator sending at the other end of the line to "please send with the other foot." He was at once placed regularly on the New York wire. While in Boston, Edison opened a small workshop, put many of his ideas into definite shape, and took out his first patent. It was upon a chemical apparatus to record votes. He tried to introduce this into Congress, but failed, although he proved that it "would work."

He left Boston not only without money, but in debt, and went to New York. This was in 1871 when he was twenty-four years old. At that time an apparatus called a "gold indicator" was in use in the offices of about six hundred brokers, to show fluctuations in the prices of gold. The system was operated from a central office near Wall street. One day this central office was filled with six hundred messenger boys, each bringing the complaint that the machinery had broken. No one knew how to repair it. A stranger walked up, looked at the apparatus, and said to the manager, "Mr. Law, I think I can show you where the trouble is." The machinery was repaired, the office was cleared, and order was restored. "What is your name, sir?" asked the delighted manager. "Edison," was the reply. He was engaged as superintendent at a salary of $200 per month, and from that hour his fortunes were assured.

Edison at once busied himself with inventing. He improved and invented various machines used in the stock markets, and in 1872 perfected his system of duplex telegraphy. Two years later he brought out the wonderful quadruplex system, by which four messages may be sent over the same wire at the same time. This system saved millions of dollars and dispensed with thousands of miles of poles and wires.

He started a large factory at Newark, New Jersey, employing some three hundred men. Sometimes he was working on as many as forty-five improvements and original inventions at once. In 1876 he stopped manufacturing and turned all his attention to inventing. In that year he established a laboratory at Menlo Park, New Jersey, twenty-five miles from New York City. When this laboratory was outgrown, he founded a new one at Orange, New Jersey, the largest laboratory ever established by one man for scientific research and invention. It comprises one building 250 feet long and three stories high, and four smaller buildings, each one hundred feet long and one story high. The principal building contains a library of thirty thousand reference books, a lecture room, and an exhibition room, where a remarkable collection of instruments of almost every kind is to be seen.

When Edison began working to produce an incandescent electric light for illuminating residences and small rooms, most of the scientists of England said that such a light could not be produced. For nine years he worked on this invention. The chief problem was to find, for the horseshoe thread or filament used to give off the light, a material that should glow with sufficient intensity and yet not be consumed by the great heat necessary to produce the light. In his search for this material he tried all kinds of rags and textiles steeped in various chemicals, different kinds of paper, wood, inner and outer bark, cornstalks, etc. Finally he sent one of his assistants to the East, and in Japan a kind of bamboo was found answering the requirements. Perseverance won, and the incandescent electric light became a reality about 1880.



AN INCANDESCENT LIGHT

Thomas Edison is one of the most systematic of workers, and nearly all his inventions have been the result of intelligent and methodical labor directed toward a definite aim. He reads carefully what other investigators have found out, so as not to waste time in going over fruitless ground. He also keeps copious note books of his own operations, so that there may be no loss of time and energy. His invention of the phonograph, however, was accidental. While he was working to improve the telephone, the idea of the phonograph suddenly came into his mind. A little while afterward the first phonograph, crude but successful, was finished. At first this instrument was regarded as a toy, but later the invention was sold for a million dollars.

Edison is a man of remarkable personality. Once when someone referred to him as a genius and said that he supposed a genius worked only when the spirit moved him, the inventor replied, "Genius is two per cent inspiration and ninety-eight per cent perspiration." He certainly possesses great native talent for inventing. This was apparent in his early boyhood. But much of his marvelous success is due to the intelligent direction of effort, to tireless perseverance, and to long hours of work. In 1897 he devoted his attention exclusively to the invention of a new storage battery, upon which he had been working for five years. For more than a year he worked harder than a day laborer. He was in his laboratory by half past seven in the morning; his luncheon was sent to him there; he went home to dinner, but he returned by eight o'clock. At half past eleven his carriage called for him, but often the coachman was compelled to wait three or four hours before the inventor was willing to suspend his work. While the first incandescent electric lighting plant was being prepared in New York City, Edison himself worked part of the time in the trenches, to be sure that the work would be properly done.

There is scarcely an electrical apparatus or an electrical process in existence to-day that does not bear the mark of some great change for the better coming from this most ingenious of American inventors. He has taken out more than four hundred patents on original inventions and improvements. Mr. Edison is still living in his beautiful home at West Orange, New Jersey, near his laboratory. He is frequently called the "Wizard of Menlo Park."

The idea of using electricity as motive power on railroads is nearly as old as the railroads themselves. In 1837, when the utility of steam for purposes of transportation was doubted, Robert Davidson propelled a car with an electric engine on the Edinburgh and Glasgow road. In the fifties Thomas Davenport, a Vermont blacksmith, constructed an electric engine containing all the essential elements of the modern electric motor. Little progress, however, was made in the use of electricity for motive power, because the cost of producing the electric current was so great. In 1887 Lieut. Sprague, overcoming most of the difficulties then existing, installed at Richmond, Virginia, the first successful electric railway in the world. Managers of street railways in other cities visited Richmond, and after an inspection of what Sprague had done there, decided to substitute electricity for animal power. No other construction has had a more rapid growth since the time of its invention than the electric railway. In 1890 there were only thirteen unimportant electric roads. Now there is hardly a city of the civilized world where the hum of the electric street car is not heard at all hours of day and night. Modern urban life could scarcely exist without it. It is rapidly pushing its way into the country and giving the farmer the privilege of rapid and cheap transit.

The uses of electricity are by no means exhausted in the four major inventions of the telegraph, the telephone, the electric light, and the electric street car. It has been put to many minor uses. Among the most interesting and important of these are the Roentgen or X-rays, discovered by Wilhelm Konrad von Roentgen, a German physicist, in 1895. They were named X-rays by their discoverer, because the ultimate nature of their radiation was unknown, the letter X being commonly used in algebra to represent an unknown quantity. The X-rays are peculiar electric rays having the power to penetrate wood, flesh, and other opaque substances. They are of much value to surgery in disclosing the location of bullets, foreign substances of various kinds, and other objective points in the interior of the human body.

The United States government has demonstrated through its Department of Agriculture that electricity applied to the soil will quicken and help the growth of certain vegetables. It has also shown that certain crops are forwarded by the application of electric light.

The New York legislature in 1888 passed a law providing that criminals should be executed in that state thereafter by electrocution, that is, by sending through the body of the condemned person, a current of electricity strong enough to produce death. Execution in this way makes death quicker and apparently less painful than by hanging, the method used previously, and subsequently several other states have passed laws for electrical execution, following the example of New York.

Elisha Gray, who contested with Bell the invention of the telephone, was the inventor of a peculiar machine called the telautograph. *Tele* and *graph* have been previously explained. *Auto* is from a Greek word meaning "itself." The meaning of *telautograph*, therefore, is "to write afar by itself." By means of the telautograph, which is operated with electric currents, if a person writes with an ordinary lead pencil on paper, say in Washington or any other place, at the same time the writing will be reproduced with pen and paper at the other end of the line, in New York or wherever the message may be sent.

One of the important uses of electricity is in connection with the electric block signal. This is a device for preventing railroad collisions. The signals are operated with electricity, and show engineers whether or not a certain section of the track ahead of them is clear.

Electricity is used also in the production of certain chemical substances; in covering base metals with a coating of a precious metal, as gold or silver, called electroplating; in producing a solid metal page from rows of type, called an electrotype, which is used in printing; in the navigation of small boats and the propulsion of automobiles; in playing organs and pianos; in driving electric fans; in drawing elevators in high buildings; in call-bells and door-bells; in police-alarms and fire-alarms; in the treatment of certain diseases; and in many other useful ways. What electricity may do for the future cannot even be guessed.

CHAPTER VI

THE DISCOVERY OF AMERICA

The birthplace of mankind is supposed to have been somewhere in Asia, untold thousands of years ago. The race is thought to have spread thence to the northern coast of Africa and to the peninsulas that jut down from the south of Europe. The travelers of ancient times were the Phœnicians. They occupied a narrow strip of land along the eastern shore of the Mediterranean Sea. Their country was small and with difficulty supported an increasing population. To the east of them were barbaric hordes, who poured over the mountains and pushed the Phœnicians to the sea, making of them traders and colonizers. As early as twelve centuries before Christ they were founding colonies, exploring strange lands, trading all over the known world, and leaving their alphabet wherever they went. Arriving at a favorable place, they would pull their ships ashore, plant a crop, wait till it had matured, reap it, and go on. They founded many colonies on such sites.

Herodotus, a Greek, born in Asia Minor nearly five hundred years before Christ, is called the father of history and geography. He tells us that in his time the earth was thought to consist of the coast regions of the Mediterranean Sea, extending rather vaguely north and south, and bounded on the west by the Atlantic Ocean and on the east by the great Persian Empire. The word *Mediterranean* is made up of two Latin words meaning "the middle of the earth." Eratosthenes, a Greek geographer who was born on the northern coast of Africa about three centuries before Christ, wrote a geographical treatise in which he announced his belief that the earth was in the form of a sphere revolving on its own axis. He succeeded in convincing only a few, however, that his theory was right. The next great geographer was Strabo, born in the northeast part of Asia Minor in the year 64 B.C. He was a great traveler and observer, and wrote a work on geography that has come down to us. The parts dealing with his own observations are especially valuable.

The great traveler of mediæval times was Marco Polo, an Italian, born in Venice in 1254 A.D. He traveled widely, had many adventures, and published an account of his travels. His experiences were a great stimulus to geographical inquiry and discovery. About this time also the mariners' compass was introduced into Europe. Civilization seems to be indebted to the Chinese for the compass, for it is mentioned by them as an instrument of navigation as early as the third or fourth century after Christ. With the advent of the compass, seamen were no longer compelled to hug the shore; they acquired more daring to sail the open sea, and geographical exploration was correspondingly widened.

Geographical knowledge grew very slowly. By the beginning of the eighteenth century, explorers had become familiar with the range of the ocean, the outline of the continents, and with many islands. At the beginning of the nineteenth century, four fifths of the land area of the entire globe was unknown. Africa, except a narrow rim of coast, was almost as little known as the planet Mars is to-day. At the opening of the last century men knew little more about Asia than did Marco Polo, three or four centuries earlier. In America the whole vast area west of the Mississippi River was unknown in 1800. The coast of Australia had not yet been traced, and nothing was known of its interior. At that time South America was better known than any other of the continental land masses, except Europe; now it is the least explored of all. The nineteenth century, wonderful for advancement in many fields of human endeavor, was a marvelous one for the growth of geographical knowledge. As we stand in the doorway of the twentieth century, there is scarcely one eleventh of the land area of the whole earth that remains unexplored. Lewis and Clark pushed their way through the unknown vastness of the American Northwest; Livingstone and Stanley penetrated the dark continent of Africa; and in September, 1909, Lieut. Robert E. Peary of the United States Navy startled civilization by announcing his discovery of the North Pole. With the exception of a few interior tracts to-day, the only portions of the earth unknown and unmapped lie around the poles, and these are being rapidly sought out and brought to knowledge.

Of all geographical conquests, by far the greatest is the discovery of America by Christopher Columbus in 1492 A.D. The story of Columbus is one of the most interesting and pathetic in history. It is a story of toil, hardship, perseverance, and great success, requited with disappointment and disgrace.

Christophoro Colombo was born in Genoa, Italy, about 1435 or 1436 A.D. Following the custom of those times in giving names Latin forms, his name became Christopher Columbus. In Latin the word *columba* means "dove." His father was a wool-comber who was wealthy enough to send his son to a university, where he studied mathematics and astronomy. On leaving the university, he worked a few months at his father's trade, but when he was fifteen years old he determined to be a sailor.

Of the late boyhood and early manhood of Columbus little is known. He seems to have traveled much, and it is certain that he studied much. It was popularly supposed in the time of Columbus that the earth was flat; that it was surrounded by a great world-river called "Oceanus" or the ocean, and that if one should come to the edge he would plunge down into illimitable space. From the time of Eratosthenes and Aristotle, Greek thinkers and scholars who lived several hundreds of years before the birth of Christ had known that the earth was round, and Columbus believed this fact too. He mastered the books, both ancient and contemporary, on geography and navigation, learned to draw charts and to construct spheres, and fitted himself to be a practical seaman and navigator.

In 1470 he arrived at Lisbon, Portugal, after he had been shipwrecked in a sea fight and had escaped to land on a plank. In Portugal he married the daughter of an old sea captain. He pored over the logs and papers of his father-in-law, and talked with old seamen of their voyages and of the mysteries of the western sea. About this time he seems to have arrived at the conclusion that much of the world remained undiscovered. There were strange rumors about the western sea. Navigators had seen queer pieces of wood and some canes in the ocean, and the bodies of two strange men had been washed ashore, "very broad-faced, and differing in aspect from Christians." European commerce was in need of a shorter route to Asia than the overland route then in use. Columbus hoped that he could reach the eastern coast of Asia by sailing west. He did not believe the earth as large as it really is, and he over-estimated the size of Asia, so that he did not realize the breadth of the Atlantic or the magnitude of the task before him.

Columbus was poor, and money was required for so huge an undertaking as a voyage to Asia. It was necessary, therefore, for him to seek aid in the enterprise. He asked help first from the senate of his native town, Genoa; but Genoa turned to him an unhearing ear. He applied next to King John of Portugal. The king referred the matter to a council of geographers, who reported against it. With the lurking hope that there might be something in the plan, the king was dishonorable enough to send out an expedition secretly to test it. The sailors who made the attempt soon lost heart and returned without having accomplished anything. When Columbus learned of the king's secret attempt, he was so outraged that he left Portugal for Spain. At about the same time he sent his brother Bartholomew to England to enlist the assistance of the British sovereign, King Henry VII. After much waiting and much vexation, Columbus at last gained the interest of the Spanish king, Ferdinand, who referred the proposition to a council of his astronomers and geographers. They finally decided that the project was vain and visionary and that they could have nothing more to do with it.

In great discouragement Columbus began preparations to go to France. At the door of a monastery in the little maritime town of Palos, he knocked and asked for bread and water for his son, Diego, who was accompanying him. He was received at the monastery, and there he met some persons of influence who interceded for him with the Spanish queen, Isabella. He went to the Court again, his plan was once more investigated, and once more Columbus was refused the aid he was seeking. He set out for France and had journeyed some distance on the way. In the meantime an official won the queen's consent to the enterprise, and there is a story that in her enthusiasm she offered to pledge her jewels to raise money for the expedition. A messenger who was sent to overtake Columbus brought him back, and on the seventeenth of April, 1492, the formal agreement between him and the king and queen of Spain was entered into, signed, and sealed.

Columbus's aim was to find the east coast of Asia. For the accomplishment of this he had a number of motives. He wanted to win wealth and fame for himself, to provide a shorter and cheaper route for commerce with the East, and to convert to Christianity the Grand Khan, a great Asiatic ruler, to whom he bore a letter of introduction from the rulers of Spain.

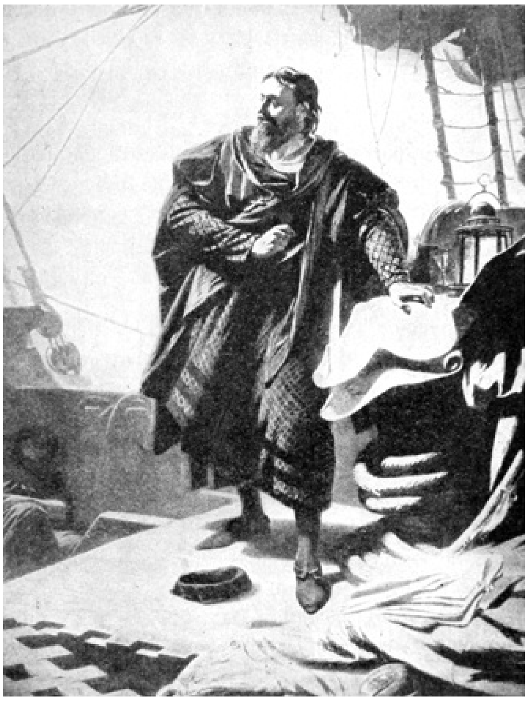
Great difficulty was experienced in finding sailors for so uncertain and terrifying a trip. Freedom was offered to convicts and bankrupts if they would accompany the expedition. At last seamen were secured to man three small ships, stores were provided, and everything was made ready for the voyage. The adventurers numbered, all told, one hundred and twenty. The shore presented a strange spectacle on the morning of departure. The friends of the sailors stood on shore weeping and wringing their hands, confident in the belief that their loved ones would be swallowed up by some fabulous monster of the western deep, or in some way be forever lost to them. On the morning of Friday, August 3, 1492, at eight o'clock, the little fleet of three ships weighed anchor at the port of Palos, Spain, and set out on the most uncertain and the greatest of all ocean voyages.

The ships had been on the sea three weeks, and no land had yet been sighted. The compass no longer pointed due north. A meteor fell into the ocean not far from the ships. The sailors lost courage. They declared that they must perish if they went on, and that their commander ought to be compelled to return. Some of them proposed to throw him into the sea. Columbus kept two reckonings; a correct one for himself, and an incorrect one to appease the sailors. He pleaded with his men to be courageous, as long as mild methods availed. He then grew harsh and commanded them. Through all the uncertainty and the mutterings of the sailors, he clung unwaveringly to his purpose—to push forward. He had no thought of going back.

Flying birds and floating objects promised land, but time went on and no land appeared. The sailors grew more and more violent. On the night of the eleventh of October, Columbus himself saw a light in the distance, which sometimes flickered and sometimes disappeared, as if it might be a torch borne by some one walking. All were now in eager expectancy. At two o'clock on the morning of Friday, October twelfth, a cannon fired from one of the vessels announced that a sailor had actually discovered land.

When daylight came, Columbus landed. The first thing he did upon reaching the shore was to fall upon his knees, kiss the earth, and with tears of joy thank God for deliverance from the perils of such a voyage. His men, ashamed of their mutiny and distrust, threw themselves at his feet, imploring his forgiveness. Columbus next drew his sword, planted the royal banner, and in the name of the Spanish sovereigns took possession of the country. In honor of his deliverance he named the place San Salvador, which means Saint Savior, or Holy Savior.

One of his three vessels was wrecked by a storm near the island of Santo Domingo, called also Hayti and Hispaniola. Columbus built a fort on this island from the wrecked ship, and left in it a colony of about forty of the crew. Desirous of returning to Spain with an account of his voyage, he set sail in January, 1493, on the return trip. A terrific storm was encountered. Columbus, fearing that his ships might sink, and wishing to preserve a record of what he had done, wrote an account of the voyage on a piece of parchment and placed it in a cask, which he threw overboard in the hope that it might be carried to shore and found. The storm abated, however, and on the fifteenth of March he sailed with two of his vessels into the port of Palos.



Columbus on the Deck of the Santa Maria
From the painting by von Piloty.

He entered the city amid the shouts of the people, the booming of cannons, and the ringing of bells. Hastening to Barcelona, where the king and queen were then holding court, he was received with a triumphal procession. Seated next to the throne, he gave an account of his discoveries and exhibited the new country's products which he had brought back—gold, cotton, parrots, curious weapons, strange plants, unknown birds and beasts, and the nine Indians whom he had brought with him for baptism. Great honors were poured upon him. The king and queen could scarcely do enough for him.

In September, 1493, Columbus sailed westward on his second voyage. The fort which he had built on Santo Domingo was found burned, and the colony was scattered. He decided to build a second fort, and coasting forty miles east of Cape Haytien he selected a site where he founded the town of Isabella, named in honor of the Spanish queen. He discovered and explored a number of the islands of the West Indies, including Porto Rico, which has belonged to the United States since the recent war with Spain. The second voyage closed with his return to Spain in June, 1496.

On next to the last day of May, 1498, with six ships Columbus set out on his third voyage. On the first day of August he discovered the Continent of South America. He thought it was only an island. Sailing along the shore, he believed that the various capes which he passed were islands, and not until he reached the mouth of the great Orinoco River did he conclude that what he had discovered was not an island but a great continent.

On his return to the new town of Isabella, he found that matters had not gone well there while he was away. The natives had risen in revolt against the tyranny of the governor whom Columbus left to rule the island in his absence. For some time Columbus's enemies, who had become jealous of him, had been trying to poison the minds of the Spanish king and queen against him. Finally the Spanish rulers sent an officer to inquire into the affairs of the new colony. When this officer arrived, he took possession of Columbus's house, put Columbus in chains, and sent him back to Spain. These chains Columbus kept to the day of his death, and his son Hernando says his father requested that they might be buried with him. After he arrived in Spain, he was restored to the good will of the king and queen who soon sent him on another voyage.

In May, 1502, Columbus set sail on his fourth and last voyage, during which he endured very great dangers. Two of his vessels were destroyed by a storm and the other two were wrecked off the coast of Jamaica. Separated from all the rest of the world, a number of his companions revolted, threatened his life, deserted him, and settled on another part of the island. The natives ceased to bring him food, and death seemed imminent. In this extremity he took advantage of an approaching eclipse of the moon. He told the natives that his God would destroy the moon as a token of the punishment to be inflicted upon them, if they did not bring the white men food. When the eclipse came, the natives implored Columbus to intercede for them with his God, and they brought him food in abundance. After the shipwreck, the navigator sent some of his boldest men in canoes to ask relief of the governor of the colony in Hispaniola. The messengers reached the colony in safety, but the governor would not undertake the rescue of Columbus. They bought a vessel, took it to Jamaica, and after a year of danger and anxiety on the island, in June, 1504, Columbus started on his homeward voyage. In September of this year he landed on Spanish soil for the last time. This final voyage was not productive of any important results.

Soon after his return Queen Isabella died, and about two years later, on May 12, 1506, Columbus himself died at Valladolid, Spain. He was buried first at Valladolid, but his remains were soon transferred to a monastery in Seville, Spain. They were exhumed in 1536 and taken across the sea to the city of Santo Domingo, on the island of Hayti, which he had discovered. In 1796 the remains were taken to Havana, Cuba, where they remained until the close of the Spanish-American war. In 1898, after the island of Cuba had passed from Spain to the United States, the body of the great admiral was taken across the Atlantic again to Spain, where it now rests.

In person Columbus was tall and well formed. Early in life he had auburn hair, but by the time he was thirty years old his hair had been turned white with care, hardship, and trouble. His face was long, and he had gray eyes and an aquiline nose. He was moderate in all his habits, and was one of the most religious of men. He was of a poetic temperament and thus lacked some of the essential qualities of great leadership. He was broad in his outlook, noble in his aspirations, and benevolent in spirit.

Columbus died ignorant of the fact that he had discovered a new world. He believed that the great continent which he gave to civilization was Asia, and that he had only found a new way to that country. He called the natives whom he found "Indians," thinking that they were inhabitants of India. When it was known that a new country had actually been discovered, it was named "America" in honor of Amerigo Vespucci, an Italian geographer and navigator, who visited, it seems, the mainland of this country in 1497. The land discovered by Columbus on the night of October 12, 1492, is believed to have been Watling's island, one of the groups of the West Indies.

Eighteen years elapsed between the time when Christopher Columbus conceived his enterprise and that August morning in 1492 when he set sail on his first voyage of discovery. He had gone about from place to place seeking aid, but spurned everywhere. These years were spent in almost hopeless anxiety, in poverty, and in neglect. The people of his day thought him crazy. When he passed by, they pointed to their foreheads and smiled. He braved the dangers of unknown waters, of mutinous crews, of hostile natives, and of starvation. What is worse, he endured the arrows of jealousy, slander, and misrepresentation. He had a contract with the Spanish crown whereby he was to receive certain honors and wealth as a result of his discoveries. He could not get King Ferdinand to fulfill the contract. He was sent home in chains from the great hemisphere he had discovered, and even the honor of its name went to another who had no claim to it.

Through the career of every successful man there runs a grim determination to do the thing in hand. Columbus had this determination and with it he triumphed. The stars hid themselves behind storms; the compass refused to act normally; a strange and terrible ocean roared; mutiny howled and jealousy hissed, but on one thing he was determined—he would do his best to accomplish the thing he had set himself to accomplish; and he did it.

One of the most inspiring poems in American literature is Joaquin Miller's "Columbus:"—

Behind him lay the gray Azores,
   Behind the Gate of Hercules;
Before him not the ghost of shores,
   Before him only shoreless seas.
The good mate said: "Now must we pray,
   For lo! the very stars are gone.
Brave Adm'r'l, speak, what shall I say?"
   "Why, say: 'Sail on! sail on! and on!'"

"My men grow mutinous day by day;
   My men grow ghastly wan and weak."
The stout mate thought of home; a spray
   Of salt wave washed his swarthy cheek.
"What shall I say, brave Adm'r'l, say,
   If we sight naught but seas at dawn?"
"Why, you shall say at break of day:
   'Sail on! sail on! sail on! and on!'"

They sailed and sailed, as winds might blow,
   Until at last the blanched mate said:
"Why, now not even God would know
   Should I and all my men fall dead.
These very winds forget their way,
   For God from these dread seas is gone.
Now speak, brave Adm'r'l, speak and say"—

He said: "Sail on! sail on! and on!"

They sailed. They sailed. Then spake the mate:
"This mad sea shows his teeth to-night.
He curls his lips, he lies in wait,
With lifted teeth as if to bite!
Brave Adm'r'l, say but one good word:
What shall we do when hope is gone?"
The word leapt like a leaping sword:
"Sail on! sail on! sail on! and on!"

Then, pale and worn he kept his deck
And peered through darkness. Ah, that night
Of all dark nights! And then a speck—
A light! a light! a light! a light!
It grew, a starlit flag unfurled!
It grew to be time's burst of dawn.
He gained a world; he gave that world
Its grandest lesson: "Oh! sail on!"

CHAPTER VII

WEAPONS AND GUNPOWDER

Man's weapons of warfare, offensive and defensive, have been many and curious. David slew Goliath with a stone from a sling. The Scriptures tell us that Samson, the mighty man of the Bible, killed a thousand Philistines at one time with the jaw-bone of an ass. The study of the development of arms makes one of the most significant chapters in the history of civilization.

The use of stone weapons seems to have been universally characteristic of the earlier races of mankind, as it still is distinctive of the ruder races. The weapons made from stone were necessarily few and simple. The most common was an ax, made from various kinds of stone and with varying degrees of skill. Spear-points and arrow-heads were made of flint. These show a comparatively high type of workmanship. The highest efforts of the ancient stone-workers culminated in a leaf-shaped dagger or knife of flint, various in form but uniform in type. These flint daggers differed also in size, but seldom exceeded a foot in length. They were never ground or polished, but delicately chipped to a fine, straight edge, and were often beautiful.

Statues Showing Knights in Armor

In the Bronze Age several kinds of bronze daggers were made. The characteristic weapon of this period, however, was the leaf-shaped bronze sword. "No warlike weapon of any period is more graceful in form or more beautifully finished." This sword had a very thin edge on both sides running from hilt to point, and the handle was of bone, horn, or wood. The thinness of the edge seems to have been produced without the aid of hammer or file. The weapon was better fitted for stabbing and thrusting than for cutting with the edge. Bronze spear-points have been found, but throughout the Bronze Age arrow-heads were made of flint. There were also shields of bronze, held in the hand by a handle fastened to the center. The period of transition between the Bronze Age and the Iron Age is marked by an iron sword, which was similar in form to the leaf-shaped bronze sword.

Homer, the great Greek bard who is supposed to have lived about a thousand years before the birth of Christ, in speaking of the wars of the Greeks, describes their weapons somewhat fully. They used a double-edged, bronze-bladed sword, the hilt and scabbard of which were adorned with gold and silver. In the combats of the Homeric age, however, the spear, lance, or javelin played the principal part; swords were used only for fighting at close range. Bows and arrows also were used. The only iron weapon specifically mentioned is the arrow-head. This was inserted in a split shaft, precisely like the flint arrow-heads of the early North American Indians and other modern savages. The defensive armor of the heroic age of Greece was entirely of bronze. It consisted of a helmet for the head, cuirass for the chest, greaves for the legs, and a shield. The bronze cuirass was often ornamented with gold. The shield was round or oval in shape, very large, and covered with hide. The Greeks of the later or historic age fought chiefly with long, heavy spears. Later the shield was reduced in size and the sword increased in length. The light-armed troops were furnished with a light javelin having a strap or thong fastened to the middle to assist in hurling. A linen corselet came into use instead of the heavy metal cuirass. The mounted troops were supplied with a longer sword, a javelin, and a short dagger.

The military strength of early Egypt lay in her archers, who fought either on foot or from chariots. The Egyptian bow was a little shorter than a man's height. The string was of hide or cord; the arrows were of reed, winged with three feathers and pointed with bronze heads, and were from two to three feet in length. The Egyptian archers carried a curved, broad-bladed sword, and a dagger or a battle-axe for combat at close quarters. Their defensive armor consisted of a quilted head-piece and coat. They used no shield, as this would have interfered with the use of the bow. The infantry were classified according to the weapons with which they fought—as spearmen, swordsmen, clubmen, and slingers. The spears were five or six feet long and had triangular or leaf-shaped heads of bronze. The spearmen carried shields shaped like a door with a curved top, having a hole in the upper portion through which they could look. These shields were about half as high as a man and were covered with hairy hide, with the hair attached. The early swords of Egypt were of bronze, straight, double-edged, tapering from hilt to point, and measuring from two and a half to three feet in length.

The ancient Assyrians fought with swords somewhat like those of Egypt. They used also bows, lances, spears, and javelins. Their shields were round and convex; and their cuirass was a close-fitting garment made of many layers of flax, plaited together or interwoven, and cemented and hardened with glue. This linen corselet was found also among the Egyptians, the Greeks, and the Romans.

The characteristic weapon of the Romans, the greatest warriors of ancient times, was what the Romans themselves called the "pilum." This weapon was a pike having a stout iron head carried on a rod of iron. The iron rod was about twenty inches long and terminated in a socket for the insertion of the wooden shaft, which was a little more than three feet in length. The entire weapon was therefore about five feet long. The pilum could be hurled as a javelin with great effect. Piercing the shield of the enemy, the slender iron rod bent under the weight of the shaft, which trailed along the ground, making the shield useless for purposes of defense. When used at close quarters, the pilum had something of the efficiency of the modern bayonet; and when wielded firmly in both hands, it served to ward off sword-strokes, which fell harmlessly upon the long and strong iron neck of the weapon. No warrior of ancient times was more formidable than the Roman with his pilum. The Romans had also swords of bronze and bronze armor, resembling the armor and the swords of the Greeks. In the prosperous days of Rome, her legions, under one of the greatest military commanders of all time, Julius Caesar, brought nearly all the world of that day to the feet of their general.

The Franks, a Germanic people who lived early in the Christian era and who gave their name to France, used the battle-ax as their chief weapon. It had a broad blade and a short handle and was used as a missile. It is said that a blow of an ax, when hurled, would pierce an enemy's shield or kill him, and that the Franks rarely missed their aim. They wore no armor, not even helmets, though they carried swords, round shields, and darts with barbed iron heads, which were used for throwing or thrusting. When this dart became fixed in an adversary's shield, it was the habit of the Frank to bound forward, place a foot upon one end of the trailing dart, and, compelling the enemy to lower his shield, slay him with the battle-ax. The Franks used also a short, straight, broad-bladed sword, double-edged and obtuse at the point. The military organization of the later Franks changed from infantry to cavalry, and this change gave way in time to the era of chivalry. The superior soldiers of the time of Charlemagne had added to their equipment the celebrated coat of mail.

A Knight in Action

Our early Anglo-Saxon fathers fought with swords, spears, axes, and a heavy, single-edged knife. The sword was especially the weapon of the horseman, and was not carried by anyone under the rank of thane. The infantry bore the other weapons. The early Anglo-Saxons do not appear to have used the bow and arrow, though in later times the long bow was an important weapon in England. The Anglo-Saxons of olden times were not strong in cavalry. Saxon warriors carried round or oval shields made of wood and covered with leather. Suits of metal armor were worn for defense.

The gallant knights of the Middle Ages fought on horseback, as they went about protecting the weak, redressing the wrongs of the injured, and upholding right against might. They were clad in armor of metal, with swords buckled to their sides. Mail armor of interlinked metallic rings was used until the beginning of the fourteenth century. From this time to the beginning of the seventeenth century, armor was made of solid plates of metal. After 1600, armor was gradually replaced by a new agent of warfare, against which it was no protection. Likewise the shield, the dagger, and the bow gave way, though the long bow continued in use as an English weapon until the close of Queen Elizabeth's reign.

An Archer of the Fifteenth Century

The invention of gunpowder was one of the most far-reaching events of all history. This terrific substance has not only revolutionized warfare, but has changed the current of human history itself. It is not known who invented gunpowder, or when it was first used. It is a compound of saltpetre, charcoal, and sulphur; the proportions in which these three ingredients are mixed vary in different countries and in different kinds of powders. It seems likely that powder was invented in the Far East, perhaps in China. Saltpetre comes, for the most part, from China and India, on whose vast plains it is found mixed with the soil. An ordinary wood fire kindled on ground containing saltpetre would bring the saltpetre into contact with charcoal, and thereby practically produce powder. It is probable that the discovery of the explosive occurred in this accidental way. Fireworks were used in China from a very early date, but it is doubtful if the Chinese, or any other nation of Asia, used gunpowder as a propelling force. It was left for the Western nations to develop and give practical value to the discovery of the Chinese.

Our first knowledge of powder as an agency of war dates from about the year 700 A.D., when it was used by the Byzantine emperors in defending Constantinople against the Saracens. It was employed there, however, not as a propelling force, but in the form of rockets or a fiery liquid called Greek fire. Its first real use in Europe as a power for propulsion was in Spain, where the Moors and the Christians both used some kind of artillery as early as the twelfth century after Christ. Gunpowder was first introduced into England by Roger Bacon, a British scientist, who was born early in the thirteenth century. He probably did not discover its properties independently, but by reading ancient manuscripts. Owing to the crude and uncertain methods of making gunpowder, it did not attain much value until Berthold Schwarz, a German monk, at about 1320 A.D. introduced an improved method of manufacture. The improved powder thus made was first used in England by King Edward III in his war against the Scotch in 1327. It was perhaps used on the continent of Europe earlier than this, but the occasions are uncertain. The tubes from which the missiles were propelled were called "crakeys of war."

Spenser called cannon "those devilish iron engines." They were probably used for the first time in field warfare by the English in the battle at Crécy, a small town in France, where on August 26, 1346, the English defeated the French. The artillery seemed to have been used in this battle merely to frighten the horses of the enemy, and the cannon were laughed at as ingenious toys.

From the Battle of Crécy onward, the use of gunpowder spread rapidly throughout Europe, the Russians being the last to adopt it. Saltpetre, at first used in its natural state, began to be produced artificially, and then the manufacture of powder extended among the nations. During the French Revolution, according to Carlyle, the revolutionists were driven to such extremities for want of powder that they scraped old cellars seeking material for its manufacture. Many recent improvements have been made in the production of gunpowder, the most important resulting in the smokeless powder.

Before the introduction of cannon using gunpowder as a propelling force, various machines were used in warfare for hurling missiles. Large stones and heavy darts or arrows were thrown by means of tightly twisted ropes, like the action of a bow, or through the aid of a lever and sling. Various names were applied to these weapons, the chief of which were the ballista and the catapult. The ballista hurled stones by means of a twisted cord or a lever; the catapult by darts or arrows could throw a projectile half a mile. Both machines were used by the Romans with great effect, in both defensive and offensive warfare. In destroying the wall of a besieged town, the Romans used a battering-ram. It consisted of a beam of wood with a mass of bronze or iron on the end resembling a ram's head. In its earliest form, the battering-ram was beaten against the wall by the soldiers; later it was suspended in a frame and made to swing with ropes. Another kind moved on rollers, the swinging movement being given to it also by means of ropes. The beam of the ram was from sixty to one hundred and twenty feet long, the head sometimes weighed more than a ton, and as many as a hundred men were necessary to swing it. For the protection of the soldiers using it, a wooden roof covered it, and the whole was mounted on wheels. Scarcely any wall could resist the continued blows of the battering-ram. The Romans were the most effective in the use of this engine, though they borrowed it from the Greeks.

The first cannon were clumsy and comparatively inefficient. They were made of wooden bars held together with iron hoops, and they shot balls of stone. Cannon of bronze were next made, and in the latter part of the fifteenth century iron cannon came into use. The next improvement was the production of cannon of steel, and for some years past the best artillery has been made of this material. After stone balls ceased to be used, round balls of iron were utilized. These in time gave way to cylindrical projectiles of steel. Originally cannon were loaded at the muzzle, but in recent years breech-loading devices have been developed, so that now all of the best modern guns are loaded from the rear.

Within the last twenty-five years, rapid-fire guns have been developed. These have a mechanism by which the breech is opened and closed again by a single motion of a lever. The loading with projectile and powder is also done with one motion. The rapidity of firing varies from two hundred shots per minute in the smallest guns to one shot in two minutes in the largest. The largest British cannon are nearly eighteen inches in calibre (diameter of bore), weigh a hundred tons, are thirty-five feet long, shoot a shell weighing nearly a ton, consume at each charge 450 pounds of powder, and have the power of penetrating solid iron armor plate to the depth of almost two feet, at a distance of one thousand yards. At least a year and a quarter is required for making one of the great, heavy guns, and often a longer time. The cost of constructing one of the largest English cannon is about $117,000, and it costs about $175 to fire the gun once. Some of the most powerful cannon may be relied upon to hit an object ten feet high at a distance of about nine thousand yards. In battle, however, owing to conditions of atmosphere and the limitations of human vision, fire would rarely be opened at a greater distance than three thousand yards, or not quite two miles.

Guns discharged by machinery have been introduced within the last half-century. The fire from machine guns is practically continuous. Several kinds have been invented and improved by various persons. One of the best types of this kind of ordnance is the Gatling gun, invented in 1860 by Dr. R. J. Gatling, of Indianapolis. It consists of a number of parallel barrels, usually ten, grouped around and fastened to a central shaft. Each barrel has its own mechanism for firing. As the barrels revolve, loaded cartridges are fed into them by machinery and the empty cartridges are ejected. By means of an automatic mechanism, the bullets may be scattered over such an arc in front as may be desired, or concentrated upon a narrower range. The Gatling gun can fire at the rate of 1200 shots per minute; it literally hails bullets.

The greatest name connected with the manufacture of modern cannon is that of Herr Alfred Krupp, of Germany, who was born at Essen in 1812 in humble circumstances. He erected the first Bessemer steel works in Germany in the city of his birth, and was the pioneer in the introduction of steel for the manufacture of heavy guns. He believed in the utility of steel when the great governments of the earth had no faith in it. The works at Essen cover in all about one thousand acres, and in them twenty thousand persons find employment. To Krupp Germany owed much, and was not negligent in paying him honor. His factory supplied artillery to nearly all the nations of Europe. He died in July, 1887, and was succeeded in the management of the works by his son Alfred, who also died recently. The plant still continues in operation.

Musketeer and Pikeman of the Early Seventeenth Century

The first portable or hand gun consisted of a simple iron or brass tube fastened to a straight stock of wood. Horsemen used the first guns, and fired them by placing the end of the stock against the breast and letting the barrel rest on a fork fastened to the saddle. The gun was discharged by applying a lighted match to a touch-hole in the top of the barrel. One kind of powder was used for priming; another for firing. Before the invention of cartridges, the powder and bullets were loaded separately at the muzzle, with some kind of packing between. The colonial rifles in America were loaded in this way. In a fight at close quarters, after a gun had been once discharged, the soldier had to fight with his sword. About the middle of the seventeenth century, the bayonet was invented, taking its name from the town of Bayonne, in France, where the inventor lived.

The lighted match which soldiers originally carried for igniting their guns gave way to the flint and steel; and in 1807 a Scotch clergyman named Forsyth obtained a patent which led to the invention of the percussion cap. This improvement revolutionized the mechanism of firearms. Many improvements have been made recently in arms, so that cartridges containing cap, powder, and projectile are fed automatically into guns so delicately constructed that they have great carrying power, precision, and rapidity.

From the dawn of human existence man has sought by some method or other to overcome natural barriers of water. The idea of the ship is as old almost as the race itself. The most primitive form of vessel was the raft. In prehistoric ages men made vessels by hollowing out the trunks of trees, either with fire or with such crude tools as they possessed. The Latin poet Virgil mentions "hollowed alders" used for boats, and indeed canoes were made from hollowed tree trunks as long ago as the Stone Age. The next step forward in the art of shipbuilding was the bark canoe. In countries where bark is scarce, small vessels were made of skins, felt, or canvas covered with pitch. In process of time, boats were made by fastening timbers together, and in this method the basic principle of modern shipbuilding was reached.

It is the relation of ships to purposes of war that interests us here. When the curtain rose for the drama of civilization in Egypt five thousand years ago, men were fighting at sea. The oldest ships of which we have knowledge were Egyptian. The vessels of war were then propelled by oarsmen, who were protected from the missiles of the enemy by planks. On the Egyptian war-galleys there was often a projecting bow to which was attached a metal head for ramming the vessels of the enemy.

Our knowledge of Greek fighting ships—thanks to Greek literature—is fairly full. In the time of Homer, about ten centuries before Christ, Greek men-of-war carried crews of from fifty to one hundred and twenty men, nearly all of whom took part in the labor of rowing. A military boat called the "bireme" came into use in Greece about six or seven centuries before Christ. The word means a vessel with two rows or banks of oarsmen on each side, one row above the other. This disposition of rowers was evidently for the purpose of securing the largest possible number in the least possible space. It is probable that the Greeks did not originate the bireme, but borrowed the idea from the Phœnicians or possibly from Egypt. When Athens was at the zenith of her glory, the principal war vessel was the "trireme," a ship with three rows of oarsmen to the side, each rising above another. Larger ships were subsequently constructed with four, five, and even sixteen banks of rowers to a side, tier above tier.

The Romans, although they were so powerful in land warfare, were not strong in naval achievement until after the First Punic War. In this war they learned the art of naval construction from their enemies, the Carthaginians. A Carthaginian "quinquereme," or boat with five banks of oars, drifted to the Roman coast. The Romans copied it, set up frames on dry land in which crews were taught to row, and in sixty days from the time the trees were felled they had built and manned a fleet. Later the Romans used grappling hooks with which they bound together their own and an opposing ship. They then boarded the enemy's vessel and carried on the fight at close quarters. These tactics gave the Romans command of the sea, and their war galley came to be the supreme object of terror in the naval history of Roman days.

Sails and wind superseded rowers as the motive force of ships. Then came steam. But after gunpowder and steam had worked a revolution in the modes of naval combat, vessels of war continued to be made of wood.

The first fight between iron ships in the history of the world was fought on the ninth of March, 1862, in Hampton Roads, near Norfolk, Virginia, during the Civil War in America. The battle was the combat between the *Merrimac* and the *Monitor*. This engagement marked the end of wooden navies. Thenceforth the nations of earth were to make their warships of iron and steel.

Among the largest battleships built for the United States navy are the *Delaware* and the *North Dakota*. Each of these battleships is five hundred and ten feet long, a little more than eighty-five feet wide, sinks to the depth of nearly twenty-seven feet in the water, and travels at the rate of twenty-one knots per hour. Each vessel weighs twenty thousand tons, and is armed with ten great guns a foot in diameter at the mouth. The *North Dakota* required 4688 tons of steel armor at a cost of more than four hundred dollars per ton. Each of its great twelve-inch guns cost nearly $110,000, weighs fifty-two tons, and hurls a projectile weighing 850 pounds a distance of twelve miles. Three hundred and eighty-five pounds of powder are consumed at a single discharge. At a distance of more than a mile and a half the projectiles of the *North Dakota* will penetrate steel armor to a depth of nearly twenty inches. When these projectiles leave the guns, they fly through the air at the rate of 2,800 feet in a second. When one hundred shots have been fired from one of these guns, it is worn so that it will be useless until repaired. The cost of a single discharge from one of these guns is about $350.

Sub-marine navigation has always been attended by the most woeful catastrophes, but in spite of numerous accidents the development of the submarine boat has progressed uninterruptedly. Each new model presents new preventive devices. Flasks of oxylithic powder are carried for purifying the air in the water-tight compartments in which the crews live while the boat is below the surface of the water. There is also a special apparatus for signalling other vessels or the shore, in case of danger. In 1904 three vessels, designated X, Y, and Z, were completed, which could achieve submersion in the short space of two minutes. The boats were armed with six torpedoes each. France owns the largest fleet of under-water warships in the world. England stands next, and the United States government is third.

CHAPTER VIII

ASTRONOMICAL DISCOVERIES AND INVENTIONS

"When I consider thy heavens, the work of thy fingers, the moon and the stars, which thou hast ordained, what is man, that thou art mindful of him?" The Hebrew psalmist feels the insignificance of man compared with the infinitude of the heavens. Victor Hugo expresses the opposite thought: "There is one spectacle grander than the sea—that is the sky; there is one spectacle grander than the sky—that is the interior of the soul."

There is nothing more dignified, more sublime, more awful, than a contemplation of the heavens. In point of grandeur, astronomy may be regarded as king of the sciences. It is also their patriarch. Thousands of years before the birth of Christ the priests of Chaldea, from the tops of their flat-roofed temples, studied the stars and laid the foundations of the science of astronomy. The heavens, with their teeming, whirling, circling congregation, obeying laws that have no "variableness neither shadow of turning" do, indeed, "declare the glory of God."

From the earliest times the stars were supposed to influence for good and ill the lives of men. There were supposed to be stars of good luck and of bad omen. The cool, calculating Cassius tells Brutus,

> "The fault, dear Brutus, is not in our stars,
> But in ourselves, that we are underlings."

When you look up into the heavens at the flickering dots of light which we call the stars, you are looking at worlds, many of them far larger than our earth. They seem small because of vast distances from us. Our own solar system, great as it is, in comparison with the celestial universe is but a clod in an acre. At the center of our system is the sun, a huge ball of fiery matter 93,000,000 miles from the earth, and as large as 330,000 worlds like ours. Circling around the sun like maddened horses around a race course are eight planets. These planets, with the sun and some comets, constitute our solar system; *our* system, for how many solar systems there are in space no one knows. These planets, in their order outward from the sun, are Mercury, Venus, our Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. Of these, Mercury is the smallest and Jupiter is the largest. The following table shows some interesting facts about the planets:

Name	Diameter in miles	Number of planets required to equal sun in size	Distance from sun in millions of miles	Time required for one revolution around sunin days	Velocity in orbit, miles per hour
Mercury	3,008	5,000,000	36	88	107,012
Venus	7,480	425,000	66	225	78,284
Earth	7,926	332,260	92	365¼	66,579
Mars	4,999	3,093,500	141	687	53,938
Jupiter	88,439	1,048	483	4,332	29,203
Saturn	75,036	3,502	886	10,759	21,560
Uranus	30,875	22,600	1,783	30,687	15,202
Neptune	37,205	19,400	2,794	60,127	12,156

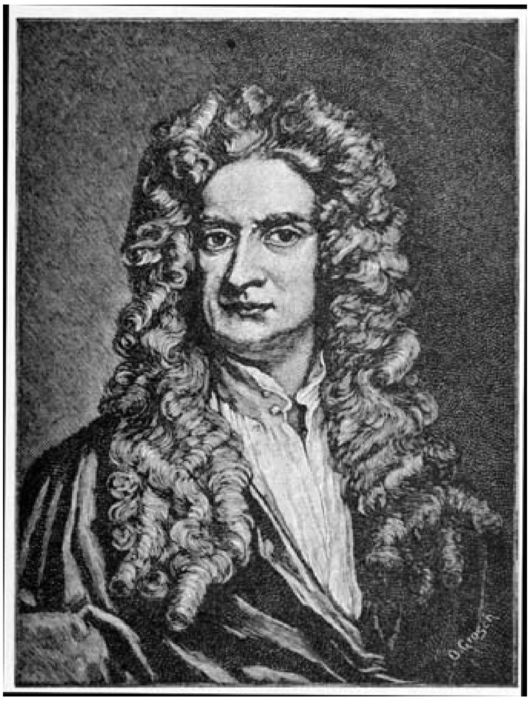
The moon is 240,000 miles from the earth, and it would require nearly 24,500,000 moons to equal the sun in size. Other planets have moons, some of them several. If you lived on the planet Mercury, your annual birthday would come around about once in three of our months. If you had your home out on the border land of the solar system, on the planet Neptune, you would have a birthday once in about 165 years, as we count time on the earth. It will be observed that the closer the planet is to the sun, the faster it travels in its orbit.

This fact is due to the power of gravitation toward the sun. This strange influence drives the planets around the sun, and the nearer the planet is to the sun the greater is the power and consequently the faster the revolution. The law of gravitation was discovered by Sir Isaac Newton.

Newton was born in 1642 in Lincolnshire, England. His father was a farmer, and the farmhouse in which the son was born is still preserved. He was educated at a grammar school in Lincolnshire, and later entered Trinity College, Cambridge, from which he was graduated in 1665. Early in life he displayed a great liking for mathematics. Within a few years after he entered college, he had mastered the leading mathematical works of the day and had begun to make some progress in original mathematical investigation.

Newton's great life work—the achievement which insured to his name a place among the immortals—was suggested to him by accident. As the story goes, while he was walking one day in a garden, he saw an apple fall from a tree. He speculated upon the reasons for its falling, and ultimately concluded that the same force which causes an apple to fall from a tree holds the heavenly bodies in their places. Further investigation brought him to the unfolding of this general law of gravitation: "Every body in nature attracts every other body with a force directly as its mass, and inversely as the square of its distance." This law is the greatest law of nature. It is the central fact of the physical universe, the cement of the material world, the mighty, mystic shepherdess of space, that keeps the planets from wandering off alone. It is this awful, silent power reaching out from the enormous mass of the sun, that lashes the planets in their furious race, and yet holds them tightly reined in their orbits.

Newton was one of the greatest mathematicians, scientists, and thinkers in the history of the world. He died at Kensington, England, on March 20, 1727, and was buried in Westminster Abbey, with the illustrious dead of Great Britain.



Sir Isaac Newton

The operation of this law of gravitation pointed the way to the discovery of the planet Neptune, which is considered the greatest triumph of mathematical astronomy since the days of Newton. Prior to the discovery of Neptune, Uranus was the outermost known planet of the solar system. It was noticed that Uranus was being pulled out of its proper path. It was being tugged away by some strange force beyond the edge of the known planetary system. As the result of a skilful and laborious investigation, Leverrier, a young French astronomer, wrote in substance to an assistant in the observatory at Berlin: "Direct your telescope to a point on the ecliptic in the constellation of Aquarius in longitude 326°, and you will find within a degree of that place a new planet, looking like a star of the ninth magnitude, and having a perceptible disk." Leverrier did not know of the existence of such a planet. He calculated its existence, location, and mass from the fact that some such body must be there, to account for the disturbance caused to Uranus. The telescope in the Berlin Observatory was directed to the place designated by Leverrier, and on the night of September 23, 1846, in exact accordance with his prediction and within half an hour after the astronomers had begun looking, Neptune was discovered within less than one degree from the exact spot where Leverrier had calculated it must be. Such are the triumphs of the human mind. Such are the failures of nature to hide her secrets from the inquiry of man, even behind untold millions of miles.

According to the principles of gravitation as unfolded by Newton, the power of attraction decreases directly as the square of the distance between the sun and a planet. Neptune, being on the outer rim of the system and hence farthest away from the sun, moves in its orbit around the sun more sluggishly than any other planet. Life such as we know it on the earth could not exist on Neptune; it would be too cold. The light and heat from the sun on Neptune are only one nine hundredth part of what we get on the earth. But even so, the sunlight falling upon Neptune is equal in power to seven hundred of our full moons. It was thought that Uranus was the last planet of the solar system until Neptune was found. Whether Neptune is the last, or whether other worlds are roaming around beyond it, is not known.

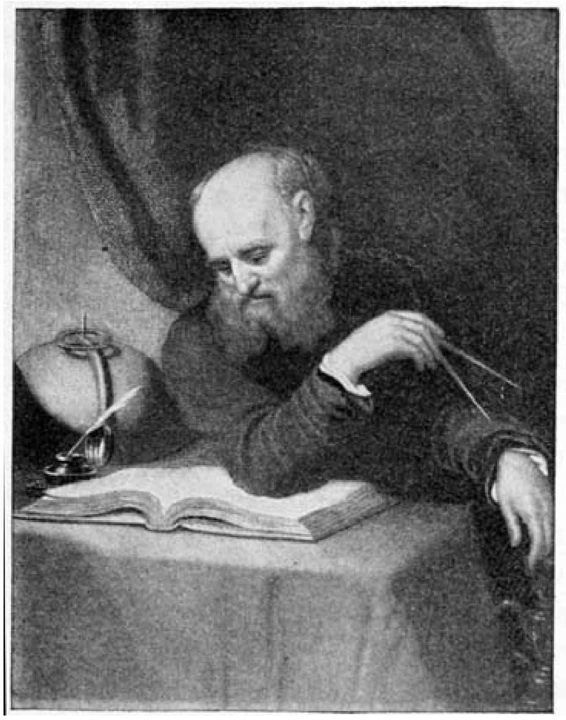
Ptolemy, who was one of the most celebrated astronomers of earlier times, was born in Egypt about a century and a half after Christ. According to the Ptolemaic system of astronomy, which Ptolemy expounded but did not originate, the earth was considered the center of the universe, and around it the other planets and the sun were believed to revolve. A passage in the Bible in which Joshua commanded the sun to stand still indicates that the old Hebrews believed the sun circled around the earth. The Ptolemaic theory did not account for all the facts observed by astronomers, but for nearly fifteen centuries it held practically universal sway over the belief of men, until another thinker set the matter right.

Nicholas Copernicus was born in Prussia, February 19, 1473. He studied mathematics, medicine, theology, and painting, but his greatest achievements were in astronomy. He made holes in the walls of his room, through which he might observe the stars. Copernicus did not believe in the theory of Ptolemy that the earth was the center of the universe, but held that the solar system had for its center the sun, and that around it the planets, including the earth, revolved. In working out this belief, which science has subsequently shown to be correct, he laid the foundations of the modern system of astronomy.

The book in which Copernicus expounded his theory was begun in 1507 and was completed in 1530. He could not be induced to publish it, however, until shortly before his death. On May 24, 1543, he lay dying in Frauenburg. A few hours before his death, when reason, memory, and life were slipping away from him, the first printed copy of his book was borne to Frauenburg and placed in the great astronomer's hands. He touched the book, looked at it for a time, and seemed conscious of what it was. Quickly afterward he lapsed into insensibility and was gone.

Johann Kepler, who was born in Germany in 1571, contributed several important facts to astronomy. He studied the motions and laws of the celestial bodies. Copernicus taught that the planets revolved around the sun in circular orbits, but Kepler discovered that their paths are ellipses. He also found that the nearer the planets are to the sun the faster they travel. Kepler's discoveries were embodied in three great laws of astronomy known as Kepler's laws. These furnished the foundation for Newton's discoveries and are the basis of modern astronomy. Kepler died in November, 1630.

Many of the wonderful discoveries that have been made in the field of astronomy could not have been possible without the telescope, the most important instrument used by astronomers. The first part of the word is the same Greek adverb meaning "afar," found in *telegraph* and *telephone*; the last part is derived from a Greek verb meaning "to see." The telescope, therefore, is an instrument for seeing objects that are far off. It is a long tube With lenses so arranged as to make objects appear much larger than they would to the naked eye. The telescope was invented by a Dutch optician named Hans Lippershey about three hundred years ago. The Italian scientist Galileo, who was born at Pisa in February, 1564, heard of the invention, began studying the principles upon which it depends, and greatly improved it. Galileo was the first to use the telescope for astronomical purposes. With it he discovered the satellites of Jupiter, the spots on the sun, and the hills and valleys of the moon.



GALILEO

At the present time the largest telescopes in the world are made and owned in America. The largest is the Yerkes telescope, belonging to the University of Chicago and located on the shores of Lake Geneva, Wisconsin. Microscopes, opera glasses, and other magnifying instruments depend upon the same principles as the telescope.

One of the most astounding of man's tools is the spectroscope, an instrument used for analyzing light. Through a knowledge of chemistry scientists can establish scientific relations between different substances and the light which they emit. By analyzing the light from the heavenly bodies with the aid of the spectroscope, and comparing this result with the light sent out from different known kinds of matter, man can stand on this little flying speck of matter we call the earth and discover of what substances the stars are made.

One of the most interesting questions arising in a study of the heavenly bodies is whether or not any of them besides the earth are inhabited. Is there any good reason for supposing that our pigmy planet, so insignificant compared with many celestial bodies, is the only one containing life? On the other hand, life such as we know it could not exist on some of the other planets. Mercury would be too hot; Neptune too cold. Climatic conditions on Mars are most nearly like those of the earth. Within recent years the telescope has revealed on the surface of Mars a number of peculiar, regular lines. Many scientists hold that these are artificial canals or irrigation ditches, and that the planet must be inhabited. The theory does not seem at all unreasonable. But the most that can be safely said is that if any of the other planets are inhabited, the most likely one is Mars.

CHAPTER IX

THE COTTON-GIN

Another great invention is the cotton-gin. It is great because of the commercial prosperity which it brought to the Southern states; because it cheapened and extended the use of an almost necessary article of life; and because of its effect on American history. The inventor was an American, Eli Whitney.

The word *gin* is an abbreviation of *engine*, and in former days was often used to denote a handy mechanical device of any kind. The cotton-gin is a machine for removing the seed from the fiber of the cotton-plant. Its essential parts are a number of saws which tear the fiber from the seeds, some stiff brushes used to remove the fiber from the saws, and a revolving fan which blows the lighter substance of the cotton away from the saws and brushes. The original cotton-gin has been little changed by improvement since its invention. It seems to be one of those inventions which have been perfected by the inventor himself.

Eli Whitney was born in Westborough, Worcester County, Massachusetts, December 8, 1765. His father was a thrifty farmer. Nature bestowed upon the son marked ability in the use of tools. While he was yet a child, his inventive genius manifested itself. Before he was ten years old, he could use every tool in the farm workshop with the ease and skill of an old workman. He made a violin before he was twelve and later he came to be noted in the neighborhood as a skilful mender of fiddles. He also turned his attention to making nails, which in Revolutionary days were made by hand, and became the best nail-maker in Worcester County. When he was twenty-four years of age, a desire for a college education possessed him. His father agreed to furnish the money to pay for his schooling, with the stipulation that the son should pay it back. He entered Yale, where he was graduated in 1792.

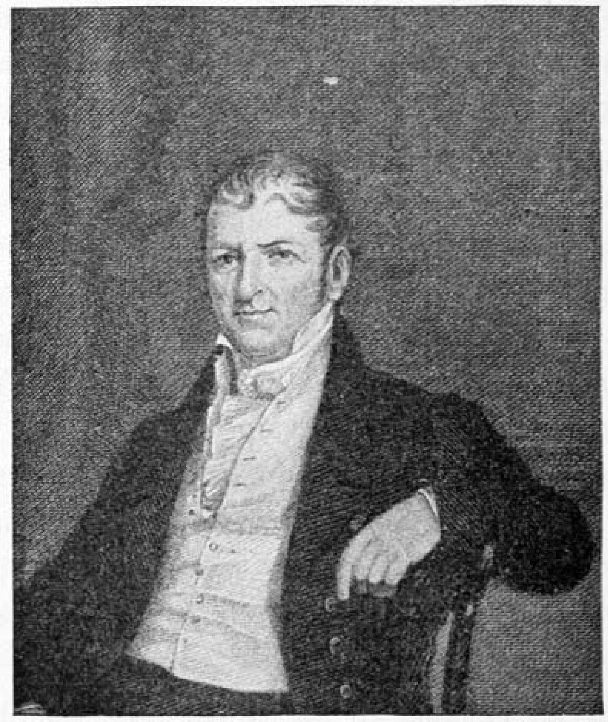
After graduation Whitney went South to act as tutor in a private family. Upon arrival at his destination, he found that the position was already filled. At that time the widow of General Nathanael Greene, who fought in the Revolutionary War, lived near Savannah, Georgia. She had become interested in young Whitney and invited him to make her plantation his home. She noted his inventive skill, and one day when a group of Georgia planters was discussing at her home the desirability of a machine for removing cotton-seeds from the fiber, Mrs. Greene said: "Gentlemen, apply to my friend, Mr. Whitney; he can make anything." Whitney was called in and the planters laid the matter of the machine before him. At this time he had never even seen cotton fiber. But he made up his mind to try what he could do toward solving the problem.

He went to Savannah and searched among the warehouses and flat-boats for samples of cotton. Mrs. Greene encouraged him in his undertaking and gave him a room in the basement of her house for his workshop. Here he shut himself up with his task, and was heard early and late hammering, sawing, and filing. No one was admitted to the room but Mrs. Greene and Phineas Miller, the tutor of Mrs. Greene's children. At the outset Whitney had neither money nor tools. The money was supplied by an old college friend; the tools Whitney made himself. He could procure no wire in Savannah for constructing his machine, and was compelled to make his own, which he did with much perseverance and skill.

In 1793 the gin was sufficiently completed to convince the inventor that it would be a complete success. Mrs. Greene invited a number of distinguished planters and merchants to witness the working of the machine. The spectators were not slow in realizing the success and the significance of the invention. They saw that with this little machine one man could separate as much cotton from the seed in one day as he could separate by hand in a whole winter. With the gin the cotton grown on a large plantation could be separated in a few days; by hand, the separation would require a hundred workmen for several months.

One dark night some unscrupulous persons broke open the shed in which the unfinished machine had been placed and carried it away. Filled with rage and despair at the wrong which had been done him, Whitney left Georgia and went to Connecticut to complete his invention. But he had scarcely left Savannah when two other claimants for the honor of the invention appeared in Georgia. A few weeks later a gin very closely resembling Whitney's came out. His stolen gin was doubtless used as a model by these false claimants.

On March 14, 1794, Whitney received a patent on his gin. Phineas Miller, who had become the husband of Mrs. Greene, entered into a partnership with Whitney for managing the new invention. Whitney was to manufacture the gins in the North and Miller was to furnish the capital and attend to the interests of the business in the South. They planned not to sell machines or patent rights, but to make and own the gins, loaning them to planters for a rental of one pound in every three pounds of cotton ginned. They would have been wiser if they had manufactured and sold the machines outright. In the first place, it required a larger capital than the firm had to manufacture the necessary number of machines. In the second place, no one firm could make gins fast enough to supply the rapidly increasing demand, and consequently great encouragement was given to infringements on the patent rights. Unending troubles beset the new firm. Whitney himself was a victim to severe illness in the winter of 1794. Scarlet fever raged that year in New Haven, Connecticut, where the manufacturing was being done, and many of the workmen in the gin factory were unable to work. In 1795 Whitney was again seized with severe sickness, and to add to the vexations of the business, the books, papers, and machinery were destroyed by fire. Besides all this, rival claimants circulated a report that Whitney's gin ruined the fiber of the cotton, and that for this reason cotton ginned by the patent process was discriminated against in the markets of England. Another gin which did its work by crushing the seeds between rollers and leaving the crushed seeds in the fiber was represented as superior to Whitney's machine.



ELI WHITNEY

In speaking of his troubles Whitney said: "The difficulties with which I have had to contend have originated principally in the want of a disposition in mankind to do justice. My invention was new and distinct from every other; it stood alone. It was not interwoven with anything before known; and it can seldom happen that an invention or improvement is so strongly marked, and can be so clearly and specifically identified; and I have always believed that I should have had no difficulty in causing my rights to be respected, if it had been less valuable and been used only by a small portion of the community. But the use of this machine being immensely profitable to almost every planter in the cotton districts, all were interested in trespassing on the patent right, and each kept the other in countenance.... At one time but few men in Georgia dared to come into court and testify to the most simple facts within their knowledge relative to the use of the machine. In one instance I had great difficulty in proving that the machine had been used in Georgia, although at the same moment there were three separate sets of this machinery in motion within fifty yards of the building in which the court sat, and all so near that the rattle of the wheels was distinctly heard on the steps of the court house."

Whitney never received fair and proper compensation for his invention. The machine itself was stolen; others sought to rob him of his honor; he was opposed by an unlimited train of vexations; and after the expiration of his patent he was never able to secure a renewal.

The effect of the invention of the cotton-gin was far-reaching, industrially and historically. In 1807, at a session of the United States District Court held in Savannah, Georgia, the inventor finally obtained judgment against the persons who had stolen his invention. In the opinion rendered in favor of Whitney, Judge Johnson said of the cotton-gin: "Is there a man who hears us who has not experienced its utility? The whole interior of the, Southern states was languishing, and its inhabitants were emigrating for the want of some object to engage their attention and employ their industry, when the invention of this machine at once opened new views to them which set the whole country in active motion. Individuals who were depressed with poverty and sunk in idleness have suddenly risen to wealth and respectability. Our debts have been paid off, our capitals have increased, and our lands have trebled themselves in value. We cannot express the weight of the obligation the country owes to this invention. The extent of it cannot now be seen. Some faint presentiment may be formed from the reflection that cotton is rapidly supplanting wool, flax, silk, and even furs, in manufactures, and may one day profitably supply the use of specie in our East India trade. Our sister states also participate in the benefits of this invention; for besides affording the raw material for their manufactures, the bulkiness and quantity of the article afford a valuable employment for their shipping."

In the South "Cotton is king." The rise of the cotton industry dates from the invention of Eli Whitney's cotton-gin. Before its invention the labor of removing the seed from the fiber was so tedious that the growth of the cotton was not profitable. Partly because of this fact and partly because the Revolutionary War was just over, the South lay dormant; its plantations were heavily mortgaged, its people were moving away in streams. Then came a little machine that awoke the South from its sleep and made it rouse itself. It brought energy, hope, and prosperity, where before were languor, indifference, and stagnation. It increased the exportation of American cotton from less than 190,000 pounds in 1791 to 41,000,000 pounds in 1803.

From the historical point of view the invention of the cotton-gin was tremendous in its influence. This machine multiplied by many times the demand in the South for slave labor and made slaves far more profitable. One writer has said of Whitney: "He was, through his invention, probably one of the most potent agencies for the extension of slavery and the terrible struggle that marked the first half-century of our nation's existence. While he was quietly sleeping in his grave, the very earth was shaken with the tread of contending armies that he had done more than any other one man to call forth to battle; for there is little doubt that but for the invention of the cotton-gin slavery would not have lived out the century of the Revolution." Macaulay says: "What Peter the Great did to make Russia dominant, Eli Whitney's invention of the cotton-gin has more than equaled in its relation to the power and progress of the United States." In the light of the wonderful, widespread material growth and prosperity that have come to the whole of our country in recent years, Macaulay's statement is overdrawn. But as matters were when it was written by the great Englishman, it was probably true.

Whitney achieved much success as the inventor of improved methods of manufacturing firearms. He was the first to conceive the plan of making the different parts of firearms by machinery, so that any part of a weapon would fit any other like weapon equally well. This principle has made possible the production of cheap watches, clocks, and sewing machines. He died in New Haven, Connecticut, January 8, 1825.

CHAPTER X

ANÆSTHETICS

If those inventions and discoveries out of which have come widespread safety, happiness, or prosperity to mankind are to be considered great, then Dr. Morton's discovery of anæsthetics and its application to surgery is entitled to a high place among the world's discoveries and inventions. The pain that has been destroyed, the lives that have been saved, the sorrow that has been averted, give their testimony to the value of this discovery to humanity.

An anæsthetic is administered to produce temporary insensibility to pain. At least something of anæsthetics was known to the ancients. Homer mentions nepenthe, a potion which was said to make persons forget their pains and sorrows. The word appears occasionally in literature. In "Evangeline" Longfellow refers to it in this line:

> "Crown us with asphodel flowers, that are wet with the dews of nepenthe."

Virgil and other classical writers mention a mythical river Lethe which was supposed to surround Hades. Souls passing over to the happy fields of Elysium first drank from this river, whose waters caused them to forget their sorrows. Milton speaks of the mythical stream in the following passage from "Paradise Lost:"

> "Far off from these a slow and silent stream,
> Lethe, the river of oblivion, rolls her watery labyrinth."

Herodotus wrote that it was the practice of the Scythians to inhale the vapors of a certain kind of hemp to produce intoxication. The use of the mandrake plant as an anæsthetic is spoken of as far back as Pliny, the Roman historian. The sleep-producing effects of the mandragora or mandrake are alluded to by Shakespeare. He also frequently mentions in a general way draughts that act as anæsthetics, without making clear their specific natures. An old Chinese manuscript indicates that a physician of that country named Hoa-tho in the third century after Christ used a preparation of hemp as an anæsthetic in surgical operations. Although the ancients had knowledge of anæsthetics of one kind or other, the practice of anæsthesia never became general, and surgeons of the ancient world appear to have looked upon it with disfavor.

When in modern times Joseph Priestley, the English scientist (born in 1733, died 1804) gave great impetus to chemical research by his discoveries in that science, the nature of gases and vapors was more and more closely studied. The belief soon sprang up that many gases and vapors would ultimately become of great value in medicine and surgery. In 1800 Sir Humphry Davy experimented with nitrous oxide gas, called "laughing gas," and discovered its anæsthetic qualities. He suggested its use in surgery, but for practically half a century his suggestion passed unheeded. Other scientists experimented with greater or less success, seeking to find something that would alleviate physical pain; but to Dr. William T. G. Morton, an American, belongs the credit for the practical introduction of anæsthetics into modern surgery.

Dr. Morton was born in Charlton, Massachusetts, August 9, 1819. His ancestors were of Scotch extraction. He passed his early years in farm work. At the age of thirteen he entered an academy at Oxford, Massachusetts, where he remained only a few months, attending school thereafter at Northfield and Leicester. His father's financial condition caused him to leave school in 1836 and enter the employ of a publishing firm in Boston. Deciding to engage in the practice of dentistry, in 1840 he took a course in the Baltimore College of Dental Surgery. Two years afterward he began the practice of his profession in Boston. As dentistry at that time was in its beginnings as a distinct profession, Dr. Morton took up, in addition to it, the study of general medicine and surgery in the Harvard Medical School.

In the days prior to the use of anæsthetics, the operations of dental surgery were attended by much pain. Dr. Morton began seeking some means for alleviating it. In the course of his investigations he became acquainted with the effects of sulphuric ether as a local anæsthetic, and frequently used this drug in minor operations. On one occasion he applied it with unusual freedom in the treatment of a very sensitive tooth. Observing how completely the tissues were benumbed by the ether, he conceived the idea of bringing the entire system under its influence, thereby producing temporary insensibility in all the sensory nerves. The most serious problem with which he had to deal was the manner of applying the ether. Although the soporific tendencies of both ether and nitrous oxide gas were well known, it had not been proved that they could be inhaled in sufficiently large quantities, or, if so, that they would produce perfect insensibility. After a long series of experiments with various animals, Dr. Morton succeeded in fully establishing the narcotic power of ether.

On October 16, 1846, he made his first public demonstration of the new discovery in the operating room of the Massachusetts General Hospital, in Boston, when he painlessly removed a tumor from the jaw of a patient. This operation was wholly convincing to the medical profession, and created profound public interest. Dr. Morton was brought into immediate prominence. A meeting of the leading physicians of Boston was held to choose an appropriate name for the new process. A long list of words was presented, from which Dr. Morton selected the term *letheon*, related to the Lethe of Virgil and the classical writers. The words *anæsthetic* and *anæsthesia* were coined from the Greek by Dr. Oliver Wendell Holmes, the American poet and physician, who was then living in Boston. The words proposed by Dr. Holmes have become the established terms of the subject, superseding the *letheon* of the discoverer.

DR. WILLIAM T. G. MORTON

Dr. Morton secured a patent on his discovery, but derived little pecuniary profit from it. Although he permitted the free use of his anæsthetic in charitable institutions, his patent was frequently infringed. He vainly applied to Congress for compensation in 1846 and 1849. A bill to give him one hundred thousand dollars as a national testimonial of his contribution to the welfare of the race was introduced into Congress in 1852 and defeated. Measures in his behalf at sessions of Congress in 1853 and 1854 were likewise voted down. The only money that ever came to Dr. Morton for his discovery was a small prize from the French Academy of Sciences and the sum of one thousand dollars from the trustees of the Massachusetts General Hospital. The governments of Russia and of Norway and Sweden conferred upon him certain awards of honor in recognition of his great contribution to science.

He died in New York City, July 15, 1868, and was buried in Mount Auburn Cemetery, Cambridge, Massachusetts, perhaps the most beautiful and illustrious of American burial places.

The monument of Dr. Morton in Mount Auburn bears this inscription: "William T. G. Morton, inventor and revealer of anæsthetic inhalation, by whom pain in surgery was averted and annulled; before whom, in all time, surgery was agony; since whom, science has control of pain." He is included among the fifty-three illustrious sons of Massachusetts whose names are inscribed upon the dome of the new Hall of Representatives in the State House at Boston; and is among the five hundred noted men whose names adorn the facade of the Boston Public Library.

The news of Morton's discovery reached England December 17, 1846. Within five days ether was in use as an anæsthetic by the English dentists and surgeons. A year later Sir J. Y. Simpson, of Edinburgh discovered the anæsthetic properties of chloroform, which has since that time been the preferred anæsthetic in Europe. Ether has continued in general use in America.

CHAPTER XI

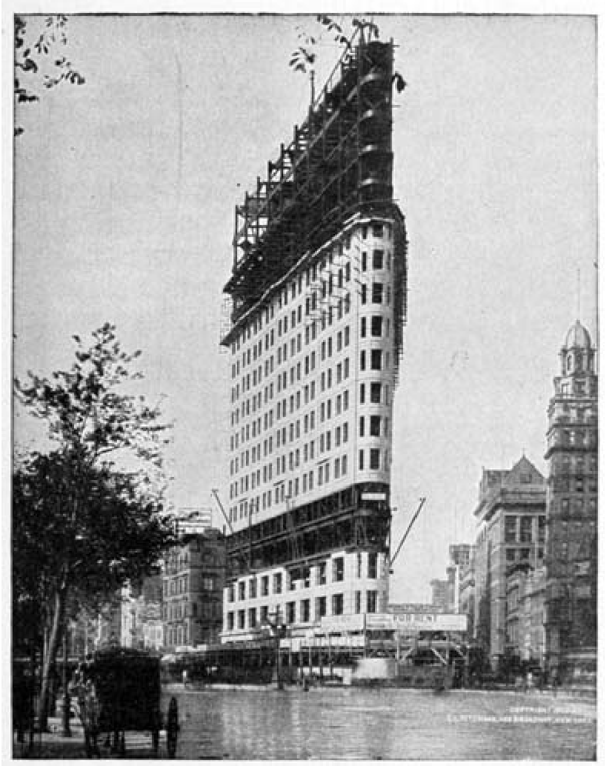
STEEL AND RUBBER

It has been shown already in this volume that the materials from which man has made his tools, and those tools themselves, are the best means of determining his advance in civilization. Man passed from the Stone Age with its few, crude implements into the Bronze Age, and from this into the Iron Age, with each succeeding step increasing the number and efficiency of his tools. The race has lately passed into an age which might well be named the Age of Steel. The discovery or invention of this metal—for there is in it the nature of both invention and discovery—is sufficiently important to mark a distinct era in human progress.

Steel is not found native, but is a compound of iron and carbon and is produced artificially. The great value of steel lies in the fact that it can be made so hard that it can cut and shape almost every other substance known to man, and yet this very quality of hardness can be so modified as to make the metal capable of cutting and otherwise shaping itself. Steel can be made nearly as hard as the diamond, or so soft that it can be cut, bent, or hammered into this shape or that, rolled into sheets, or drawn out into the finest wire. Nearly the whole of the compound is iron, the carbon ranging from one-fourth of one per cent to two and one half per cent. Ordinary steel contains certain other chemicals, such as silicon, manganese, sulphur, and phosphorus, but these are mere natural impurities existing in the metal. The essential ingredients are iron and carbon. Steel is hardened by being heated to a high temperature and then suddenly cooled by contact with cold water, or in other like ways. Fixing the degree of hardness in a piece of steel is called tempering. The degree of hardness is dependent upon the suddenness of cooling.

The widespread use of steel and its importance in the life of to-day are due to Sir Henry Bessemer, an English inventor, who was born January 19, 1813, and died March 15, 1898. The substance was known, made, and used before the time of Bessemer, but its production was so costly that it was little used. By his process of production the cost was greatly reduced and steel consequently came into much wider usage. By the Bessemer process molten iron is poured into a vessel with holes in the bottom. Air at a powerful pressure is forced through these openings, so that the pressure of the air prevents the melted metal from running out. The air removes the carbon from the molten iron. Afterward the required amount of carbon is admitted to the iron, and the result of the union is a piece of steel. The process of Bessemer was patented in 1856.

Steel is used in the construction of great modern buildings, bridges, and battleships; and in making cannon, railroad cars and rails, pipe, wire, bolts and nails, swords, knives, saws, watch-springs, needles, and innumerable tools and articles of every-day usage. Manifestly a material that is used in the manufacture of articles ranging from a needle to a great city sky-scraper or a battleship must be of prime importance to the human race.



STEEL FRAMEWORK OF THE FLATIRON BUILDING, NEW YORK CITY

The United States Steel Corporation is the largest combination of capital in the world. It was organized in March, 1901, under the laws of New Jersey, for the manufacture and sale of steel products. This giant corporation was formed by the union of ten large corporations, each of which was, in turn, made up of smaller companies. Its total capitalization is $1,404,000,000, or one half of all the money in the United States. Its property consists of 149 steel works, with an annual capacity of 9,000,000 tons; 18,000 coke furnaces; over 100,000 acres of land; and 125 lake vessels and several small railroads. The Corporation employs over 150,000 men, to whom it pays in Wages annually over $120,000,000.

When on a wet morning one puts on rubbers and a rain coat, one scarcely wonders about the history of the articles that give so much protection and comfort. The story of rubber is an interesting one. The substance at first was called "elastic gum." About 1770 it was discovered that the gum would rub out lead pencil marks. It was imported into Great Britain and sold for this purpose, and because of this property its name was changed to rubber. The correct name of the material now is caoutchouc, though its common name is India-rubber or simply rubber. It is obtained from the sap of certain tropical trees and shrubs. The best quality of rubber comes from Brazil, though supplies are procured from other parts of South America, from Central America, the West Indies, Africa, and parts of tropical Asia.

The details of collecting the sap and preparing it for market vary somewhat according to locality and the nature of the trees or shrubs from which it comes. In the region of the Amazon, when the sap is to be obtained from a tree, cuts are made each morning in the bark. The milky sap that exudes is collected in little tin or clay cups fastened to the trunk. At the end of about ten hours these cups are emptied into larger ones, and on the morning of the following day new incisions are made in each tree, about eight inches below the old ones. This process is continued until incisions have been made in the bark from a height of about six feet down to the ground; the lower down on the trunk of the tree, the better is the quality of the sap. For the evaporation of the sap, a fire is built of material yielding dense volumes of smoke. Workmen dip wooden paddles into the liquid and hold them in the smoke until the sap solidifies and acquires a slightly yellow tinge. They repeat the process of dipping the paddle into the sap and holding it in the smoke, until the paddle is covered with a layer of the dried gum about an inch and a half in thickness. This layer is then removed from the paddle and hung up to dry; and the process of evaporation is commenced anew. The raw material, which is an elastic, yellowish, gum-like substance, is sent away to be vulcanized. From the vulcanized product are made the rubber goods of commerce.

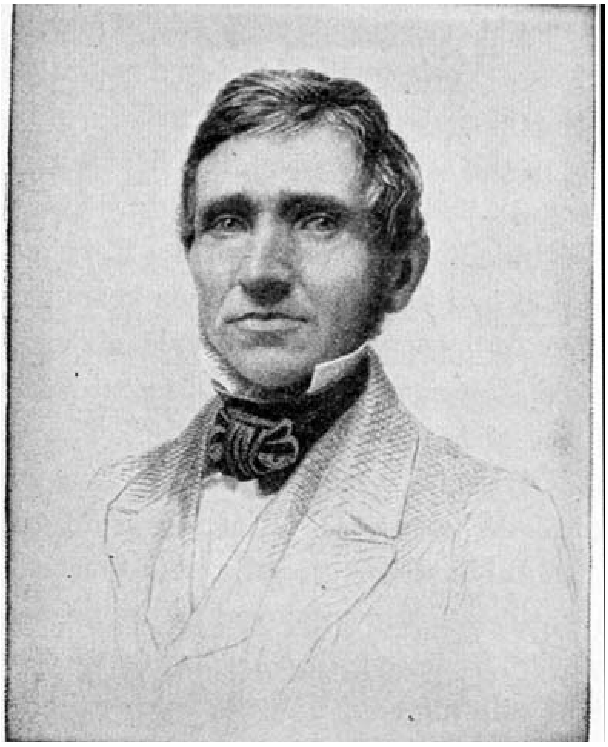
As far back as 1615 A.D. the Spaniards used rubber for waxing canvas cloaks so as to make them water-proof. But it was not until two centuries later that caoutchouc began to attract general attention. Charles Goodyear, an American inventor, found a way for making it commonly useful, and brought about its practical and widespread utility.

The story of Goodyear's life is pathetically interesting. He was born in New Haven, Connecticut, December 29, 1800. His father was Amasa Goodyear, a pioneer hardware manufacturer, from whom the son inherited much of his inventive ability. Charles Goodyear was educated in the schools of New Haven, and spent much of his time on his father's farm and in the factory, where the father manufactured steel implements and pearl buttons, the first ever made in America. The son intended to become a preacher, but obstacles arose and he abandoned his purpose. Though he was not to minister to man's spiritual needs, yet he was to bring to the race a material blessing of great value.

Goodyear entered into the hardware business with his father in Connecticut and at Philadelphia, but their business failed. During the ten years extending from 1830 to 1840 he was frequently imprisoned for debt. All this time he was working to perfect unfinished inventions in order that his creditors might be paid.

While a boy on his father's farm, he one day picked up a scale of rubber peeled from a bottle, and conceived the notion that this substance could be turned into a most useful material if it were made uniformly thin and prepared in such way as to prevent its melting and sticking together in a solid mass. When he was first imprisoned for debt, the use of rubber was attracting general attention. He became strongly interested in finding a way for making the article more useful. The chief difficulty in treating rubber lay in its susceptibility to extremes of temperature; it melted in summer and became stiffened in winter. Strenuous effort had been expended in attempting to overcome this difficulty, but without success. Goodyear dedicated his energies to a solution of the problem. His experiments were conducted in Philadelphia, in New York, and in Massachusetts towns.

During this period he and his family lived literally from hand to mouth, and more than once subsisted upon what was virtually the charity of friends. Sometimes it was necessary to sell the children's books and articles of household furniture to drive the wolf of hunger from the door. Much of his experimentation was carried on in prison, with no encouragement from any source to cheer him on. At times his hopes arose as victory seemed near; they soon fell, as what he had mistaken for triumph proved to be defeat. He became the butt of those who did not share his own constant faith in the ultimate success of his labors. He was calm in defeat, patient in ridicule, and always bore himself with magnificent fortitude.



CHARLES GOODYEAR

In the early months of 1839 Goodyear could shout with the old Syracusan mathematician, "Eureka!"—"I have found it!" He had discovered that rubber coated with sulphur and then heated to a high degree of heat is rendered uniformly elastic in all temperatures. He had solved the problem, but it was two long years before he could convince any one of the fact. William Rider, of New York, finally furnished capital for carrying on the business of manufacturing rubber goods according to the new process. The firm was successful and Goodyear had soon paid off thirty-five thousand dollars of indebtedness owed to creditors of his old business that had failed ten or fifteen years before.

The new process was called vulcanizing. Vulcan was the old Roman god of fire and metal working, and was patron of handicrafts generally. The word *volcano* is derived from *vulcan*, and melted sulphur is associated with volcanoes. The term *vulcanize*, therefore, is traceable either directly or indirectly, through the fire or the sulphur employed in the process, to the name of the Roman god. According to the relative amount of sulphur used and the temperature to which the compound is raised, either soft or hard rubber may be produced. Hard rubber contains a greater quantity of sulphur and is heated to a higher temperature. The heat used in vulcanization reaches as much as three hundred degrees Fahrenheit.

Goodyear's first patent was taken out in 1844, the year in which Samuel F. B. Morse invented the telegraph. About this time he was imprisoned for debt for the last time in the United States, though he suffered a jail sentence for debt in France later. His patents were repeatedly infringed in this country, and he could not secure any patents in Great Britain or France. The United States Commissioner of Patents said of Goodyear, "No inventor, probably, has ever been so harassed, so trampled upon, so plundered by pirates as he, their spoliations upon him having unquestionably amounted to millions of dollars." Daniel Webster was the lawyer employed in the trial in which Goodyear's legal right to the honor and profits of his invention was established. For his services in this case Webster received a fee of twenty-five thousand dollars.

Goodyear himself made no very large sum of money from his invention, though he added to life not merely a new material but a new class of materials, applicable to many cases. Before his death he had seen rubber put to more than five hundred different uses, and thousands of persons engaged in manufacturing the various articles fashioned from it. Goodyear died in New York City, July 1, 1860.

CHAPTER XII

STENOGRAPHY AND THE TYPEWRITER

It is difficult to see how man could now dispense with any of the great inventions and discoveries that give him power over time and space. Not one of them could be sacrificed without corresponding loss of power. Among the great devices that economize time are stenography and the typewriter. Stenography is the world's business alphabet; the typewriter, its commercial printing press.

The word *stenography* is derived from the Greek adjective *stenos* meaning "narrow" or "close," and the Greek verb *graphein* signifying "to write." Stenography, therefore, is the art of close or narrow writing, so named, perhaps, from the great amount of meaning that by its use is packed into a narrow compass. It is a phonetic system in which brief signs are used to represent single sounds, groups of sounds, whole words, or groups of words.

The idea of stenography or shorthand writing originated in ancient times. Antiquarians have tried to show, with more or less plausibility, that it was practised more than a thousand years before the birth of Christ by the Persians, Egyptians, and Hebrews. Abbreviated writing, for taking down lectures and preserving poems recited at the Olympic and other games, was used by the Greeks. The first known practitioner of the art of shorthand writing was Tiro, who lived in Rome 63 B.C., and who was the stenographer of the great orator Cicero. He took down in shorthand the speeches of his master, by whom they were afterward revised. Plutarch says that when the Roman Senate was voting on the charge which Cicero had preferred against Catiline, Cicero distributed shorthand reporters throughout the Senate House for the purpose of taking down the speeches of some of the leading Senators. At the close of St. Paul's letter to the Colossians there is a note to the effect that the Epistle was written from Rome by Tychicus and Onesimus. It has been supposed that Tychicus acted as shorthand writer and Onesimus as transcriber. Certain it is that the early Christian fathers employed a system of shorthand writing. Saint Augustine refers to a church meeting held at Carthage in the fourth century of the Christian era, at which eight shorthand writers were employed, two working at a time. Charlemagne, the great king of the Franks, who died in 814 A.D., delved deep into the art of shorthand writing as practised by Tiro, Cicero's stenographer.

In Chapter xxxviii of *David Copperfield*, Charles Dickens describes his own experience with shorthand thus: "I bought an approved scheme of the noble art and mystery of stenography (which cost me ten and sixpence), and plunged into a sea of perplexity that brought me, in a few weeks, to the confines of distraction. The changes that were rung upon dots, which in such a position meant such a thing, and in such another position something else, entirely different; the wonderful vagaries that were played by circles; the unaccountable consequences that resulted from marks like flies' legs; the tremendous effects of a curve in a wrong place—not only troubled my waking hours, but reappeared before me in my sleep. When I had groped my way, blindly, through these difficulties, and had mastered the alphabet, which was an Egyptian temple in itself, there then appeared a procession of new horrors, called arbitrary characters, the most despotic characters I have ever known; who insisted, for instance, that a thing like the beginning of a cobweb meant *expectation*, and that a pen-and-ink sky-rocket stood for *disadvantageous*. When I had fixed these wretches in my mind, I found that they had driven everything else out of it; then, beginning again, I forgot them; while I was picking them up, I dropped the other fragments of the system; in short, it was almost heart-breaking. "

Till near the middle of the last century all systems of shorthand writing were more or less crude and illogical. About 1837 Isaac Pitman, an Englishman, put stenography upon a phonetic basis and therefore a scientific basis. As there are in the English language forty-three different sounds represented by twenty-six letters, Pitman adopted a shorthand alphabet in which consonants were represented by simple straight or curved strokes, the light sounds denoted by light strokes and the heavy sounds by heavy strokes. "The leading heavy vowels are represented by six heavy dots and a like number of heavy dashes, placed at the beginning, middle, or end of the strokes, and before or after as they precede or follow the consonants. The same course is followed with the light vowels. Diphthongs are provided for by a combination of dash forms, and by a small semicircle, differently formed and placed in different positions. Circles, hooks, and loops are employed in distinct offices."

Pitman's invention of a phonographic alphabet for shorthand was the beginning of verbatim reporting that has spread to every land which Anglo-Saxon civilization has touched. There is scarcely a legislative body, a court of importance, or a great convention of any kind, whose proceedings are not taken down on the spot in shorthand, accurately and at once, to say nothing of the very wide use of stenography in private business. In this bewildering commercial whirl of the twentieth century time is money, and stenography is time.

The typewriter, invented about forty years ago, is parallel to stenography in importance. The daily volume of the world's business could not be accomplished without it. And, as in the case of all the great inventions, men do not see how they got on before it came. The world owes the typewriter to two Americans, John Pratt and Christopher L. Sholes. Pratt was born in Unionville, South Carolina, April 14, 1831. In 1867, while in England, he produced the first working typewriter that ever secured a sale. A description of his machine in one of the English periodicals attracted the attention of Sholes, who was born in Pennsylvania in 1819, but who at that time was living in Milwaukee, Wisconsin. He began working at the idea of the typewriter borrowed from Pratt, and in the same year that Pratt's machine was first made, Sholes produced a typewriter that was practically successful and started the manufacture of a machine that was to become increasingly useful, and finally indispensable.

No business in recent years has grown more rapidly than the typewriter industry. From nothing forty years ago, it has grown into an industry producing nearly a quarter of a million machines a year and employing thousands of workmen. American manufacturers not only supply the home trade with their output, but export machines to every part of the civilized world, making this country the home and center of the world's typewriter industry.

CHAPTER XIII

THE FRICTION MATCH

The biggest things are not always the most important. A little article, used many times in the course of every day and familiar to every person, is one of the world's great inventions. It is the friction match.

Fire is one of man's absolute necessities. Without it civilization would have been impossible, and life could scarcely continue. The story of man's power to produce and use fire is practically the story of civilization itself. So far as history can reveal there has never been in any time a people who were without the knowledge and use of fire; which, on its beneficent side, is man's indispensable friend; and in its wrath, a terrible destroyer.

A mass of mythological stories has come down from the days of antiquity regarding the origin of fire. The Persian tradition is that fire was discovered by one of the hero dragon-fighters. He hurled a huge stone at a dragon, but missed his aim. The stone struck another rock. According to the story, "the heart of the rock flashed out in glory, and fire was seen for the first time in the world." The Dakota Indians of North America believed that their ancestors produced fire from the sparks which a friendly panther struck with its claws in scampering over a stony hill. Finnish poems describe how "fire, the child of the sun, came down from heaven, where it was rocked in a tube of yellow copper, in a large pail of gold." Some of the Australian tribes have a myth that fire came from the breaking of a staff held in the hands of an old man's daughter. In another Australian legend fire was stolen by a hawk and given to man; in still another a man held his spear to the sun and thus procured fire.

According to Greek mythology, fire was stolen from heaven by Prometheus, friend of men, and brought to them in a hollow stalk of fennel. As the legend runs, he took away from mankind the evil gift of foreseeing the future, and gave them instead the better gifts of hope and fire. For the bestowing of these gifts upon the human race, Prometheus was sorely punished by Zeus, king of the gods. The myth that fire was stolen from heaven by a hero is not confined to the Greeks; it is scattered among the traditions of all nations. It is not strange that primitive man should ascribe the origin of fire to supernatural causes. Before he learned how to use and control it, he must have been strangely impressed with its various manifestations—the flash of the lightning, the hissing eruption of the volcano, the burning heat of the sun, and perhaps the wild devastation of forest and prairie fires caused by spontaneous combustion.

Because of its mysterious origin and its uncontrollable power for good or ill, fire was supposed from the earliest times to be divine. The Bible tells us that the Lord went before the children of Israel in their journey from Egypt to the Promised Land in a pillar of fire by night. From the earliest hours of religious history the sun has been worshiped as a god. All the tribes of antiquity had a fire god. It was Agni in ancient India; Moloch among the Phœnicians; Hephaestus in Greece; Vulcan among the Romans; Osiris in Egypt; and Loki among the Scandinavians. In ancient religious belief fire and the human soul were supposed to be one and the same in substance. In some instances fire was held to be the very soul of nature, the essence of everything that had shape. "From Jupiter to the fly, from the wandering star to the tiniest blade of grass, all beings owed existence to the fiery element." This theory was believed by the Aztecs, who invoked in their prayers "fire the most ancient divinity, the father and mother of all gods." Of these ancient fire-divinities some were good and some evil; just as fire itself is both beneficent and malignant.

Among some peoples fire was used for purification from sin and the cure of disease. It also burned upon the tombs of the dead to dispel evil spirits. Greek colonists, in setting out from the mother country for the purpose of founding new homes, took fire from the home altar with which to kindle fires in their new homes. Upon some altars fires were kept constantly burning, and their extinguishment was considered a matter of great alarm. If by chance the fire that burned in the Roman temple of Vesta went out, all tribunals, all authority, all public and private business had to stop immediately until the fire should be relighted. The Greeks and the Aztecs received ambassadors of foreign countries in their temples of fire, where at the national hearth they prepared feasts for their guests. In some cases ambassadors were not received until they had stood close to fire in order that any impurities they might have brought should be singed away. No Greek or Roman army crossed a frontier without taking an altar whereon burned night and day fire brought from the public council hall and temple at home. The Egyptians had a fire burning night and day in every temple, and the Greeks, Romans, and Persians had such a fire in every town and village.

Among our Anglo-Saxon ancestors the ordeal by fire was one of the modes of trying cases of law. The accused was compelled to walk blindfolded over red-hot plowshares. If these burned him, he was adjudged guilty; if not, he was acquitted, for it was supposed that the purity of fire would not permit an innocent man to suffer. The custom of the North American Indians was to discuss important tribal affairs around the council fire. Each sachem marched around it thrice, turning to it all sides of his person. Among peoples in both hemispheres it has been the practice to free fields from the demons of barrenness by lighting huge fires. The fields were supposed to be made fertile as far as the flames could be seen. In Bavaria seeds were passed through fire before they were sown to insure fertility. In some places children were held over the flame of an altar fire for purposes of purification.

Nothing has played a more important part in the history of the race than fire. Human culture began with the use of it, and increased in proportion as its use increased. For ages man felt his helplessness before fire; he did not know how to produce it, or to turn it to good account. By and by the secret was discovered; mind began to gain the mastery over this great force.

The most primitive method of producing fire artificially was by rubbing two sticks together. This method was probably discovered by accident. Fire from friction was caused also by pushing the end of a stick along a groove in another piece of wood, or by twirling rapidly a stick which had its end placed perpendicularly in a hole made in another piece of wood. Focusing the rays of the sun powerfully upon a given point by means of a lens or concave mirror, was another method used for starting fire. The story is told that when the ancient city of Syracuse in Sicily was being besieged, the great mathematician Archimedes, who was a resident of that city, set on fire the enemy's ships by focusing the sun's rays upon them with a mirror. In China the burning-glass was widely used not very long ago. When iron came into use, it was employed for making fire. A piece of flint was struck against an iron object. The concussion produced a spark, which fell into a box containing charred cotton called tinder. The tinder took fire but did not burst into flame. The flame came by touching the burning tinder with a strip of wood tipped with sulphur. This flint-and-steel method was used for producing fire until less than a century ago.

No attempt was made to produce fire by chemical means until 1805. In that year M. Chancel, a Paris professor, invented an apparatus consisting of a small bottle containing asbestos, saturated with sulphuric acid, and wooden splints or matches coated with sulphur, chlorate of potash, and sugar. The wooden splint, when dipped into the bottle, was ignited. The first really successful friction matches were made in 1827 by John Walker, an English druggist. They consisted of wooden splints coated with sulphur and tipped with antimony, chlorate of potash, and gum. They were sold at a shilling or twenty-four cents per box, each box containing eighty-four matches.

The modern phosphorus friction match came into use about 1833. It is not possible to ascertain precisely who the inventor was. But in that year Preschel had a factory in Vienna, Austria, for the manufacture of friction matches with phosphorus as the chief chemical. For years Austria and the States in the south of Germany were the center of the match industry. Phosphorus is still used as the principal chemical ingredient in the manufacture of matches. The first patent in the United States for a friction match was issued October 24, 1836, to Alonzo D. Phillips, of Springfield, Massachusetts. The "safety match," which will not ignite unless brought into contact with the side of the box in which it is packed, was invented by Lundström of Sweden, in 1855. The match industry in Norway and Sweden has developed during the last few years with great rapidity. About sixty factories are in operation in these countries. One town alone contains six thousand matchmakers. In France the government has the sole right to manufacture matches.

Phosphorus is very poisonous, and the early manufacture of phosphorus matches was attended with loss of life and great suffering. Inhalation of phosphorus fumes produced necrosis, or decay of the bone, usually of the lower jaw. In the first years of phosphorus match making, the business was chiefly carried on by the poorer people in large cities. The work was done in damp, foul cellars; and the peculiar disease of the bone caused by the phosphorus fumes became so widespread that the different governments drove the match factories out of the cellars and ordered that the business be conducted in better ventilated buildings. But the discovery of red phosphorus, which never produces the disease, the use of lessened quantities of the ordinary phosphorus, and better ventilation have all combined to make the malady now very rare.

The first matches were made by hand, one by one, and were of necessity few and costly. Matches are now made and boxed by machinery. One million splints can be cut in an hour with the machinery in use. Some single manufacturing firms make as many as one hundred millions of matches in a day. With diminished cost of production have come decreased prices, so that now a large box can be purchased for a very few cents. Until about 1860 railroads in the United States would not receive matches for transportation, owing to the danger involved. The distribution before that year was mainly by canal or wagon. A match is a little thing, but it is one of the world's really great inventions.

CHAPTER XIV

PHOTOGRAPHY

Photography is one of the many triumphs of the human mind over time and space. Thousands of miles are between you and the wonderful Taj Mahal. You may never be able to go to it. But as the mountain would not go to Mohammed and Mohammed therefore went to the mountain, so photography brings the Taj Mahal to you. The chief struggle for civilization is with these two abstract antagonists—time and space. In this struggle the achievements of photography are such as to win it a place among the world's great inventions and discoveries.

Here, again, we borrow words from the Greeks. *Photography* comes from the Greek noun *phos* meaning "light" and the Greek verb *graphein* signifying "to write," already referred to several times in this volume. Photography is therefore the science and the art of writing or reproducing objects by means of light. The science of photography depends upon the action of light on certain chemicals, usually compounds of silver. These chemicals are spread upon a delicately sensitized metallic plate, which is exposed to light. The action of light fixes the object desired upon this plate, from which copies of the picture are made on paper of suitable kind.

Like most of the great discoveries and inventions, photography is not old. It had its beginning in 1777, when the Swedish chemist Scheele began to inquire scientifically into the reason and effect of the darkening of silver chloride by the rays of the sun. The first picture ever made by the use of light on a sensitive surface was made in 1791 by Thomas Wedgewood, an Englishman. The principle of the photographer's camera was discovered in

1569 by Della Porta, of Naples. To Nicéphore Niepce, a Frenchman, belongs the honor of producing the first camera picture. This was in 1827 after thirteen years of experimenting. He called his process "heliography," *helios* being the Greek word for *sun*. His process consisted of coating a piece of plated silver or glass with asphaltum or bitumen, and exposing the plate in the camera for a time varying in length from four to six hours. The light acted on the asphaltum in such a way as to leave the image on the plate.

The predecessor of the modern photograph was the daguerreotype. It was named for its inventor, Louis Daguerre, a French scene-painter, who was born in 1789. In 1829 he formed a partnership with Niepce, and together they labored to advance the art of photography. The discovery of the daguerreotyping process was announced in January, 1839. The process of Daguerre consisted in "exposing a metal plate covered with iodide of silver for a suitable time in a photographic camera, the plate being afterwards transferred to a dark room, and exposed to the vapor of mercury, which develops the latent image, it being afterwards fixed. Although this process has become almost obsolete, it was really the first which was of any practical value, and experts all agree that no other known process reproduces some subjects—for example, the human face—with such fidelity and beauty."

A little while before the daguerreotyping process was announced, Fox Talbot, a British investigator, discovered a method of making pictures by means of the action of light on chemically prepared paper instead of metal, as in the case of Daguerre. Talbot originated the terms *negative* and *positive* which are still used in photography. Daguerre in France and Talbot in Great Britain had independently achieved success in producing pictures, but neither had discovered a way to make photographs permanent. In the course of time the pictures faded. In 1839 Sir John Herschel of England found a chemical process for making photographs permanent, by removing the cause for their fading. The first sunlight photograph of a human face was that of Miss Dorothy Catherine Draper, made by her brother, Prof. John William Draper, of the University of the City of New York, early in 1840.

Various chemical discoveries for improving photographs have been made by different persons from time to time, until the art of photography has now reached a high state of development. An important improvement is in the lessening of the time of exposure to light necessary for producing a photograph. Formerly hours were required, but under improved conditions only the shortest instant of time is requisite.

In 1906 a photographic paper for producing prints in color from an ordinary negative was placed on the market. This paper is coated with three layers of pigmented gelatin, colored respectively red, yellow, and blue. After being exposed to the daylight in the usual way, the paper is placed in hot water, where the image is developed. The grays and blacks of the negative are translated into the colors they represent in the object.

The brothers Lumière of Paris have found a method of producing a photograph on a sensitive plate which, viewed as a transparency, shows the object in its original colors. No prints can be taken from this plate, and the picture cannot be viewed by reflected light, but the colors are true and brilliant.

The cinematograph is an instrument by which about fifteen photographs per second can be received on a film, each representing the photographed group at a different instant from the others. The advantages of this mode of photographing and of throwing pictures on a screen over the older methods are obvious. By controlling the rate at which the pictures are represented on the screen, movements too rapid to be analyzed by the eye may be made slow enough to permit observation; and, similarly, movements too slow for comprehension or rapid observation may often be quickened. The busy life of a city street, the progress of races or other competitions, many scenes in nature, and even the growth of a plant from seed to maturity, may be shown by means of a "moving picture."

Photography is a noble servant of mind and soul. It brings to us likenesses of eminent persons and objects of nature and art which perhaps we should never be able to see otherwise. It has been used in measuring the velocity of bullets and in showing the true positions of animals in motion. Photography has created the "new astronomy." Immediately after its discovery, photography was applied to the science of the stars, and it has been ever since of incalculable service in this field of inquiry. Photographs of the moon were made as early as 1840, and much that is known to-day of the sun has been revealed by photography. So sensitive is the modern photographic plate to the influence of light, that photography has discovered and located stars which are invisible through a strong telescope. Astronomers are now engaged in making a photographic chart of the sky.

CHAPTER XV

CLOCKS

The matters of every-day life, much less the affairs of a complex civilization, could scarcely be carried on without some accurate and uniform system of measuring time. Nature herself furnishes measurements for certain divisions of time. The "two great lights" that God made, as the Bible tells us, were designed "for signs, and for seasons, and for days and for years." The revolution of the earth around the sun marks the year; the revolution of the moon around the earth determines the month; the rotation of the earth on its axis causes and measures day and night. But no object of nature distinguishes the hours of the day or the divisions of the hour.

Man requires a smaller unit of time than the day. He must divide the day into hours; the hours into minutes; the minutes into seconds. The division of the day into twenty-four hours is as old as authentic history. But the means for determining the hours and their subdivisions were at first quite crude and inefficient.

A Sun Dial

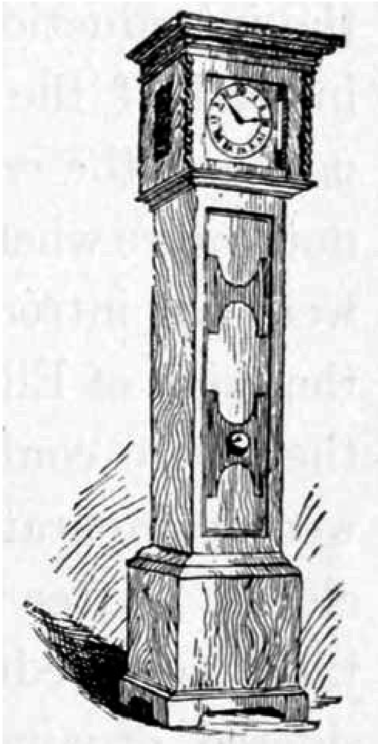
Perhaps the most primitive of all time-measuring devices was a stick or pole planted upright in a sunny place. The position of the shadow which it cast marked time. The sun-dial was a development of this simple device. It consisted essentially of two parts: a flat plate of metal marked off much like the dial of a modern clock or watch, and an upright piece, usually also of metal, fastened to the center of the dial. To make the direction of the shadow uniform for any given hour throughout the year, the upright piece was made parallel to the axis of the earth. As the earth rotated on its axis the shadow cast by the upright piece moved from point to point on the dial, measuring the flight of time. The sun-dial was in use among the earliest nations. Herodotus is authority for the statement that the Greeks borrowed it from the Babylonians. The sun-dial was obviously of no use on cloudy days or dark nights, and even in sunny weather it could not accurately or delicately indicate the passage of time. However, it continued in use so long that to the end of the seventeenth century the art of dialling was considered a necessary element of every course in mathematics.

Another ancient invention for measuring time was the water-clock. Water was permitted to drop from a small orifice in a containing vessel. The period required for emptying the vessel marked a unit of time. Its principle was the same as the common hour-glass, according to which time is measured by the slow dropping of sand from one receptacle into another. The water-clock was used by the ancient Chaldeans and the Hindoos, and also by the Greeks and Romans. Demosthenes mentions its use in the courts of justice at Athens.

In order to mark the hours of the day, the Saxon King Alfred the Great is said to have made wax candles twelve inches in length, each marked at equal distances. The burning of six of these candles in succession consumed, roughly, just twenty-four hours. To prevent the wind from extinguishing them they were inclosed in cases of thin, white, transparent horn. The candles thus inclosed were the ancestors of the modern lantern.

Our word *clock* comes from the Anglo-Saxon verb *clocean* meaning "to strike," "to give out a sound." It is impossible to ascertain by whom clocks were invented, or when or where. It is fairly clear, however, that a Benedictine Monk named Gerbert, who afterward became Pope

Sylvester II, made a clock for the German city of Magdeburg a little before the year 1000 A.D. Clocks may have been made before this, but if so it would be hard to establish the fact. In Gerbert's clock weights were the motive power for the mechanism. Weight clocks were used in the monasteries of Europe in the eleventh century, but it is probable that these early clocks struck a bell at certain intervals as a call to prayer, and did not have dials for showing the time of day.



A "Grandfather's Clock," belonging to William Penn

The first clocks were comparatively by large and were stationary. Portable ones appeared about the beginning of the fourteenth century, though the inventor is not known, nor the exact time or place of invention. When portable clocks were invented, the motive power must have been changed from weights to main-springs, and this change in motive force marks an era in the development of the clock. The introduction of the pendulum as a regulating agent was, however, the greatest event in clock development. This invention has been credited to Huygens, a Dutch philosopher, who was certainly, if not the discoverer of the pendulum, the first to bring it into practical use, about 1657. Credit for inventing the pendulum is also claimed for Harris, a London clockmaker; for Hooke, the great English philosopher; for a son of Galileo, the celebrated Italian scientist; and for others.

The modern watch is in reality but a developed type of the clock. Watches were made possible by the introduction of the coiled spring as motive power, instead of the weight. The coiled spring came into use near the end of the fifteenth century, though it is not known where or by whom it was invented. Watches were not introduced into general use in England until the reign of Elizabeth, and then on account of the cost they were confined to the wealthy. At first watches were comparatively large and struck the hours like clocks. After the striking mechanism was abandoned, they were reduced in size and for a time were considered ornamental rather than useful. They were richly adorned with pictures in enamel and with costly jewels. They were set in the heads of canes, in bracelets, and in finger-rings.

Watches and clocks had originally only one hand, which indicated the hour. Minute and second hands were added later. Devices have been introduced to counteract the effect of temperature on the mechanism of time-pieces, so that they run uniformly in all kinds of weather. Within recent years clocks operated with electricity have been invented. With the advent of clock and watch manufacture by machinery, the cost has been so reduced that practically any one may own an accurate time-piece. The United States is one of the foremost countries of the world in the manufacture and sale of clocks and watches.

CHAPTER XVI

SOME MACHINES

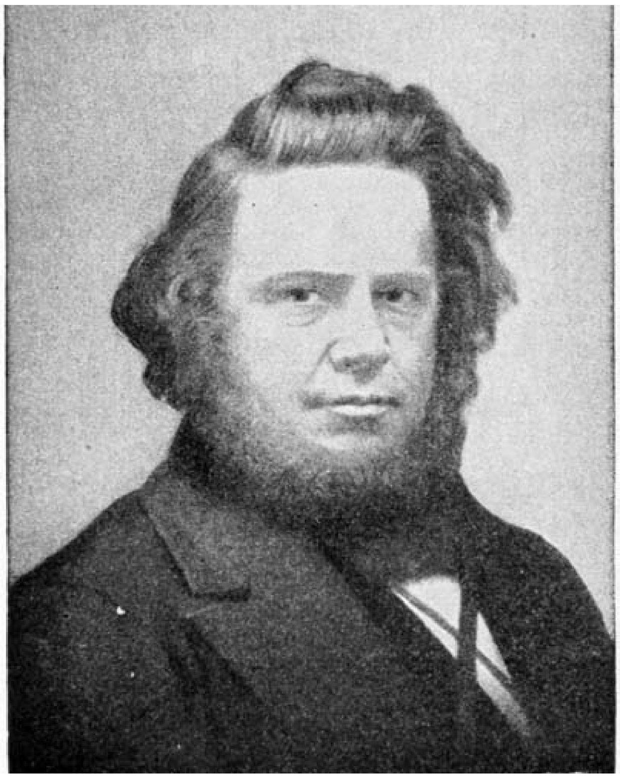
The Sewing Machine

Civilization owes the invention of the sewing machine to Elias Howe, an American. Howe was born at Spencer, Massachusetts, July 9, 1819. His father was a miller, and work in the mills gave the son's mind a bent toward machinery. One day in 1839 while Howe was working in a machine-shop in Boston, he overheard a conversation among some men regarding the invention of a knitting machine. "What are you bothering yourselves with a knitting machine for? Why don't you make a sewing machine?" asked one. "I wish I could," was the reply, "but it can't be done." "Oh, yes it can," said the first, "I can make a sewing machine myself." "Well, you do it," replied the second, "and I'll insure you an independent fortune."

This conversation impressed Howe with the idea of producing a sewing machine. The hope of relieving his extreme poverty set him to work on the invention in earnest in the year 1843. George Fisher, a coal and wood dealer of Cambridge, Massachusetts, who was a former schoolmate of Howe, formed a partnership with him for producing the invention. In December, 1844, Howe moved into Fisher's house, set up his shop in the garret, and went to work. In the following April he sewed the first seam with his new machine, and by the middle of May he had sewed all the seams of two suits of clothes, one for himself and one for his partner.

On September 10, 1846, a patent on the sewing machine was issued to Howe from the United States Patent Office at Washington.

The tailors of Boston, believing that a sewing machine would destroy their business, waged fierce warfare against it. In the spring of 1846, seeing no prospect of revenue from his invention, Howe took employment as a railroad engineer on one of the roads entering Boston, but this labor proved too hard for him and he soon gave it up. Howe's partner, Fisher, could see no profit in the machine and became wholly discouraged. Howe then determined to try to market his invention in England, and sent a machine to London. An English machinist examined it, approved it, and paid $250 for it, together with the right to use as many others in his own business as he might desire. Howe was afterward of the opinion that the investment of this $250 by the English machinist brought ultimately to that man a profit of one million dollars.



Elias Howe

During all this time Howe was extremely poor. He and his wife and children had gone to England, but on account of poverty he was compelled to send his family back to America. His fourth machine, which he had constructed in England, he was obliged to sell for 5 pounds (about $25), although it was worth ten times as much, in order to procure money enough to pay his return passage to America. He also pawned his first-made machine and his patent on the invention. In April, 1849, he landed at New York with only an English half-crown in his pocket. Procuring employment in a machine-shop, the inventor took up his abode in one of the cheapest emigrant boarding-houses. At this time his wife lay dying in Cambridge, Massachusetts, and his father had to send him ten dollars to enable him to go to her.

Finally the sewing machine began to succeed commercially. The inventor's long night of discouragement was breaking on a day of assured prosperity. In 1850 Howe was in New York superintending the manufacture of fourteen sewing machines. His office was equipped with a five-dollar desk and two fifty-cent chairs. A few years later he was rich. Isaac Merritt Singer became acquainted with his machine, and submitted to him the sketch of an improved one. It was Singer who first forced the sewing machine upon the attention of the United States. Howe charged that Singer was infringing his patent rights. Litigation ensued. Judge Sprague of Massachusetts decided in favor of Howe. In his opinion he stated that "there is no evidence in this case that leaves a shadow of doubt that, for all the benefit conferred upon the public by the introduction of a sewing machine the public are indebted to Mr. Howe." From this time Howe began to reap the financial reward of his labors. His revenues from the sewing machine amounted ultimately to more than $200,000 a year. He spent vast sums, however, in defending his patent rights, and many others of the "sewing machine kings" were wealthier than he. Howe died at Brooklyn, New York, October 3, 1867.

The sewing machine is used not only for sewing cloth into all kinds of garments, but for making leather into boots, shoes, harness, and other necessary articles of daily life. Great improvements have been made in the sewing machine since its invention, but its essential principles to-day are for the most part those that the inventor discovered and brought into successful operation in his first machine. It is agreed by disinterested and competent persons that "Howe carried the invention of the sewing machine further toward its complete and final utility than any other inventor before him had ever brought a first-rate invention at the first trial."

The Reaper

In the Louvre at Paris is one of the noblest and most famous paintings of modern art, purchased some years ago at a cost of three hundred thousand francs. It is "The Gleaners" from the brush of the French artist Jean François Millet. It pictures three peasant women who have gone out into the fields to glean at the end of the harvest. They are picking up the grain left by the reapers, seeking the little that is left on the ground. In the background are the field, the groups of reapers, the loaded wagons and the horses bringing the garnered sheaves to the rick, the farmer on horseback among his men, and the homestead among the trees. The transparent atmosphere of the summer day, the burning rays of the sun, and the short yellow stubble are all as if they were nature and not art. In the foreground are the three gleaners, "heroic types of labor fulfilling its task until 'the night cometh when no man can work.'"

One of the most beautiful stories of the Bible is the tale of Ruth, the Moabitess, who went out into the fields of Palestine to glean. "And she went, and came, and gleaned in the field after the reapers; and her hap was to light on a part of the field belonging unto Boaz, who was of the kindred of Elimilech."

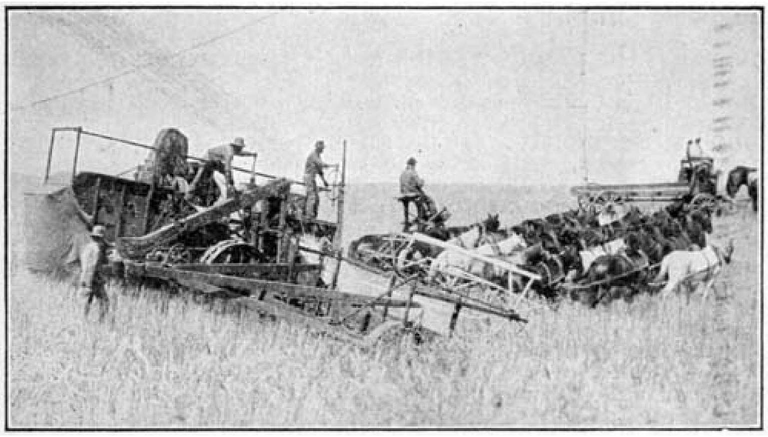
According to the old English law, gleaners had the right to go into the fields and glean. And those needy ones who went for the leavings of the reapers could not be sued for trespass.

But it is not with reaping in art, literature, or law that we are here concerned, but with the reaper as a machine, a concrete thing, a tool, an instrument of civilization.

From the earliest times until nearly the middle of the last century the cutting of grain was done by means of a hand sickle or curved reaping-hook. The sickles used by the ancient Jews, Egyptians, and Chinese differed very little from those of our own ancestors. This tool was only slightly improved as the centuries went by, and to this day the sickle may be seen in use. In many parts of the British Isles the reaping-hook gave place to the scythe in the earlier part of the nineteenth century. An attempt to trace the idea of a machine for reaping would carry us far back into the early stages of agriculture; Pliny, the Roman writer, born early in the first century of the Christian era, found a crude kind of reaper in the fields of Gaul. For the great modern invention of the reaping machine, civilization is indebted to Cyrus Hall McCormick, an American.

McCormick was born in Rockbridge County, Virginia, February 15, 1809. His father, Robert McCormick, a farmer of inventive mind, worked long to produce a reaper. In 1831 he put a reaping machine in the field for trial, but it failed to work and its inventor was completely discouraged. Against the counsel of his father, Cyrus McCormick began a study of the machine that had failed, to determine and to overcome the causes of failure. He produced another reaper, and in the late harvest of 1831 he tested it in the wheat fields of his father's farm and in some fields of oats belonging to a neighbor. The machine was a success.

McCormick's invention, soon destined to revolutionize agriculture, was combated for the alleged reason that it would destroy the occupation of farm laborers during the harvest season. It was some years before McCormick himself realized the importance of his invention, and he did not take out a patent on it until June 21, 1834. It was not until 1840 that he began manufacturing reapers for the market. In that year he constructed one and sold it to a neighbor. For the harvest of 1843 he made and sold twenty-nine machines. These had all been built upon the home farm by hand, the workmen being himself, his father, and his brothers. In 1844 he traveled with his reaper from Virginia to New York State, and from there through the wheat fields of Wisconsin, Illinois, Ohio, and Missouri, showing the machine at work in the grain and enlisting the interest of agricultural men.



A Modern Reaper
This machine cuts, threshes, winnows, and sacks the wheat

In 1847 and 1848 Chicago was but a trading village. McCormick, foreseeing its future growth, located his reaper factory there. In that factory he constructed about nine hundred reapers for the harvest of 1848.

In 1851 he exhibited his invention at the World's Fair in London. The London *Times* facetiously called it "a cross between a wheel-barrow and a flying machine." Later the same paper said of the reaper that it was "the most valuable contribution to the Exposition, and worth to the farmers of England more than the entire cost of the Exposition."

In 1848 McCormick's patent on the reaper expired. Although his claim as the inventor was clearly established, and the commissioner of patents paid him the highest compliments in words for his invention, a renewal of the patent was denied. Other reapers had been made in the meantime, and others have been brought out subsequently. It is an historical fact, however, and one now seldom questioned, that every harvesting machine which has ever been constructed is in its essential parts the invention of Cyrus Hall McCormick.

Besides being a great inventor and successful business man, McCormick was a liberal philanthropist. He gave freely to educational and religious institutions. He died at his home in Chicago, May 13, 1884.

An improved type of the ordinary reaper of McCormick is the self-binder, now in common use, a machine which not only reaps the stalks of grain but binds them together in sheaves.

The most primitive method of threshing grain from the straw was doubtless by beating it with a stick. The ancient Egyptians and Israelites spread out their loosened sheaves upon a circular plot of earth and threshed out the grain by driving oxen back and forth over it. Later a threshing-sledge was dragged over the sheaves. The Greeks and the Romans beat out grain with a stick, trod it out with men or horses, or used the threshing-sledge. The primitive implement for threshing in northern Europe was the stick. A modification of this was the flail, made of two sticks loosely fastened together at one end by means of stout thongs. This implement was used by our ancestors in America and has not yet entirely disappeared from all parts of the world. The threshing machine was invented in 1787 by Andrew Meikle, a Scotchman. Only a few years ago threshing machines were drawn by horses, but of late years they have been moved with self-propelling steam engines, commonly called traction engines.

A remarkable combination machine has come into use recently, particularly in the vast wheat fields of California, eastern Washington, and the West. This machine is drawn by as many as thirty-two horses. At one operation it cuts the grain, threshes it, winnows it, and puts it into bags ready for the market.

Spinning and Weaving Machines

The low, monotonous hum of the spinning-wheel in the old farmhouse on winter evenings, as the housewife spun the yarn which she was afterward to knit into warm stockings for the family, has not entirely passed away from the memory of the older generation of to-day. Thomas Buchanan Read has a pathetic allusion to the old spinning-wheel in one of his best poems, "The Closing Scene." And who has not felt the charm of the spinning-wheel scene in Longfellow's "The Courtship of Miles Standish," which pictures John Alden as he sits clumsily holding on his hands the skein which Priscilla winds for knitting.

There are two essential principles in the art of spinning: first, the drawing out of uniform quantities of fiber in a continuous manner; and second, the twisting of the fiber so as to give it coherency and strength. The earliest spinning apparatus, and for ages the only one, was the distaff and spindle. The former was a staff upon which was loosely bound a bundle of the fiber to be spun. It was held in the left hand or was fastened in the belt. The spindle, a tapering rod smaller than the distaff, was held in the right hand. The rotation of the spindle gave the necessary twist to the thread, and around the spindle the thread was wound as it was twisted. The next development in spinning machinery was the spinning-wheel, which has continued in use in some rural parts of the world practically to the present day.

The series of inventions that overthrew hand spinning, and made this industry possible on a large scale, really began in 1738 when Lewis Paul, an English inventor, discovered a process for drawing out and attenuating threads of wool or cotton by passing the fiber through successive pairs of rollers. To-day this principle forms a fundamental feature of all spinning machinery. In 1764 James Hargreaves, an illiterate weaver and carpenter of Lancashire, England, invented the spinning-jenny, a device by which eight threads could be spun at once. With a little improvement in this invention, eighty threads were produced as easily as eight. The idea of the spinning-jenny is said to have been accidentally suggested to its inventor by watching the motions of a common spinning-wheel which one of his children had unintentionally upset.

Hargreaves is another in the long list of those who have suffered persecution because of having done something to make the world better. His fellow-spinners, filled with prejudice toward his invention because they feared it might rob them of employment, broke into his house and destroyed his machine. He then moved to Nottingham, where he erected a spinning mill. In 1770 Hargreaves took out a patent on his invention, but the patent was subsequently annulled on the ground that he had sold a few machines before patenting the invention.

Valuable as was the spinning-jenny of Hargreaves, it was adapted only to producing the transverse threads, or the woof. It could not produce sufficient firmness and hardness for the longitudinal threads, or the warp. In 1767 Richard Arkwright, another native of Lancashire, invented the spinning-frame, which was able to yield a thread fine enough and firm enough to make the warp. At the time of his invention Arkwright was so poor that he had to be furnished with a suit of clothes before he looked respectable enough to appear at an election. Like Hargreaves, he also was persecuted. Both were driven out of Lancashire to Nottingham to escape popular rage. Arkwright's patent was annulled, and at one time his factory was destroyed by the populace in the presence of a powerful military and police force, who did nothing to restrain it. And why were Hargreaves and Arkwright driven out of Lancashire? They had invented machines that would produce more and cheaper clothing; that would give powerful impetus to the cotton and the woolen industries; that would lift the race higher in the path-way of civilization. What was the reason? Misunderstanding, prejudice, and selfishness. The interests of the few were shutting out the interests of the world. And these interests of the few were imaginary.

In spite of all opposition, however, Arkwright succeeded, and may be regarded as the founder of the modern factory system.

In 1779 Samuel Crompton, another Lancashire inventor, produced an improved spinning machine called the spinning-mule. This invention combined the good qualities of the spinning-jenny of Hargreaves and the spinning-frame of Arkwright. Its chief point of excellence lay in the fineness of the threads which it spun; from this kind of thread could be made finer fabrics than were possible with the machines of Hargreaves and of Arkwright.

Crompton was very poor. By day he worked at the loom or on the farm to earn bread for himself, his mother, and his two sisters, and at night he toiled away on his invention. No sooner had he perfected his machine than he was beset by persons seeking to rob him of its benefits. All kinds of devices were employed for learning the secret. Ladders were placed against his windows in order that unscrupulous spectators might get a view of the machine. He did not dare to leave the house, lest his secret be stolen from him. He had spent his last farthing upon the invention and had no funds for securing a patent. A manufacturer persuaded him to disclose to the trade the nature of his invention under promise of a liberal subscription; but Crompton received only a paltry sum amounting to less than $350. He finally saved up enough money to begin manufacturing on a small scale, but his rivals had already out-distanced him. He died in June, 1827, dısspirited at the ill treatment he had received, but not until he had seen his invention a powerful agency in British cloth manufacturing.

An interesting glimpse of the days when weaving was done by hand in England may be found in the first chapter of George Eliot's *Silas Marner, the Weaver of Raveloe*. The hand-loom in weaving was superseded by the power-loom early in the nineteenth century. The loom was the invention of the Rev. Edmund Cartwright, an English clergyman, poet, and inventor. The date of the invention was 1785. Cartwright's first loom was very crude, but he subsequently improved it. The idea for the invention of his power-loom came to Cartwright after a visit to the spinning mills of Arkwright. He too was subjected to opposition from the weavers on account of his invention. At one time he was associated with Robert Fulton in his experiments in applying steam to navigation.

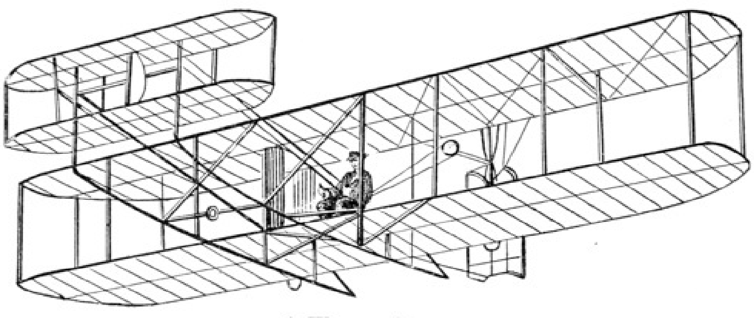
CHAPTER XVII

AERONAUTICS

To fly in the air has been the dream of all peoples in all ages. "Oh that I had wings like a dove! Then would I fly away and be at rest!" sang the Psalmist. It would seem from the recent inventions in the science of aeronautics that this dream is to become in the near future a practical experience of our every-day lives.

A balloon is an apparatus with an envelope filled with gas, the specific gravity of which is less than that of the atmosphere near the surface of the earth. It is practically at the mercy of air-currents. The science of balloon aeronautics dates definitely from 1783, when the Montgolfier brothers at Angonay in France constructed their first balloons. These Frenchmen and their successors developed the spherical balloons to a state of efficiency which has scarcely been improved upon to this day. The balloon in time came to be adopted throughout Europe for military uses, mainly for the purpose of spying out the enemy's position and defenses.

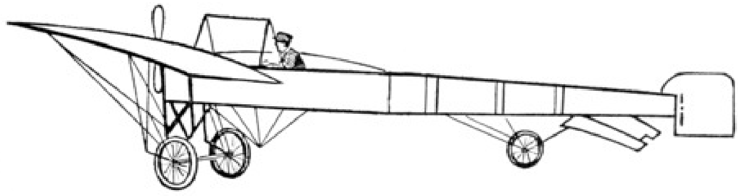
A dirigible balloon usually has an elongated envelope and is equipped with a motor and a rudder by which it can be steered at will against a moderate wind. Balloon aeronautics became popular in 1898, when Santos-Dumont, a wealthy young Brazilian, performed a series of spectacular feats with his dirigible balloon. Immediately ballooning became the sporting fad in France and the craze spread rapidly over the Continent and to England. Numerous airships of the dirigible type made their appearance and many balloon factories were established.



A Wright Biplane
By Courtesy of Brooks Brothers

In Germany every community has its aero club. In the United States there are about 300,000 club members scattered throughout the land who individually or collectively own over 200 balloons. All of the great nations own one or more aerial warships of the dirigible type, as well as numerous spherical balloons.

An aeroplane, as commonly known, is a machine which is sustained in the air by one, two, or three sets of rigid surfaces or planes. Unlike the balloon, it is heavier than air, and it must therefore maintain its position in the air by some form of mechanical propulsion. It must, in other words, fly like a bird.



A BLERIOT MONOPLANE

The first aeroplane was invented by Henson, an Englishman, who in 1843 flew his machine, using a two-horse-power steam engine. In 1888 and in 1900 two other practically successful models appeared, one made by a French and the other by an English inventor. Langley, an American, who began experimenting in 1885, managed to fly over the Potomac in 1896. The Wright brothers made their initial flights under motor power in 1903.

During the years since 1903 innumerable types of aeroplanes have been developed, all based upon the lines laid down by Langley, Henson, Maxim, and other pioneers. Among the most successful experimenters have been Farman, Delagrange, Bleriot, Curtiss, and the Voisins.

The flapping-wing machine is called an orthopter (*orthos*, straight, + *ptera*, wing) and is supposed to copy bird flight. Screw-flyers, called helicopters, lift themselves from the ground by the thrust of varying numbers of rapidly moving propellers, revolving horizontally.

Some startling feats have been performed in the field of aeronautics. On August 7, 1910, John B. Moisant, an American, flew in a Bleriot monoplane across the English Channel, a distance of about twenty-five miles, in thirty-two minutes. He carried one passenger. On September 12, 1910, Claude Grahame-White, an Englishman, flew in a Farman biplane thirty-three miles in thirty-four minutes, near Boston, winning a prize of ten thousand dollars.

Every day new ideas take shape and are developed in some form that promotes the pleasure, comfort, or safety of mankind. There seems to be literally no limit to man's inventive power. His brain teems with thoughts and his hands labor incessantly to force his thoughts into material forms. He mounts higher and higher on the scale of civilization, casting away old ideas, inefficient methods, and worn-out machines, and substituting the new and wonderful things which he has achieved.

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