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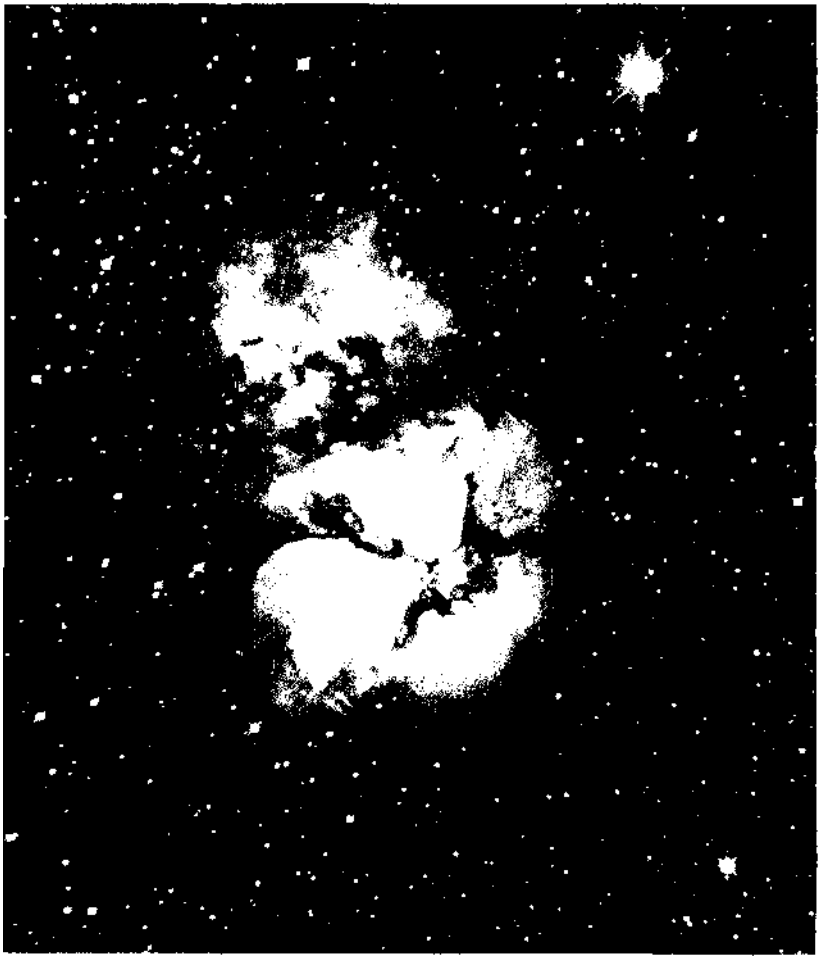
THE WORLD WE LIVE IN

AND

HOW IT CAME TO BE



Courtesy Mt. Wilson Observatory

The powerful eyes of modern telescopes have revealed trailing clouds of fire-mist and glowing masses of gas, called nebulae, spinning in the heavens. Scientists believe that our earth has developed from some such whirling cloud of fire.

THE WORLD WE LIVE IN

AND

HOW IT CAME TO BE

By

GERTRUDE HARTMAN

With 177 *Illustrations*

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The Greeks believed that each day, when Aurora, the dawn, had opened the purple gates of night in the east, Ploebus Apollo, the sun-god, set out in his golden chariot across the sky
(From a painting on an old Greek vase.)

THE GREAT BALL ON WHICH WE LIVE

INTRODUCTION

AS IT WAS IN THE BEGINNING

How did the earth, on which man lives, come to be ? From the earliest days men have watched the sun rise in the east in the morning, travel overhead during the day, and set in the west at night. They have looked up at the night sky, with its millions of stars gleaming diamond-like in their deep blue setting. They have watched the seasons -spring, summer, autumn, winter—return with never-failing regularity. And always they have wondered about the earth on which they lived and how it came to be. Nature is full of wonders that man, ever since his first days on the earth, has been trying to understand.

The early people had little real knowledge of the world, and so they made up stories to explain to themselves, as best they could, the things they did not understand. Perhaps you know the beautiful old Greek story of Phoebus Apollo, the sun-god, who each morning when

Aurora, the dawn, opened the purple gates of night in the east, set forth in his golden chariot on his daily journey across the sky. This is only one of the many, many stories about the earth imagined by early peoples. Every early nation had a store of such stories, which we call myths, which grew out of their attempts *to* understand the world in which they lived.

Nature, with its many great mysteries, impressed these folk of the early days with awe and often with fear. Realizing that these mysteries represented some power greater than themselves, men worshipped them as gods. But also realizing the unvarying law and order of the universe, even the earliest peoples believed that there must be some one god who regulated the work of the others. Among the Greeks, Zems was considered the father *of* gods and men. Among the Romans, Jupiter was the ruler of heaven and earth. The early Hebrews came to believe that there was only one God, Jehovah, the wise and just ruler of the universe. That part of the Bible known as the Old Testament tells us the Hebrew belief, and the beautiful verses at the beginning of the book of Genesis tell us how the Hebrews thought the earth was created :

In the beginning God created the heaven and the earth
And the earth was without form, and void , and darkness was upon the face of the deep
And God said, Let there be light ' and there was light . . .
And God called the light Day, and the darkness he called Night . .
And God made the trimament, . . . and called the firmament Heaven

And God said, Let the waters under the heaven be gathered together unto one place, and let the dry land appear And it was so
And God said, Let there be lights in the firmament of the heaven to divide the day from the night , and let them be for signs, and for seasons, and for days, and years
And God made two great lights , the greater light to rule the day, and the lesser light to rule the night He made the stars also
And God set them in the firmament of the heaven to give light upon the earth, and to rule over the day and over the night, and to divide the light from the darkness and God saw that it was good

Coming down the centuries, we find that man has constantly modified his ideas about the earth as his knowledge of it increased. For many centuries people had many wrong ideas about the shape

Copernicus, the father of modern astronomy, was one of the first men of his time to believe that the earth revolves around the sun.

of the earth. As we look out upon the earth it appears to be flat ; so it is not to be wondered at that for a long, long time most people thought it to be so, especially as they had not travelled enough on its surface to find out what it really was like. But even as far back as the time of the Greeks learned men came to believe that the earth was round. One of their great .scholars said : " When there is an eclipse of the moon, the shadow is caused by the earth which gets in the way of the sun'-

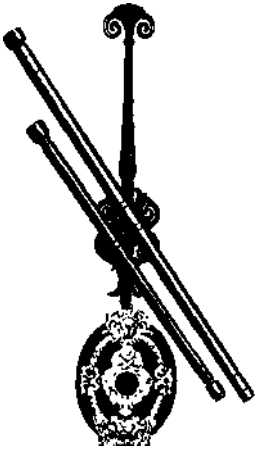
light. The shadow is curved, so the earth that makes it must be curved."

For many centuries, too, every one believed that the sun revolved around the earth. Was it not natural to think so, when men saw it rise in one part of the heavens in the morning and set in the opposite part at night ? Then in the fourteenth century came a great original thinker named Nicholas Copernicus. From his earliest childhood Copernicus had always loved nature, and when he grew up he began studying the heavens, often sitting up all night long, watching the heavenly bodies from the high steeple of the cathedral of his town. He eagerly read everything he could find out about them, and after studying and thinking for years, he came to believe that the older writers were mistaken in thinking that the sun revolved around the earth. The rising and setting of the sun, Copernicus explained, is caused, not by the movement of the sun, but by that of the earth. It just appears to us that the sun is moving and that we are standing still. When he was quite an old man, Copernicus wrote a book explaining his ideas, but he scarcely lived to see it appear. A printed copy of it was gently laid in his hands just before he died, so that he might feel it.

Copernicus was not able to prove his belief because he had no means of studying the heavens except his own eyes. When you realize that the eye admits only as much light as falls on a circle a fifth of an inch in diameter, you can understand that a person cannot see much of the heavens with his eye alone. Shortly after the time of Copernicus man increased his seeing power by making an eye of curved glass which collected the rays of light over a large area and bent them so that they would pass through the little pupil of his own eye. This is the principle of the telescope. There is an interesting story as to how this discovery was made. About three hundred years ago there was living in Holland a man by the name of Hans Lippershey whose business was making eyeglasses. One day, so the story goes, while he was working in his shop, his children were playing outside with some of his lenses- They happened to hold up one lens in front of another to look at the weather-cock on a near-by church steeple. Their excited cries of suprise upon seeing how near it seemed through the glasses brought their father from his shop, and he took a look himself. Sure enough with the glasses held about a foot apart, he could see the weathercoel quite plainly.

The children of Hans Lippershey looking at the weathercock on the steeple of a church. Their surprise at seeing how near it seemed through the glasses led to the making of the telescope.

Lippershey began experimenting with lenses and finally fastened two in a tube for convenience in holding. This spyglass, as he called it, attracted a great deal of attention. Some one wrote about it to Galileo, the great Italian scientist of the day. Galileo at once realized what a wonderful help such an instrument would be to him in studying the heavens, and he eagerly set to work to make a spyglass for himself. He worked and worked with infinite patience for a long, long time, grinding pieces of glass and curving them first one way and then another. Finally he took an old piece of organ pipe and fitted into it two pieces of glass that he had ground so that one curved out and the other curved in. He found that it magnified everything greatly. On the first clear night he pointed his instrument toward the sky, and what was his amazement to find that what had before seemed to him like dark empty space was in reality filled with brightly gleaming stars ! You can imagine Galileo's delight when he was first really able to see the wonders of the heavens through his telescope (for this was the first real telescope).



Galileo's telescopes. These would seem like mere toys to the modern astronomer, yet they revealed many wonders of the heavens for the first time.

Night after night Galileo climbed to a high tower and swept the sky with his telescope, turning it this way and that ; and mystery after mystery was unfolded to his wondering gaze. In whatever direction he looked through the magic eye of his new invention, he discovered new stars. One night he turned his telescope toward the planet Jupiter, and great was his surprise to find near it three bright little stars, two to the east and one to the west. On the next night when he directed his telescope toward Jupiter, he found that all three little stars were to the west of the planet. The next few nights were cloudy, and he waited with impatience. On the next clear night he saw only two stars to the east and a fourth star. He then realized that all four of these stars were circling around the planet. He found other planets with

stars circling round them. From all his study Galileo became convinced that Copernicus had been right in thinking that the earth and the other planets revolve around the sun, just as the smalle' stars revolve around the planets.

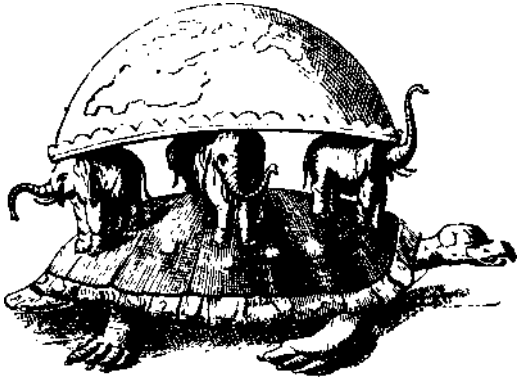
The news of Galileo's discoveries spread far and wide and aroused great excitement among the thinkers of his day. From all over Europe, students came flocking to hear more about these new ideas. But such ideas as Galileo's, which upset the belief of centuries and made it necessary for men to change their whole way of thinking, were not to be generally accepted by people in a day nor in a century. To the

Galileo being tried by the Church for his ideas about the earth.
(From a modern painting.)

Church at this time such ideas as Galileo's seemed wicked. The Bible was thought to teach that the earth was the centre of the universe. Galileo was commanded by the Church not to believe, nor to lead others to believe, such things. When he published a book in which he defended his ideas, he was summoned to Rome. He was found guilty by a court of teaching false beliefs, and was forced to agree never again to teach the forbidden doctrine.

Nevertheless the work of Copernicus and Galileo revolutionized men's ideas about the earth, and in time there was not to be found in all Europe a thinker who did not accept their belief. But if the earth is a great ball in space, how is it held in its place ? Why do things stay

on it ? Why don't they fall off into space ? Questions like these puzzled thinkers for centuries. Early peoples, knowing from experience that everything has to be supported in some way, reasoned that the earth, too, had to be supported. The early Hindus believed that the earth rested on the backs of four elephants, that stood on a huge tortoise which floated on the universal ocean. The early Greeks thought that a mighty man, Atlas, who had rebelled against the authority of the gods, was punished by being made to stand in the middle of the ocean and support the world on his shoulders.



The early Hindus believed that the earth rested on the backs of four elephants that stood on a huge tortoise which floated on the universal ocean

Many, many centuries later a great English scientist, Isaac Newton, was pondering over these same great questions in his garden. It is said that, as he sat quietly thinking, an apple from a near-by tree suddenly snapped from its branch and dropped to the ground. The sound attracted his attention. " Why did the apple fall to the earth ? " Newton, the scientist, asked himself ; and then he answered, " Because the earth pulled it." Gradually the idea unfolded in his mind that everything near the earth is pulled toward it by a great invisible magnetic force which he called gravitation ; and he reasoned that the earth and all the other planets were held in their places through the attraction of the sun by this same great force. What an inspiring

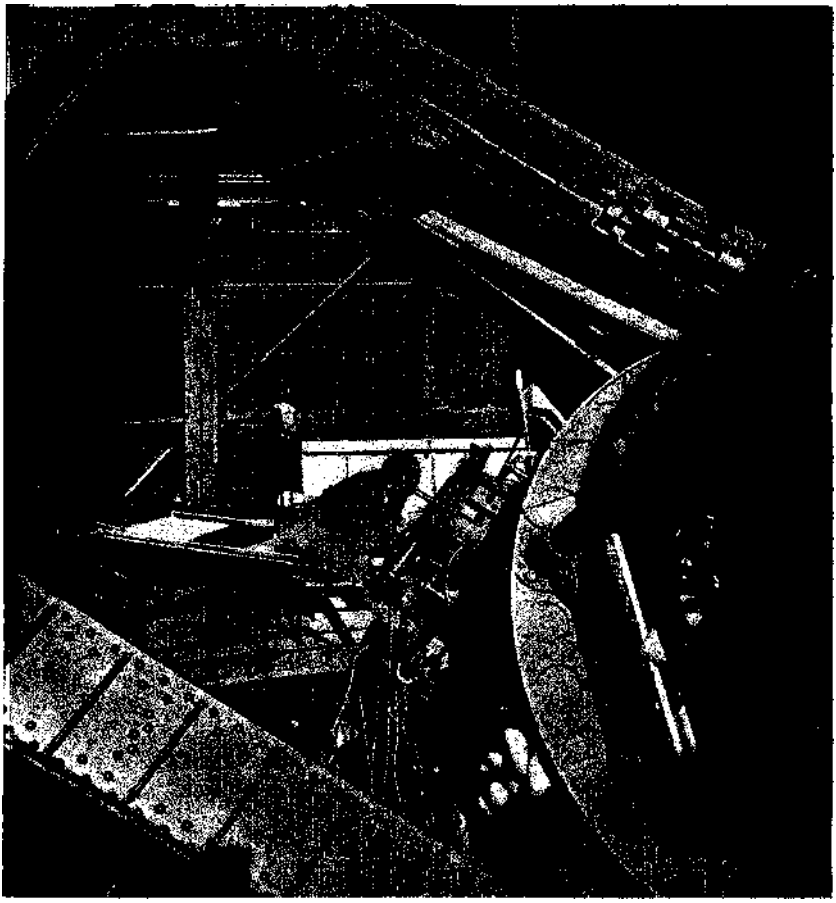
The Greeks thought the mighty Atlas had rebelled against the gods, and in punishment had to support the earth.

picture of the heavens Newton's theory gives us, with the heavenly bodies swinging in great circles about the sun, all securely held in their places in space through the working of a single all-embracing force !

But how did the earth come to be in the first place ? Century after century people kept trying to answer this question. By the close of the eighteenth century the telescope was so well developed that scientists could study the heavens fairly well through it. The more powerful eyes of these giant telescopes sweeping over the night sky

Isaac Newton, the scientist who discovered the law of gravitation, experimenting with a ray of light.

revealed trailing clouds of fire-mist, and glowing masses of gas, called nebulae, spinning in the heavens, filling the vast gulfs of space for thousands of miles with incandescent light. Some of them had long spiral arms so that they looked like giant pinwheels revolving in space. These nebulae suggested to the great French scientist Laplace that perhaps in the beginning of time, millions and millions of years ago, there was a gigantic nebula of fire, spinning in endless space, and that out of some such cloud of fiery gas our earth had come. He thought that from this whirling cloud of gas, flaming spirals were hurled off from time to time like gigantic rings or streamers. The original mass,



An astronomer studying the heavens through the world's largest telescope, on Mount Wilson, California.

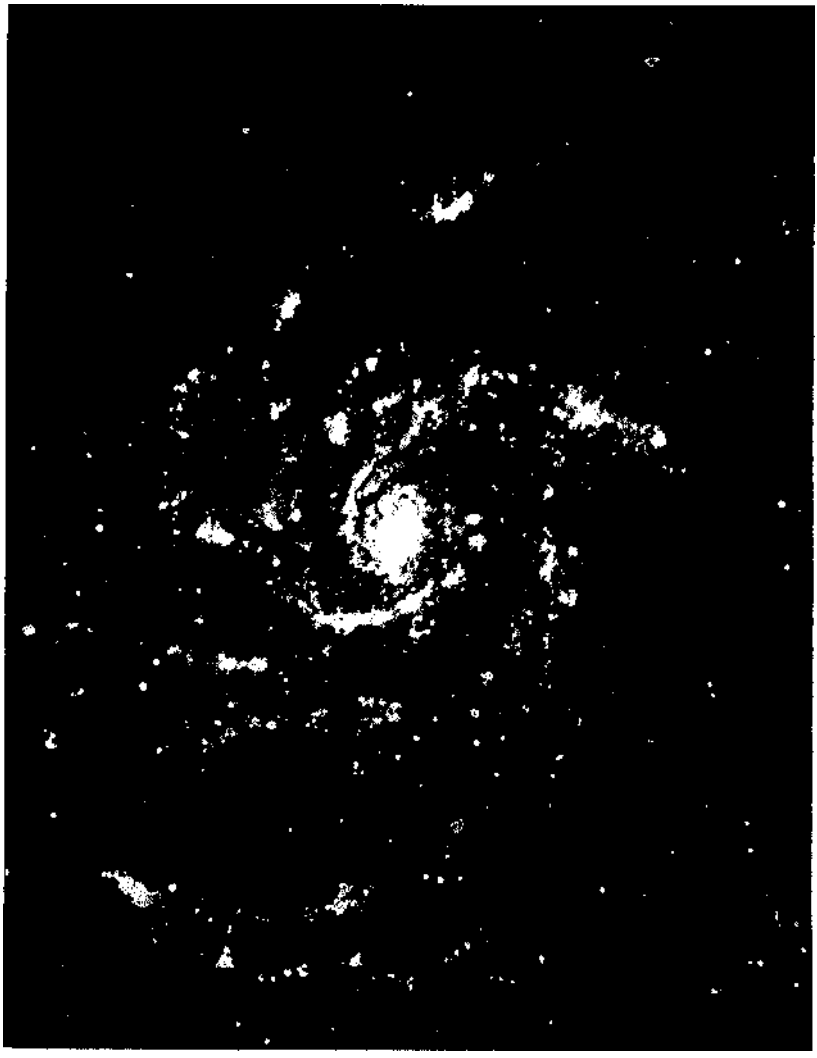
with much spinning, gradually condensed into a ball. After vast ages the far-flung whirling rings also gathered together into balls of fire, forming the great stars, or planets, of which our earth is one. All of these spinning balls kept on revolving around the original ball of fire, the sun. This explanation of the earth's origin is called the nebular hypothesis, and for the last hundred years has been accepted by most scientists.

Recently, however, through their greater observation and study, scientists have begun to believe that the earth may have been made in another way. Some of them think that it and the other planets were formed out of the sun when another great star, rushing through space some thousands of millions of years ago, happened to pass so close to the sun that gigantic currents of magnetic attraction were set up between them. It pulled and tugged at the sun with terrific force, and raised huge waves of solar substance which stretched out like great shining arms from the sun and were eventually torn off from it, breaking into a thousand fragments. These fragments of the broken sun whirling through space condensed into knots and, attracting other particles in their paths, little by little, after untold ages, grew into the earth and other planets.

So by the patient work of the scientists through the centuries, the stars have been made to yield up many of their secrets, and as one discovery has followed another the size of the universe has steadily grown. It is now believed that our earth, which seems so big to us, is just one small star in a vast starry universe, the size of which we can scarcely imagine.

More questions. What happened to the earth after it left the sun ? How did it come to be like it is now ? Again scientists come to our aid. They tell us that as this huge mass of flaming matter went spinning through space, age after age, its great heat gradually radiated out into space and it became cooler and cooler. From a ball of glowing gas it became a ball of liquid fire, seething and boiling on the outside like lava. Gradually this cooled and hardened into a rocky crust.

When the fiery valour that was constantly rising from the cooling earth came in contact with the cold surrounding space, it condensed into a dense atmosphere of thick clouds. And these clouds floated about the earth, enveloping it for thousands and thousands of years in a steamy vapour. All was darkness on the earth. There was as yet



Courtesy Mt. Wilson Observatory

Some of the nebulae have long spiral arms, so that they look like giant pinwheels revolving in space.

no day, because the sun could not send its rays through the thick clouds that hung about the earth on all sides.

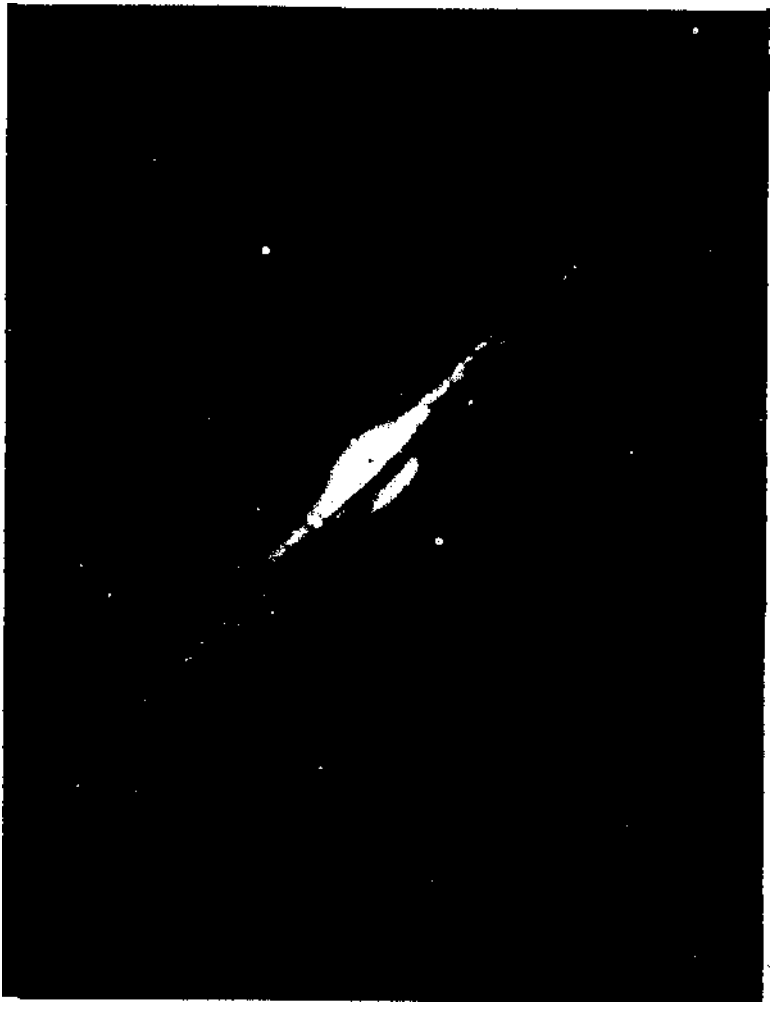
Year followed year, century followed century, and the earth was constantly cooling. As the earth became cooler and cooler, the steamy cloud atmosphere about it condensed and fell in torrents. This deluging rain beat down upon the surface of the earth, converting it into a desolate, rain-drenched world, covered by a dark, seething sea.

Little by little, as the water poured from the skies, the clouds surrounding the earth grew thinner, and a dull grey light spread over the part of the earth which was turned toward the sun. And now for the first time day could be told from night. As time went on, the clouds became thinner and thinner, the sun's rays penetrated more and more, and the days became brighter.

And still the earth was cooling. The outer part cooled faster than the inside and shrank, as most things do when they cool ; and as the crust shrank it became too tight for the hot expanding gases shut up inside. Every little while there would be a terrific eruption. The earth, shaking and trembling, would burst open in a great fissure, and the surface crust would crumble and buckle and be bent back on itself. Great showers of molten rock would be hurled high into the air, lighting the whole sky with a lurid glare. All would be quiet for a time, and then the earth would crack and split open again, throwing up great streams of glaring red rocks into the steam-filled air.

And so passed thousands of years, with storms raging over the world-wide ocean, and the earth shaken by terrible quakes and volcanic eruptions. By some of these mighty upheavals the crust of the earth was bent upward in some places above the level of the water, and thus the great continents of land were formed. Sometimes gigantic folds were made in the earth's crust, and these were the first mountains.

The surface of the earth was now made up of great masses of land separated by vast seas, which still filled the hollow places in its uneven surface. Terrific winds, lashing the sea, drove the waves against the land, pounding night and day, grinding and carving out the shore lines. The deluging rain, falling in the deep valleys between the mountains, flowed down to the sea as rivers. As yet there was not a single tree—not even so much as a blade of grass—to be seen on the surface of the land, only bleak rocks and barren sand.



Courtesy Mt. Wilson Observatory

An unusual view of a nebula from the side.

So the great forces of heat and wind and moving water worked on ceaselessly through the early ages, carving out valleys, washing away shore lines, smoothing the face of the rugged land, moulding and remoulding the surface of the earth. Through hundreds of thousands of years, mountain ranges rose and sank, rivers took new courses, coast lines changed, until in the course of time the earth became somewhat as we know it to-day, with its oceans and continents, its lofty mountains and rivers, lakes, valleys, plains, and sandy beaches on the outside, and a hot interior.

Courtesy Field Museum of Natural History

The cooling earth before there was any life on it.
(From a painting by Charles R. Knight.)

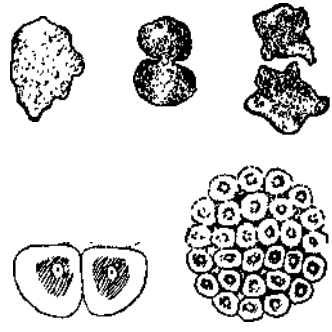
HOW LIFE CAME UPON THE EARTH

As time passed, soil accumulated on the barren surface of the rocks. Rut as yet there was no living thing in the whole world ; there was not a sign of life anywhere. There was only the vast bare expanse of land and water and sky. No life could exist while the rocky crust was hardening over the molten earth. Countless ages had to go by before the surface of the earth was suitable for even the simplest form of life.

How did the first life come to be ? This is the great riddle of the universe, which even our greatest scientists have not yet been able to solve. They can only tell us that when the earth was ready for

life, life in some mysterious way began. We know that earth and water and air contain the elements that are necessary to life. So, away back in the dim morning of time, when the surface of the earth had cooled sufficiently, and the great forces of wind and water had made our planet into a place for living things, these elements came together in such a way that living matter was formed. And then began the wonderful story of life upon the earth.

It is thought that life first appeared in shallow inland pools or along the edge of the werm waters of the ocean that covered a great part of the earth in the early days. The first living things were probably like infinitely small specks of greyish green jelly, floating about in the water, too tiny to be visible even under the most powerful microscope in the world. And these simple forms, consisting of only a single tiny cell, no doubt remained for ages the only life upon the earth. They had within them, however, a marvellous quality that nothing on the earth had ever had before—the power of growth and development.



A cell grew and divided into two. Each new cell did the same, and soon there were millions.

These living cells drifted about in the vast spaces of the warm ocean, absorbing from the water and the air the nourishment necessary for their growth. When a cell had grown, it divided into two, and each part was a tiny, living cell. Both new cells grew, and in time each one divided. Again the new cells grew, and divided. So it went on, over and over again, and more and more of these living cells were formed until there were millions and millions of them floating about in the water. Out of the growing and dividing of these simple forms of life all the many and varied plants and animals living on the earth to-day have gradually developed through the ages. All living things—even man—are combinations of innumerable tiny cells of living matter.

It is thought that the earliest forms of life must have been plant-like, because plants can live on water and air, and animals need plants or other animals for their nourishment. Some of these early living beings began to devour others, and this is thought to have been the

beginning of animals. Very likely it would have been very difficult to tell the difference between the earliest plants and animals, but as time went on the differences between them became greater and greater. Plants remained in one spot, but animals could move about and they developed eyes and ears and noses with which to explore the world, and a brain and nervous system which directed their movements. Then they were better able to find food.

Life multiplied and increased in the warm seas of the early world, and by and by the waters were teeming with countless forms of living creatures. After a time the fish, the king of the early world, appeared. And in the course of time fish of all sorts swam the seas. You can see how beautifully the fish's body is adapted to cutting through the water, how his fins act as oars, and his tail as a rudder for steering. Indeed the fish is so perfectly adapted to the water that it cannot live anywhere else. When it is taken out of the water, it dies.

It is probable that for millions and millions of years both plants and animals lived entirely in the water. Then the great advance landward began. Plants must have been the first to appear on the land, since animals cannot live without them. There were still violent changes on the earth at this time, and seasons of pouring rain were followed by long periods of dry weather. The shallow pools that covered the earth in various spots would often dry up during the dry season, leaving only swampy soil. This caused the plants to extend themselves downward into the wet soil, for without moisture they would die. These were the first land plants developing their roots.

The earliest simple forms of plant life gradually became more and more varied and luxuriant. The climate was still very warm, and the air was heavy with moisture. This perpetual summer lasted for millions and millions of years. Warm, humid air is favourable to the rapid growth of plants. So out of the moist fertile soil of the early world grew rank forests of tangled vegetation, and the earth was covered with a thick green carpet of mosses and giant ferns and a jungle growth of great trees and huge tropical plants. These grew sometimes as high as one hundred and fifty feet. They formed dense forests in the vast marshes which were so large a part of the earth's surface in those days.

In the terrible storms that still raged at this time great gales often swept over the earth with terrific violence. The giant trees swayed back and forth, and frequently they were torn up by the roots and

Early sea creatures.

went crashing down to the ground and sank into the soft swampy soil. There they lay with their great masses of tangled roots and branches almost covered with water. Year after year they lay decaying in the warm dampness of the swamps, until they became a thick bed of matted vegetable matter, always kept wet by the heavy layers of mud and sand that were gradually deposited over them. As they rotted, they made fertile soil for other trees which in their turn flourished and fell into the swamps. This happened over and over again. We have no way of knowing how long it went on. Probably for thousands and thousands of years, generation after generation of forests lived and died in this way in the low-lying swamps of the early ages.

Century followed century, and as time went on these beds of buried decaying vegetable matter reached great thickness. The layer of earth covering them grew thicker and thicker, and its increasing weight gradually crushed them together into a solid mass. As this grew harder it became darker and darker in colour until it was a black rock-like substance. For untold ages this lay hidden deep in the recesses of the earth ; then man found it and put it to use as coal. Thus the buried forests of those far-off early days of the earth became the coal which we are using to-day. Sometimes miners, in breaking coal, find beautifully embedded in it the exact pattern of a leaf or a fern from the great trees of those forests that flourished on the earth millions and millions of years ago.

Time passed. Gradually animals began to crawl out of the water on to the land. Very likely it was the drying up of the water in various places that forced them landward. As the shallow pools and lakes dried up gills were useless, and some fish began to develop lungs to breathe with. The ganoid, which lived in muddy streams and marshes at this time, had air sacs as well as gills. During times of drought it was able to gulp in air and thus keep alive. Slowly and awkwardly these fishlike forms dragged their bodies over the ground by means of their fins in search of new pools. These are thought to be the first ancestors of all the later land animals.

The first of these were the amphibians, creatures that could live both on the land and in the water. They laid their eggs in the water and spent most of the early part of their lives in the water. Such creatures were well equipped to survive the great changes of the early world. In the water they could swim about and breathe through their

An early forest that afterward became coal.

gills ; when the water dried up they could breathe through their lungs. No doubt for ages animals used gills or lungs as they were needed. But gradually some animals adapted themselves n -e and more to life on the land, and there came to be greater and greatei differences between them and the sea creatures. As they crawled about more and more in search of food, their clumsy finlike limbs became more and more like legs. In time their gills disappeared entirely and they breathed by lungs alone. Instead of laying their eggs in the water, they laid them in the warm sand. In this way the true land animals evolved.

Amphibians, **the** first land animals. They could live both on the land and in the water.

MIGHTY ANIMALS

And now the earth came to be inhabited by the most extraordinary creatures the world has ever known. Among them were developed many strange forms entirely unlike any animals living to-day. They were the most gigantic of all the animals that have ever appeared upon the earth, their lizardlike bodies sometimes reaching eighty feet in length. Science has named this race of strange and mighty animals

dinosaurs, or terrible lizards. They were indeed the dragons of olden times and seem more like the monsters of fairyland than any other creatures that ever lived on the earth. But not even the dragons supposed to have been slain by brave knights could equal these real dragons whose bones have been found buried in the earth. They swarmed over land and sea and ruled the whole world. Probably at no other time of the world's history has any one kind of animal so completely dominated the earth as did the great reptiles of this age. The moist damp climate of this time greatly favoured the development

Triceratops, one of the largest dinosaurs. He was well protected with three massive horns on his face and a great frill of bone like a fireman's helmet over **the** back of his head.

of these gigantic creatures. They basked in the hot sun and browsed in the warm mud and slime of the endless marshlands that covered a large part of the earth.

They were of great variety in size and shape. Some lived entirely on the dry land ; some lived in the shallow waters of the swampy low-lands, feeding on the water plants. Some lived entirely in the water. Some walked heavily on all fours ; some had long hind legs and tails and very short front legs, so that they must have hopped about

somewhat as the kangaroos do to-day. Some had beaks and webbed feet like those of birds. Many of them were covered with horny plates like armour. Some fed on the luxuriant vegetation ; some were flesh-eaters, pursuing the smaller species as their prey.

One of these curious dinosaurs has been named by scientists Triceratops. He was a great, lumbering, huge-bodied, stupid creature, somewhat like a hippopotamus, with a tiny little brain weighing less

Courtesy American Museum of Natural History

Brontosaurus, the thunder-lizard. These animals were about ten times the size of an elephant, with remarkably small heads for such huge bodies. (From a painting by Charles R. Knight.)

than a pound, although his body weighed about forty tons. He was a plant-eater, living upon coarse vegetation. His jaws ended in a great horny beak for clipping off branches and rushes, and his back teeth were adapted to champing them. These back teeth were arranged in many rows under one another and were always being pushed upward by the new teeth forming below ; so as fast as a tooth was worn out it was replaced by a new one. His legs were like great pillars and his

forelegs were bowed out so that he could more easily reach the ground while feeding. He had three massive horns on his face, one over each eye and one over his nose. Over the back of his head projected a great frill of bone somewhat like a fireman's helmet. With such protection Triceratops must have been practically invulnerable.

Another great dinosaur was Brontosaurus, the thunder-lizard, beneath whose mighty tread it almost seemed as if the earth shook.

Courtesy Field Museum of Natural History

All the dinosaurs laid their eggs in the sand and left them to develop with the heat of the sun.
(From a painting by Charles R. Knight.)

He was from forty to sixty feet long and ten to fourteen feet high, or about ten times the size of an elephant. He weighed about twenty-five tons. He was a stupid, slow-moving animal with a remarkably small head for his huge body and a long neck and tail. These animals lived in the shallow lakes and pools and were equally at home on the land and in the water. They fed on the rank water plants that grew so abundantly. One animal would probably devour several thousand

pounds of plants a day—maybe more, if he was really hungry. One can easily see the advantage of the long neck in reaching up among the leaves. With the support of the powerful tail the whole body could be reared high up in the air to scan the surrounding country for the approach of enemies.

Most curious of all, perhaps, were the armoured dinosaurs, which were covered with hard bony plates and spines. Some of them had horns in front, and one kind had a row of large plates standing up all along his back and a long lashing tail with two or more pairs of long sharp spines near the end of it.

All 6f these reptiles laid their eggs in the warm sand and left them

Courtesy Field Murium of Natural History

Ichthyosaurus, a dinosaur that lived in the sea. It had great alligatorlike jaws and devoured fish and others of its own species. Overhead are some pterodactyls, the first flying creatures in the world.

(From a painting by Charles R. Knight.)

there to be developed by the heat of the sun. Left unprotected no doubt many of these eggs were destroyed by other animals.

Some of the dinosaurs lived in the water. The commonest of these was Ichthyosaurus, a huge and terrible creature sometimes as large as a whale. It had great alligatorlike jaws and devoured fish and others of its species.

While these strange creatures swarmed over the warm land and seas of the early world, another kind, called Pterodactyls, leapt and parachuted through the air. They were the first flying creatures in the world. Perhaps they began by taking flying leaps from the ground to escape from their enemies. This in time developed into the ability

The first birds had sharp teeth in both jaws and claws on their wings and long lizardlike tails, with feathers on both sides arranged in pairs.

(From " The Origin of Birds," by Gerhard Heilmann.)

to leap from limb to limb of trees. The greatest of these pterodactyls had the middle finger of each forefoot greatly elongated, sometimes to the extent of three or four feet, and had a tough weblike skin stretched from these fingers in such a way as to form long pointed wings, somewhat like those of a bat. Sometimes they had a wing spread of twenty-five feet, and their wings ended in long claws. Their bodies were very light and were covered with overlapping scales. With their great wings and their light bodies they flew great distances, and with the claws in their wings they could even light and cling to bare perpendicular surfaces like the edge of a rocky cliff.

These flying dragons were the forerunners of the birds. For ages these birds-in-the-making soared through the air, and gradually changed. For instance feathers took the place of scales.

The first real birds were about the size of a crow. They still had sharp teeth in both jaws like the reptiles, and claws on their wings, As they flew through the air they trailed after them lizardlike tails, longer than their bodies, with feathers on both sides arranged in pairs.*J*

Gradually the climate of the earth changed. It grew very cold. A great portion of the earth was covered by a sheet of ice and snow. The swamps and marshes dried up. The luxuriant vegetation of the warmer period disappeared. Food became scarce, and the great reptiles that needed ample vegetation gradually perished. They were small-brained, huge-bodied beasts, suited to a warm climate and an easy life. These slow-witted monsters could not adapt themselves to the new conditions on the earth, and so they were doomed to perish. Thus the reign of the great reptiles over the earth, the sea, and the air came to an end. They had their day and passed away, giving place to the more intelligent animals which were just coming into being.

The world now began to be occupied by very different creatures. They were warm-blooded and had larger brains, and their bodies were covered with a thick hairy coat that protected them from the cold. Scientists call these animals mammals, or milk-givers. Instead of laying eggs as the dinosaurs did, the mother kept her young warm and safe within her own body until it was far enough developed to be born alive. Then she nourished it until it was able to take care of itself. Animals born and cared for in this way had a much better chance of surviving the great changes of the early world than the young of the dinosaurs.

The mightiest of these animals were the mammoths. They were like huge elephants, but much larger than any elephants that exist to-day. Some mammoths grew to the height of twelve feet, with tusks from eight to ten feet long. The name mastodon is given to other elephantlike beasts. They were covered with long hair and their tusks were sometimes bowed upward to form a huge half-circle. These great beasts roamed in all directions in search of food.

Courtesy American Museum of Natural History

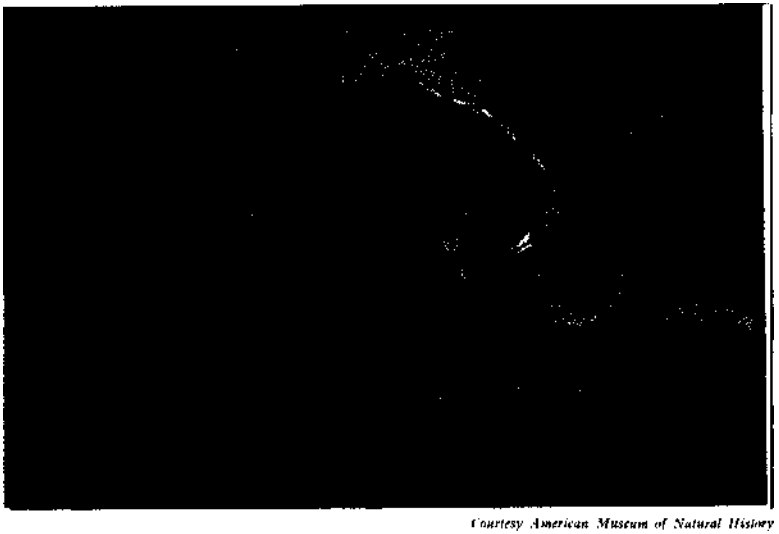
Mammoths and mastodons, much larger than any elephants we have to-day, roamed over the land.

(From a painting by Charles R. Knight.)

The animals of the earth became very varied. One terrible beast of this time was Smilodon, a sabre-toothed tiger with great tusks that acted like hooks when he sprang upon his prey. Many other fierce creatures roamed over the land. There was the woolly rhinoceros, with horns on the top of his head, one of which sometimes grew to be three feet long. There was the urus, or aurochs, a great ox with a ferocious disposition. Just how long these animals prowled about the

forests, no one can tell. In the trees were living at this time the first members of the ape-tribe, small, hairy, long-limbed, agile creatures. In their life among the branches they were led to develop their senses and other powers.

Again the climate of the earth changes. It becomes temperate. Now the grasses begin to appear. The forests in many places become transformed into broad stretches of meadowland sparsely covered with fine grasses and wild grains. The forest inhabitants must either adapt



Courtesy American Museum of Natural History

One of the fiercest animals of the early world was Smilodon, the sabre-toothed tiger. (From a painting by Charles R. Knight.)

themselves to the new conditions or perish. Many of them pass away. The animals that feed on grass develop rapidly and there now appear a number of grazing animals

Eohippus, the earliest known ancestor of the horse, was one of the animals that had lived in the forest. He was an insignificant little creature no larger than a fox, with four toes on each forefoot, and three on each hind foot. In running on the dry plains the four-toed foot was a disadvantage, and the horse gradually lost all but one toe which

hardened into a hoof of horn, which is what our horse nas to-day. With this he could travel long distances and run very fast and so escape from the flesh-eating animals which pursued him. The rank rushes of the forests gave way to fine grasses, often browned and withered by the heat of the sun, and the cutting teeth which the horse developed at this time enabled him to crop the grass closely and thus get enough to eat.

Courtesy American

Eohippus, the earliest horse, was no larger than a fox. He had four toes on his forefeet and three on his hind feet.
(From a painting by Charles R. Knight.)

Thus he could live on the grasses which require more chewing than the softer green plants of the forest. The horse changed as the earth changed and thus survived while many other animals died out.

And so after countless centuries our earth came to be covered with all sorts of living creatures. They spread in every direction, over all the land and the water. Century after century both plants and animals

changed. As there were so many great changes on the earth in its early days, the plants and animals that were unable to adapt themselves to the new conditions perished ; those which were able to adapt themselves, survived. Any individual creature which happened to vary in a way that gave it an advantage had a better chance of surviving, and it passed on this variation to its descendants. These variations were sometimes accumulated until new and different animals and plants were produced. So the process of life development has gone, on through the ages until to-day we have on the earth an infinite variety of living things.

MAN THE INVENTOR

CHAPTER I

THE FIRST DAYS (3F MAN

THUS, after untold ages, the fire-mist cooled, put on a crust, plants and animals developed, and the earth finally became the home of man. Hundreds of millions of years must have passed before man appeared on the earth. Ages and ages were required for life to develop from the one-celled organism to the many-celled, from fish to amphibians, from reptiles to mammals, and, at last, to man.

We know very little about the first people on the earth. Probably they lived in the forest little less wild than the animals that shared the earth with them. They had a harder struggle to live than the animals did because they were not so strong as most of the animals were. Most of the animals had thick fur to keep them warm. Some had sharp teeth or long tusks with which to pierce their enemies. Others had hoofs with which to trample them, or wings with which to escape from them. Man had none of these things. He had no home, no clothing, no tools. He had to be always searching for food, and wandered about the forest eating wild things as nuts and acorns, seeds and roots, wild berries and grains, and any small animals that he could catch with his hands. His life was very hard because he had nothing but his own body with which to get what he needed to live. In his constant search for food he could travel only as far as his two legs could carry him. He had to gather his food with his bare hands and chew it raw.

The life of early man must have been one of constant want and uncertainty, and often grim starvation must have stared him in the face. Fierce animals like the sabre-tooth, the cave-bear, and the woolly rhinoceros were a constant source of terror, for it is probable that he was hunted by the giant flesh-eaters. Many and fierce must have been the encounters between the small-framed man, and the huge beasts

of those early days. How was it possible for man to survive in such a world ? How did he manage to keep on living under conditions which constantly threatened his very existence ?

Although man seemed to be inferior to the animals, he had certain characteristics which in the end enabled him to win over them. One of these was the ability to stand up and walk on two feet. Before man learned to devise weapons of defence against the more powerful animals the trees offered him the greatest safety. Consequently our earliest ancestors are thought to have been tree-people. Probably they spent most of their time on rough platforms made from the interlacing branches of trees, coming down to the ground only to *get* food.

As he grew more powerful man descended more and more from the trees, and gradually became accustomed to life on the ground. But he still used his legs to support his body, and they became stronger and stronger with walking. This two-footedness gave man a great superiority over the animals. It freed his arms and hands for other uses than that of supporting the body. Another wonderful advantage of man was the fact that his thumb was placed opposite his fingers so that he could use his hand in a great variety of ways. No animal had a hand like man's, and the work which it made possible had much to do with man's rise in the world.

Another way in which man differs from animals is in the power to talk. Beasts can chatter, or bellow, or roar, but only man can speak. In the beginning his speech must have been very crude, with little of what we now call words. The language we use to-day has developed slowly through the ages. But early men gave vent to their feelings by making sounds of one kind or another. They shouted and laughed when they were happy, they wept and moaned and groaned when they were unhappy or in pain. And in their struggles with the more powerful animals that surrounded them there must often have arisen a need for communicating with one another. Possibly at first this was done mainly by signs and gestures. But people often imitated the cries of animals and other sounds in nature to indicate their thoughts. If, for instance, a hunter wanted to warn his companions that a wild beast was near, he might point in the direction where it was and roar like a lion or growl like a bear, and his companions, hearing him, would understand and would run away just as if they had seen the animal themselves.

In the course of time these grunts and groans and other guttural sounds became more varied and refined. With many repetitions sounds changed until they were entirely unlike what they had been in the beginning. Probably in some such way men gradually developed a spoken language by which they were able to communicate their thoughts, their needs, and their desires to one another.

You can easily see what a tremendous help language must have been to early man. Constant danger drew people together and they came to rely upon one another for help. By himself little man was comparatively powerless against the great animals, but many men, combining their powers, were able to subdue the wild beasts and surmount their other difficulties. Language of some sort was most necessary if they were to understand one another and work together. Then, too, with language, what was learned by one person could be told to another. Thus people could learn much from one another, and the older people could tell the children the things they had learned in their hard struggle for existence. So each generation could profit by the experience of the last generation, and be a little better off in their knowledge of the world and how to meet the problems of living. It is in this way that useful knowledge has gradually accumulated in the world and man has been continually learning through the ages.

Man was also superior to the animals in his ability to think. If danger came upon him suddenly, he had to use all his ingenuity and take every advantage that was offered in order to save himself. He was living in a strange unknown world where almost anything might happen at any moment. He formed the habit of observing the things he saw. He began experimenting with things to find out whether they might be useful to him in one way or another.

The necessity for protecting his children also helped to develop man's powers. Unlike the young of the animals, most of which were able to care for themselves very early, man's children were very slow in growing up and had to be protected for a long time, while they were too young to take care of themselves. Then there would be younger ones to think about and bring up. So it was that all the experiences of early man, in fact, his whole way of living, constantly developed his mind ; and with the growth of his intelligence his ability to solve his problems of living constantly increased. Then, as man's mind developed, he discovered more and more things to help him in his work

and things with which to defend himself against the larger and more powerful animals. Thus he began supplementing the powers of his own body with things that he made. Had he not been able to do this he would have been overpowered by the stronger animals and put out of existence.

Things to help him in his work and things with which to defend himself against the larger and more powerful animals- these were the needs that led man to invent tools and weapons. In the beginning man, as we have seen, had no tools or weapons. He depended for his food upon such fruits and berries and seeds of plants as he could find and such smaller animals as he could catch in his hands, and he tried to avoid the larger animals As time went on man may have discovered his first weapon, the club, by accident Some one, pursued by a wild beast, may have been swinging up into a tree to escape when the branch to which he clung snapped off in his hands and he fell to the ground. Instinctively he would strike at the animal with the broken branch with all his might, and perhaps drive it off. Or perhaps a man, attacked by a fierce animal, happened to pick up a large stone and fling it at the animal, and chased it away. Such successful methods would be repeated, and in some such way man learned that loose sticks and stones were of immense value in protecting himself.

We can only guess how man first learned to make tools. Very likely his first tools, like his first weapons, were loose sticks and stones which he picked up and learned to use for all sorts of purposes In the beginning he probably used things just as he found them, choosing whatever best suited his needs. Heavy stones were used for cracking nuts and other hard things Other stones were used for crushing and grinding. Shells and hollow gourds were good for carrying water. Someone discovered that he could cut the flesh or skin off an animal with a sharp-edged stone, and this was the first knife. It was soon noticed that a stone with a jagged edge was good for sawing things. The sharp points of the horns and bones of animals were used for boring holes, and these were the first awls. Perhaps someone wanted to move a heavy stone out of his way, or to dig up a stubborn root. He tugged at it with all his strength. Then he found that with the aid of a stout branch of a tree he could prise up things that were much too heavy to be pulled up by his arms alone. In this way he got the idea of the lever, which has since become one of the most important parts

Courtesy American Museum of Natural History

Before man learned to make weapons his only way of defending himself against the animals was by throwing stones at them.

The great change in the climate was probably also responsible for man's first clothes. In the earliest days, when the climate was warm, man didn't need clothes ; but the increasing cold made him feel the need of some covering for his body. Hunters carrying home on their backs the bodies of animals they had hunted, soon noticed how nice and warm their furs felt and how they protected them from the rain and snow. So people began putting the skins of animals around their shoulders and fastening them with thorns, thus making a loose but warm covering for the body. These were man's first clothes. In time the women learned to scrape and cure the skins and lace them together with the sinews of animals. To bore holes in the tough skins for the sinews they used little sharp slivers of bone. In the course of time, they learned that it was easier to bore a hole in the end of the bone sliver, put the sinew through it, and draw both through the skin together ; and then they had the first needle and thread.

CHAPTER II

MAN LEARNS TO USE EIRE

ONE of the most tremendous helps to early man was his discovery of the use of fire. Exactly how he made this discovery, we do not know. Perhaps it was by accident. Nature often kindles tires. Lightning may have struck a tree in the forest, or two dry branches rubbing together in a strong wind may have caused fire Or perhaps a heap of dry leaves or sun-parched grasses may have burst into flame.

Very likely men were at first terrified by fire, just as the animals are. Before they knew better they probably thought of fire as a terrible monster, belching forth smoke and flame, and fled from it. Hut perhaps after a great fire in the forest had died down, some men, their curiosity overcoming their fear, crept near to see what it was like, and felt the pleasing warmth from the smouldering tree trunks. When the weather was cold or wet, they came to enjoy the heat of the fire, and little by little they learned not to be afraid of it.

One of man's first discoveries about fire was that if it was constantly fed with fuel it would not die out. So people tried in every way to keep the fire always burning, for they did not yet know how to make fire and were afraid that they might not be able to get any more. Day and night they watched it and fed it lest it go out. But sometimes the person tending it left it too long, or fell asleep, or a heavy rain put it out. This was a very great misfortune.

How long man used fire without knowing how to make it, and how he learned to kindle a fire, we do not know. Someone discovered, possibly by accident, that friction sometimes causes fire. Perhaps in chipping stones man discovered that two very hard stones hit together would sometimes produce a spark, and that with this he could light a handful of dry leaves or grass and start a fire by blowing it violently. Imagine his joy at the discovery ' Now he could start a fire whenever

Man has learned to make fire.

he wanted to, and need no longer fear that he could not get any more if it went out.

In boring holes in his wooden tools and weapons man learned that he could make a fire by twirling one dry stick rapidly in a narrow groove cut in a second piece of wood. The wood dust catches fire from the friction, and if it is blown and dropped on some dry leaves a flame can be kindled. Very early someone invented a way of making this easier by wrapping around the stick a string that could be pulled, causing the wood to rotate very rapidly.

MAN LEARNS TO USE FIRE

As time passed man found more and more uses for fire. One of these was for cooking his food. Probably for ages early man ate his food raw. But perhaps one day, after a fire in the forest had died down, a hunter may have unexpectedly come upon the half-burned body of an animal, and being very hungry, decided to eat it. Or perhaps a piece of meat fell into a fire and was quickly snatched out by someone who, on tasting it, discovered that the heat of the fire had improved it. So man began cooking his food.

Early potters at work.

The clay of this hearth that had become hardened by the fire taught man that clay could be baked and made fireproof and waterproof. It was found that gourds could be used for cooking food if the outside was smeared with clay to protect them from the fire. It was not long before the gourd was discarded and the clay moulded into the shape of a bowl and hardened in the fire. Later little knobs were placed at the side of the bowl to help in holding it. Then holes were made in the knobs so that they could be grasped with the fingers. Often a bigger hole was made so that the whole hand could be passed through.

The first ornamental markings on these clay bowls may have come from the marks made by the fingers and nails as the clay was pinched and pressed into shape. Or a cord tied around the bowl to hold it together while the clay was damp may have left an imprint like a border. These markings looked so pretty that man began decorating his clay bowls and dishes by making impressions on the damp clay with prettily shaped shells, bits of bone, little sticks, or anything that caught his fancy. These marks repeated over and over in different ways made pleasing designs. In some such ways man got his first dishes and cooking utensils and learned the art of pottery-making.

The fire also gave early man his light. But the lire sputtered and smoked. So man began supplementing the feeble, flickering light of the fire with burning brands used as torches. The fat that dropped into the fire from a roasting animal, making it blaze up every little while so that it lighted up the whole cave, may have given man the hint for a better kind of light. Someone had the idea of putting a piece of burning fat on a hollow stone. These lamp-stones were shaped so that they could be carried about from place to place. In time man learned to use a hollowed-out piece of clay to hold melted fat and a fibrous wick. This was the lamp, which was the first form of light man learned to make.

Fire also unlocked for man the treasures of the mineral world. The great metals had lain buried in the rocks through the ages ever since the beginning of the earth, but no one knew that they were there. It was probably through digging in his search for roots and seeds that man first became acquainted with the earth's mineral treasures. It is thought that copper was the first metal discovered by man, attracting his attention by its bright colour in the rocks. He found that by pounding and hammering it in various ways he could make better tools and weapons than those made from stone. So man now gave up making stone tools and began making tools of copper.

Man would have made very little progress with metals, however, if he had had to depend upon the copper he could find lying around loose. Luckily he early made a very important discovery, which was that he could smelt copper out of the rocks with fire. Perhaps a hunter building a fire happened to gather together loose rocks for a fireplace where copper was plentiful, and the heat of the fire melted the metal.

You can imagine his surprise at seeing the bright shining liquid ooze from the rocks. Perhaps he caught some in a bowl to examine it more closely and found that, in cooling, the strange liquid took the shape of the bowl. This gave him the idea that metals could be melted out of the rock and then could be made into any shape he wanted by pouring the liquid into moulds. So man began using copper for a great variety of things.

Early metal workers.

But copper by itself was not hard enough to make a good edge for weapons and tools. Some early metal worker made another important discovery : that copper mixed with tin makes a hard substance that will keep its shape and make a good edge. Very likely this discovery was also made by accident, when ore that happened to have both copper and tin in it was heated and the two ran together and mixed. This taught men how to make an alloy, called bronze, that was harder and more durable and so useful that, for hundreds of years, it was used for all sorts of pointed and sharp-edged tools and weapons. Thus man

discovered the great treasures of the mineral kingdom hidden under the earth and learned the art of working with metals which has come down through the ages.

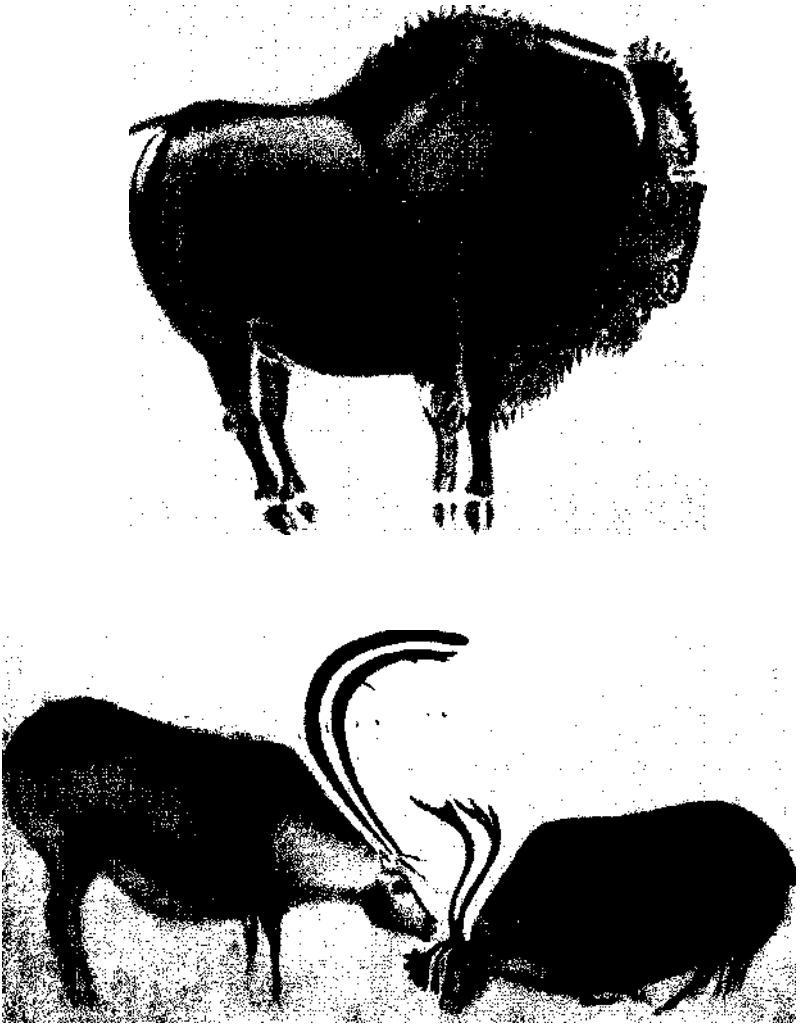
With the conquest of fire much of man's fear of the animals disappeared. A fire at the entrance of the cave kept the animals away. This relieved man from a great strain and enabled him to devote his mind to other things. The fire within the cave became the centre of interest and drew people together. A number of people taking refuge in the same cave would warm themselves over the same fire and talk over their experiences. Sometimes they amused themselves with songs and stories. They loved to tell over and over again tales of heroism in the hunt. Many of these stories were told by mothers to their children and thus passed on from one generation to the next. With each telling something was added to the original story and the heroes became greater and greater.

After an exciting hunt, a hunter would often recount his thrilling adventures to those who had been left behind, often illustrating his story with gesture and pantomime. The other hunters would join in, and sometimes they would act out together a particularly exciting part of the hunt to show just how it was done. Some of them would pretend to be the animals and would imitate their movements and the sounds they made. Often they danced and sang and acted out the things they wanted to have happen, swaying their bodies to and fro and repeating the same words over and over again. These were the first plays ever given in the world.

In their moments of leisure the cave people made vivid and lifelike pictures of animals and hunting scenes on the rocky walls and ceilings of their caves. A hunter might draw pictures of the wild animals he had pursued on a particularly thrilling hunt, and thus live over again in imagination his exciting experiences. Or he might be thinking of the hunt on which he was to go the next day and believe that drawing pictures would please the gods and induce them to give him good fortune ; for the early peoples all believed that the fate that befell them was controlled by the gods of nature. The pictures were beautifully coloured with the juices of berries or with pulverized red and yellow earth found in the beds of streams, or with charcoal from bits of burnt wood. The shoulder blades of animals were used as palettes, and the colours were carried about in tubes made from reindeer horns.

Courtesy The Illustrated London News

The cave people made vivid and lifelike pictures of hunting scenes on the walls of their caves. They coloured them with the juices of berries or pulverized earth. They carried their colours in tubes made from reindeer horns, and their palettes were the shoulder blades of animals.



Courtesy American Museum of Natural History

Paintings of bison and deer found in ancient caves in Spain.

Thus on the walls and ceilings of the dark caves of early man, art first came to life.

Some of the most wonderful of these ancient pictures were discovered in Spain not so very long ago in an interesting way. A Spanish nobleman was digging in a cave near his home when his little five-year-old girl, who had gone farther into the cave, alarmed her father by crying out, " Bulls ! Bulls ! " Wondering how bulls could be in the cave, he found the little girl gazing at the roof of the cave, where there were wonderfully lifelike paintings of bulls, deer, bison, and other animals.

CHAPTER III

THE FIRST BOATS

IN his constant search for food early man had to be always on the move, and his search carried him over great distances. He learned to follow in the tracks made by wild horses and cattle, using the trails that they had beaten down. Wandering in the valleys, over the plains, and through the forests, his course was often blocked by streams, lakes, and other bodies of water. How could he ^*et* across ? The animals probably suggested to man the idea of swimming across streams. An animal, pursued by a hunter, would often take to the water and swim out of harm's way.

When man came to a narrow stream he sometimes waded or jumped across, or perhaps he picked his way across on stepping-stones. If a loose tree trunk was handy and the stream not too wide, he might throw it across and walk over. This was man's first bridge. Perhaps a tree that had been blown down by the wind and lay across a ravine suggested the idea to man. Later he found that it made his crossing easier and safer to flatten the upper side of the log. Later still he added more logs side by side and a railing, and then he had quite a respectable bridge.

But whenever the earliest people wanted to cross wide bodies of water thdy had to swim across, carrying their goods and their children on their backs. This was dangerous and exhausting, and people must often have drowned if the stream was wide and the current strong. So they began trying to find a better way. Possibly floating trees first suggested the idea of the boat to man. In the springtime rivers often overflow their banks, and great floods inundate the land, uprooting trees and carrying them away. Men noticed these tree trunks floating in the streams and discovered that they would hold them up in the water.

So before long they were taking little voyages by straddling the logs and floating downstream. But by this method they could go only in the direction the water was flowing. By and by they learned that by putting their hands in the water and paddling or by shoving the log along with the branch of a tree they could make the boat go wherever they wanted, even against the current if it was not too strong. So man had a boat. Probably for a long, long time after this whenever a man

Burning out a log to make a boat.

wanted to travel on a stream he found or cut a tree trunk in the forest, launched it, and sitting astride it, propelled it with his hands or feet or paddled it with a stout branch broken from a tree.

In time man learned that pointing the log at the ends made it go more easily through the water. By and by it occurred to some one that it would be more comfortable to sit inside the log than on it. Very often the trunks of trees are hollow. Perhaps someone found a hollow tree trunk and discovered how nice it was. Or he may have thought of hollowing out the tree trunk with fire. Early peoples when

travelling were quite apt to select the foot of a tree as a place for a fire. The tree acted somewhat like a fireplace. Other people coming later to the same spot might use the same camping place and the same tree for building their fire. In the course of time the trunk of such a tree became hollowed out by the flames of successive fires. Cut above and below the burnt place the tree trunk made a comfortable and serviceable boat. It kept man's load dry and his legs out of the water.

Now when man was seated in the hollow log he was so far away from the water he could no longer use his hands for paddling, and he had to invent some way of lengthening his arms so that he could propel his boat. So he made a long wooden arm, and the part intended to paddle the water he flattened out like his hand. This was the first oar. If you think about it you will see that oars are made in imitation of a man's arm and hand. Now man had a row-boat.

But all boats made of single logs were long and narrow and easily upset. Someone thought of an improvement. He fastened two or three logs together with thongs of hide and made a steadier boat. This was the first raft. Possibly the trunks of trees united by attraction as they floated downstream may have suggested the idea to man. The added space gave him more room for the things he needed to take with him. If his load was unusually heavy he blew up the skins of animals and placed them underneath the raft to help keep it up. The number of logs was increased as the need for them arose, and in the course of time the sides were built up to keep the cargo from falling off into the water. Thus boats became more and more elaborate as people thought of more ways of improving them

But man found rowing a boat very fatiguing and longed to find some better way of propelling it. Very early some primitive navigator noticed how the wind blew his boat about in various directions and he thought of utilizing the strength of the wind to move his boat for him. He held up the skin of an animal on his outstretched arms, and when the wind was blowing from behind him it drove his boat along. Now man had a sail. It was not long before he thought of attaching the sail to a pole so that he would not have to hold it. With his sail man could sit in his boat without doing any work to make it go ; the wind pushed his boat along for him. But unless the wind was blowing in just the right direction man still had to use oars to propel his boat. For many

centuries boats were equipped with both oars and sails, because it took man a long time to discover that a sail could be set at a slant so that a boat could work its way first one way then another in a zigzag course when the wind was trying to blow it in another direction. This is called sailing against the wind.

The people who lived near the bodies of water learned to make nets and fish traps and caught fish near the shore. The shoals of

Early peoples living near the water learned to make nets and traps and caught fish near the shore. With a boat, trips could be made farther out on the water for deep-sea fishing.

deep-sea fish that came to the shore at spawning time tempted man to follow them. With the boat, voyages could be made farther out in the water for deep-sea fishing. Thus man found another means of increasing his supply of food. So the early peoples learned the arts of fishing and travelling upon the water.

Nothing ever helped man more in his knowledge of the earth on which we live than the sailboat. As time went on people learned how

to build bigger and stronger boats, and voyaged farther and farther out on deep waters. They also learned how to make all kinds of sails and to put many of them on a boat. After learning the secrets of sailing and guiding his boats in all kinds of weather man could go on the water to any part of the globe he wanted to. Ages passed, however, before man was able *to* do this. We shall tell about it later in the book.

CHAPTER IV

MAN THE ANIMAL TAMER

ONE more tremendous advance man made in these early days. He learned how to tame animals and make them work for him. At first man had no friend among the animals, as we have seen. Either they were afraid of him, or they tried to kill him. How man turned wild animals into tame ones, no one exactly knows. As time went on it became more and more difficult to secure animals for food by hunting them, because the animals became more and more skilful in eluding the hunters. This made it necessary to work out some other way of obtaining them.

Man soon found that he could outwit the animals by making traps, digging deep holes in the ground and laying over them a loose covering of branches and leaves. These were made in the paths which the animals took on their way to the streams to get water. The animals would fall into the traps and be unable to *get* out. Frequently, no doubt, young animals were caught in these traps and taken home by the hunters. Perhaps the children made pets of them and cared for them, and gradually they outgrew their wild ways. It was only a matter of time before man realized what an advantage it would be to have tame animals near his home instead of wild ones that had to be hunted.

Scientists think that the first animal to become man's friend was the wolf or wild dog. Possibly puppies found in a trap were brought up, or perhaps a stray hungry dog prowling about may have found some scraps of meat and bones thrown out by people near where they lived, and gradually was tamed by being given food. Man found that the dog could be of great help to him in his hunting. A dog's instinct is to obey and remain faithful to his master, and his keen sense of smell was a great help to the hunter in tracking game. It also guarded him while he slept and gave warning of the approach of danger. So, in the course of time, the dog became man's companion and loyal friend.

MAN THE INVENTOR

Man, always on the look-out for ways of making his life easier, was not slow to realize uses he could make of other animals, and he soon discovered that the grass-eating animals were less fierce than the others and could be domesticated through care. Here also the dog was a great help. He assisted his master in rounding up and driving herds of wild cattle and sheep into enclosures where they could be kept. So, little by little, other animals were tamed—goats, pigs, cattle, sheep, and horses. By and by these animals had little ones, and in the course of time man had a large number of tame animals. After man had herds the dog took on new duties in driving them and guarding them at his master's command. Thus the dog grew more and more to be man's helper and made his life easier.

Man found the other animals useful in various ways also. This is the time of the beginning of transportation. In the earliest days, when a hunter killed a large animal and wished to take it home to his cave for food, he had to carry it on his back. This was so exhausting that he tried to think of a better way of carrying it. He discovered that dragging the animal after him was easier than carrying it on his back. But the ground was rough and apt to tear the animal's flesh. So he sometimes strung it on the branch of a tree and dragged it along that way.

After the ox and the horse were tamed, their value for carrying burdens was soon discovered. Things were often laid on a skin and dragged by the horse or ox. To prevent the skin from wearing out, the trunks of trees were placed underneath and the load rolled along on them. Someone, after rolling loads along on tree-trunks, thought of a better way. He cut oft two small sections of a log, made a hole in the centre of each, stuck a piece of wood through each hole and thus made two wheels that revolved as the horse or ox drew the load. This was the first cart. By hitching it to a horse or an ox, man could carry a burden ten times as heavy as he could without it, and over a much greater distance. Later it was discovered that the wheel need not be solid, that strong spokes and a strong rim were sufficient and made the wheel lighter. The first trails that man used were the trails beaten down by the wild animals , but now with his wheeled vehicles man felt the need of better roads, so he began widening and straightening the trails.

As time went on, man discovered more and more ways of using animals. One verv great discovery was that he could twist the wool

of the sheep into a long continuous thread. Possibly he made this discovery by accident just as he made so many others. The first spinner may have been a shepherd boy. Sheep shed some of their wool in the springtime. Lying in the shade of a tree watching his flocks, perhaps the boy picked a piece of loose fleece from the ground and began idly twisting it between his thumb and finger. At any rate in some way man discovered that he could spin the sheep's wool into thread by twirling it. As a greater length of thread was spun it was wound upon a twig to prevent it from tangling. A notch was made at one end of the twig to prevent the thread from unravelling, and thus the spindle was invented.

Weaving is the interlacing of threads crosswise somewhat as in darning. The weaving process by which many birds build their nests may have given man the idea of weaving fibres for various purposes. He learned to weave grasses and reeds into baskets and other things. And he learned to weave the wool that he had spun. So each year in the spring-time he sheared his sheep of their wool, spun the wool into yarn, and wove it into cloth. Now he had a way of making much more comfortable clothes than he had been able to make from the skins of animals.

Man indeed made a tremendous step upward in his way of living when he discovered how to tame animals and keep them near him, because he could make them work for him, and because he now had a much surer supply of food. So long as he had to hunt animals his food supply was uncertain. He never knew from one day to the next whether he was going to find the food he needed. Now he was free from this constant fear of starvation. With his flocks and herds, he was sure of a constant supply of milk and meat.

This new way of living brought with it many new problems. When man had lived as a hunter the wild animals that furnished him with food took care of themselves, and he did not have to think about feeding or caring for them. But now he had a whole new range of duties in taking care of his tame animals. He had to watch his flocks and herds day after day to see that they did not stray away, he had to protect them from the fierce wild animals that preyed upon them, and he had to feed them through the long winter months when there was no grass. He still could not have any settled home, and was still forced to be a wanderer. When his flocks had eaten up all the grass in one place

Long before the house was invented shepherds following their flocks to new grazing places would often fasten several young saplings together at the top and cover them with skins to make a shelter from the rain and cold.

he had to drive to a new grazing ground. As he had to move so often his shelter and all his possessions had to be as light as possible. Shepherds, following their flocks to new grazing places, would often lie down on the ground to rest under coverings of skins sewed together. These had only to be raised on a pole or two to form a tent, which was the first form of house man invented. When he was ready to move on again it could be quickly taken down and another one set up wherever he happened to stop. Or perhaps several young saplings were fastened together at the top and skins thrown over them, to make a shelter from the cold and rain.

We call this early time of man's life with flocks and herds the pastoral stage of his development. The pastoral life was, as you can easily see, much better than the life of a hunter. But so long as man was without a settled home, and had to be always wandering about in search of new pastures, civilization could not progress very far. The discovery which made it possible for man to settle down in one spot and thus laid the foundation for a permanent civilization, is a story that will be told in the next chapter.

MAN BECOMES THE BUILDER OF EMPIRES

CHAPTER V

MAN, TILLER OF THE SOIL

WE have followed the long slow progress of man in the earliest days. We have seen how he began making tools and weapons, how he discovered the value of fire, how he developed a spoken language, how he tamed the animals, how he learned to mine and smelt metals, how he worked out better ways of travelling over the land and the water. All these things were tremendous helps in his hard struggle for existence. But even with all these early improvements he was still forced to wander over the earth seeking new pastures for his herds and flocks, and plant food for himself. Then he made one of the greatest discoveries of early times—a discovery that changed the whole future history of the world by making it possible for man to settle down in one place and build up a permanent civilization. This discovery was that he could secure a constant supply of food by planting the seeds of plants and cultivating the soil.

Exactly how man made this discover}', no one knows. Probably he had been gathering such wild seeds and berries as he could find for ages before it occurred to him that he could plant the seeds himself and gather the crops. Plants which man had found to be good for food often grew far apart and were frequently choked out by other plants growing too close to them. So man began pulling up the useless plants. In searching the ground for seeds he often scratched the soil, and he noticed that plants grew better when the soil around them was stirred in this way. So he began loosening the soil around plants with a digging stick made by sharpening a branch ol a tree and hardening the point in the fire. He noticed that at certain times of the year the seeds fell to the ground and grew into new plants. So he began saving seeds and planting them where he wanted them. By dragging his

stick along he made a furrow to plant them in. Some early thinker discovered that a sharp-forked limb of a tree pulled through the soil after it had been softened by the rain was excellent for this purpose. Thus the first plough was made. Later a horse or an ox was attached to this forked stick. In some such ways man gradually learned that

In searching the ground for seeds early man often scratched the soil around the roots of plants, and he noticed that these plants grew better afterwards. This was the first step in agriculture.

he could produce what he needed by planting the seeds in fertile spots and caring for the plants as they grew.

Man learned that the wild grains were rich and sweet when chewed. At first he probably cut the grain with the jawbone of an ox or a sheep. Later he found a bent knife better, while a knife fastened to a handle was better still. This was the first sickle. He rubbed the ears of grain

together in his hands to get out the seeds. Then he put them in his mouth and ground them with his teeth. But this was such hard work that he selected a stone with a slight hollow in its upper surface. On it he put another stone and ground the grains between them. Now man had a mill to grind his grain. This made a kind of flour. Adding a little water to it the women mixed it into a sort of paste, made it into little cakes and placed them in the sun to dry on flat stones heated in the fire. In this way the first bread was made.

Some early thinker discovered that a sharp-forked limb of a tree pulled through the soil made a good furrow to plant seeds in. Thus the plough was invented.

Man found that grains could be stored over the winter and would still be good for food. This was a great discovery assuring him of food all through the year. At harvest time he gathered more grain than he needed and stored it away in earthen jars, so that he could have it whenever he needed it.

So man learned how to sow, plough, reap, thresh, and grind the grains. Man now became a tiller of the soil, and by solving the problems of seed-time and harvest gained control of the plant world.

From this time on he could settle down and live his life in one place. The land yielded him a living.

Man's whole way of living changed as the result of this discovery. His home took on a more permanent character. The house now took the place of the tent. This was made of whatever material was at hand —wood, stone, clay. From the cave with its natural openings useful as windows and doors, and its walls and roof, man no doubt got his idea of raising walls to support a roof, which was the first form of house.

At first man ground grains by chewing them raw. But this was such hard work that he selected a stone with a slight hollow in its upper surface. On it he put another stone, and between them he ground the grain. This was the first mill.

Now the family had a place where they could keep their possessions, and furniture was invented and many household improvements were made.

There was so much land that each family could choose the place they wanted for a home, clear it, build a house, till the fields, and care for their flocks and herds. The household duties, such as the care of the children, the grinding of the grain, the preparation of the meals, and the making of the clothes, were usually the mother's work. Thus

people settled down and began making the spot they had selected into a better place in which to live.

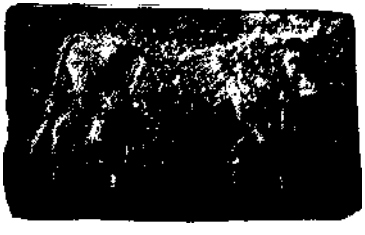
Houses were often placed close together for protection. Neighbours in these communities gradually became better acquainted with one another and found that they had many needs and interests in common. They also began finding various ways of working together. It was soon discovered that some people could do certain things better than other people. So it was found to be a better arrangement for a man with a special gift or skill to spend most of his time at a work in which he could exercise it. Other workers would agree that, if he would provide things lor them, they would provide him with other things which he needed in exchange. So different occupations arose and people began exchanging their work and their possessions. Perhaps a man would invent some device. When his neighbour saw how good it was, he might offer to exchange some of his extra grain for one like it. Or perhaps a particularly expert hunter would agree to give some of the meat of the animals he had caught for something else he needed. Or a farmer who raised more food than he needed would exchange it with the herdsman for cattle, or to the toolmaker for tools. In ways like these, people who had more of one thing than they needed began trading off some of it, and people came to depend more and more on others for things they wanted but did not have.

The custom of exchanging things raised a great new problem. Suppose a man had a cow which he wished to exchange for wheat. It would be very difficult to decide just how much wheat he should get in exchange for the cow. It might also be quite difficult to find a man who had extra wheat who also happened to want a cow. So people had to work out a more convenient way of exchanging things. They settled on a central place of exchange, and on certain days for bringing the things they had to offer. After some time they fixed one thing, like cattle or sheep, in which to express the value of others, saying that one thing was worth so many cattle and another worth so many more. Very likely the value of an article depended on how many people wanted it. A thing that many people wanted would be worth more than another that very few people wanted.

After metal came into use it was found to be more convenient as the measure of the value of goods. At first pieces of metal were used, and a trader might take a pair of scales with him to weigh it. Then it

seemed more convenient to have the chunks made of definite weights. These were stamped in various ways so that they could be easily distinguished. It was in this way that money first came into existence. The first coins were just bars of stamped metal. The ox was used on many coins because it had been used as money before coins were invented.

Man in his early wanderings had no notion of owning land. All land was free and men roamed over it as they wished. But now a great change came about. When men began tilling the soil, they got the idea of owning the land. There was a long time between the sowing of the seed and the reaping of the harvest. During all that time the plants were in constant danger of being destroyed by storms, droughts, insects, and so on, and they required constant care. The crops requiring so much thought and care were valued very highly. So man came to have the idea of owning the crops and the soil in which they were planted. He had put his labour into the soil and felt entitled to the results of his work. Without the land he could raise no crops. This was the beginning of the idea of owning land.



Some of the earliest coins were merely rough bars of copper with the figure of an ox stamped upon them.

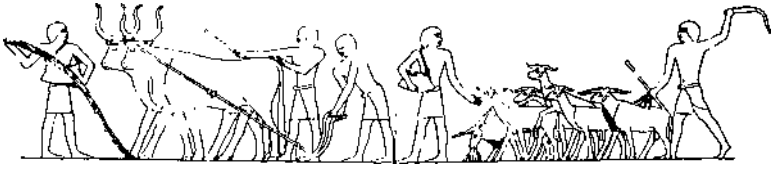
Up to this time there were no nations ; there were only groups of families, or tribes, that had settled in some favourable spot. They would choose, a chief because of his strength and courage. The people obeyed their chief in all things because their safety depended upon his leadership.

These early settlements grew and flourished. As the people on one piece of land gradually spread out perhaps they would come to the land occupied by some other tribe. Then the two tribes would fight for possession of the land. Or perhaps a tribe whose harvest had failed would raid the land of another tribe. Thus sprang up warfare. The victors would seize the land of the weaker people, make slaves of them and force them to work for their conquerors. Powerful military leaders arose who seized many wandering herdsmen and tillers of the soil, and united their territories. Such leaders were called kings, or emperors.

Thus nations gradually came to own certain portions of the earth's surface.

Society had not developed very far before it was divided into different classes. Besides the kings and emperors there were other wealthy landowners, called nobles, who were very proud of their rank, scorned work of any kind, and made the slaves do their work for them. Every early nation had great numbers of slaves who did all the work. They toiled under overseers who carried sticks and used them freely. " Man has a back," said a very old proverb, " and only obeys when it is beaten."

So the early wandering peoples were gradually changed into settled groups living in various places who began learning the ways of living together in larger communities called states. When man began to settle down in one spot the way to unending development was open. Thus the foundation of civilization was laid and man, the tiller of the soil, became the builder of kingdoms and empires.



Coio/t-sy *Metropolitan Museum of Art*

After the Nile had watered the fields of the Egyptians, a sower scattered seeds in front of a plough which turned the earth over them. To trample in the seeds, sheep were then enticed across the field by a man holding some green food before the noses of their leaders, while a man behind them urged them on with a stick

CHAPTER VI

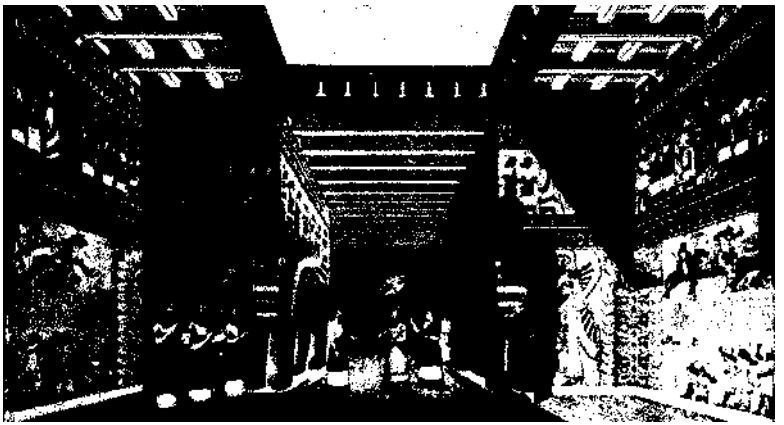
CRADLE LANDS OF CIVILIZATION

SCHOLARS have not yet decided in just what part of the world the first settled home of mankind was. For a permanent settlement there had to be good living conditions—the right kind of climate and soil and water—so that people would not need to move. This was the case in many river valleys, but nowhere were conditions more favourable than in Mesopotamia—"the land between two rivers "—a broad fertile valley in south-western Asia lying between two mighty rivers, the Tigris and the Euphrates. Scientists think that it may have been in this valley that the earliest people settled down, became prosperous, and built up a permanent civilization.

While the settlements in the Tigris-Euphrates valley were thriving and growing, another great state was developing in Egypt, in the north-eastern part of Africa. Through Egypt flows a great river called the Nile. Every spring heavy rains fall and the snow melts in the mountains where the Nile has its source. As the rain and melting snow flow into the streams, the small rivers swell to overflowing and pour torrents of muddy water into the Nile. Then in the summer the Nile begins to rise. Higher and higher the water rises until at length it overflows its banks and spreads over all the land to the base of the hills on each side. The water reaches the highest point in October and then gradually subsides. When the river returns to its banks, it leaves a deposit of rich black earth in which it is easy to raise things. It is easy to see why Egypt, one of the world's first great nations, grew up in this narrow strip of green, fertile land, lying between the endless

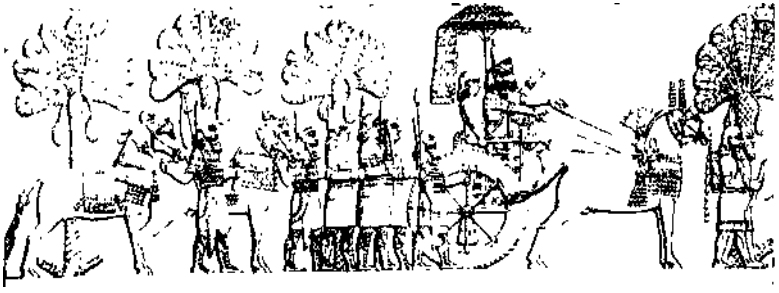
wastes of almost rainless desert. Egypt was called by one of the early historians " the gift of the Nile," which seems a very good name for it.

Nature was so kind that the Egyptians did not have to work very hard for their food. After the Nile had covered their fields and then receded, the ground which had been under water for two or three months was soft and yielding ; and from it soon sprang up fruits and



The palace of an Assyrian king as restored from actual remains by the great English scholar, Sir Austen Layard. The panelling is of sculptured alabaster, the ceiling is gilded and inlaid. The walls are brilliantly painted. The king is entering, accompanied by his vizier and attendant, and is received by musicians playing harps.

flowers and grains in the warm sunny climate. The sower, with a bag of grain slung over his left shoulder, scattering a constant stream of seeds over the rich mud, walked in front of the plough, which turned the earth over them. Then cattle or sheep were driven over the field to trample in the seeds, enticed across by a man holding some green food before the noses of the leaders, while another man behind them urged them on with a stick. In a few months the people were able to harvest



An Assyrian king sets out in his war chariot on his

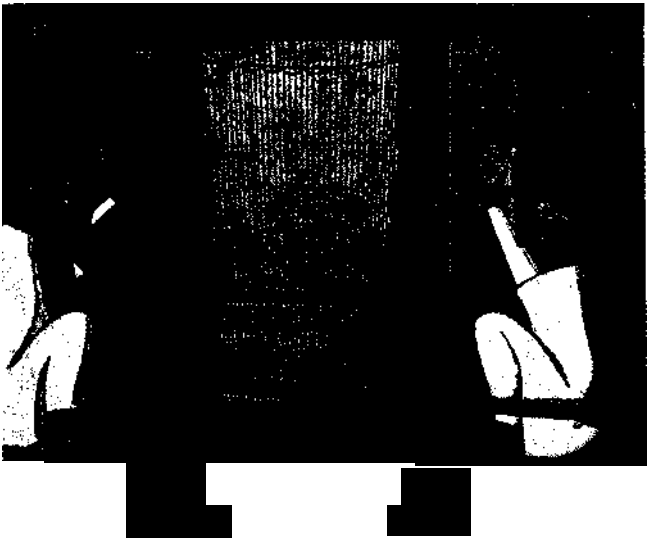
good crops of wheat, barley, rye, and other grains. The grain was cut by a short sickle, the men often working in rhythm to the music of a pipe.

As the climate of Egypt was warm people needed protection from the heat rather than from the cold ; so they tried to find cool garments to wear. Fortunately flax grew in their valley, and they found that the inner part of the flax plant could be divided into long thin strands. The stalk was soaked in water for several days, then cracked open, and the strands were twisted into thread. From this the Egyptians learned to make fine light material called linen. The climate was so good, with many sunshiny days, not too hot and not too cold, that the Egyptians could get along without many clothes.

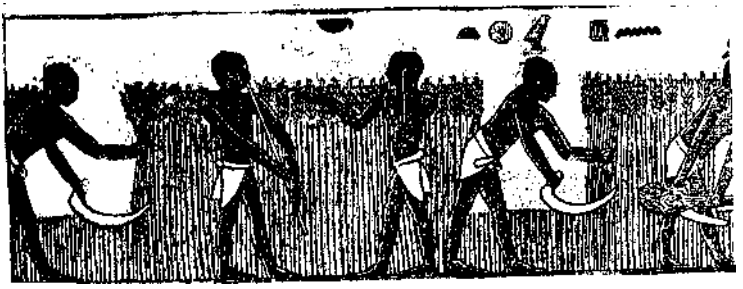
In a land where it was so easy to get a living the people had time to learn how to do a great many things, and a thousand and one details of civilization originated among the Egyptians. They were the first people to measure time and devise a calendar. It came about in a very natural way. So long as man made his living by hunting and fishing, he did not need a calendar. But when he began to raise crops it became very necessary to work out some way of reckoning time in order to calculate the right time for sowing the seeds. Early tillers of the soil formed the habit of observing the heavenly bodies and noticing the change of the seasons, and learned to calculate the time when these various changes took place. They divided time into days, depending on the sun, into weeks and months, depending on the moon, and into years, depending on the overflow of the Nile. The Egyptian year therefore began in October.

way to besiege a city, preceded by his warriors.

The Egyptians did not know the natural reasons for the change of seasons and other changes in nature, and believing, like other early peoples, that gods regulated them, made these their chief deities. They sang hymns of praise to the sun-god upon whose kindness their crops



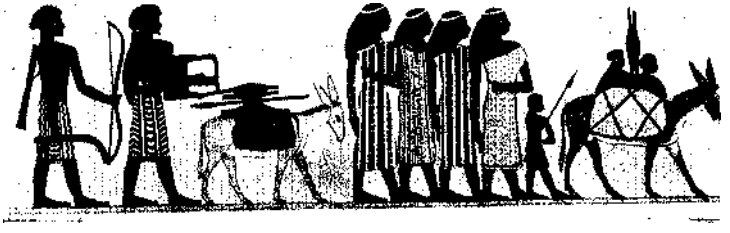
The Egyptians learned how **to make linen of marvellous fineness. This picture, from a tomb painting made more than five thousand years ago, shows the Egyptian method of weaving.**



The grain was cut with a short sickle, the workmen

depended. In times of drought when the crops failed they offered sacrifices to the gods. They worshipped Father Nile, because they thought they were dependent upon his good will for the water that made their land fertile. Spring, when the seed was sown ; summer, when the fresh fruits were gathered ; and autumn, when the crops were harvested, became times of great religious importance when great festivals were held. In time these religious rites became so complicated that special people had to take charge of them, and special buildings were erected for them. So we have the first great temples built to the gods, and the priests who conducted the religious rites and ceremonies.

The Egyptians attained a wonderful knowledge of the arts of construction. They learned how to move, over great distances, massive blocks of stone weighing several hundred tons which they used for building magnificent temples to their gods and mighty monuments

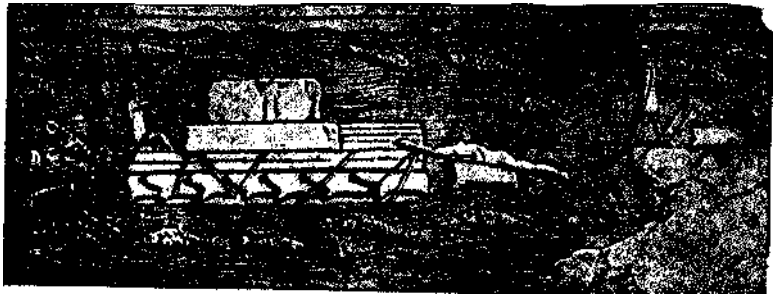


An Asiatic family visiting in Egypt.
(From a painting made on the wall of a tomb about four thousand years ago.)

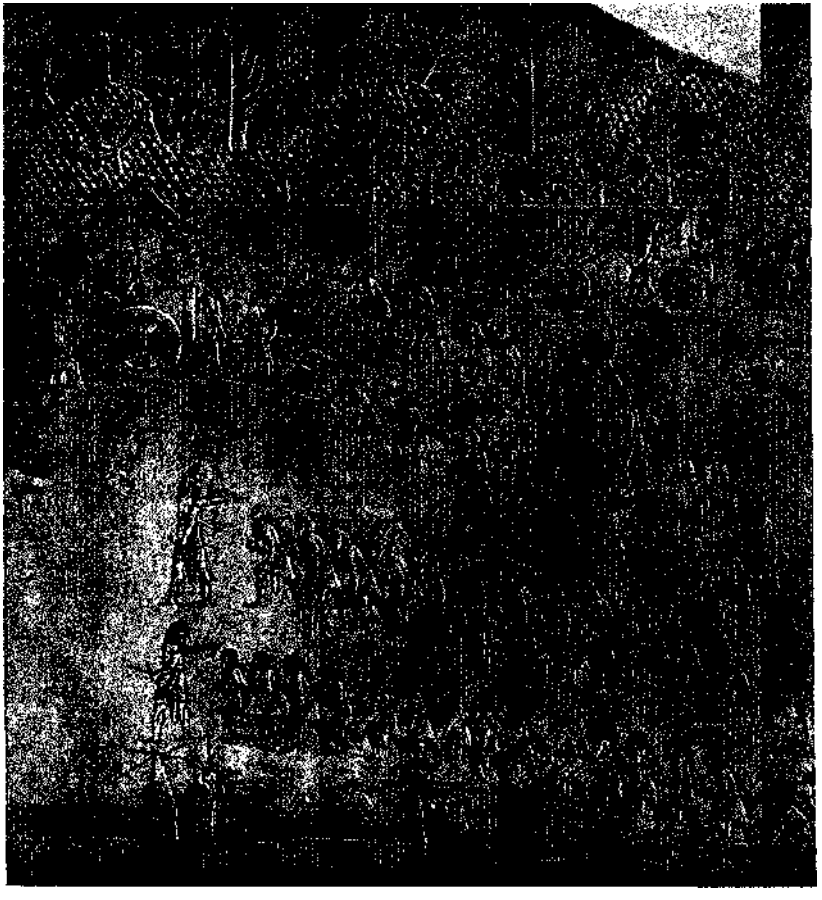
often moving in rhythm to the music of a pipe.

called the pyramids, which were the tombs of their kings. Some of them were formed of millions of blocks of stone weighing more than a ton each. These huge piles, more ancient than any buildings now standing in Europe, have survived all through the centuries and are still among the chief wonders of the world.

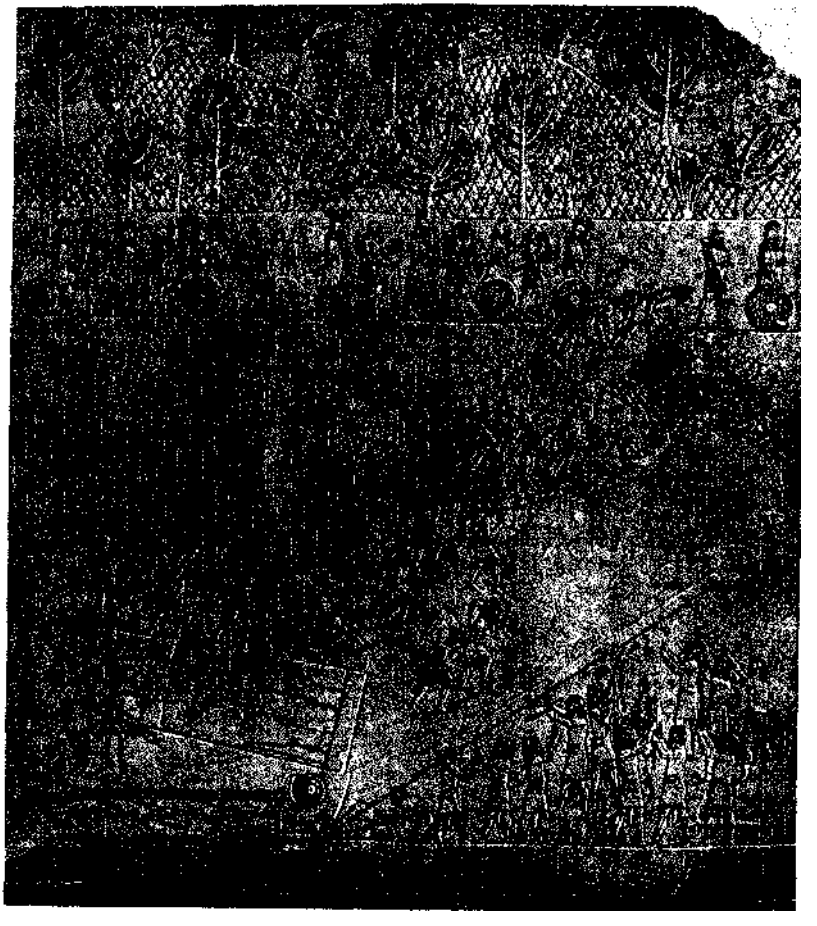
How could those ancient dwellers on the Nile build such magnificent structures without derricks or other machines such as we have to-day ? This is still a puzzle to scholars. Most of the granite of which the pyramids were built came from a place nearly six hundred miles away. How did they quarry it, and how did they move it such a distance ? It is thought that, to break the blocks from the solid rock, a groove was cut and holes bored along the groove at intervals, into which



Rafts buoyed up by inflated skins were used for transporting heavy stones on the water. Behind the raft is a man pushing, swimming with the aid of an inflated skin ; at the right another man is giving directions.



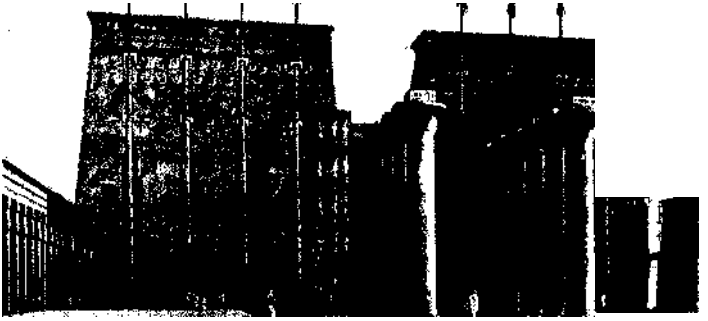
Transporting a huge block of stone in 660 B.C. It rests on a sledge with rollers dragged by four lines of slaves, each line under the direction of an overseer. The back of the sledge is being eased off a barge by a lever and wedges. Some workmen



cling to the ropes of the lever to add weight. On the stone are four more overseers, one in front, clapping his hands to regulate the movements of the workmen, another giving directions through a trumpet. (From a rock carving on the walls of Nineveh.)

wooden wedges were forced. Then the groove was filled with water which caused the wood to swell and crack the stone along the groove. Rollers made from branches of trees were used to move the great blocks of stone to the bank of the Nile, where they were floated on rafts buoyed up by the inflated skins of animals, to the place where they were needed.

Then these great blocks were lifted into position. One scholar



The great temple at Karnak, built in the days of Egyptian splendour, as restored by a modern scholar.

strength, so that the stone was lifted up a short distance. While it was suspended another army of workmen, working furiously under the lash of the whip, quickly filled the space underneath with dirt. Then the process was repeated over and over again. It is said that it took one hundred thousand workmen over twenty years to lift the mammoth blocks of the Great Pyramid into place. It is probable that most of them were slaves.

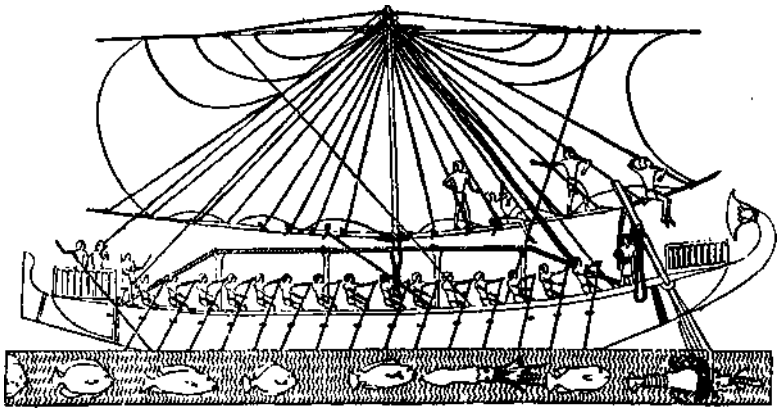
The Egyptians were the first people to study surveying. Each year when the Nile overflowed its banks it would destroy a great many

Courtesy U.S. National Museum

A modern artist's idea of how the pyramids may have been built/ Even with these thousands of workmen, it took over twenty years to build a pyramid.

landmarks showing the boundaries of different people's property. This made it necessary to devise some mathematical calculations to find them again.

The Nile River was the natural highway through Egypt and led to the development of boat-making. The earliest boats were propelled by oars, or sails, or both together. Rowers sat in the middle of the boat, a look-out man with a sounding stick to measure the depth of the water was stationed at the bow, and at the stern was a pilot steering with two oars slung over the side. The Egyptians often painted an

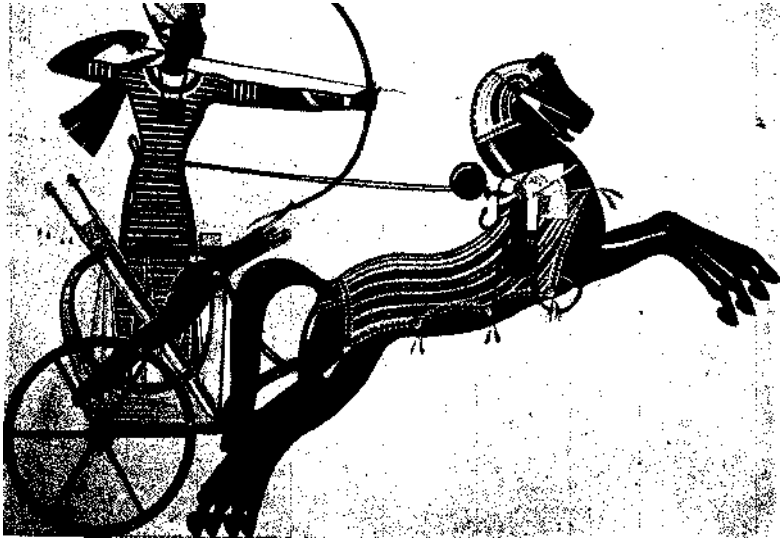


An Egyptian ship of 1600 B.C. At the bow there is a sailor taking the depth of the water and an overseer with his stick. Over the stern are slung oars which are used to steer the ship.
(From an Egyptian .bas-relief.)

eye on the bow of the boat to represent the eye of the god Osiris, who was supposed to guide the ship safely. The experience gained on the safe waters of the Nile was a good preparation for the bolder venture on the open sea. After a time the Egyptians learned to cross the seas to other places where they obtained many useful things not found in their own land.

So by degrees the people of Egypt came to be organized into a well ordered state and in the rich valley of the Nile built up a great empire which lasted until the time of Alexander the Great, who conquered it and made it a part of the Greek empire.

As the early settlements of the world spread out along the fertile river valleys they came to a large body of water which they named the Mediterranean Sea, meaning the middle of the earth. The Mediterranean was well named for, as time went on, new nations formed around it, and for centuries all the civilized nations of the world centred about this great landlocked sea. It was fairly calm and free from



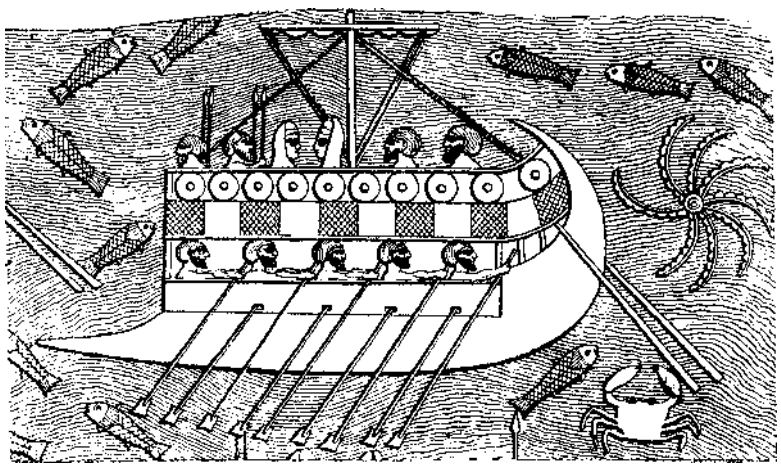
The war chariot of an Egyptian pharaoh. He is shooting an arrow and at the same time guiding his horses with the reins tied around his waist. The case at the side holds more arrows.
(From an Egyptian wall painting.)

storms, and its islands and peninsulas were like stepping-stones, leading men on from place to place, while its many inlets and bays offered safe harbours.

At the eastern end of the Mediterranean, half-way between Egypt and the Tigris-Euphrates valley, was another nation, Phoenicia, which also played an important part in the world's early history. The

Phoenicians were fishermen and lived near the good fishing centres on the coast. One of these was called Tyre. Here they found a kind of shell-fish from which they learned how to make a wonderful purple-red dye. With this they dyed and embroidered fabrics, which were much sought after.

The Phoenicians were the first great sailors. They invented new kinds of boats, the bireme and the trireme. These were huge combined rowing and sailing boats in which as many as a hundred rowers were



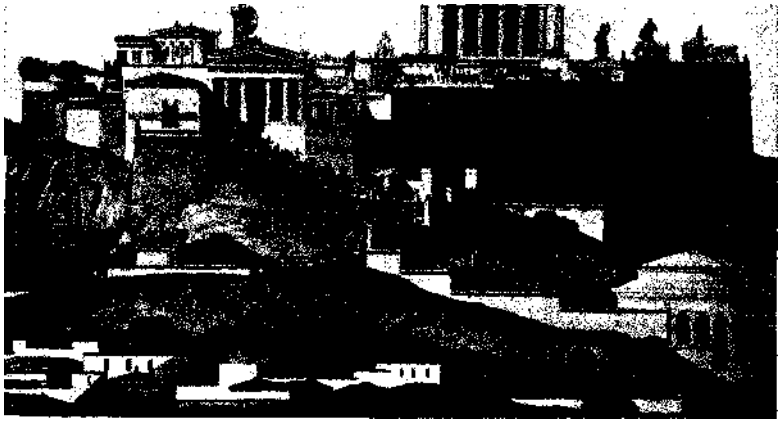
A Phoenician bireme. In order to get more power without increasing the length of their ships, the Phoenicians used two rows of oarsmen, one above the other. This was called a bireme. With these combined sail-and-oar boats they voyaged all over the Mediterranean and even as far north as England.

used, seated in two or three rows of benches, one above another. The oarsmen were usually slaves and sometimes were chained to their benches. The Phoenicians were the most daring seamen of ancient times, and in their great sail-and-oar boats they explored all the Mediterranean shores. It is said that they even ventured beyond, sailing as far north as England, where they found tin, which was very much needed for making bronze. As it was to be found in only a few places, the Phoenicians were always searching for it.

In their boats laden with Tyrian cloth and other things the Phoenicians gradually became the world's first traders. Trade was still carried on by bartering. The Phoenicians would sail up to the land, spread out their goods on the shore and build a signal lire to attract the natives. Then they would go back to their ships. The inhabitants, seeing the signal, would come down to the shore, look over the goods, leave their own wares, and retire. The Phoenicians would come back to the shore, and if they were satisfied they took the goods left in exchange and sailed away. If they were not satisfied they went back to their ships and waited for the natives to add more to their wares.

At first the Phoenicians carried only their own wares, but as they travelled farther and farther and found places where some things grew more plentifully and other places where people had learned to make many useful things, they found it worth while to carry the surplus of one place to another and bring back other things in return. Thus they became the world's first traders. Out of this beginning made by the Phoenicians has developed all the commerce of the world.

When the Phoenicians traded with far-away nations they carried with them more than their wares. They introduced knowledge and the arts and industries of the early peoples wherever they went. Thus they linked together the peoples of the ancient world and were the means of spreading the civilization of their time.



The acropolis of Athens with its beautiful temples and statues of gods and goddesses, as a modern scholar thinks it may have looked. At the right stands the Parthenon, the best example of Greek architecture.

CHAPTER VII

THE GLORY THAT WAS GREECE AND THE GRANDEUR THAT WAS ROME

FROM north-eastern Africa and south-western Asia civilization spread westward along the Mediterranean Sea to Greece. It is easy to see why Greece became civilized before the other countries of Europe. It is the borderland between the great countries to the east and those to the west. The sea is narrow between Greece and the countries in which civilization first arose, and the islands between are like stepping-stones.

The little country of Greece is a beautiful land. It is broken into many small regions by lofty mountain ranges and long arms of the blue Mediterranean that run far inland. The character of the country explains why the early Greeks did not join together into one nation.

Many a Greek city, called a *polis*, was built on the steep side of a hill. The hill-top was crowned with a walled fortress, in which the

Greek musicians.
(From an old vase painting.)

citizens could defend themselves against invaders. And on the sides of these hills cities gradually grew up with their shops and dwellings and market places, adorned with public buildings and temples. The top of the hill was then called the acropolis, meaning "top of the city." Each one of these cities with its surrounding lands became in time a little separate Greek state, managing its own affairs.

As they lived in such a beautiful land it is no wonder that the Greeks learned to love beauty in its various forms. Greece has been called "the mother of the arts." It had an abundance of beautiful white marble suitable for building and sculpture, and with it the Greeks erected many-columned buildings beautiful in their simplicity and proportions. Their great sculptors also worked in marble, carving wonderful statues of their gods and goddesses that have been among the most admired for centuries. With the alphabet brought to them by the Phoenicians the Greeks found a means of recording in literature

Harnessing a Greek chariot.
(From an old Greek vase painting.)

the deeds of valour of their gods and great heroes. They wrote beautiful poetry that has endured through the ages and has given inspiration to many other poets of later days.

Themselves loving beauty, the Greeks taught the world to love the beautiful in architecture, sculpture, and literature. The statues they carved, the poems they wrote, the temples they built are among the most exquisite ever made.

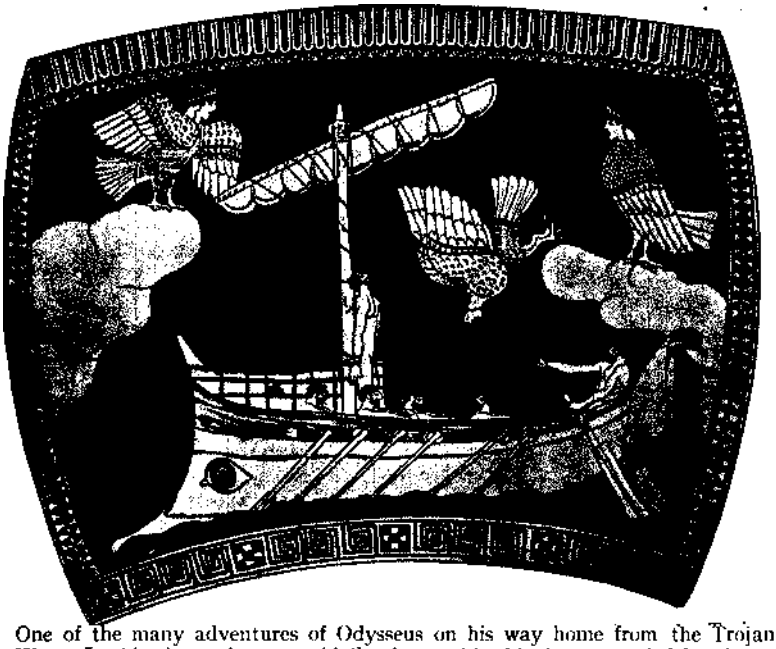
The most famous of all the tales of the Greeks is the Iliad, in which their great poet Homer tells the exploits of their heroes in the long war against the inhabitants of Troy. For ten years they struggled against the Trojans, and had got very near to taking the city when a terrible quarrel broke out between the leaders of the Greeks ; and Achilles the bravest of all the warriors refused to fight any more. Then the Greeks were very nearly destroyed, for the Trojans drove them right back to their ships, and they were hemmed in with the sea behind them. It was only after his friend had been killed that Achilles would fight again and defeated the Trojans. Later the city fell and all the Greeks could go home.

In the Odyssey, Homer tells of the long wanderings of the hero Odysseus (often called by his Latin name Ulysses) on his way home from the Trojan War. He had all sorts of adventures and met with many terrible creatures such as Scylla, the six-headed monster, always on the look out for ships ; the enchantress Circe, who changed men into beasts ; the Sirens, who lured mariners to their death with their songs ; and the one-eyed giant Polyphemus, who devoured men with relish. After ten years of such strange experiences he finally arrived

The famous wooden horse built by the Greeks and filled with armed men by means of which they conquered Troy.
(From a Greek gem.)

safely home to be united again with his faithful wife Penelope, who had been waiting all that time.

The Greeks were the first nation to pay much attention to the writing and acting of plays. Their great dramatists pictured the tragedies in the lives of their gods or brave heroes, or fashioned comedies full of merry-making. These were given in open-air theatres built on the slope of hills, with rows of stone seats cut into the hill-side rising tier upon tier in a great half-circle around a small stage at the bottom of the hill.



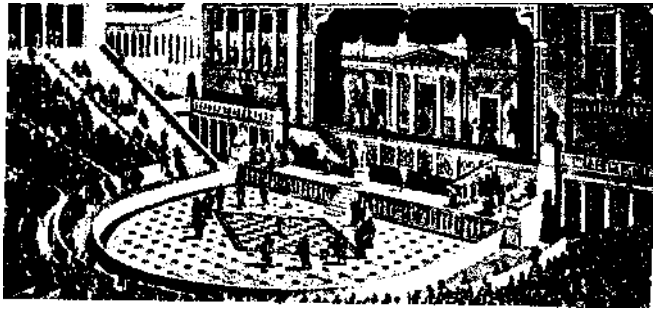
One of the many adventures of Odysseus on his way home from the Trojan War. In this picture from an old Greek vase his ship is surrounded by sirens, who bewitched mariners with their songs. But Odysseus had commanded his companions to stop up their ears with wax, and had had himself lashed to the mast, and so escaped.

Everyone went to the plays, which sometimes lasted all day long. The poor people were admitted free of charge. It was believed that these great plays would make the citizens more religious and proud of their gods and heroes.

Like all early peoples the Greeks believed that the earth and the affairs of men were ruled by many godlike beings. They thought of them as strong and beautiful men and women, only more powerful than people. They were supposed to live in a marvellous city on the cloud-tipped summit of Olympus, the loftiest mountain in Greece.

The chief of these gods was Zeus, who ruled the heavens and the earth. His wife was Hera, the queen of heaven. One of his brothers, Poseidon, was lord over all the waters, and another, Hades, was king

of the dark underworld. There were many other gods who presided over the affairs of men, rewarding them when they were good and punishing them if they were wicked. Zeus sent the rain to water the earth and make the crops grow, but if he was angry he hurled his terrible thunderbolts from the sky and men trembled. Phoebus Apollo, the son of Zeus, was the god of the sun, who gave light and warmth to men. Athena, goddess of wisdom, protected the Greek

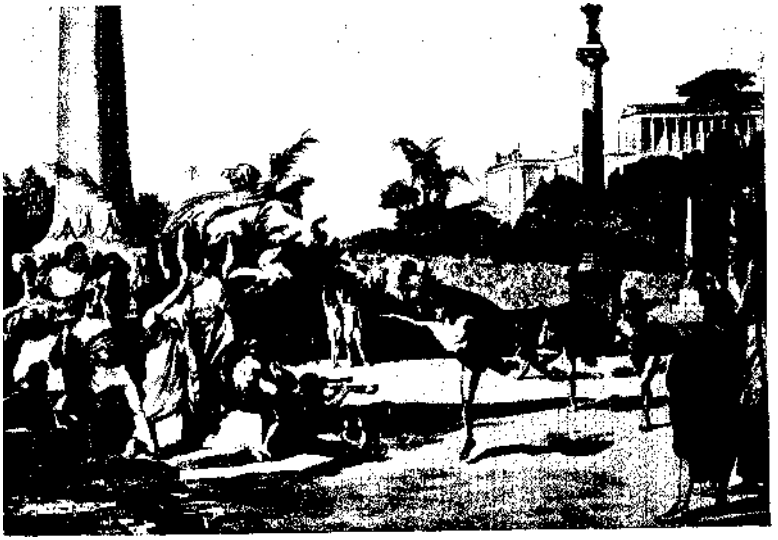


The Theatre of Dionysus. One of the many open-air theatres built in a half-circle around the stage.

cities. Demeter was the goddess of the harvest who made the grain ripen. Dionysus looked after the vineyards and made the grapes fruitful. Aphrodite was the beautiful goddess of love. Ares was the terrible god of war. Many interesting stories were told about the gods and goddesses which we still enjoy reading to-day.

Beautiful temples were built to the gods, with altars where the devout offered up their daily prayers and made sacrifices to them. On festival days there was singing and dancing in their honour. The most beautiful of all the Greek temples was the Parthenon, built on the acropolis, in Athens, in honour of Athena.

The Greeks greatly admired a beautiful body. Boys were taught all sorts of sports to develop strong, healthy bodies. Every afternoon they spent several hours in exercising, learning how to wrestle, to run, to hurl the spear, and throw the discus. In every town there were free gymnasiums where grown men could exercise. In no other country did the people have such beautifully developed bodies. These were



An exciting moment at the close of a foot race in the Olympic games. At the right are the judges.

often the inspiration for sculptors, who used them as models for their statues.

Believing that the gods liked to see men display their strength and skill, the Greeks often held great athletic contests in honour of a god, with all kinds of races, and wrestling matches, and boxing. The greatest festival of this sort was the Olympic games, held once in every four years at Olympia, in honour of Zeus. From far and near people travelled to Olympia to witness or to take part in these games. Although the only prize given was a simple wreath of olive leaves, it was the

highest honour anyone could receive, and the victor in the games was considered a hero by his city.

Of all the city-states of Greece the one that contributed most to the enrichment of human life was Athens. In the fifth century B.C., it was the most beautiful city in the world and the home of great artists, sculptors, poets, and men famous for their learning. Great philosophers arose among the Athenians, " lovers of wisdom," as the word means, who gathered men about them and tried to help them toward the best way of living. One of the wisest of these was Socrates. He loved truth and justice and all high and honourable things. He tried to teach men their duty in the world and show them how they could become wise and just and good. Day after day he walked in the Athenian market place, questioning and teaching rich and poor alike. What is justice ? What is virtue ? What is duty ? Such were the questions he asked. By skilful questioning he led his listeners from one point to another until they saw for themselves the ideas he was trying to teach. Crowds of young men followed Socrates through the streets and flocked around him to learn wisdom from him.

Socrates began questioning the religion of the Greeks, and they became alarmed at his ideas. He was accused and condemned to death for teaching that there is only one God When he was tried he stood firm in his belief, saving : " Either acquit me, or do not acquit me, but be sure that 1 shall not alter my way of life, not if I have to die for it many times." And he bade his judges farewell in noble and gentle words, closing, " O judges, be of good cheer about death and know of a certainty that no evil can happen to a good man either in life or after death."

Then, according to the Athenian custom, Socrates drank the cup of hemlock poison, and so ended his long quest for truth. His teaching lived on, however, in the minds of his pupils, of whom the greatest was Plato. One of Plato's great pupils was Aristotle. The ideas of these Greek philosophers have influenced the thinking of men ever since.

The Athenians were the first to have a government by the people. They believed that every freeman should take part in making the laws and ruling the state. It is from them we get the word " democracy," which means government by the people. Gradually all the Greek city-states became little democracies. All the citizens met together and voted directly upon the proposed laws, and any freeman might

hold office. But there were hundreds of thousands of slaves in Greece, and they had no voice in the making of the laws. So, in reality, only a small proportion of the people governed.

Athenian youths, when they came to the age of eighteen, were led to the shrine of Athena, and there they pledged themselves to the service and defence of their country in the following solemn oath :

" We will never bring disgrace on this, our city, by any act of dishonesty or cowardice. We will fight for the ideals and sacred things of the city, both alone and with our companions. We will severe and obey the city's laws. We will try unceasingly to quicken the sense of civic duty in others. In every way we will strive to pass on the city to our sons greater and better than it was when our fathers passed it on to us."

Now a new power was rising in the Mediterranean—Rome. In the earliest days Rome was only a tiny settlement on the Tiber River in Italy. It grew steadily in size and importance. Gradually the Romans extended their dominion. First they conquered the territory around them until they ruled all of Italy. Then they fought the Carthaginians and conquered the Greeks and Egyptians and so became masters of the Mediterranean. The Roman Empire at its height was practically the whole civilized world as it was then known.

The Romans were great builders and engineers. They were great road-makers and bridge-builders. You may have heard the saying, " All roads lead to Rome." In ancient times this was literally true.

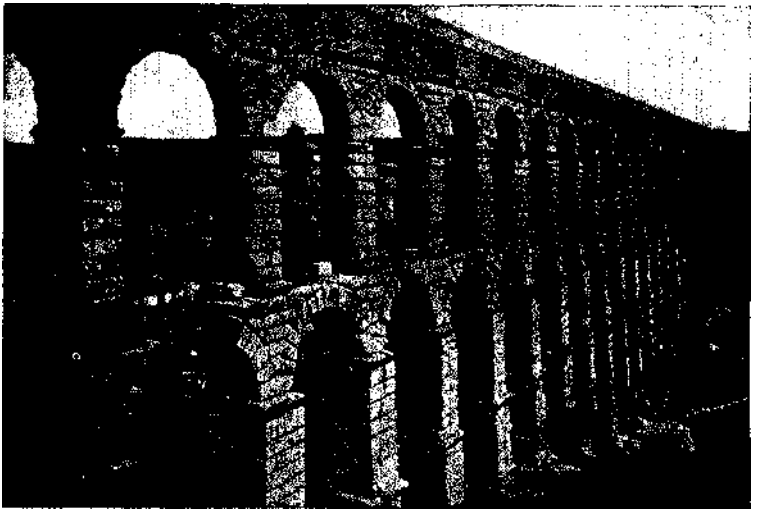
Roman soldiers on the march. They are crossing over a river on a bridge. (From the column of Trajan.)

THE GRANDEUR THAT WAS ROME

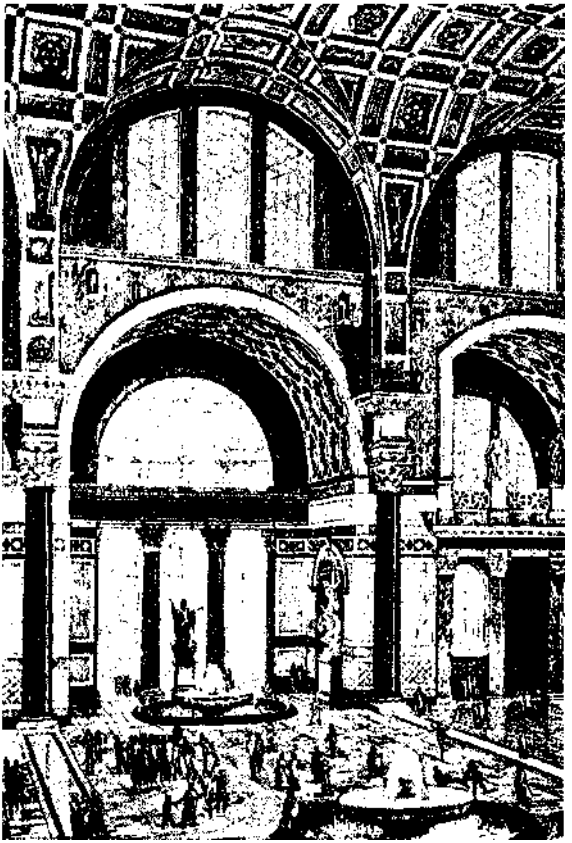
One of the first things Rome did after conquering a country was to. connect it with Rome by good roads so that the soldiers could get about easily wherever they were needed. In the course of time a great network of roads and bridges led to the farthest parts of the empire. These roads and bridges were so well made that many of them are still in use.

The Romans erected great temple-like buildings of marble which they used as public baths. There were hot and cold baths, and marble tubs, and swimming pools. Often, too, these buildings contained libraries, picture galleries, gymnasiums, and eating rooms, so that they were like great public club-houses. Many people spent a large part of their spare time there.

The lakes from which Rome got its water were many miles away from the city. So the Romans had to build great pipes of stone or concrete which they called aqueducts, or water leaders. When an aqueduct had to be carried across a river, they raised a great structure of arches to support it. Many of these aqueducts are still being used.



These massive arches, so solidly built by the Romans, arc still standing, and the aqueduct is still used to convey water to the town.



The interior of one of the luxurious public baths of Rome. They were like great clubhouses. (From a restoration by a modern scholar.)

THE GRANDEUR THAT WAS ROME

The Romans conquered Greece, and they learned much from the Greeks. They wanted Rome to be beautiful, so around the forum, or market place, where the people came together for public meetings, they erected magnificent public buildings, beautiful temples, imperial palaces, splendid monuments, and statues of famous Romans, similar to those in Athens and other Greek cities. But they added something to Greek architecture—the arch. This is the strongest form of support, and the combination of arch and column made possible greater building constructions than those of the Greeks. They built great amphitheatres combining arches and columns one row above another. One of these, the Colosseum, an immense building almost round, held about eighty thousand people. In it took place games and chariot races and battles between gladiators for the entertainment of the people.

The Romans united all the ancient peoples in a single great civilization. They adopted many Greek ideas and so were the means of spreading Greek culture and ways of living and thinking to every part of their great empire.

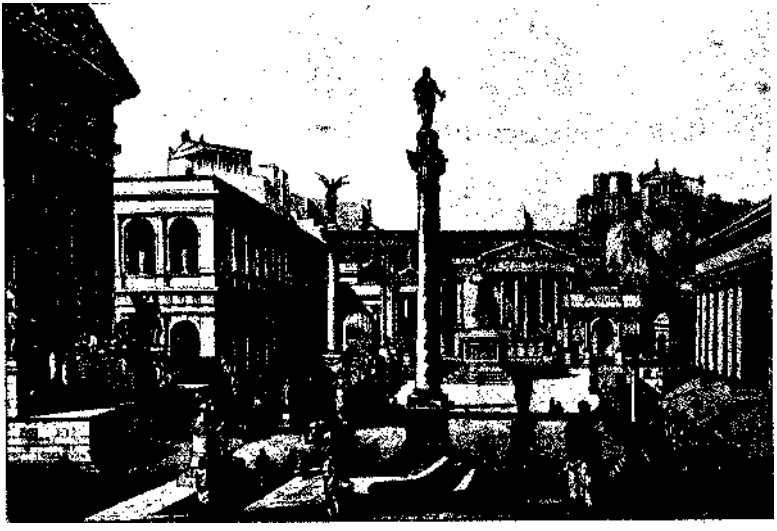
One of the greatest things the Romans left to the world was their law. In all the countries they conquered, Roman law was established. The emperor Justinian had all the Roman laws collected and put into a great book. This code became the foundation of the laws of many European countries. There is no modern country that does not rely to some extent upon the system of laws worked out by the Romans so many centuries ago.

Rome was also responsible for spreading throughout the civilized world a new religion which was to have a tremendous influence upon the world for centuries and centuries afterward. On the eastern border of the Roman Empire dwelt the Hebrews, a simple shepherd people to whom religion was the one end and aim in life. Here in the little village of Bethlehem was born a boy to whom was given the name Jesus. As he grew to manhood he began teaching a new religion of peace and love and brotherly kindness. Few could resist his eloquence, and he made many converts to this new faith.

Jesus went about doing good among the humble and the lowly. He healed the sick, he fed the hungry, and always he taught the people how to live good lives by simple stories, or parables, which all could understand. His heart went out to the poor and oppressed and

downtrodden, and he comforted them. The poor people and the slaves, worn out by toil, turned eagerly to this new religion for comfort and hope. It is no wonder that these unhappy people flocked to hear Jesus, and that they were converted by hundreds. Everywhere he went, little Christian churches sprang up. But finally he was brought before Pontius Pilate, the Roman governor, and sentenced to death.

Among the last words of Jesus to his followers were " Go ye into all the world, and preach the gospel to every creature." So after his death his disciples carried on his work and went about spreading the gospel of Jesus to many parts of the Roman Empire. The Roman government, fearing the spread of these new ideas among the people, forbade the Christians to worship and began punishing those who disobeyed. Persecutions became widespread and terrible. Churches were burned down, Christians were arrested and cast into prison, many were burned at the stake, others were thrown to wild beasts in the Colosseum. Nevertheless the new faith continued to spread. Often



The Roman forum, with its great public buildings, its temples and palaces, its triumphal arches and statues of famous Romans, as a modern scholar thinks it looked when Rome was mistress of the world.

the Christians had to worship in secret places. In Rome they were forced to seek safety in their subterranean cemeteries known as catacombs. In several places in Rome to-day are still to be seen the tunnels and underground rooms where, huddled together with very little light or air, the early Christians held their services.

In spite of persecution for nearly three hundred years the new religion continued to spread. By the third century after Christ almost one-tenth of the Roman Empire was Christian. By this time the

A chariot race in the Circus Maximus, where drove four horses abreast at breakneck speed seven times around the course. (From a modern painting.)

Church was becoming too strong to be persecuted, and the emperor was forced to let the Christians carry on their worship publicly without interference. With the emperor Constantine, who became a Christian in the year 313 A.D., the persecution came to an end. When Constantine became emperor he had to fight rivals for the throne. There is an old story which tells how Constantine decided to change from worshipping the pagan gods and became a Christian. In a vision before the battle, he saw a flaming cross of brilliant white light in the heavens and under it words which meant, " In this sign thou shalt conquer."

A few years later Christianity was made the official religion of the whole Roman Empire. The emperor ordered that there should be no other religion in the empire. The worship of the old Roman gods was forbidden. Temples to Jupiter and Venus and other pagan gods and goddesses were torn down, and those who still tried to worship in the old ways were punished.

A village of one of the Teutonic tribes in Germania during the Dark Ages. The people dressed in skins and lived in round huts made of reeds or twigs woven together.
(Restoration by a modern scholar from ancient descriptions.)

Thus about three hundred years after the death of Christ, the Christian religion, which at first had been the faith of a small group of people who were cruelly persecuted, became the law of the vast Roman Empire. In every village and town of the empire there was a priest to look after the religious services of the people. In the larger towns there was a bishop to oversee the priests of his community. The bishop of Rome became the head of the Church and was called the pope. To the Church as organized by Rome the word catholic, meaning universal,

came to be applied, as this church was for centuries the only form of church in all civilized Europe.

Rome ruled the Mediterranean world for six hundred years or more, but its great empire was not to endure for ever. It grew too big and wide-spreading. No one was strong enough to carry on the task of governing so vast a realm. Other nations were to rise and play their parts in the history of the world.

The northern boundary of the Roman Empire followed two great rivers—the Rhine and the Danube. Beyond these boundaries lay a vast unsettled region called Germania, which was inhabited by various wild tribes of barbarians. Their villages were small clearings in the forest. Their homes were round huts built of roughly hewn logs, or rudely constructed of reeds and twigs woven together. Often their cattle and other beasts were sheltered in the same room with the family. Their dress was usually made from the skins of deer or bear. It was to keep out these peoples that Rome built boundary walls and kept her warlike legions always on guard.

About the year 400 A.D. these Teutonic tribes began to come in as conquerors, bursting through the frontier barriers. The first tribes to break through were the Goths who had been living just north of the Danube. A horde of fierce warlike peoples from the wild regions of Asia swept over Europe, plundering and conquering the land held by the Goths, and the Goths fled before them. They looked across the Danube and begged the emperor to allow them to settle within the empire. The emperor consented and thousands of Gothic warriors with their women and children and their herds and cattle crossed the river. The Romans promised to treat them justly, but the promise was soon broken ; and the angry Goths rose against the Roman armies and defeated them in a great battle. Then they decided to have a king of their own. Other tribes of barbarians surged over the empire in search of new homes and settled here and there. So by the fifth century after Christ the Roman Empire had come to an end. Instead of one far-spreading empire, regulated by Roman law and protected by Roman power, the land was now divided up by a number of small fighting tribes, each ruled over by its own king.

With the passing of Rome as a great world power we have come to the end of the story of the ancient empires of the world. We have seen how different early nations grew up in various places and how

each took many important steps in discovering ways of increasing man's power over nature and in making contributions to the arts of community living. Our debt to these early nations is very great. As we pass down the centuries we shall be able to realize more and more clearly how the foundation of later civilization was laid by the people of ancient times.

CHAPTER VIII

HOW MAN LEARNED TO WRITE

WE are indebted to the early nations for one of the greatest contributions which have come down to us through the ages, one which has been of the greatest importance in the progress of man. This is the alphabet. To us to-day it seems quite natural to set down our thoughts on paper by combining in various ways the twenty-six queer little signs called the alphabet ; but it took thousands of years in the world's early history for the alphabet to develop. It took man a long, long time to learn how to write, and we can only surmise how writing came about. Probably for ages and ages there was only spoken language.

You remember that in the early cave days men began painting pictures of the hunt and other exciting events on the walls of their caves. In a certain sense these pictures were a form of writing, because they expressed a man's thoughts, and whoever looked at the pictures could understand what had taken place just as well as if the story had been written out. It is thought that, as time went on, this drawing of pictures developed by slow degrees into making signs and symbols to express thought. At first written words were merely little pictures. If a man wanted to write " sun," he drew a little circle like this : . The moon was represented by a crescent, A star was a live-pointed figure, The sky was represented thus : . Wavy lines, meant water, and so on. But drawing a whole picture for every word was very slow. As man began writing more and more rapidly he learned how to give the idea he wanted to express just as well in a shorter way by leaving out parts of the picture. For instance, if he wanted to show a house, he would not trouble to draw the whole house but would make only the peak of the roof ; and instead of drawing

a whole man he might just draw a circle with dots for eyes, a vertical line for the nose, and a horizontal line for the mouth. This was much quicker and easier and people understood just as well as if the whole picture had been drawn. Sometimes two or more pictures were combined to express a thought. For example, when a man wanted to write " rain," he drew a picture of water turned downward and combined it with the picture of the sky, thus : If he wanted to

Papyrus growing on the banks of the Nile.

write " night," he added the picture of a star to the picture for the moon, somewhat like this : Also, as he came to express his thoughts more and more in writing, he found that certain ideas could not be expressed in pictures ; so he made up little signs for them. In natural ways like these the pictures gradually changed so that they no longer looked like the originals they were meant to imitate, and picture writing developed into a system of signs for expressing ideas.

The early Egyptians used a kind of picture writing which they cut in stone on the walls of their temples and tombs to make a permanent record of important events. For ordinary writing they used the papyrus, a tall graceful plant which grew plentifully in marshy places along the Nile River, sometimes reaching the height of eight or ten feet. Its triangular stem, often as thick as a man's arm, was made up of thin layers of fibres. Out of this the Egyptians learned to make a kind of paper. The stem was peeled off and the inner fibres separated by a sharp instrument and laid side by side on a flat surface with their edges overlapping. Other strips were placed over them at right angles. Then the sheets thus formed were dampened and pressed together with

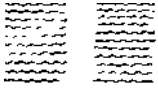
A portion of " The Book of the Dead," a famous Egyptian papyrus.

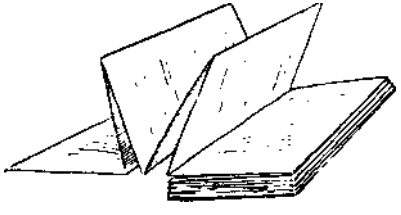
The earliest books were long scrolls rolled on sticks

heavy weights, dried in the sun, and fastened together into long rolls. Thus a long smooth surface was made for writing on. This was used in the form of a long roll, wound around two sticks, which the reader held in his two hands, the roll being unwound from one stick on to the other as it was read. These rolls were the first books.

The inconvenience of rolling and unrolling each time led eventually to the folding of the scroll between the columns of writing. The next step was to join the folds at the back, and the idea of economy suggested slitting the front folds and utilizing both sides of the page for writing. Thus came our modern form of book with its series of pages folded at the back. A thick cover was added for the protection of the pages of writing.

In Egypt the writing was done by scribes. The scribe's outfit consisted of two reed pens and a case, two little jars of water, and a palette with two round holes in which to make red and black ink. This outfit was often carried over the shoulder or in the hand, so the various things were tied together for convenience. When writing, the scribe made his ink in one compartment by mixing lampblack with water thickened with a gluelike vegetable gum. For red ink iron oxide was





The inconvenience of rolling and unrolling the scroll while reading led eventually to folding it between the columns of writing. This was the first step in the evolution of the modern form of book

Courtesy Metropol. Museum of Art

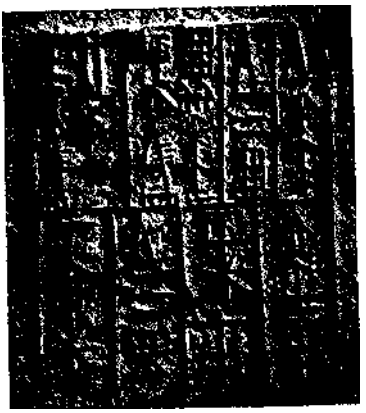
An Egyptian scribe at work. His pen case has places for making red and black ink, and his pens are stuck over his ear.

used. The use of red and black ink accounts for the two pens often seen stuck behind the scribe's ear.

Another kind of writing grew up in Assyria, where clay was plentiful. A lump of soft clay was spread out until it made a little tablet a few inches square. The Assyrians wrote on these tablets by pressing the clay with a sharp-pointed instrument called a stylus. It was difficult to make curves with the stylus, so their writing was made of little wedge-shaped marks like arrowheads. These tablets were dried by being baked in the sun.

In the course of time signs or symbols, instead of standing for a whole word, came to stand for parts of a word, and several of them were combined to form a word. This was the origin of the alphabet. You remember that the Phoenicians were the world's first great traders. In carrying on their trade the Phoenician merchants developed practices that would help them. They were the first people to keep accounts. They were also the first people to arrange letters in an orderly fashion to form an alphabet, for use in making their bills.

The Phoenician alphabet consisted of twenty-two signs which had evolved out of the pictures of familiar subjects simply made with all unnecessary details omitted. As the Phoenician traders travelled around and they came in contact with the other nations of the ancient world their alphabet gradually spread to other peoples. First it spread westward to the Greeks, then to the Romans, and through the Romans it was passed on to the later nations of Europe, and became the basis of the alphabet we use to-day. Of course it was greatly changed in the course of time, as each nation made changes



An Assyrian clay tablet.

in it to suit its needs. The Greeks found use for fifteen of the Phoenician signs, and added enough more to make twenty-four letters. The Romans borrowed from the Greeks and spread the alphabet to the far ends of the ancient world. Twenty-three letters of the English alphabet were taken from the Roman, and the English added three more for convenience. This is the alphabet that we use to-day.

Let us see how all of this worked out.

Since the getting of food was so important in early times it is not strange that the Phoenicians called the first letter of their alphabet " aleph," which was the Phoenician name for the ox. Only the head was represented, so : The Greeks modified it thus : Unknowingly they were drawing the ox's head upside down, and so it has remained to this day. The Greeks called their first letter "alpha."

Shelter is almost as important as food, and the second letter of the Phoenician alphabet represented a house, or more likely a tent, which was so much used for shelter in the early days. It was drawn thus : The Greeks turned it round and made it with two triangles . They called their second letter " beta." The Romans introduced the curves, which gave the letter the form in which we have it. If you will put together the Greek names for their first two letters (alpha-beta) you will see where our name " alphabet " comes from.

The third and seventh letters of the alphabet, C and G, come from the Phoenician word which represented a yoke or, as some think, the long neck of the camel. It was made like this The Greeks turned it around so, and the Romans rounded it and added a little bar to the G to distinguish it.

The next letter, D, represented a door, made by the Phoenicians . It does not look like a door but probably was meant to represent the triangular opening to the tent. The Greeks retained the triangular form. Romans rounded the two right-hand sides of the triangle into a half-circle in making the letter with one stroke, and thus it came to have its present form.

E was made from the picture of the window of a house, made originally After a while the Phoenicians, who wrote from right to left, found it more convenient to make it and the Greeks, who wrote from left to right, turned it about thus : E.

F comes from the Phoenician representation of a hook or peg. The form was The Greeks changed it to p.

Two fence posts and three horizontal boards gave us the form of the letter H, made by the Phoenicians thus : The Greeks simplified it to , and the Romans gave it the form it has to-day.

Parts of the body were represented in several letters. The hand held in profile and bent at the knuckles and wrist gave us the letter I, made by the Phoenicians . By the time the Romans received it, it was simply a vertical line.

Originally I and J were the same letter. It was not until the fifteenth century that it was realized that it would be more convenient to have two forms. Then a little tail was added to the I to make the J.

The letter K also came from the hand. It was originally made . If you point the thumb and first finger of the right hand toward your left you will see the resemblance. The Greeks changed it to our form.

The letter L comes from " lamed," which was the Phoenician name for the ox goad. They made it like this :

As the Phoenicians were great sailors, it is not surprising that the sign for water, was the origin of the letter M, or that the head of a fish, , was the origin of N. The Greeks straightened them up.

Man's eye was the original of the letter .O in the Phoenician alphabet. The letter retains to-day the form that it had originally.

P represents the mouth. The Phoenicians made it , the Greeks changed it to p, and the Romans made it curved as we do to-day.

made by the Phoenicians , represents the back of the head.

R comes from the Phoenician letter " resh," representing the profile, from its resemblance to the head supported by the neck, made thus : ^. The Greeks turned it round, but that made it exactly like the letter P, so the Romans added a down stroke at the end to distinguish it.

The letter S is from the Phoenician letter " shin," meaning the lower teeth. It was made W. The Greeks turned it on its side, , and the Romans gave it curves.

T is made from the sign or cross, X, used to mark cattle. The Romans raised the cross-bar and put it on top, thus giving the letter its present form.

The letters U, V, Y are all taken from the Greek upsilon. The Phoenicians had no need for these letters.

Phoenician			Greek	Roman
name	meaning	form		
Aleph	ox		A	A
Beth	house		B	B
Gimel	camel		Γ	C
Daleth	door		Δ	D
He	window		E	E
Vau	hook		F	F
				G
Cheth	fence		B	H
Yod	hand		ζ	I
Kaph	palm		K	K
Lamed	whip		Λ	L
Mem	water		M	M
Nun	fish		N	N
Ayin	eye		O	O
Pe	mouth		Γ	P
Qoph	head		Q	Q
Resh	head		P	R
Shin	teeth		Σ	S
Tau	sign		T	T
			Y	U
			Y	V
Samekh	post		X	X
			Y	Y
Zayin	weapon		Z	Z

How our alphabet came to be

U and V were originally interchangeable, but later on it was found more convenient to have two letters.

W was first introduced by the people of England. Although it more nearly resembles a double V, it is called double U because U was originally identical with V.

X comes from the Phoenician character meaning a post or support, made thus : ‡

Z is from the Phoenician ‡ zayin," †, meaning a weapon. The Greeks changed it to its present form.

Thus ends the story of how the ancient pictures were gradually changed into our A B C's.

The invention of writing was one of the greatest steps in the progress of mankind. It enabled man to set down his thoughts in permanent form and also to communicate with people at a distance. Before the days of written language things had to be remembered, and the memory is not always reliable. Sometimes we forget very important things. Then, also, the knowledge that one person possessed often died with him. With written language it could be preserved for future ages. Just think of all the great thoughts from the past that have been preserved for us to-day through writing. We have to thank the Phoenicians for this great contribution to the world's progress.

CHAPTER IX

IN FEUDAL DAYS

CENTURIES of war and confusion followed the great days of Rome as a world power. Until about 600 A.D. the various swarms of barbarians followed one another through Europe. During this time industry and trade died down. Many of the old cities were in ruins. Great centres of learning were destroyed. Libraries were burned. Art and literature declined. The four centuries after the passing of Rome are sometimes called the Dark Ages because during that time the marvellous civilization of the Greeks and the Romans disappeared in Europe, and it seemed as if the splendour of the ancient world had entirely passed away.

In time the great migrations ceased. The tribesmen established a number of kingdoms under their chieftains or kings, and the continent settled down to a more orderly existence. These people gradually built up a new civilization upon the ruins of the Roman civilization, and Europe entered upon a new period of history called the Middle Ages.

Of all the German peoples who settled within the Roman Empire, the Franks were the most important. They had conquered all of Gaul and part of western Germany. They prospered and grew strong. About 800 A.D. Charlemagne, or Charles the Great, became their king and made the Franks a great nation. He reigned for nearly half a century. Much of his long reign was filled with warfare. On even border warlike peoples were constantly threatening his lands. Charlemagne at the head of a great army would invade their territories and defeat them in battle. His conquests gave the Franks a larger empire than had existed since the Roman Empire had begun to break to pieces.

It was Charlemagne's great desire to set up a good government over all his vast realm, so that a better civilization might grow up.

He built splendid churches and public buildings. He made many just laws. He loved learning and set about educating his people. He founded schools throughout his kingdom. He gathered at his court the greatest scholars of his time and established a court school, in which learned men gave instruction to his children and those of his nobles. The emperor himself tried to learn to write and kept his tablets and writing book near at hand so that in his leisure moments he might practise making his letters. All this civilizing work, and the peace and order which Charlemagne maintained throughout his wide territory, made his reign the most important period of the early Middle Ages.

After Charlemagne died there was no ruler strong enough to keep his great empire together. Europe now relapsed into a long period of violence and disorder, during which Charlemagne's possessions broke up into separate and warring kingdoms. As no country of Europe at this time had a strong enough government to keep order, there grew up a curious organization of society called " feudalism." The king in each country claimed all the land in his kingdom, but as he was unable to manage it all, he gave large portions of it to his great lords, who in return promised to become his vassals, to be loyal to him and aid him in case of war. With great ceremony the noble knelt bareheaded before his king, and putting his clasped hands within those of the king, solemnly promised : " For these lands I make homage and fealty to you, my lord." Then placing his hands upon the Bible he declared : "I swear upon these four gospels of God I will always be a faithful vassal to you and defend you and your land against all invaders."

Then the king kissed his vassal upon the forehead and answered : ' I receive you and take you as my man and give you this kiss in sign of faith." The great nobles, in turn, gave parts of their land to lesser nobles, who in return for their protection, swore similar vows of loyalty to them. In such lawless times men were quite willing to become the followers of some more powerful man for the sake of his protection in time of need.

Many of the kings were no more than figureheads, often surpassed in power by their own nobles. So there arose a struggle among these strong lords for land, and a way of living based on the holding of land by force. Every noble took the land he wanted and held it until someone stronger took it away from him. So feudal princes were constantly struggling among themselves. Daring warriors gathered

bands of followers, seized new lands, and in turn were conquered by stronger warriors. War, plunder, conquest were the rule of life.

In order to be safe in a time of such constant danger, every noble had to live in a strongly fortified castle. This was usually built in some place hard to reach or attack, like the top of a steep rocky cliff or an island. A castle without such natural defences was usually surrounded by a wide, deep ditch, called a moat, which was kept filled with water.

A noble doing homage. He is swearing to be a faithful vassal and to defend the king and his lands against all invaders. (From an old manuscript.)

The castle and its grounds were enclosed by a massive stone wall, sometimes twenty feet high and six or eight *feet* thick. The top of this wall was made level so that warriors could walk around it, and the outer edge, called the parapet, was raised for their protection. But every few feet there were narrow slits in the parapet, through which the defenders could shoot arrows, or hurl stones, or pour boiling pitch, if their foes attempted to scale the wall. As an attack might be expected at any moment without warning a high tower was built at each corner

of the wall, where sentinels were stationed to keep constant watch for the approach of enemies and give the alarm by a blast of the trumpet. The only entrance to the castle was by a drawbridge over the moat which was always lifted at night and in time of danger.

When the nobles fought outside their castles, they protected their bodies with heavy steel armour so strong that scarcely any weapon could penetrate it. Their heads were covered by steel helmets with little slits to see and breathe through. They carried heavy shields and long swords and lances. They always fought on horseback, and the horse, too, had to have its body protected by armour ; for without his horse the noble was helpless in his heavy armour.

When they were not fighting the nobles passed a great part of their time feasting, and hunting, and playing at war. Their favourite sport was a sort of mimic battle, called a tournament. These mock combats took place in a railed-off space, called the lists, about which the spectators eagerly gathered, the fair ladies sitting under a canopy on a raised stand, the humble yeomen crowding about the ropes that enclosed the lists. On the day appointed, knights in full armour came from far and near and entered the lists, some at one end and some at the other. At a blast of the trumpet from the herald the knights rode toward one another at full speed, each one trying to unhorse his opponent.

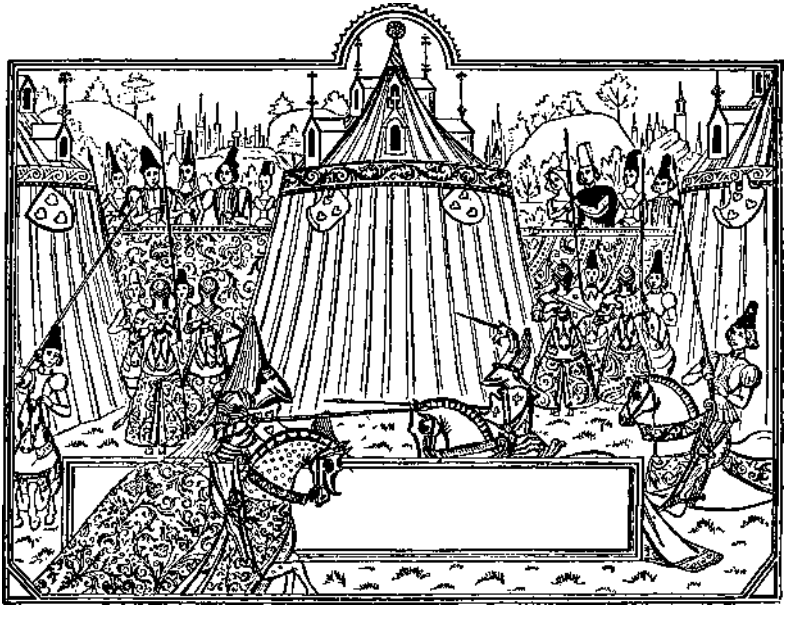
Victory went to the one who unhorsed his opponent or broke in the proper manner the greatest number of lances. At the conclusion the victor was invited to choose from among the ladies present the one whom he deemed the most worthy to be called the queen of love and beauty, and from her hands he received his prize.

Every boy of noble family was ambitious to become a knight when he grew up. He had to spend many years preparing for knighthood When he was only seven years old he became a page ; when he was fourteen he began serving as a squire.

When he came of age and it was time for him to become a knight, there was a solemn religious ceremony. The whole night before it, the young squire spent alone praying and meditating in church, kneeling before the altar on which lay his sword, his shield, and his lance. The next morning came a bath. Then he was clad in fresh new garments as he was to begin a new life—first a snow-white tunic, the symbol of purity ; then a red robe, symbolic of the blood he might be called upon

Courtesy Keystone View Co.

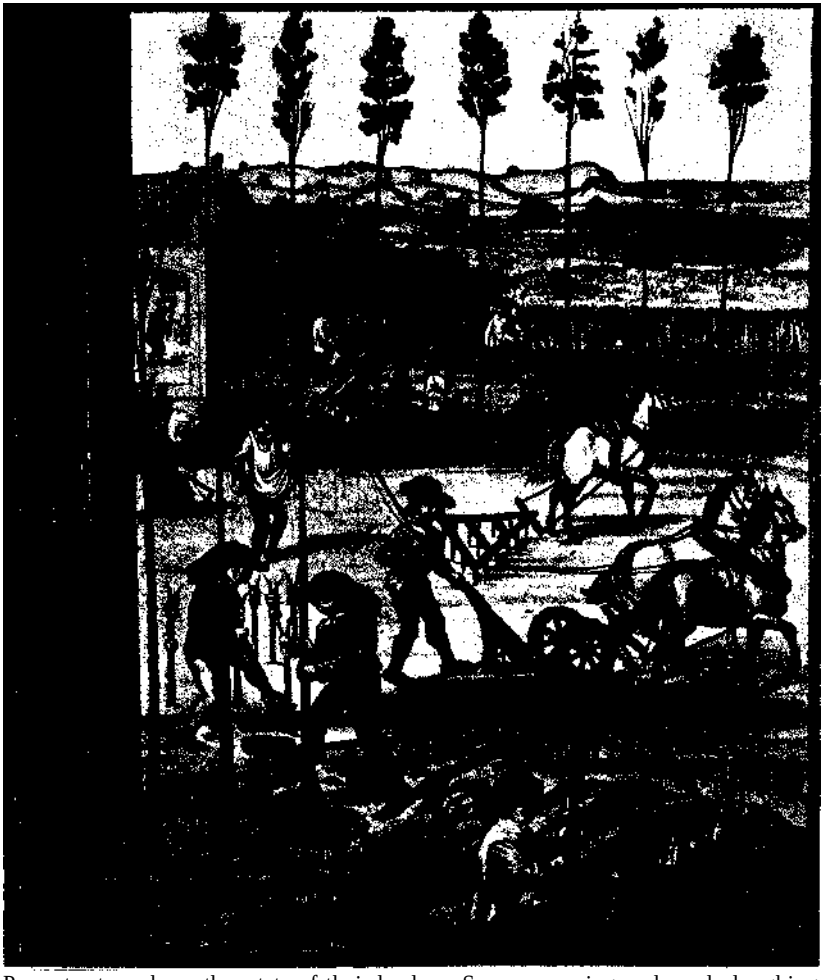
Carcassonne, a famous medieval castle, built high up on a hill. Far below are a high outer wall and a moat.



One of the favourite pastimes of the nobles was the tournament, a sort of mimic warfare, in which the knights displayed their prowess in the lists. (From a medieval manuscript.)

to shed in defence of the oppressed ; and over this a black garment, representing the mystery of death. He attended mass and listened to a sermon on his new life and duties. He gave his sword to a priest, who laid it upon the altar and blessed it. He made solemn vows to defend the Church, be true to the king, and help women in distress, for every knight must be a lover of Christ and a defender of the Church, and his weapons must be consecrated to God's cause.

Then the knight of the highest rank came forward to confer upon him the order of knighthood. The young man knelt before him with clasped hands, and solemnly vowed to uphold religion and chivalry. The lord buckled on the youth's sword with his own hands ; his golden spurs and his armour were presented to him ; then, tapping him lightly on the shoulders with his sword, the lord pronounced over him the solemn words : " I n the name of God, of St. Michael, and of St. George,



Peasants at work on the estate of their lord. Some are sowing seeds, and ploughing and harrowing, others are cutting and binding the grain. Still others are digging ditches and planting trees. The woman on her knees is weeding the garden, and the man in the barn is winnowing grain with a flail.
(From a miniature in an old manuscript.)

I dub thee knight. Be valiant, fearless, and loyal." And the young man rose a knight. Then the young knight, clad in his shining new armour and wearing his golden spurs, mounted a fine horse which a servant had been holding for him as his charger.

The good knight always kept his word, never took unfair advantage of others, protected women and children, and sought to make justice and right prevail in the world. If a knight broke his vows, he was entirely disgraced. His spurs were cut off, his sword broken over his head, his armour taken from him, and he was laid in a coffin and the burial service said over him just as if he were dead.

In a cruel warlike age chivalry gave men fine ideals of gentleness and courtesy. Our ideas to-day of the courtesy a gentleman should always show have come down to us largely from medieval days when knighthood with its high ideals of chivalry flourished.

There were not many knights. Most of the people were peasants. All the work was done by the peasants, who were called villeins or serfs. Day in, day out, rain or shine, in the cold of winter and in the heat of summer, they worked on the estate from sunrise to sunset, tending their lord's sheep and cattle, and tilling the soil with their rude tools, and raising the food and other things needed by the great lord and his fighting men. The peasants lived in a little village, usually of one street near the castle, in houses that were often little better than huts, with roofs made of thatch or interwoven boughs. In the smaller houses there were no chimneys, and the smoke from the fire escaped as best it could through a hole in the roof. The peasants were very poor and their lives were hard. They were not paid for their work, but had to give it and even some of the produce from their own little patch of ground to their lord in return for his protection.

Each castle with its surrounding land was really like a little kingdom ruled over by its great lord. He was absolute ruler. The peasants belonged to the lord who owned the land, and had to obey him in all things. They could not leave the estate without their lord's permission. They could not marry without his approval. They could not own their own homes. The children of peasants became peasants when they grew up. So generation after generation of peasants lived and died in the village where they were born, knowing little of what went on in the world beyond. They had no freedom but were bound to the soil, with little return from it except their living.

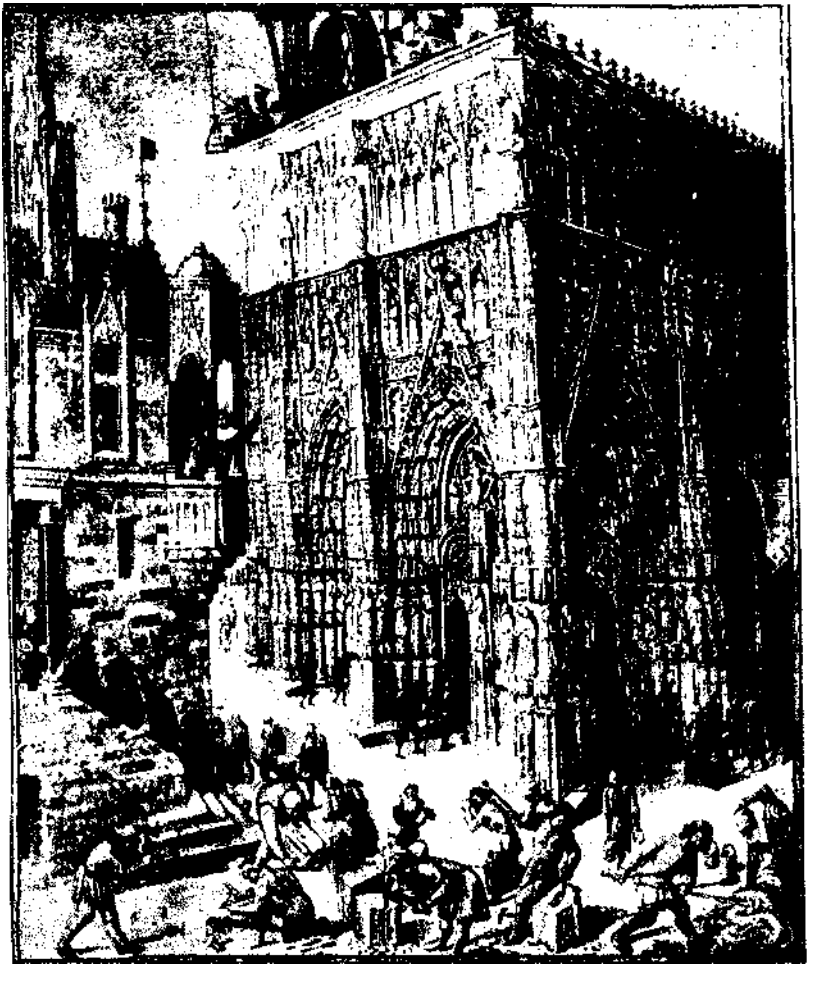
feasants darning at the May feast.
(From a fifteenth century miniature.)

But there were some bright spots to relieve the monotony of the peasants' daily round of labour. They loved to watch the gay processions of lords and ladies starting out on the hunt, to listen to a wandering minstrel, or witness a tournament. Best of all were the festival times and holy days of the Church, at Christmas or Easter, when they were free from work and could take part *in* the games and merry-making. The gayest day of the whole year was May Day, which they celebrated by singing and dancing their rustic dances around a Maypole on the village green.

During the disorder and strife of the early Middle Ages the Church came to be a very great influence. This was the great flowering time of the Christian faith. Before the Roman Empire came to an end Christian missionaries had carried their religion beyond the boundaries of the Empire to the barbarians. When the Teutonic tribes broke over the boundaries in the fifth century, many of them had already become Christians ; and by the eleventh century almost all Europe had been won to Christianity. So, although western Europe was split up into many nations, all of the people still belonged to the Roman Catholic Church.

The Church became a great power for good. It protected the weak and stood for peace and taught right living during the long period of strife and warfare. It wove itself into the daily life of all the people, the rich and powerful as well as the poor and lowly, uniting all classes of society from the greatest noble to the humblest peasant in the same form of worship and belief.

The great place that religion held in the lives of the people is shown by the many beautiful churches built during this time. All over Europe cathedral builders were busy, and craftsmen worked lovingly in stone and wood, seeking to express their ideas of faith and goodness. Master builders devised a new kind of architecture called Gothic. They learned how to erect high-arched roofs supported by many columns, and towering spires rising hundreds of feet into the heavens. The walls were often carved with beautiful figures in stone and were interspaced with great windows of quaintly designed stained glass in lovely colours, picturing scenes from the Bible. Many great artists were engaged in making decorations which adorned the walls and ceilings of the churches. On Sundays and great holy days, the church service was very splendid. The high altar was ablaze with the lights



Medieval workmen building a cathedral. The king is directing the work from the balcony of his palace opposite.
(From a miniature by Jean Fouquet, made in 1455.)

from many tapering candles, and beautiful banners and crosses were borne aloft as the procession of priests in richly embroidered robes solemnly approached it through long lines of humbly kneeling worshippers. Europe is still dotted with these magnificent monuments to the great faith of the people of medieval days.

Many religious men called monks believed that they could lead the best kind of lives by withdrawing from the world. They came together in great monasteries, leading quiet holy lives of faith and work

Monks at their devotions.
(From " The Miracles of Our Lady," written by the scribe Jean Mielot in 1456.)

and teaching people how to live in peace and charity. To them the poor and afflicted turned for help. Much time each day was given to fasting and prayer and reading the Bible. For most of the day, however, the monks worked industriously. Every monastery had its workshops where the monks made the various things they needed. Around the monastery lay its fields and woodlands. Here the monks raised their food and kept their cattle and sheep.

Many women also gave up the life of the world and became nuns. They founded convents where they lived together and worked, ministering to the sick and needy. Within their quiet convent walls they gave

much of their time to making fine needlework or embroidery. Most of the richly embroidered altarpieces and beautiful banners used in the church service were the work of their skilful fingers.

Religion led many people to travel during the Middle Ages. From very early times it had been considered an act of piety to go on a

Pilgrims on their way home from the shrine of Thomas a Becket at Canterbury.
(From a medieval manuscript.)

pilgrimage to a place connected with the life of Christ, or to the grave of a holy man. People believed that this would win forgiveness for their sins or would bring them good fortune. The pilgrimage that they most wanted to make was to the Holy Land, where Christ had lived. They wanted to see with their own eyes the place where he was born, and to kneel in prayer at his tomb. So from very early days a stream of pilgrims from every European country had visited Palestine.

In the eleventh century Palestine and Jerusalem, the Holy City, fell into the hands of the Turks, who were followers of Mohammed. They treated the Christian pilgrims very cruelly and prevented their worshipping at the Holy Sepulchre. Returning pilgrims brought back to Europe with them many tales of outrages committed by the Turks. Such a sacrilege did this seem to the devout Christians of the Middle Ages that it roused all the nations of Europe.

In the year 1095 Pope Urban called a great meeting of churchmen and nobles, and preached a powerful sermon urging the nobles to rescue the Holy Sepulchre from the infidels. " It is the will of God that you fight this quarrel in his cause," said he.

All who heard the Pope were deeply moved. " *Dens vult ! "* (God wills it), they shouted. And they fell upon their knees and took vows of service in the holy war. Then noble after noble pressed forward to receive the cross of red cloth to wear upon his breast as a symbol of his vow. Those who took the cross were called crusaders, that is, cross-bearers.

Crusaders setting out for Jerusalem.

Pope Urban sent preachers through all Europe calling upon the people to help free the Holy Land, and before long thousands and thousands of people from all classes of society -kings, nobles, peasants, monks, even children—flocked from all parts of Europe to join the armies that started out to drive the Turks from Jerusalem. For about two hundred years, armies set out every now and then for Jerusalem. But the Crusades were unsuccessful, and finally about the year 1300 they came to an end

CHAPTER X

GREAT CHANGES

FOR several centuries the great lords in their castle-fortresses and the steel-clad warriors on horseback ruled over all Europe. But their rule was destined to pass away. The world is always changing, and gradually the customs and ways of living of the Middle Ages changed. Many forces were slowly working for the greater freedom of the masses of the people.

Although the Crusades failed, they brought about many changes in the lives of medieval people. During the many centuries when the nations of Europe had been growing up, wonderful civilizations had been developing in the countries of Asia. But they were far away and were separated from Europe by high mountains and great stretches of desert, so that the people of Europe knew little about them.

During the Crusades countless thousands of people, most of whom had never been more than a few miles from their birthplaces, went to the East and learned for the first time about many things which the people of the various countries of Asia had and enjoyed. The Persians dressed in gorgeous red and purple stuffs, heavy with beautiful embroidery. In Arabia were to be found beautiful tapestries and delicate wines and sweet-smelling perfumes and rare fruits. India was a land of gold, and great temples filled with statues of marble and bronze. And in the islands beyond India grew rare spices—cinnamon and cloves and nutmegs. Still farther away was Cathay, as China was called in those days, with its embroidered silks, and carved ivory, and precious gems. The people of Europe had none of these things. Is it any wonder that Asia seemed to them like a wonderful treasure house of richness and beauty ?

Besides the Crusaders, other travellers journeyed to the lands of Asia, and brought back strange tales of their marvellous wealth and of the thousand and one wonders they had seen there. Among the most

noted of these were two merchants named Polo, who lived in Venice. Hearing about the mysterious land of Cathay, they decided to visit it. They took with them their nephew, Marco, a boy about fourteen years old. Across the Mediterranean they sailed to Constantinople, and then they travelled by land to the court of the great Kublai Khan, emperor of China. They lived for many years at the court, and the emperor took quite a fancy to young Marco, sending him on many important

The Polos leaving Constantinople on their way to the East. (From the " Livre des Marseilles," a fifteenth century book.)

missions to far-off ports of his empire. In this way Marco saw the great lands of the East from one end to the other.

At last the Polos wearied of the East and decided to return to Venice. So they bade farewell to Kublai Khan and journeyed home. When they arrived in Venice no one recognized them, dressed in their odd Tartar garments that were shabby and travel-stained. No one would believe that they were the great Polos who had left Venice so many

The landing of the Polos in Persia on their way home from the court of Kublai Khan.
(From the same book.)

years before. People thought that they were impostors. The cousins of the Polos, who were living in their house, refused to let them in. Something had to be done, so the Polos devised a scheme. They arranged a magnificent banquet to which they invited all their relatives and friends. They dressed themselves in beautiful robes of crimson satin reaching to the floor. When the feast was over, Marco, going into another room, returned with the old padded garments which they had worn on their arrival. Taking a sharp knife, he quickly ripped

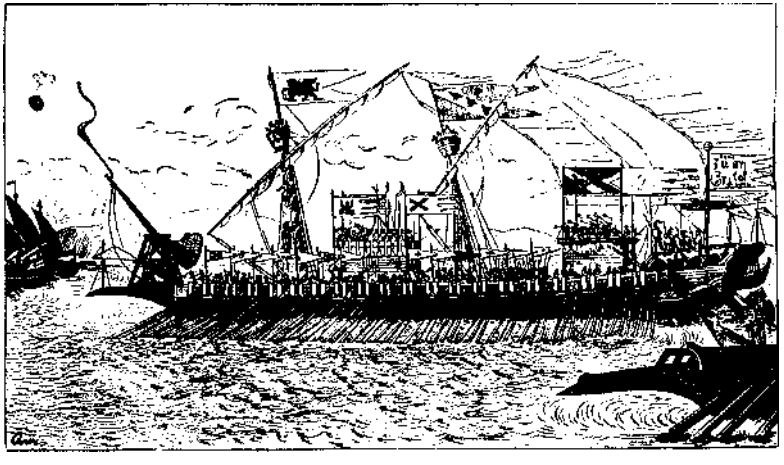
open the seams, and from the linings poured a great stream of gleaming sapphires, rubies, emeralds, diamonds, and other jewels of great value, which the Polos had carried hidden in this way for safety on their long dangerous journey from the East. They had been so artfully stitched

The Polos returning to Venice from China are denied admission to their own house.
(From Sir Henry Yule's " Book of Ser Marco Polo.")

in that no one would have dreamed they were there. Dazzled by the sight of such great wealth, the guests were now quite ready to believe that these men really were the Polos.

Marco Polo never tired of telling wonderful stories of Kublai Khan and his great empire, and people never tired of hearing his tales. They

seemed to open up a perfect fairyland on earth. A few years later in a battle between Venice and Genoa, Marco Polo was captured and cast into prison. To while away the time, Marco related his many adventures in the East to a learned man who happened to be put into the same cell. This man persuaded Marco to let him write down his story, for, he said, " never hath there been any man of any nation, who in his own person hath so much knowledge and experience of the divers parts of the world and its wonders as hath had this Messer Polo." Thus the



Marco Polo's galley going into action in a war between Venice and Genoa. It has a sharp beak and a war machine at the bow for ramming boats, and crows' nests on the masts for lookouts and archers.
(From the same book.)

story was written down and, after printing was invented, it was published and was eagerly read by people all over Europe.

It is not strange that tales of riches like those told by Marco Polo and other travellers to the East should have stirred the imagination of the people of Europe, and that they should have longed for the rare and precious things that were to be found in the great countries of Asia. Traders therefore set out from European ports to get these things, and gradually introduced them into Europe. People now became interested in making their dress and their homes more pleasing. Instead of

covering their floors with rushes, they began using Persian carpets and rugs. Instead of dressing in coarse European woollens they bought soft Eastern fabrics made of camel's hair, or beautiful Chinese damask. They hung gaily coloured tapestries from Arabia to brighten the stone walls of their gloomy castles. They bought rich jewels with which to adorn themselves, sweet-smelling perfumes for the toilet, rare fruits for the table, and rich spices with which to season their food.

To supply all these new needs, centres of trade and manufacturing, or towns, grew up. In the beginning a town usually belonged to some

Shops in a medieval town. On the left are tailors at work with the finished garments above them for sale. At the right is a grocer, and in the background a furrier. In the centre a barber is shaving a customer.
(From a medieval manuscript.)

noble. The people of the town had to pay him taxes and had no voice in ruling the town. But the rapidly increasing trade brought wealth to the townspeople. The king or noble who owned the town was sure to need money sooner or later, and the people would agree to give it in return for certain rights or privileges that they wanted. In this way the towns gradually freed themselves from the nobles and began governing themselves.

The use of money and the growth of towns helped many of the serfs to become free. During the early part of the Middle Ages there had been little money in circulation. The great lords produced everything they needed on their great estates, and the peasants received the use of the land instead of wages ; so money was not greatly needed. But with the growth of towns and commerce the supply of money increased. When money came into circulation, the lords often accepted money payments from the peasants instead of services. So a peasant was often able to buy his freedom, when his lord needed money. Many fathers bought freedom for their sons so that they need not be peasants.

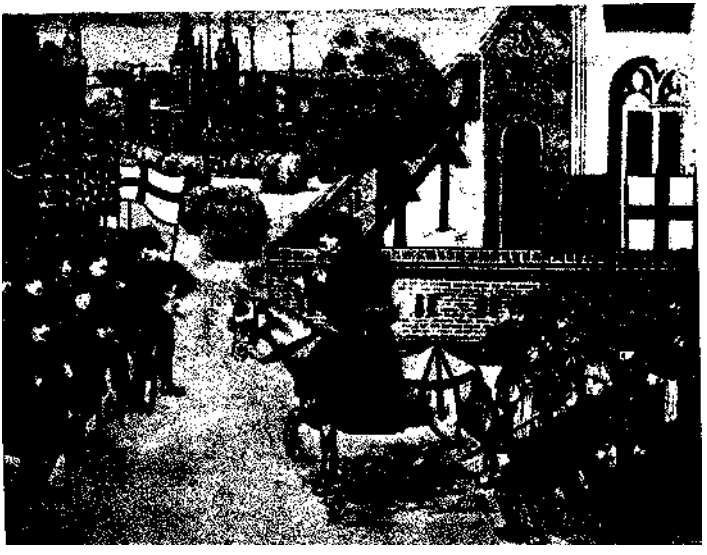
A peasant was forbidden by law to leave his master, and he was liable to be punished by being put in the stocks or cast into prison if he broke the law. If, however, he could manage to run away and remain for a year and a day within the boundaries of a free town, he acquired his freedom. Freedom was the ambition of every peasant, and in one way or another, many peasants found their way out of bondage into the freer life of the towns. There they engaged in trade and often became wealthy. The men who practised the same trade often lived side by side *on* the same street, each working in his little shop at the front of his house and selling the goods he made. They still had to work hard, but they were free.

With the growth of trade it became common for men engaged in the same craft in a town to organize a guild, which gave them certain rights and privileges. There were guilds of weavers, carpenters, butchers, bakers ; in fact almost every trade had its guild. They were a great help to the workmen. They made rules for the hours of work, they fixed the prices of articles, they regulated wages. They helped members who were sick or in need. If a member died poor, leaving a widow and children, the guild cared for the family. So the members of the guilds came to have a strong feeling of brotherhood for one another. The guilds also built beautiful halls, where on days of

ceremony the members held great banquets and had many good times together. Often they gave plays ; and because religion entered so largely into their lives, these were usually based on scenes from the Bible.

One other happening greatly helped in freeing the serfs. In the year 1348 a terrible plague called the Black Death swept over Europe, causing the death of thousands and thousands of people ; many of these were peasants. Because of this many of the lords no longer had serfs enough to do their work. The fields were left unfilled, the sheep and cattle strayed over the deserted fields with no one to care for them, and the great nobles saw their lands going to ruin. All of this led to trouble between the workers and the great landowners, and brought about revolts among the peasants against the whole system of social inequality.

One of the leaders of these revolts in England was a poor preacher named John Ball. Every Sunday, after mass, as the peasants came



The poor preacher, John Hall, addressing the peasants. His preaching so roused the peasants that they revolted in 1381.
(From the Chronicles of Froissart.)

out of church, he would gather a crowd around him and talk to them in some such way as this :

" My friends, things will never be well in England so long as goods be not common, and so long as there be vassals and lords. By what right are they, whom we call lords, greater folk than we ? On what grounds have they deserved it ? For what reason do they hold us in bondage ? Are we not all descended from the same father and mother, Adam and Eve ? And what reason can they give why they should be more masters than ourselves, if it be not they make us gain for them by our toil what they spend in their pride ? They are clothed in velvet and warm furs, while we are forced to wear poor clothing. They have wine and spices and fine bread, while we have only oatcakes and water to drink. They have leisure and fine castles, while we must brave the wind and the rain in our labours in the fields. And yet it is by our toil that they hold their state."

Such speeches as this roused the peasants, and they decided to go to London and put their grievances before the king. They believed that he would *get* justice for them. Along the country lanes and roads they tramped, farmers carrying their scythes and pitchforks, blacksmiths with their hammers, wood-cutters with their axes, shouting as they went :

" When Adam delved and Eve span,
Who was then the gentleman ? "

And about sixty thousand of them arrived in London under the leadership of John Ball and Wat Tyler and Jack Straw.

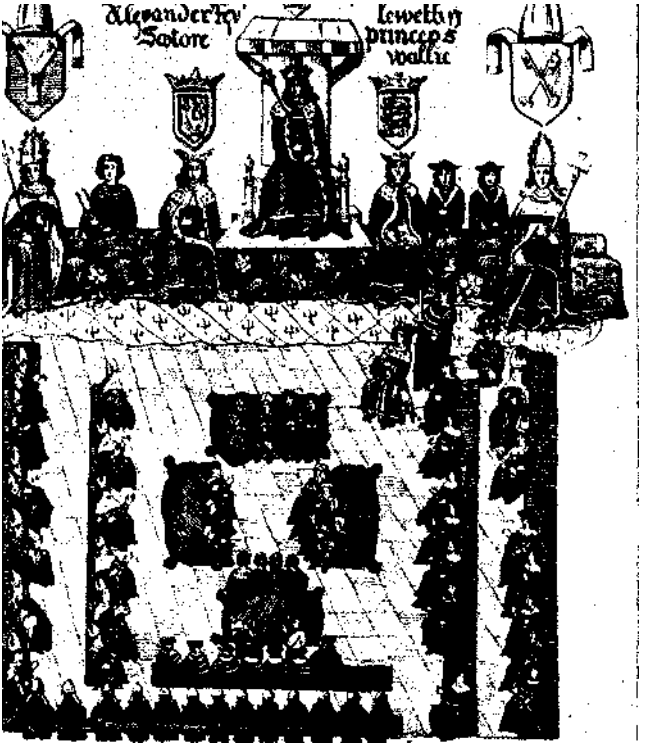
The young king, Richard I I , rode out to meet them, saying : " My good people, I am your king. What is it you want, and what is it you would have me do ? "

The peasants answered : " We wish that thou wouldst make us free for ever, us, our heirs, and our lands, and that we should no longer be called slaves and be held in bondage."

The king replied : "I grant your wish. Now therefore return to your homes."

The greater part of the people departed, saying : " It is well said. We do not wish for more."

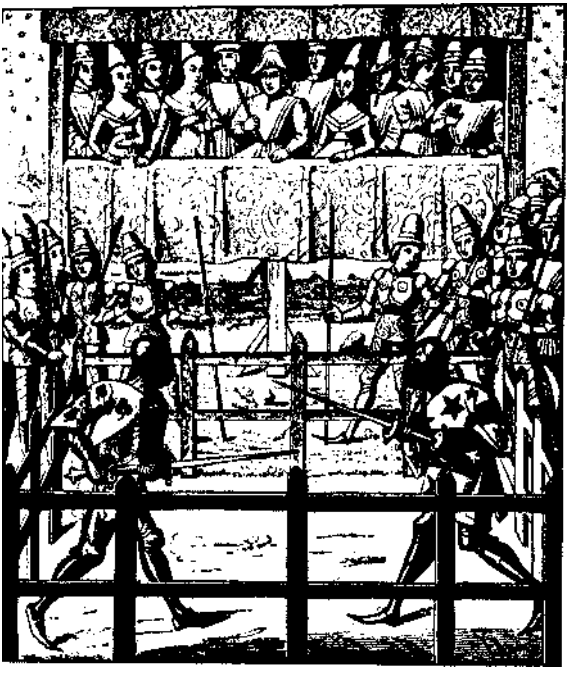
But then the king and his party turned against the peasants and had their leaders seized and executed. So this attempt of the poor



A meeting of the House of Lords in the thirteenth century. The king is on a dais with great princes and churchmen beside him. The lords are seated on woolsacks -large cushions stuffed with wool, which were placed in the House of Lords to remind the peers of the importance of the wool trade to England.
(From a medieval manuscript.)

peasants to get their freedom failed. Nevertheless a seed had been planted in the mind of the common folk that took root and grew steadily as the ages passed.

We have also during the Middle Ages the beginning of representative government. It came about in rather an interesting way. The kings



Trial by combat. The accused and the accuser fight, and the one who is defeated is thought to be guilty.
(From a miniature in " Ceremonies des Gages de Bataille," a manuscript of the fifteenth century.)

often had great trouble in governing their great lords. Every little while there would arise a king who would take away some right or privilege gained. Such a king was King John of England. He was really a very bad king. He robbed the nobles of their lands. He made many people, even the rich and powerful, pay heavy fines. Enemies

Trial by jury : a scene in one of the earliest law courts. At the top are the judges; in front of them are the clerks with their parchment scrolls. At the left jurors are being sworn in. In the middle stands the prisoner with his jailer and the counsel for the prosecution and the defence. In front are other prisoners waiting to be tried. (From a medieval manuscript.)

of the king were thrown into prison and sometimes kept there for years without being tried to find out whether they were guilty. Time and again John made fair promises to the nobles and afterward refused to keep them. At last the nobles decided to endure the king's tyranny no longer. In the year 1215 they met secretly and set down all the rights they thought no king should take away from them. This document is known as Magna Carta, or the Great Charter.

The nobles asked John to meet them at Runnymede, a broad stretch of meadowland on the Thames River not far from London where the old Saxons held their meetings ; and the king had to come. Fully armed as if for battle, all the most important lords of the realm appeared before John, read the charter to him, and asked him to sign it. When John heard what he was expected to sign, he became very angry and cried out : " Why don't they ask me for my crown ? I will never grant liberties that will make me a slave." But John had to yield to the will of the barons or lose his kingdom.

Two very important rights were included among those in Magna Carta. One was that no freeman should be thrown into prison and kept there without being tried. The other was that the king should not impose taxes without the consent of the barons. Thus the foundations of personal and political liberty were laid in England on that June day in the thirteenth century when King John unwillingly set his seal upon the great charter of English liberties and took a solemn oath to keep its promises. Before this kings had acted as if they were above the law. Now it was set down in black and white that the people had certain rights and that the king had certain duties toward his people.

In order to make sure that John, and all future kings as well, kept the charter, it provided for a council of twenty-five barons. All the most important nobles of the realm were members of this council. " They have given me five-and-twenty overlords," cried poor John, when he heard about the council. This council came to be known as parliament, from the French word *parley,* meaning to talk.

After about fifty years representatives of the towns and counties chosen by the merchants and traders were admitted. Thus parliament became a more representative body. After a while the representatives of the counties and towns met in one room, called the House of Commons, and the lords and higher clergy met in the House of Lords.

GREAT CHANGES

In the beginning parliament's chief business was to raise money for the king's treasury. But it was not long before parliament, in return for the money it paid, began asking the king for changes in the laws made by him. In the course of time the rule was made that the king should make no law and lay no taxes without the consent of parliament. This was a tremendous step forward in the gaining of civil liberty by the people. From then on a king could no longer rule exactly as he pleased. He had to obey the laws of the land which were made by the representatives of the people in parliament.

Another great improvement was in the method of trying people accused of crime, to decide whether they were innocent or guilty. For

This picture from the Chronicles of Froissart shows the method of attacking a castle or a walled town before gunpowder came into general use.

many centuries there had been several very strange ways of trying people. One of these was called the ordeal by fire. A piece of red-hot iron was blessed by a priest and placed in the hands of the accused person, who had to carry it three paces. Or he might have to plunge his hand into boiling water, or walk over red-hot coals. It was thought that if he was innocent no harm would come to him, or any burn would heal right away. If at the end of three days he had no wound, he was declared not guilty.

Another method was the ordeal by water. A pond or stream was blessed by a priest, and the accused person was tied hand and foot and thrown in. If he sank it was thought that he was innocent because it was believed that holy water which had been blessed by a priest would not receive a guilty person.

Still another form was the trial by combat. The accused and the accuser appeared before their lord. After reciting his grievances, the accuser threw down his gauntlet as a challenge to arms, and the accused picked it up to show that the challenge was accepted. On the day appointed for the combat each swore on the Bible and the cross that his cause was just, and God was asked to show the right. Then they donned their armour and fought each other with clubs or swords. The person who won the combat was thought to be innocent.

About the middle of the twelfth century King Henry II of England worked out a better way of trying people. He sent his judges to all parts of England. In each district the judges picked out twelve men who were to bring to their notice any person suspected of crime. These men talked with the accused person, and found out all they could about him from his neighbours ; and after all the evidence was gone over in court it was decided whether the person was guilty or innocent. As the twelve men had to swear to the truth of the facts they related they were called jurors, from the Latin *word juro,* meaning " I swear." This was the beginning of the system of trial by jury which we have to-day.

With all these great changes giving greater freedom to the people the old feudal system was breaking down. The days of the knights in armour were almost over. Then came a new invention that sealed their fate. About 1340 the people of Europe began using gunpowder for the first time, and the gradual spread of fire-arms had a far-reaching effect upon the way people lived. Up to this time the only kinds of weapons they knew about were those used by the ancients, such as the sword,

the spear, and the crossbow, the mangonel for hurling stones, the battering ram to break down castle walls, and the movable tower to lift besiegers to the top of a wall. Now, with cannon and gunpowder, it was no longer necessary to go close up to a castle ; it could be attacked from a distance. And the thick stone walls, moats, and other forms of defence were no longer valuable. A castle was therefore no longer the

An attack upon a castle after gunpowder came into use.
(From a medieval manuscript.)

safe retreat it had once been ; in fact, now, in case of an attack, it was little more than a trap. Even the strongest fortress was helpless against this new invention, and armour was no protection against bullets. People now began building houses less like fortresses and more like comfortable homes with walls only thick enough for protection against the weather, and with broad windows admitting light and air. The rich built great palaces and beautiful country estates surrounded by terraced gardens with fountains and curving walks.

The Crusades also had a great deal to do with putting an end to feudalism. Many of the Crusaders sold their lands to raise money for their expeditions. Many of them never returned from the Holy Land and their estates passed to the king. In many ways the kings in the various countries were able to strengthen their power while their unruly lords were away fighting the Mohammedans, and they became strong enough to exert their authority, to put down private warfare, and maintain order in their kingdoms.

So by the end of the fifteenth century the great feudal strongholds were deserted and the castles with their fighting knights and nobles were gone. Many of them remain in ruins to-day as silent reminders of a bygone day in the world's history when they served a useful purpose.

A scribe copying a book by hand. He steadies his parchment with a weight and holds a ruling knife in his left hand. By his side are three ink bottles and on the wall hang his paint pots, In the' open drawer are three more pen holders and a double eyeglass.
(From a picture made by the monk Jean Mielot in the " Miracles of Our Lady " in 1456,)

CHAPTER XI

THE **WORLD LEARNS TO** READ

AND now we come to one of the most tremendous changes during the Middle Ages. This was the new way of making hooks through the invention of printing.

One of the great things the Church did was to keep education alive through the long strife and turmoil of **the** feudal period. The monasteries were the centres of learning. Scarcely anybody except the monks could even read or write, and for almost a thousand years there were no schools outside the monasteries, When we think of all the books we

A page from the Book of Hours belonging to Queen Anne of Brittany, made by a scribe, with a beautiful border done in rich colours on a gold background. If you look closely, you can see the snail, the grasshopper, the butterfly, the caterpillar, and the ladybird all worked into the design.

have to-day it seems hard to realize that, as late in the world's history as the middle of the fifteenth century, there was not a single printed book in existence. The only books were those written by the monks. Every monastery had its writing room, called a scriptorium, where the

The cover of a medieval book made of beaten gold inlaid with jewels and enamels.

monks who showed particular ability in writing worked patiently, day after day, slowly and carefully copying manuscripts by hand. It often took even a skilful and industrious scribe several months to make a single copy of a book. Many books were beautifully decorated, and these, of course, took even longer to make.

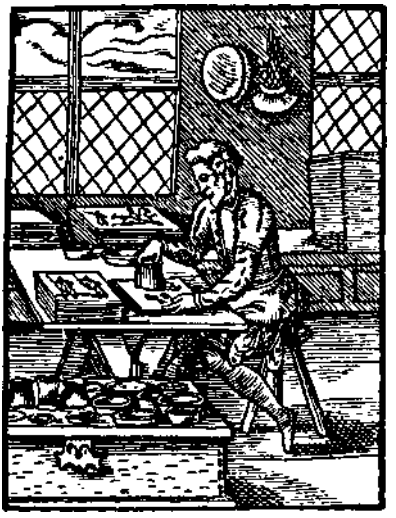
The books made by the monks were very beautiful. Instead of paper they used parchment made from the skins of lambs, upon which they wrote with pens made from goose quills. On their parchments they copied sermons, hymns, prayers and recorded events which seemed important to them. It was the monks' custom to begin each chapter with a large, elaborately drawn capital letter in coloured inks, beautiful blues and reds which they produced from berries and flowers.

Medieval ladies and gentlemen playing cards.
(From an old manuscript.)

After the book had been copied by the monk, it was sent to an illuminator who made lovely coloured illustrations called miniatures, in the spaces that the scribe had left for them. Every bit of space on a page was made gay with colour. Often even the margins were filled with quaint ornamentation—flowers, birds, butterflies, little animals, even caterpillars and little insects—all painstakingly worked into a lovely design. When the parchment leaves had been written and decorated the binder encased them in covers made of beaten gold, with rich jewels and coloured enamels set in. Other books were more simply bound in

leather, but they too were beautifully decorated according to the fancy of those artists of olden days.

Under such circumstances *it* is not strange that books were rare and precious. Even wealthy people seldom owned more than one or two. Most of them were kept in the monasteries, for books were not of much use to people who could not read or write. A book was considered the noblest present that a monastery could make to a great prince. Not until a quicker way of making books had been discovered could books be produced in such numbers that everybody could have them. This was brought about in the middle of the fifteenth century through the invention of printing.



A medieval workman colouring playing cards by sweeping a brush over a *metal* stencil. Neat piles of finished cards are before him.

(From a sixteenth century woodcut by Jost Amman)

It may seem strange to think that we owe this invention to playing cards, but it came about in a very natural way. Card games had been very popular in China long before any one in Europe knew about them. Probably travellers to the East learned to play them while they were there. We can well imagine with what pleasure they discovered these new games and brought them back to Europe. They soon became a favourite amusement with rich and poor alike, and the making of playing cards became an important industry in Europe.

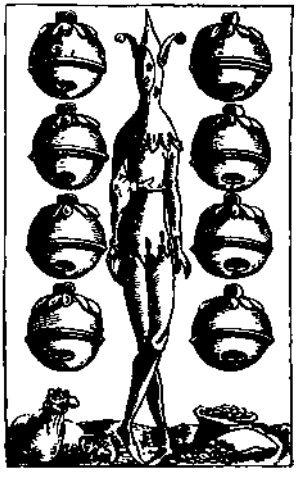
At first cards were made and coloured by hand. Then it was found that they could be made more quickly by stencilling, that is, cutting the figures out of thin pieces of metal, placing them over the cards, and brushing them over with ink or a colour. Later still the figures were cut out of blocks of wood and printed on the cards.

When people saw the effect of cutting figures from blocks of wood for making playing cards, they began cutting scenes from the Bible and the lives of the saints in the same way, cutting out simple outlines of

the figures with perhaps a few lines of text below. These image prints, as they were called, were much sought after, especially by the poor people. They liked to put them up on the walls of their homes, believing that they protected them against evil.

One of the most popular of these prints was that of St. Christopher, who was the symbol of the Church. This was a quaint picture showing the giant figure of St. Christopher crossing a stream (you can see the little fish at the bottom of the water) with an uprooted tree for a staff, and bearing a child on his shoulders. According to the legend, it was the duty of St. Christopher to carry people across the stream beside which he lived. One evening a child presented himself. He was so light that St. Christopher easily lifted him to his shoulder with two fingers. But he grew heavier and heavier, until finally the good saint was staggering under his load. He looked up to see the cause of this, and the child said : " Wonder not, good friend, I am Jesus, the Lord of the world, and you have the weight of the sins of the whole world upon your back."

On the left bank of the stream is pictured the earthly life of man with its familiar daily occupations. A peasant is driving a donkey loaded with a sack of grain to the water-mill to have it ground while



The three-spot and the eight-spot from an old German set of playing cards.

A famous medieval woodcut of St. Christopher made in 1417. He is fording a stream with the infant Jesus on his shoulder. On the left is represented the life of this world: a miller is taking grain to a mill to be ground and a peasant is carrying a bag of flour from the mill to his home. The right symbolizes the spiritual life . a hermit is holding up the lamp of faith to the wayfarer.

An artist cutting a wood block.
(By Jost Amman)

another peasant is toiling up a steep hill to his humble home with a bag of flour on his back which he has just had ground. The right bank of the stream represents the life of the spirit. There we see a hermit kneeling in front of his hut, and holding the lantern of faith high over his head as a beacon to whatever wayfarer the ferryman may bring across. Underneath the print is a couplet in Latin, which says:

> Each day that thou the likeness of
> St. Christopher shalt see,
> That day no frightful form of death
> shall make an end of thee

From making such single prints with simple texts, to making a series of prints with connected texts like a continued story and fastening them together, was but a step ; and so there came into being what were called block books (because each page was printed from a block of wood). One of the earliest block books was the Biblia Paupcrum, or Poor Man's Bible, a book of forty pages of pictures from the life of Christ and Old Testament scenes. On each page were four portraits (two at the top and two at the bottom) of the prophets whose writings were used in the text. The middle part of each page consisted of three pictures, those to the right and the left being scenes from the Old Testament and the one in the middle a scene from the New Testament. The poor people could not afford the beautiful hand-made Bibles of the monks, but these simple picture books became very popular.

Block printing was much more rapid than the monks' laborious copying of books, line by line, for a number of prints could be made from the same carved block. But the block could print only the particular page for which it was made because *it* was all one piece. About 1450 John Gutenberg, who lived in Mainz, Germany, thought of a much quicker way of making books.

A page from the Biblia Pauperum, or Bible of the Poor, a block-book made in 1470. At the left is pictured the Burning Bush, in the centre the Birth of Christ, and at the right Aaron's Rod.

John Gutenberg cut and polished stones for a living. One evening after supper, we are told, as he and his wife were sitting in the room behind their little shop, he picked up a playing card and began studying it. He thought he could make one. In his first leisure time he took a block of wood and drew a picture on it. Then he cut away the wood, inked the high part, and pressed it on a piece of paper. Several weeks later, he surprised his wife by showing her a number of playing cards he had made.

Gutenberg looking at a page of printing from the lust printing press. (From a modern engraving.)

"Now I will print thy name on a block," he said. Cutting away the wood so that the letters were exposed, he moistened them with ink, pressed them carefully on a piece of paper—and there stood his wife's name Anna .

Early paper making: Pulp made from rags was beaten with the aid of a water-wheel ; then a thin layer was spread over a sieve and the water drained out, and the sheet of paper pressed and hung up to dry. In this illustration from a book on machinery printed in 1662, you can see the pulp in the tub, one man about to put some in a sieve, another at the press, bundles of rags below, paper hanging above to dry, packages of finished paper at the left, the water-wheel, and a man carrying away some paper on the back of a donkey.

A fifteenth century schoolmaster and his scholars. Notice that he is provided with a switch.
(From a medieval book.)

"Famously done," cried his wife, smiling with pleasure at seeing her name in print.

Encouraged by his success, Gutenberg made several prints of St. Christopher which he placed in his shop window. People admired them, and many bought the prints instead of buying gems. Day after day, after this, whenever Gutenberg had a moment to spare, he devoted it to making prints. The abbot of a near-by monastery gave Gutenberg a copy of the Biblia Pauperum and said that he would take all the copies he could make.

While he was engaged at this work, a great idea came to Gutenberg : instead of cutting all the words at once on a block, why not cut the letters separately so that they could be used over and over in any combination he needed to make words ? That would be a much quicker way of printing. He went to work with great eagerness. Sawing a big piece of wood into a thousand tiny blocks, he carved a letter on each block. Soon he had a pile of all the letters of the alphabet, each letter on its own little piece of wood. He tied several of them together in a row to form words. In time he made a wooden frame to hold the type while he was setting it. After inking the letters with a ball of leather stuffed with wool, he spread paper over them, laid a blanket over it to soften the impression, and then screwed a heavy press down on top of the type. Thus the first printing press in the world came into existence.

In this way Gutenberg could print as many copies of a book as he wished and then take the letters out of the frame and put them away in

their little boxes ready for use in new combinations whenever they were needed for other books. He found, in using the wooden letters over and over again, that they soon lost their shape so that they did not make a clear impression ; and he began making type of metal, which was much more durable and made a hard clear-cut line.

There could not be much printing, however, without a cheap and plentiful material to print on. Even Gutenberg's great invention would not have been much use if men had not found a way to make cheap paper. Parchment, on which the monks made their books, was expensive, and it was not suited for use with the printing press. Fortunately the making of paper from rags, which was introduced into Europe from the East at this time, supplied a cheap material. The Arabs had learned from the Chinese how to make paper by beating rags into a pulp and pressing the pulp into thin sheets, and they brought this knowledge to Europe. Large waterwheels set in motion a wooden cylinder which was spiked with heavy wooden projections. As the cylinder revolved, these projections first tilted high in the air and then dropped with great force upon torn and well soaked rags, gradually beating them into a pulp. This was then transferred to tubs. Then a man with a sieve made of fine wire in a wooden frame the size of a piece of paper dipped it into the pulp. As he shook it gently to and fro in a horizontal position, the water was drained out through the sieve and the fibres of the pulp became matted together. Then it was put under a heavy press which squeezed out all the rest of the water, and the paper was hung up on a line

The first primer was called a horn-book. It was a sheet of paper on which were printed the alphabet and the Lord's Prayer, placed in a frame of wood and covered with a thin sheet of horn to protect it. It had a handle in which was a hole for a cord by which it could be fastened to the girdle.

to dry. Now men had a material for writing that was cheap and durable and one that would easily receive the impression of the type in printing.

The first book Gutenberg printed on his new press was, very naturally, the Bible. At first all books were printed in Latin, the language of the Church, but gradually they came to be printed in the

Medieval scholars.
(From an old print.)

languages of the various countries. Then people no longer had to understand Latin in order to read, and a great desire to read sprang up. Thousands of grown people who had never known how to read learned, so that they might study the Scriptures for themselves. For a long, long time the Bible was the only book most people had.

The Bible was a very great influence in educating people. Those who learned to read in order to study the Bible could read anything.

Interest in reading spread rapidly among the common people, and soon all kinds of books with their precious contents enlightening the minds of the people were pouring in a steady stream from the presses in the various countries of Europe. They became much cheaper, so that even poor people could afford to have them.

Many scholars who had lived in Constantinople came to Europe just at this time, bringing valuable manuscripts with them. These were

The interior of an early printing shop.
(From an old woodcut.)

printed and sent from country to country. Thus the people of Europe discovered again the riches of the old Greek and Roman civilizations that had seemed to be lost for so many centuries. Schools and universities were established. More and more people began learning their letters in order to find out what was in the new books. We still have in museums some of the curious old primers called horn-books that were used to teach the alphabet to children and others. They consisted of a

single sheet of paper on which were printed the alphabet and the Lord's Prayer, placed in a frame of wood, and covered with a thin transparent sheet of horn. It had a handle with a hole for a string by which it could be fastened to the girdle.

The reading of the Bible by the people led, in the course of time, to great changes in the Church. During the Middle Ages the Church of Rome had grown to be all-powerful. The great nobles as well as the poor people were subject to it. The Pope was considered to be the representative of Christ on earth, and as such was above even the greatest princes and kings. If any person, even a king, displeased the Pope, the Church might excommunicate him. That means putting him out of the Church, and people believed that the soul of such a person would be for ever lost. When men began reading and studying the Bible for themselves, many explained parts of it in ways different from those taught by the Church, and criticized certain of its practices and teachings. As early as the eleventh century some people had begun turning away from the Church, and gradually the movement spread.

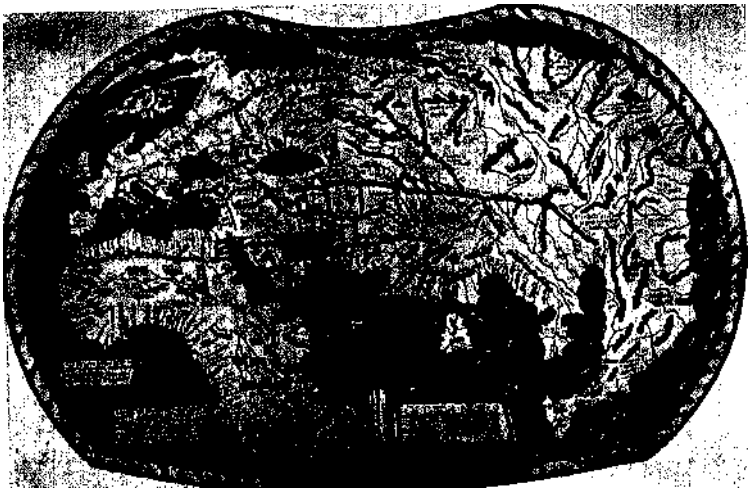
In 1517 a monk in Germany named Martin Luther began questioning some of the practices of the Church. He made a list of the things he thought were not right and posted it on the church door of the town where he lived. One thing led to another, and in 1520 the Pope ordered Luther to retract or be excommunicated. Luther burned the papal bull, as it was called, in the market square in the presence of a great crowd of people, and denied the right of the Pope to rule all Christians. He was tried for heresy, and in the presence of the greatest dignitaries of the Church and kings and courtiers, he bravely declared, " I cannot and will not retract anything, for it is neither right nor safe to act against one's conscience." Thus he proclaimed to the world the great principle that a person must be free to worship God in the way that he thinks best, which men have believed ever since that time.

A new church called the Lutheran Church was founded in Germany. Other nations also began disputing the right of the Pope to control people's religious beliefs. Gradually the new movement for religious freedom spread all over Europe and a number of new religious beliefs came into being. This movement has been called the Reformation because it had to do with the reforming of the Church. The new churches were called Protestant because they all arose as protests against the Catholic Church.

To the Catholic Church these new creeds seemed like terrible heresies. Soon all Europe was divided by quarrels over religion. To-day we are so used to religious freedom it seems strange to think that there ever was a time when men were not allowed to worship as they thought right. But this freedom was won only after centuries of struggle. At first every government thought it had the right to tell the people what to believe. If a ruler was a Catholic, none of his subjects was allowed to belong to a Protestant church. If the ruler became a Protestant, he would order his people to become Protestants and punish those who refused to change. So the struggle went on until people became broadminded enough to allow each person to choose his religious beliefs for himself.

When we think of all the great changes that were brought about by printing, we realize how tremendously important Gutenberg's invention was. It was one of the great steps out of the ignorance and superstition of the Middle Ages.

An early type caster, pouring metal that he has melted on his little furnace out of a ladle into a mould. When it is cool he will drop it into the basket beside him. Near by are wood and bellows.
(By Jost Amman.)



A map of the world made by Henricus Martellus Germanus in 1492. The only-lands known to Europeans were parts of Europe, Asia, and Africa. All the rest of the world was thought to be water.

CHAPTER XII

BEYOND THE PILLARS OF HERCULES

To the people of the fourteenth century the world was not much larger than it had been to the Greeks and the Romans. The only lands known to exist were parts of Europe, Asia, and a narrow strip of land extending part way down the west coast of Africa. All the rest of the world was supposed to be ocean. Little did any one at that time dream what vast stretches of land and sea lay beyond the world then known.

In the great trade that had sprung up between Europe and the various countries of Asia, Venice and Genoa in Italy were the two greatest centres. For many years merchants of these cities brought to Europe the longed-for luxuries from the East. Their trade grew steadily, but it was very difficult. Goods from the Far East had to be carried across great deserts by long caravans of heavily laden camels to Constantinople. Here they were loaded on to ships and carried across the Mediterranean Sea to Italy, and from there sent to all parts

A caravan with a load of spices from the Far East.
(From de Bry's " India," published in 1599.)

of Europe. The long journeys across the deserts were very slow and were beset with danger. Bands of bold robbers infested the routes, and would often attack a rich caravan, kill any merchant who resisted, and make off with their booty. The search for a water route to the East occupied the nations of Europe for the next two centuries and led to remarkable voyages of discovery between 1400 and 1600, in the course of which two new continents were made known to the world.

The first people to engage in the search for this water route to the East were the Portuguese. In those days Portugal was a daring and hardy nation, with mariners who were bold and fearless. Portugal looked with envy upon the rich trade of Venice and Genoa with the East and longed to have some share in it. If India could be reached

At Constantinople the goods were transferred to ships and carried across the Mediterranean.
(From de Bry's " America," published in 1590.)

by sailing around Africa some of the trade which had made the Italian merchants so rich might come to Portugal.

The youngest son of the king of Portugal at this time was Prince Henry, who was so interested in navigation that he was called the Navigator. When he was quite a young man he gave up all the high honours and gay social life of the court, and went to live in one of the dreariest spots on the southern coast of Portugal. Here on a great rocky cliff overlooking the sea, the young prince built a high tower with an observatory on the top of it, and devoted himself to the study of geography. He invited distinguished navigators and map-makers from all countries to come there. From the top of the tower they studied the stars in their courses. Within the tower they pored over all the maps and charts that had been made. Seamen who had

voyaged to far-away places came to the prince's tower and told him all that they had learned in their travels to strange lands. Thus the prince tried to learn all he could about the world as it was known in his day.

Prince Henry believed that a sea route to the East could be found by sailing around Africa. For many years Portuguese sailors had gone part way down the west coast of Africa ; but at a certain cape they had always turned back, believing that beyond this cape the air was burning flame and the sea boiled, and that anyone who passed beyond it would be changed from white to black. This seemed a very reasonable belief because as they journeyed toward the Equator the air grew hotter and hotter, and all the people of Africa they had seen were dark-skinned. But Prince Henry fitted out ships, trained Portuguese sailors in the art of sailing them, and year after year he sent expeditions down the coast of Africa, inspiring his captains to venture farther and farther. At last a captain was brave enough to pass the dreaded cape. Later others passed other points farther south.

In 1460 Prince Henry died without having accomplished his purpose. But although he was dead, his work went on. In i486 Bartholomew Diaz sailed right down to the southern end of Africa, and would have gone farther had not his men stubbornly refused because of the terrible storms they encountered there. When, on his return to Portugal, he was relating his experiences to the king, Diaz suggested that this southern point of land be called Cape of Storms, but the king disapproved lest other Portuguese seamen be deterred from venturing there. Was it not the long sought passage to India ? Rather, said he, call it Cape of Good Hope. And that is the name it has borne ever since. Twelve years after, Vasco da (jama succeeded in rounding the Cape of Good Hope, reaching India, and returning to Portugal with a rich cargo of spices. Thus was the dream of Prince Henry at last realized.

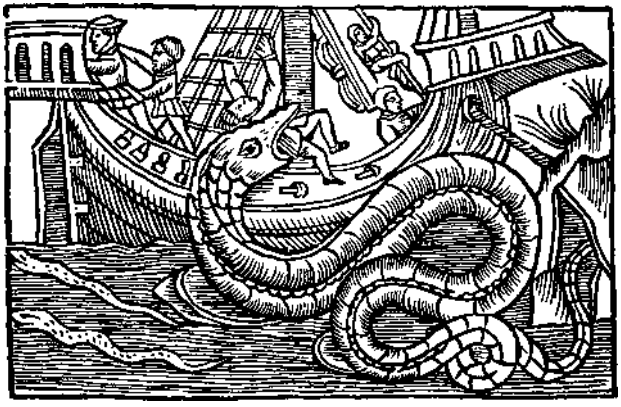
While Prince Henry had been sending his ships down the west coast of Africa, other students of geography in Europe were wondering whether the lands to the East might not be reached more quickly by sailing westward. Of course no one in Europe at this time had the slightest thought that a huge continent and two wide oceans lay between it and Asia. They had no idea that the earth was as large as it is.

Prince Henry the Navigator. On the shelf under his books are an astrolabe, a compass, a sundial, and instruments for drawing. Prince Henry was a knight and a crusader. At the bottom of the picture is the army which he led against the city of Ceuta in Africa. At the right is the seal of the Order of the Garter, to which he belonged.
(From a contemporary print.)

Although learned men ever since the days of the Greeks had declared that the earth was round, people in general still had the most fantastic ideas about it. They still thought that it was flat, and that any ship which sailed too far out on the sea would come to the edge of the earth and fall off into endless space.

Up *to* this time scarcely a sail was to be seen on the vast Atlantic Ocean that lay to the west of Europe, except near the sheltering coasts. The "Sea of Darkness," as it was called, stretched away until it seemed to touch the sky, a great unknown expanse of water. To be sure, far away to the north, the wild Vikings, those fearless and hardy sailors, had fared forth from their lonely fiords in their dragon-boats and explored the gray waters of the North Atlantic ; but the rest of Europe knew little of their doings.

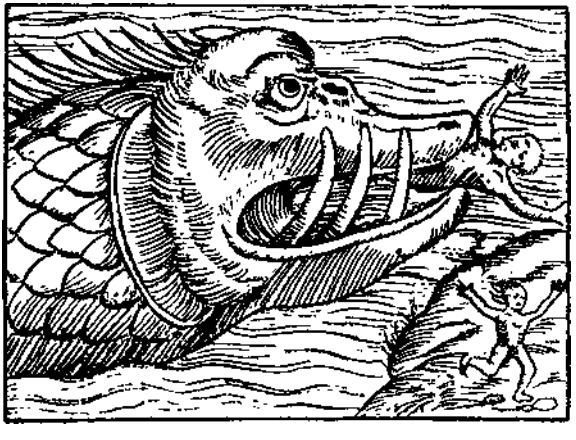
For the most part, sailors were terrified at the thought of sailing far out on the ocean because of the stories told about it. It was said to be infested by weird and horrible monsters that dragged ships down and strangled men. It was believed, too, that somewhere beneath the sea lay a magnetic mountain that would draw a ship near, pull out the iron parts that held it together, and strew the timbers over the water. Another amusing belief was that great whales would often lie quite



What the people of Europe thought would happen to sailors on the Atlantic Ocean, which they called " Sea of Darkness." (A woodcut from a book published in 1555.)

still on the surface of the water for a long time so that sand gathered on their backs. Sailors, seeing one and thinking that it was an island, would land on it and light a fire to prepare their meal. Then the whale, feeling the fire, would dive down into the sea and drown the sailors. Map-makers of the time pictured whirlpools, serpent-rocks, demons, and all sorts of queer monsters which they imagined living in this unknown sea. It is small wonder then, that mariners feared to venture out on such strange waters. For centuries they had been content to sail their boats up and down the well known routes of the peaceful Mediterranean.

During this time of voyaging on the Mediterranean, many important improvements were being made in navigation. Among these one of the most valuable was the compass, which now came into use in Europe for the first time. A compass is a needle which has been touched by a magnet. Some unknown genius in Arabia or China had discovered that if he rubbed a needle with a magnet and floated it on a cork in a basin of water, one end would always point toward the north. Later, someone placed a magnetized needle on a pivot over a card marked with the four principal directions and many others in between, and placed it in a box for convenience. This "nautical box," as it was called, was the first compass.



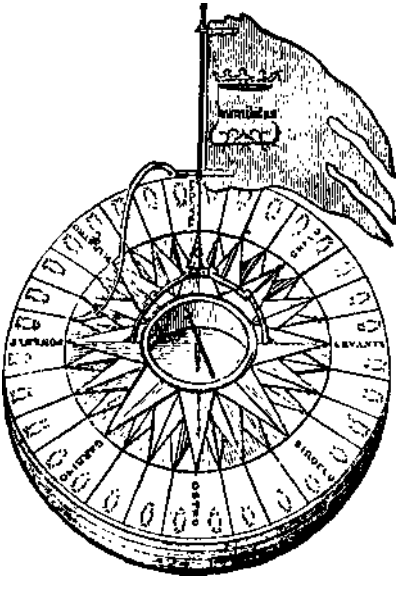
Another imaginary terror of the sea.
(From the same book.)

The compass was used in Asia long before the people of Europe knew anything about it. Possibly the crusaders learned about the compass when they went to the East, just as they learned about many other things that were used there. For a long time European sailors

" The whale," warns the writer of the medieval book containing this woodcut, " is a very great beast It takes the sand in the sea, spreads it on its back, raises itself up in the sea, and lies still on the surface The seafarer thinks it is an island, and lands upon it to prepare his meal. The whale feels the lire and the people and will dive and drown them all if it can."

would not use it. They thought there must be some kind of magic in it and were afraid to have anything to do with it. But gradually they came to recognize its usefulness. They found it a marvellous help in steering their ships. Before they had it sailors long out of sight of

land often had no idea where they were or in what direction they were sailing. Of course on clear days they could tell directions fairly well by the position of the sun, and on clear nights they used the North Star as guide. But in case of fog, or storm, or on nights when there were no stars, ships might go far out of their way and be hopelessly lost at sea. It was a bold mariner, therefore, who sailed very far from land. Now, however, provided with a compass, with its little swinging needle

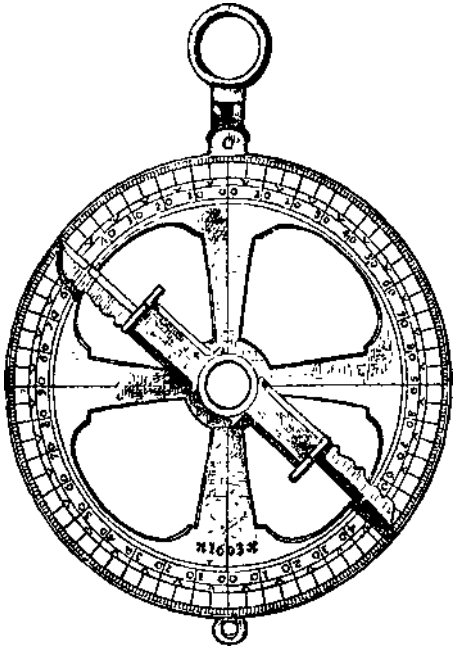


An early compass.

always faithfully pointing toward the north, seamen could find their way over the trackless waters and come safely home again. The use of the compass spread rapidly and by 1500 practically every Mediterranean ship had one.

The astrolabe, another useful instrument, was also introduced into Europe at this time. It helped seamen in calculating distances and directions. But when the pitching and rolling of the ship made it difficult to use the astrolabe, another instrument called the cross-staff

was used, which could be held more steadily in the hands. Holding it up to his eye with one end pointed to the sun and the other to the horizon, the mariner moved the cross-bar, on which degrees were marked, back and forth in such a way as to make it possible to calculate the position of the vessel. With the aid of the compass and the



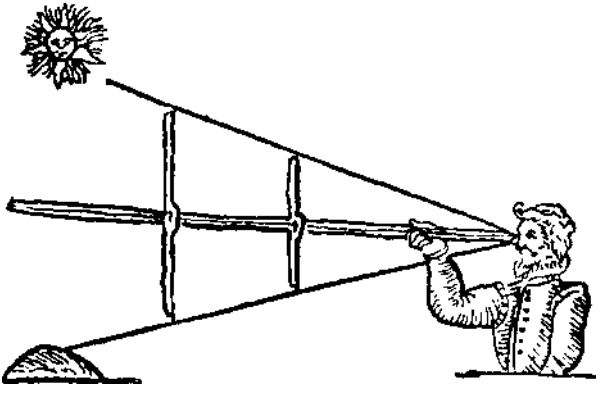
An astrolabe.

' astrolabe and the cross-staff, navigators could determine the position of their ships even when they were far from land and could steer them directly where they wanted them to go.

Mediterranean seamen were also improving their ships. They began building bigger and stronger boats. Up to this time both oars and sails had been in use on boats. For men had not yet learned how to use the sail to the greatest advantage. They could use it only

when the wind was favourable. The main reliance was still upon the rower's arm. Now sailors began learning the art of sailing against the wind. After they discovered how to do this, oars were given up entirely and ships were built with two or three masts instead of only one, and were equipped with different kinds of sails. Each sail was divided so that part of it could be reefed while the rest remained spread. There were also jib sails, flying over the bow to catch the wind.

This was also the great time of chart-making and map-making. Men who sailed to far-away places first began writing out descriptions



A manner getting the height of the sun with a cross-stalt.

of the coasts they had seen and directions as to how to get there, so that other sailors might use them. Later, instead of writing out the description they began making careful drawings of the coasts along which they sailed. These sailors' charts were the first maps to be drawn from land actually seen. Earlier map-makers had been very apt to fill in from their imagination places they did not know about, and so their maps were not very reliable. At first the sailors' charts showed only well-known places, but as knowledge of the earth increased they became more and more complete. Geographers and map-makers worked over them, correcting errors and making them more accurate as more information came in. It was possible for sea captains to buy these charts and sailing directions. Thus they came to have more

accurate information about places they had never seen and how to reach them.

With larger and better boats to sail in, with the compass and the astrolabe and other instruments to show them directions, with charts and maps to guide them, seamen became more confident of finding their way about in strange waters, and so they were no longer confined to the well-known routes of the kind-locked Mediterranean. All of these things helped to make possible the great age of discovery, when men at last, after many centuries, steered safely and boldly out of the Mediterranean Sea. Out beyond the Pillars of Hercules—those lofty rocks standing at the gateway to the Atlantic, which ever since the days of the ancients had marked the western limits of the world—they sailed, and went exploring the unknown waters of the earth. And in the course of their voyaging they came upon two new western continents which most Europeans had never before known existed.

CHAPTER XIII

GOING EAST BY SAILING WEST

CHRISTOPHER COLUMBUS grew up in Genoa during the time of her great trade with the countries of Asia. From his earliest childhood his delight was in the sea. He haunted the wharves and watched the ships coming into port laden with rich cargoes of beautiful things from the East. He listened to the sailors telling of their adventures, and he picked up many strange tales of distant lands and peoples. His greatest ambition was to be a sailor himself, and when he was fourteen years old he went to sea for the first time. For the next ten years he spent most of his time sailing on the Mediterranean. Later he went to Portugal to live and came to be recognized as a seaman of distinction.

By this time the idea that the earth was round was beginning to spread more widely. Among those who thought about this question was an Italian map-maker and geographer named Toscanelli. He felt sure that the earth was round, and he made a map showing how Cathay, or China, could be reached by sailing west. Columbus heard about this map when he was in Portugal, and wrote to Toscanelli asking for a copy of it. Toscanelli answered : "I perceive your magnificent and great desire to find a way to where the spices grow, and in reply to your letter I send you a copy of a letter sent to a friend and favourite of the most serene King of Portugal, and I send you another sea-chart like the one I sent him."

Columbus studied this map carefully. Of course Toscanelli, like the other geographers of his time, knew nothing of the western continents, and his map represented the world as being much smaller than it really is.

By 1484 the great scheme of crossing the Atlantic Ocean to Asia was fully worked out in the mind of Columbus, and he laid his plan before the king of Portugal. The king was inclined to believe in Columbus, but his advisers laughed at the idea ; so he did nothing about it. For eight long years Columbus sought support from one

Columbus bidding farewell to Queen Isabella and King Ferdinand.
(From de Bry's " America.")

government after another in Europe, before he finally persuaded King Ferdinand and Queen Isabella of Spain to give him enough money for the expedition.

Three small ships, the Santa Maria, the Pinta, and the Nina, and about a hundred men to sail them, were secured, and on August 3rd, 1492, the little fleet left port and headed straight west into the Sea of Darkness, on the most daring voyage of all time. Day after day, week after week, they sailed, and saw nothing but the great unknown sea stretching about them on all sides as far as the eye could reach.

As time passed and still there was no sight of land, the sailors became more and more frightened. Once they were becalmed for days and days, and they thought they must have reached a place on the earth's surface where the wind never blew, and that they would never be able to ^et back home again. One night the compass began acting strangely. Instead of pointing a little to the east of the North Star as it did in Europe, it shifted to the west of the North Star. The sailors thought the sea must be bewitched and they determined to go no farther. They formed a plot to throw Columbus overboard and then try to make their way home.

Fortunately Columbus was able to persuade the sailors to keep on for a few days longer. And at last, on October 12th, seventy long days after they had set sail from Spain, they were rewarded by seeing unmistakable signs of land. Birds came flying around the ships, and a small branch with red berries on it floated by. Great was the excitement, and everyone looked in all directions for land. At ten o'clock at night they thought they saw a light moving, and at two o'clock in the morning the look-out on the Pinta cried, " Land ! Land ! "

With the dawn they could clearly see a green stretch of land with dark-skinned natives gathered on the shore. At sunrise, Columbus, richly clad in a scarlet cloak and carrying the royal standard of Spain, stepped out upon the unknown land, and kneeling, set up the banner of King Ferdinand and Queen Isabella. Although he little dreamed what he was doing he had planted the first European banner on the soil of a vast new hemisphere. The natives told Columbus that the land was an island. Columbus thought it must be one of the islands off the coast of India and called the natives Indians.

After exploring for a short time Columbus was eager to get back to Spain and tell his wonderful news. So he left some of his men

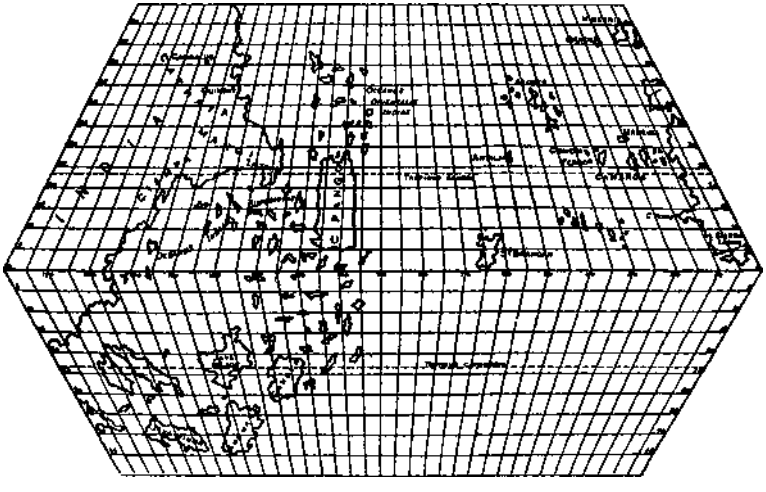
behind and sailed for home. Bells pealed joyously and guns boomed in salute as Columbus landed in Spain. He had brought with him strange beasts and birds from the new land and several Indians. The king and queen asked Columbus to come at once to the court.

Columbus landing in America.
(From de Bry's " America.")

All along the way great crowds cheered. Before him walked the half-naked Indians, painted in their gay savage fashion, with their bows and arrows and their strange ornaments and head-dresses. Then came sailors carrying curious birds with brilliant plumage, and odd-looking plants and animals. Last came Columbus himself. The king and queen made him tell all about his strange adventures while ministers and great nobles gathered about eagerly listening. When he had

finished, all the court threw themselves down on their knees and gave thanks to God.

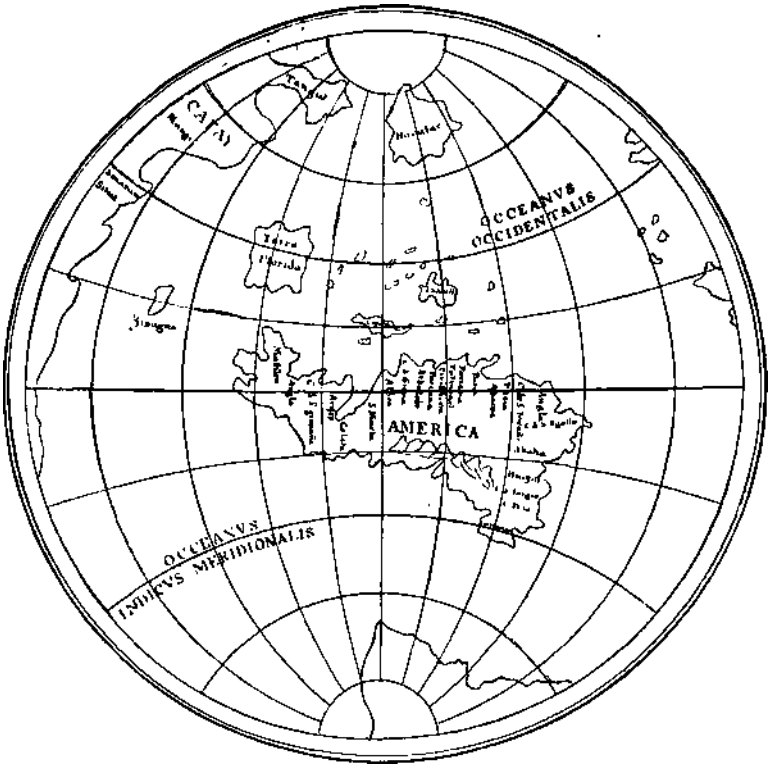
Columbus made four voyages to the new land without ever knowing that he had discovered a new world. He died without knowing it. When he returned from his last voyage, Queen Isabella had died and he no longer had anyone to help him. Because of his repeated failure to find India, people had lost faith in him ; and in 1506 the great discoverer died friendless and penniless.



A chart made by the famous geographer Toscanelh in 1474 and used by Columbus on his first voyage to America Notice that India and Cipango (Japan) are placed on the Atlantic Ocean opposite Spain.

Columbus by his daring and courage had broken the magic of the unknown Sea of Darkness. For centuries men had dwelt along its edge without daring to explore it. Now other explorers began to follow the trail that Columbus had blazed. In 1513 Balboa stood upon a peak in Darien, the first European to look upon the blue waters of the Pacific Ocean. In 1519 Magellan sailed down the coast of South America, passed through the strait that now bears his name, and crossed the Pacific Ocean ; and although he himself was killed his ship, the

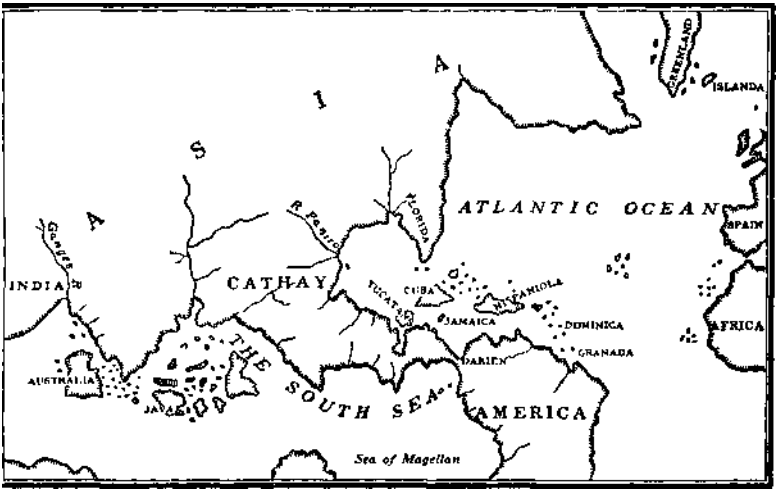
Victoria, continued to Spain, having sailed around the world. This voyage proved beyond a doubt what learned men had believed for centuries : that the earth was round. People could no longer believe



A map made by Leonardo da Vinci in 1515. Florida and America are pictured as islands off the coast of Cathay (China).

that the earth was fiat and fear that ships coming to the edge would fall off into space. Magellan's voyage also showed that America was not a part of Asia, but an entirely new body of land separated from the eastern continent by a vast ocean.

Tales about the wonders of the new land and promises of untold wealth spread like wildfire. It was said that somewhere there was a magic spring, and that whoever drank from its crystal waters would be for ever young. Stories were told of Kl Dorado, a wonderful city built entirely of solid gold. With prospects of such treasures ever before them it is not strange that bold and adventurous men set out to seek their fortunes in the new world. Fleet after fleet of treasure-laden



A sketch of part of a globe made by Otontius Fmeus m 1531. The parts of North and South America which have been explored are fairly accurate, but Cathay and India still join them to " Asia," with the East Indies and Australia near by.

galleons returned to Spain, and conquest followed conquest. Cortez won Mexico, Pizarro conquered Peru, and both of these yielded treasures surpassing all expectations. By the middle of the sixteenth century the Spanish dominions in America stretched for thousands of miles and wealth poured into Spain, making her the richest nation of the time.

The success of the Spanish stimulated other nations to make voyages, and before long the ships of all the leading nations of Europe were furrowing their way across the broad Atlantic. At first England took little part in these adventurings. As early as 1497 John Cabot

had made a voyage to the new world. Later his son Sebastian had made several voyages. But they went much farther north than the Spanish, and their descriptions of the land they had found discouraged the English from exploration for nearly a century. The fish and furs they told about seemed to be poor substitutes for the gold and silver and jewels of the Spanish lands, and England did not take much interest

A map from the " Geographia Universalis " of 1540. North and South America appear as separate continents called Novus Orbis (New World), but North America extends only to the Mississippi River, and India and Cathay are still near.

in them. Moreover, all through the early days of discovery England had very few ships. It was not until the reign of Queen Elizabeth that England began building ships. Then there sprang up a host of English seamen who made her reign famous for its sea captains and merchant adventurers, and who bore the flag of England into seas where it had been little known before.

These daring sea dogs, envious of Spain's ever growing power, decided to gain a share in the wealth of the new world for England.

Sir Humphrey Gilbert, Sir Walter Raleigh, Sir John Hawkins were all great names of this time. Among the greatest of these gentlemen adventurers was Francis Drake. He loved adventure, he loved his queen, and he loved England. Many were his exploits on the seas fighting the Spanish dons.

In 1588 occurred an event which was to have a tremendous effect upon the future history of the world. King Philip of Spain decided to

The first ship to sail around the world. Magellan's ship, the Victoria, with its winged figurehead of a Greek statue of Victory.

invade England. He wanted to get rid of the English menace to Spanish trade. So he began building a mighty fleet of vessels. " The Invincible Armada," the Spanish called it, thinking that nothing could conquer it.

As the news of Spain's intentions reached England, Francis Drake was selected to collect a fleet to defend England. The stately Spanish galleons sailed into the English Channel, like an imposing array of great floating castles towering high above the waves. Their countless banners, each gaily emblazoned with the insignia of the saint after which the ship was named, were flying gloriously in the breeze, their decks were crowded with the best fighting men of King Philip. There were

so many ships that they extended for seven miles in the water in the form of a great crescent.

Long before the Spanish vessels came in sight, beacon fires had flashed from headland to headland along the west coast of England, carrying the news to the people that the Spaniards were on the way. Elizabeth, the queen, mounted upon a charger, went among her people and addressed them in a stirring speech : " My loving people, we have

John Cabot landing on Labrador.
(From an old American engraving.)

been persuaded by some that are careful of our safety to take heed how we commit ourselves to the multitude for fear of treachery. Rut I assure you that I do not desire to live to distrust my faithful and loving people. Let tyrants fear. I have always placed my chiefest strength and safeguard in the loyal hearts and good-will of my subjects, and therefore am I come among you at this time resolved to live or die amongst you all, to lay down for my God, for my kingdom, and for my people, my honoui and my blood even in the dust."

All England rallied to the support of queen and country. Excitement was intense. It is said that Francis Drake and Lord Howard were playing a game of bowls when a messenger rushed up announcing that the Armada was in sight. Noting the terror of the people around him and realizing that he must quiet their fears and give them courage, Drake replied, in a voice loud enough for everyone to hear: " Come, come, my lord. Let's to the game and finish it. The score is even. There's time to beat the Spaniards after."

The English sallied forth to defy the might of Spain. Their ships were long and narrow and low in the water and so could be more easily managed than the high, wide, clumsy ships of the Spaniards. For days the battle raged furiously. In the end the Spanish ships were hopelessly scattered. Many of them were captured by the English, and the rest took flight. To end it all a great storm came up which wrecked many of the retreating Spanish vessels so that only a few battered ships of the great Armada returned to Spain.

The defeat of the Armada marked the downfall of Spain as a great power. From this time on Spain steadily lost her power on the sea, and her power in the new world steadily dwindled, while that of England steadily increased. Rasing her claim to America on the early voyages of the Cabots, England took possession of the land along the eastern coast, and many English settlements were made there.

France was not to be left out in the quest for wealth in the new world. The French tried to find a North-west Passage through America to Asia. They began working their way up the St. Lawrence River. In 1535 Jacques Cartier sailed up the river. Champlain also made explorations, and discovered the lake which bears his name and two of the Great Lakes. For the next two hundred years this great inland water-way lured many French explorers deeper and deeper into the wilderness. Then came La Salle with his dream of a New France.

Sir Francis Drake.
(From a contemporary engraving.)

The Spanish Armada in the English Channel. There were so many ships that they extended for seven miles in the form of a great crescent.
(From a tapestry in the House of Lords.)

Following the Mississippi River from its northern source, he found that it flowed southward all the way to the Gulf of Mexico ; and all that vast territory he claimed for France and named Louisiana in honour of the French king.

Holland also took up the search for a North-west Passage. Henry Hudson left Holland in the Half Moon and first sailed around Norway and Russia thinking that he might be able to find a north-east route to Asia. Finding his way blocked by a frozen sea, he turned his ship about and steered for America. If he could not find a north-east route to Asia, perhaps he could find one to the north-west. Henry Hudson gave his name to the river which he discovered and to the great icy bay to the north, but he did not succeed in finding a North-west Passage to Asia.

We have seen that North and South America were discovered by chance in the search for a water route to the East, and that for a long, long time they were not recognized as continents. But bit by bit their main features were revealed by the explorations of the fifteenth and sixteenth centuries. Probably no other event in the history of the world had the far-reaching effect that the discovery of America had. For centuries the people of Europe had faced toward the east. Then

at the end of the fifteenth century the unknown sea to the west was at last ventured upon. For two hundred years after this, adventurous seamen took to their little wooden boats, spread their broad sails to the wind and went out to sea, pushing farther and farther into the unknown western world. And with each exploration the size of the known world grew.

Through the daring and courage of these navigators the little medieval world, which ever since the earliest days had centred around the Mediterranean Sea, was expanded into a great earth-round world, with its land masses and oceans at last revealed as they really are. In the course of time the nations of Europe, instead of pressing the

Henry Hudson on the bank of the river named after **him.**
(From an old American engraving.)

search for a route through America to Asia, became interested in the great land to the west for the treasures it had to offer them, and the great trade of the world shifted from the Mediterranean Sea to the Atlantic Ocean.

What tremendous changes have taken place during the centuries we have been considering in the last three or four chapters ' How much men have learned and how their whole outlook on life has been changed by what they have learned ' During the Crusades people began travelling away from the familiar little spot that was their home, and began to see the marvels of distant lands and the customs of strange folk. The spirit of investigation took hold of men, and through the great era of world exploration that followed in the fifteenth and sixteenth centuries the great bodies of land and water on the earth began to be known for the first time in history.

In many ways men's minds and eyes were opened to the wonders of the world just being revealed to them. During the Middle Ages learned men had spent most of their time studying what the ancient thinkers believed about the world, and thought that no one should question their conclusions. But a new questioning spirit was coming to many men. They were beginning to think for themselves, and to look at the world and form their own ideas about it. As a result of this advanced thinkers were beginning to see that many theories that had been accepted for centuries were not true. Ignorance and superstition began giving way to real knowledge based upon observation and experiment, and new methods of science spread. Then in the fourteenth and fifteenth centuries Copernicus and Galileo upset the belief of centuries that the earth was the centre of the universe.

There was the decline of the castle type of life with its great overlords and the mass of the people held in subjection. There was the steady growth of towns through the development of trade and commerce. There was the gradual change of serfs into independent workmen. There was the growth of social and religious freedom. The newly awakened desire for freedom and equality brought the beginnings of government by the people themselves. There was the weakening of the authority of the Church over the minds of the people and the rapidly spreading belief that a person should be free to worship God in the way he thought best. All these things together gave people a

new sense of freedom—the freedom of each individual to think for himself and the responsibility of acting as he thought best.

With the invention of printing, knowledge which for centuries had been a special privilege of a few was put within reach of everybody and the stored-up wisdom of the ages was opened up to all who could read. There was a great sweep of new ideas ail over Europe, and education became widespread.

The minds of men were greatly stimulated by all these new experiences. People began to feel the need of giving expression to the many new ideas that came crowding upon them. They began to study, to write, to paint. Art came to life in new forms of beauty, and artists learned to paint lovelier pictures than the world had ever known. It was at this time that some of the world's greatest artists lived : Michelangelo, Raphael, Leonardo da Vinci, and others. Poets wrote in the language of the people, and this marked the beginning of literature in many European countries. People travelled and wrote down their strange adventures, and other people who had learned to read could share in their experiences.

With all these powerful influences at work freeing the minds and spirits of the people from age-long bondage, a new era in the world's history was beginning. This great intellectual awakening, called the Renaissance, marks the end of the Middle Ages and the beginning of modern civilization.

HOW ENGLAND BECAME THE WORKSHOP OF THE WORLD

CHAPTER XIV

FROM TOOL TO MACHINE

ALL the many happenings of the Middle Ages brought about great changes in men's ways of living, as we have seen, but there were very few changes in men's ways of working. They still went about their daily work much as they had done in ancient times. Farmers in the fields and people in their homes were still doing their work with the same simple tools that had been invented in quite early days. Then in the middle of the eighteenth century began a series of remarkable inventions that completely changed people's ways of working, when men discovered how to make machines run by the mysterious power that resides in steam.

When a wheel turns completely around we sometimes say that it makes a revolution. When a nation entirely changes its form of government we sometimes say that it goes through a revolution. The great inventions of the eighteenth century followed one another so quickly and brought about such a complete change in the way people worked and lived that this period has come to be known as the Industrial Revolution, for this great turn of the wheel of progress transformed a world of hand-workers into a world run by machines, and created a new era in the life of mankind.

The first inventions which brought about such great changes in the world were made in England. There were a number of reasons for this. From very early times England had been one of the great wool-producing countries. On her upland pastures the sheep could graze in peace, and the streams from the hills gave plenty of soft water for the preparation of the wool. In the Middle Ages sheep-rearing and cloth-making became great industries in England. All through the thirteenth and fourteenth centuries England's wool trade grew. Then came the

great Elizabethan Age when England's bold mariners began the series of expeditions to the new world which in the short space of a century placed much of the new land in her control. While Spain was bringing home gold and silver, England was receiving from her colonies useful raw materials and finding in them ever-growing markets for her products. Thus her trade grew enormously.

Spinning with the distaff in England in the eighteenth century.

The end of the seventeenth century found England largely a nation of sheep-farmers and cloth-makers. This work, from the shearing of the sheep to the weaving of the cloth, was all carried on in the homes of the people. The wool was sheared from the sheep's back by hand, the tangled fibres were brushed and carded by hand. After that they were spun into thread on a spinning-wheel, little different from that which had been used for centuries. In weaving, the warp threads were

stretched on a cumbersome wooden frame called a loom, and the woof threads were drawn back and forth across the loom by hand. For wider cloth two people were needed to carry the thread across the loom. The pieces of finished goods were gathered up from the villages and drawn over the poorest of roads to the waiting ships to be exported.

With England's rapidly expanding trade, so much cloth was needed that young and old throughout the countryside were busily engaged in spinning yarn, and every village had its weavers. The hum of the spinning-wheel and the clack-clack of the loom could be heard in every cottage as whole families busied themselves at spinning and weaving all day and far into the winter evenings. The wool was picked clean by the young children, carded and spun by the older girls and the mother, and woven by the father and his sons. But even so the merchants needed more goods than the people could produce. So they began casting about for quicker ways of making cloth.

The first improvement was made by John Kay, a poor weaver, who in 1733 invented a device by which the shuttle of the loom, instead of being passed slowly from one hand of the weaver to the other in weaving, could be shot across the loom by a quick jerk on a string. This simple invention brought about a great saving of time, enabling a weaver to produce about twice as much cloth in the same time. Because of its quick motion Kay's invention was called the Fly Shuttle.

To the people of that time any change in the way of doing things seemed dangerous. So when Kay's neighbours

with the spinning-wheel before Revolution. On the floor are spindles and cards for carding the wool.

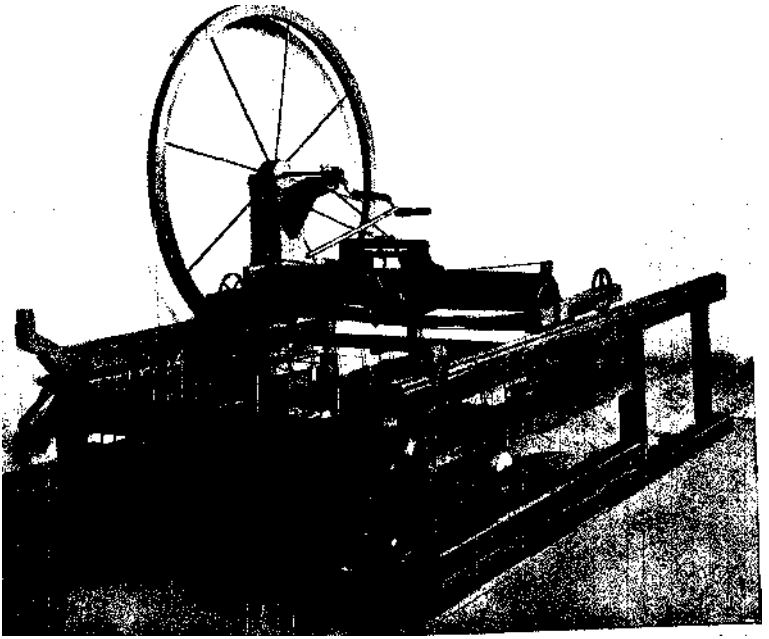
discovered that his device would enable one man to do the work of two they were very much upset because they were afraid that it would deprive many weavers of their livelihood. In great excitement they burst into his home and destroyed his shuttle. Poor Kay would no doubt have been killed had not friends carried him to a place of safety [hidden in a bundle of woollen goods. His invention did not do him much good, for the hostility of the other weavers forced him to leave the town where he had always lived, and he died in poverty and neglect.

Nevertheless Kay's invention came into use everywhere and eventually changed the art of weaving. Now a new trouble arose. Everywhere the weavers were dependent for their yarn upon the spinners, who had no better way of producing it than the very slow method of spinning out one thread at a time on a spinning-wheel. In some places the spindle and distaft were still used for making yarn. Spinning by these ancient methods was very slow, and a pound of yarn represented a good day's work. After Kay's invention came into use it kept about ten spinners busy to supply one weaver with yarn. So scant was the supply of yarn that a weaver frequently had to begin the day by walking three or four miles, gathering enough yarn from his neighbours to keep his loom busy the rest of the day. The spinning-wheel, spinning a thread at a time, even though it was kept turning from morn till midnight in thousands of cottages, was now entirely too slow to keep up with the weaver's shuttle.

Under these circumstances it was not strange that people were constantly trying to find some quicker way of making yarn. James Hargreaves, a poor but ingenious weaver, was the first to discover a better way. The story goes that one day, as he sat idle in his humble cottage for lack of yarn, he noticed his wife's spinning-wheel, which had toppled over on the floor so that the spindle was thrown from a horizontal to an upright position. It still continued to whirl, and as he stood looking at it the idea came to him that a number of spindles might be placed side by side on a frame, and thus a number of threads might be spun at the same time by one pair of hands. He set to work and soon produced a frame carrying eight spindles operated with a wheel turned by hand. With this he was able to spin eight threads at once with no more effort than one thread had required on the spinning-wheel. It is said that he named his invention the Spinning-Jenny

after his wife, whose overturned spinning-wheel had suggested the idea to him.

The first jenny was completed in 1767. By constant improvement Hargreaves was soon able to spin thirty threads at a time. He tried to keep his invention secret and use it only in his own home, but knowledge of the wonderful device which gave him such an advantage over

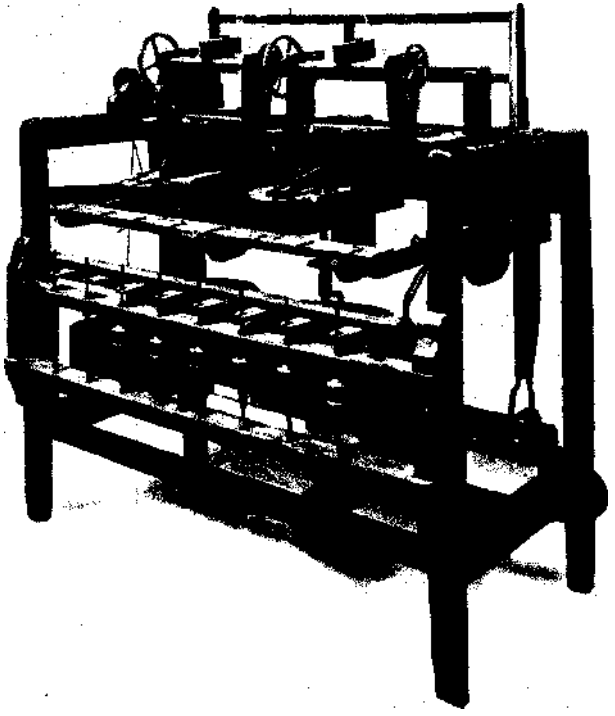


Courtesy Science Museum, London

Hargreaves' spinning-jenny.

his neighbours soon spread. They thought the invention would decrease the number of spinners needed and take their work away from them. So they burst into his house shouting, " Down with the machines, and down with the traitors who invented them ! " and they hacked the spinning-jenny to pieces and trampled it underfoot. Hargreaves was compelled to flee for his life.

Gradually, however, the value of Hargreaves' invention came to be recognized and spinning-jennies with eighty spindles all working at once soon came into general use. The spinning-jenny, in improved



Courtesy Science Museum, London

Arkwright's water-frame.

form, is still the chief machine for spinning. A modern spinning frame has more than a thousand spindles spinning at the same time.

The next improvement in spinning was brought about by the invention of a water-frame, driven by a water-wheel, which was invented by a barber named Richard Arkwright. It may seem odd that one of the great spinning inventions was made by a barber, but

Hall-in-the-Wood, a rambling old house surrounded by a garden, where Crompton worked secretly on his invention. His neighbours, hearing strange noises and seeing glimmering lights through the casement windows late at night, thought the house must be haunted.
(From an old engraving.)

it came about in a very natural way. Richard Arkwright had been familiar from childhood with spinning and weaving. As the youngest of thirteen children he did not get much schooling and was early apprenticed to a barber. Finally he set up for himself in a little underground cellar. After a while he grew tired of being a barber and began travelling around the countryside to the fairs which the young country girls frequented, purchasing their long hair for the wigs which were then the fashion in the upper classes of society.

In travelling Arkwright met many people who were engaged in spinning and weaving. There was much excitement about the spinning-jenny, and everywhere people were talking about it. Arkwright took an interest in the new machine and found out all he could about it. Then the idea came to him that spinning might be done more rapidly with the help of two rollers, one of which, revolving much faster than the other, would draw the twisted thread together exactly as it was done by hand.

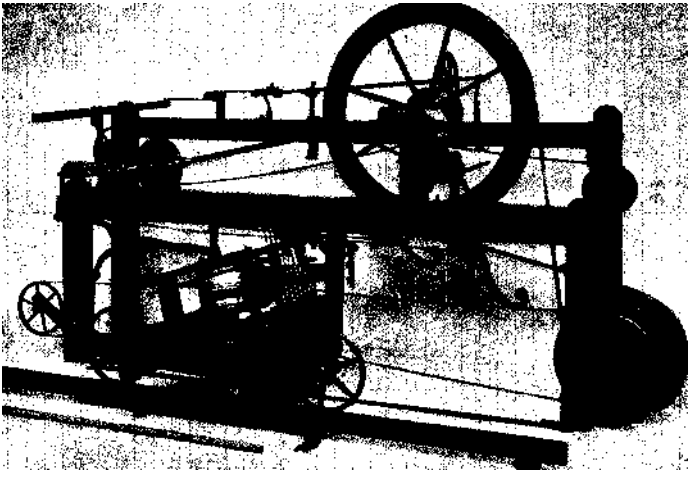
From that time on he had but one thought. He gave up his business and devoted himself to making such a machine. So sure was he of the value of his invention that he spent all his savings on it and brought his family to want. It is said that his wife destroyed his first model in an attempt to cure his madness. Time and again it seemed as if his strength would fail before he finished the work.

After several years of poverty and suffering Arkwright completed the machine. Gradually it became known and he began to reap the results of his years of labour. He was a good business man as well as an inventor. Rival manufacturers imitated his designs, but he succeeded in spite of obstacles. Thus the man who began life as a humble barber in a cellar became rich and prosperous and was knighted by the king.

Hargreaves' spinning-jenny and Arkwright's water-frame increased the quantity of yarn, but neither of them could spin yarn of fine quality. This led to another invention by Samuel Crompton.

Samuel's father was a farmer and like most of the farmers of that time spent most of his spare time spinning yarn and weaving it into cloth. When Samuel was but five years old, his father died leaving his mother with three children to bring up as best she could. All the children had to do their share of the work, and from his earliest childhood Samuel helped his mother. His special job was to weave the yarn

which had been spun by other members of the family. His little legs became accustomed to the loom as soon as they were long enough to stretch to the treadle. Widow Crompton heard about Hargreaves' spinning-jenny and decided to get one for Samuel. Owing to the imperfections in it much of Samuel's time was spent mending the ever-breaking threads of his yarn, and he could not make satisfactory progress even by working early and late.



Courtesy Science Museum, London

Crompton's mule.

The annoyance caused by the imperfections in his spinning-jenny led Crompton when he grew older to think how a better machine might be made. His great object was to make a machine that would spin fine yet strong threads. Every moment he could spare was given to this project. He had only a scanty supply of tools which he had bought with every shilling he could lay his hands on.

He worked diligently and in secret, often far into the night. Hall-in-the-Wood, the house in which Crompton lived, was a rambling old mansion surrounded by a garden. While Crompton was working on

his invention, strange sounds were heard by his neighbours at most untimely hours from a large upper room in the house, and lights were often seen late at night glimmering through the upper casement windows. What could it be ? Two old ladies who lived close by declared that they heard noises of a humming nature as if the devil were tuning up his bagpipe and his assistant were dancing a reel. So the rumour spread abroad that the old house was haunted. When the

A scene in an early mill in England shortly after the invention of the power loom.

neighbours discovered that the spirit was Crompton, who was working in secret with bits of iron and wood, they called him a conjurer, a term often applied to inventors in those days because people believed that they were in league with evil spirits.

After years of hard work Crompton finally succeeded in 1779 in making a machine that would spin fine but strong yarn. It was an ingenious combination of the best features of the spinning-jenny and the water-frame. Crompton called it a mule. He was very happy when he succeeded, but fearing ruin if his secret were discovered, he spun only small quantities of yarn.

But Crompton's invention could not be kept secret. Soon the neighbours became curious and began asking, " How can Sam Crompton spin such fine yarn ? " They suspected that he must have some new device that made his yarn the finest and strongest of any made, and they began trying to find out what it was. Crompton tried in every way to keep them from learning about his new invention. He had a special lock put on his workroom and screens at the windows. But his neighbours were not to be outdone. When he denied visitors admission to his house they resorted to all sorts of tricks to get in. Some of them brought ladders and peered into the upper windows of the house in the hope of seeing the invention at work. One ingenious fellow, it is said, crept into the house and hid himself in the loft overhead and peeped down into the workroom through a gimlet hole which he made in the floor.

No sooner had Crompton completed his mule than the spinners and weavers became excited over the new-fangled machines that would take their work away from them, and anti-machine riots broke out. Mobs of men went about shouting " Men, not machines ' " and smashing every machine they could lay their hands on. Fearing that they would destroy his precious invention Crompton took it to pieces and hid it in a secret place in the garret which could be reached by moving a secret panel in the wall. Here it stayed for several weeks before he had the courage to take it out again.

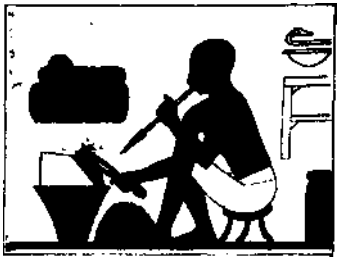
The continual spying drove Crompton almost mad. " A few months reduced me," he afterwards wrote, " to the cruel necessity either of destroying my machine altogether, or giving it to the public. It was not in my power to keep it and work it. To destroy it—I could not think of that , to give up that for which I had laboured so long was cruel. In preference to destroying it I gave it to the public."

He yielded to the persuasions of some manufacturers and gave them the machine for which they agreed to pay later on. After receiving the machine they refused to keep their word. A few years before his death Crompton almost came to want, but some friends raised a fund which gave him a yearly income.

Crompton's mule, like the jenny, was at first worked by hand, but to-day improved forms of the mule are run by machinery, some carrying a thousand spindles. They are used to spin the finer kinds of goods.

With the inventions of Hargreaves and Arkwright and Crompton, spinning was so improved that the old clumsy loom could no longer keep pace with the output of yarns. In 1787, Edmund Cartwright, a minister who knew little about machinery and had never seen a loom at work, was the successful inventor of a loom operated by mechanical power. He was a clergyman of independent means who led the quiet, uneventful life of a scholar. One day a party of gentlemen met at dinner table. They were talking about the wonderful new spinning inventions. " Before long we shall have weaving-johnnies as well as spinning-jennies," Cartwright declared. His companions laughed at the idea, because, they said, weaving was too complicated a process to be done by a machine.

To invent such a machine now became the passion of Cartwright's life. He knew nothing about weaving, so he went to watch some weavers at work. With the help of a carpenter he constructed a strange-looking loom and devoted himself to weaving. After much thought and repeated experiment the power loom was invented. By the use of the power loom one weaver could look after several looms at the same time, so that wool could be woven in great quantities. Manufacturers soon saw the value of a loom run by mechanical power, and the power loom came rapidly into use.



An Egyptian smith smelting metal with a blowpipe.

CHAPTER XV

PUTTING SUNSHINE TO WORK

THE machines invented by Hargreaves, Arkwright, and Crompton were small and were made of wood. For these great inventions to develop greater usefulness two things were necessary—strength and durability in the material of which they were made, and some steady, dependable power to run them. People in England were at work on these problems and finally solved both of them.

Iron was found to be a very valuable material for making machines ; but the iron industry was very feeble in the eighteenth century. Let us trace very briefly the history of iron from early days. Like all elements iron goes back to the beginning of the world when the earth's crust was being formed. For vast periods in the early history of the earth, when the low-lying swamp lands of the earth were covered with the rank forests that afterwards became coal, water containing carbon seeped through the soil and picked up every particle of iron it found in its way. Ever seeking lower levels it sank through the cracks and fissures of the rocks. Wherever the rock was limestone, the water dissolved pockets in the rock and deposited the iron in these pockets. There it lay hidden for centuries, and people did not know it was there.

We do not know when early man first learned to use iron. But since it is so buried in the rocks and cannot be melted out without great heat, he probably did not discover it for a long time after he had learned to use copper and tin, which melt at much lower temperatures.

Who first discovered how to smelt iron we shall probably never know. Probably the first iron furnace was just a pile of wood with a layer of iron ore on top of it, covered with clay to keep in the heat, with a hole at the top to let out the smoke and holes underneath to let in the air. The reward of several days' work with such a furnace was a few pounds of iron.

Man early learned that he could make a hotter fire by applying more air to it. At first he probably blew air through long pipes of hollow cane but, finding this very hard work, sought a better way and invented the bellows. The earliest bellows was a bag made by sewing up the skin of a goat, filling it with air, and fitting it with a valve and nozzle. This was used to force air into the fire. By such slow toilsome methods early man succeeded in getting a little iron.

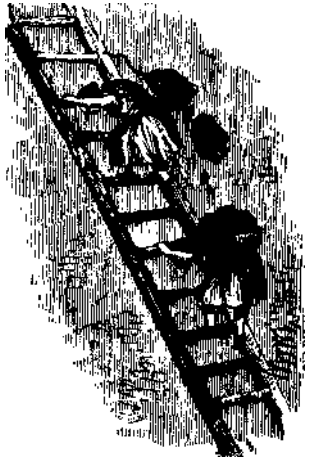
Possibly the next advance was to change the fuel from wood to charcoal, which makes a hotter fire. The Catalan forge was also invented. This was a conical furnace of clay or stone. More powerful bellows came into use, worked by horse power or water power. All these improvements were made during the Middle Ages.

The blast furnace was just an improvement on the old Catalan forge. As men went on using the Catalan forge they found ways to make the air blast stronger. Then they could make the furnace higher and still force the air through. The higher furnace and the stronger blast of air enabled them to melt more iron, which would trickle down to the bottom of the furnace on to a hearth prepared for it. They found also that, if limestone were mixed with the charcoal, many of the impurities of the iron ore would combine with the limestone to form slag. This was not as heavy as iron, and so, when it got to the bottom of the furnace, it floated on top of the iron and could be drawn off separately.

By the eighteenth century men had discovered that there was plenty of iron in England, but without charcoal it could not be melted out of the ore. Smelting iron required so much wood for charcoal that at this time England's supply was almost exhausted. The great forests which had originally overspread the land were rapidly disappearing. Parliament, fearing the shipbuilders would be left without timber to build their ships, passed very strict laws about cutting down the trees. So the great problem was how to get iron for the new machines without charcoal.

Medieval smelters at work. One smelter is digging away impurities from the mouth of the furnace, the other is carrying a basketful of charcoal on his head.

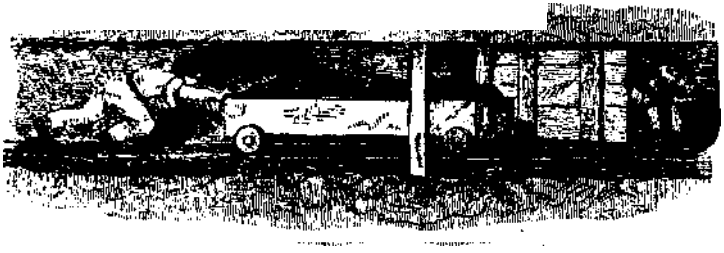
(From Agricola's "De Re Metallica," 1556.)



Girls and women carried coal out of the mines in baskets on their backs sometimes up ladders, sometimes up steep circular stairways.

Now, ever since the beginning of the world, wonderful beds of coal had lain buried beneath the soil of England. In many places coal cropped through the surface of the earth, and people must have been familiar with it from early times; but for centuries it was regarded merely as a black rock, and the idea that a rock would burn never entered people's heads. After a while it became known that this substance would burn and give a great heat; but so long as there was plenty of wood to burn nobody bothered about any other kind of fuel. Sometimes people in the coal districts gathered it by hand for fuel. Then they began digging shallow pits.

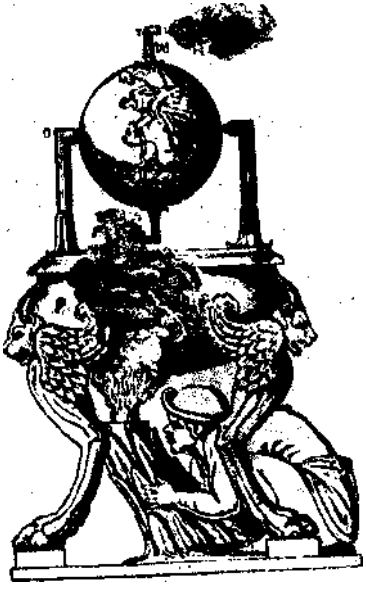
The demand for iron which sprang up when the new spinning and weaving machines came in, and the scarcity of wood, made the need of fuel pressing. So people began digging coal. The work was terribly hard. Men and women carried the coal out in baskets. If you had visited a coal mine two hundred years ago, you would have seen women bending under heavy baskets of coal toiling up ladders or winding stairways from the depths of the mines. In some mines the passage-ways were so small that men could not get in to bring out the coal, and



A little boy " trapper " in an old coal mine opening the door in a passage-way for the coal wagon to come through.

Workmen raising water and coal in baskets from a mine by means of a windlass. (From Agricola's " De Re Metallica.")

children were employed. Some of them were used as " trappers," sitting all day long in a little hole scooped out for them behind a little door with a string attached to it. When they heard a car coming with coal, they would open the door for it to pass, and then close it again. These poor little things passed the whole day in the dark, without even the light of a candle. Other children pushed and dragged the little cars of coal along the passage-ways. In some mines they used baskets slung on chains and worked by hand rollers to get the coal up. Four or five men at the surface would drive the roller round and round, and



Hero's Ball of Aeolus, the earliest steam engine. Water was heated in the globe, and steam coming out at the top kept a ball dancing in the air.

very slow and hard work it must have been. When the mines got deeper, horses walking round and round were used to work the rollers. A combination of windlass and pulleys made it possible for a horse to lift heavy baskets of coal out of the mines.

The demand for coal to smelt iron was steadily increasing, and people dug deeper and deeper. But now another trouble arose to make the work even more difficult. The deep mines were constantly flooded with water, which had to be drained off by a chain of buckets. As a bucket reached the bottom of the mine, it dipped up the water; and the endless chain lifted the bucketful of water. It was slow, weary work, and with such crude methods it was impossible to supply the iron workers with enough coal. There was pressing need for a machine to pump the water from the mines and hoist the coal quickly.

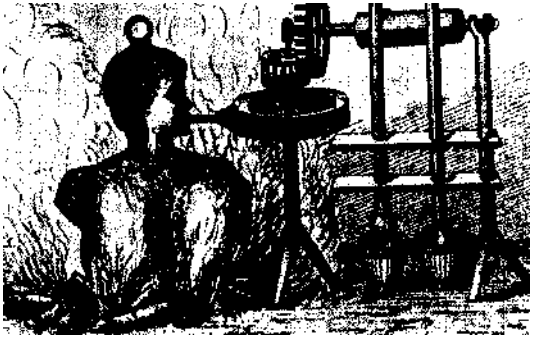
Now all through the ages man had been searching for some power to help him in his work. In the beginning he had only the strength of his own body. Back and arms and legs were ever weary with their increasing burden. He looked about for other means. Then he learned how to make the animals work for him. It had occurred to someone in quite early times as he watched a swift mountain stream sweeping everything before it, that the power in falling water might be utilized. He set a wheel in the water, and the water turned the wheel and did work. Men had also utilized the wind in windmills with great revolving arms to pump water, grind grain, and perform other useful services.

All of these devices gave men much greater power than they had in their own bodies. But the water-wheel was useful only where there was a waterfall, the wind was uncertain, the strength of animals was

limited. All through the centuries men had dreamed of a power that might be more useful than any they knew. That power was the expansive power of steam.

For centuries men had been wondering about steam and experimenting with it to see what it would do. The oldest experiment with steam of which we know was made in the time of the Greeks, by a man named Hero who invented a very simple device called the Ball of Aeolus. Water was heated in a globe with an opening at the top. Steam came out of the top through two tubes and kept a ball turning round and round on two pivots. Of course this was nothing more than a toy, but it suggested the idea that steam might be utilized to do work.

This idea persisted through the centuries, and men kept experimenting with steam, trying to find a way of making it work for man. In 1629, an Italian physician, after reading about Hero's engine, invented one himself. He made steam in a boiler of metal shaped like



A steam engine invented by the physician Branca in 1629. Water was heated in the man's head, steam came out the tube and blew against a wheel, making it turn. The wheel was geared to two shafts which lifted two rods. Branca used this for crushing medicines. It was the first time that steam had been made to perform useful work.

a man's head. The only place the steam could get out was through a tube held in the man's mouth. A jet of steam issued from the tube and blew against a wheel making it turn. The wheel was geared to a shaft lifting two rods which Branca used for crushing medicine in a mortar. Thus was steam for the first time made to do useful work.

Denis Papin, a Frenchman, was the first to think of using steam in a tube, or cylinder, so that none of its force would be lost. In a cylinder

Young Humphrey Potter making an improvement on one of Newcomen's engines.

he placed a disc called a piston, fitted just loosely enough for it to move up and down. At the bottom of the cylinder water was heated and turned to steam. The expanding steam forced the piston up. When the steam cooled the piston fell with such force that it enabled an attached rope to lift a weight. When the moving piston was attached to machinery and the thrusting power of steam was transferred to it, man at last had a steam engine, a machine that he could control and make work at will.

Thomas Savery was the first man to attempt to make steam useful in mines. He built an engine named the Miner's Friend that could be used to raise water and drain a mine without the hard labour of pumping and bailing with buckets. Several of Savery's engines were used in mines and enabled the miners to work at a greater depth than they had ever worked before. But they were very slow and wasteful of coal.

The next advance was made by Thomas Newcomen, an ironmonger living in Dartmouth. After a great deal of work and many failures, Newcomen succeeded in making a pump that worked fairly well. It had a beam with a weight attached to one end. When this weight dropped, it pulled the piston up to the top of the cylinder. Steam was then let into the cylinder from the fire below. A jet of cold water was then forced into the cylinder. This condensed the steam, and the piston went down, causing the weight at the end of the beam to be lifted. By this action work could be done.

An important improvement in Newcomen's pump is said to ha\e been the invention of an ingenious boy named Humphrey Potter. The pump required someone to open and close the valves admitting the cold water and the steam, but the work was so simple that it was usually done by a boy. In one mine Humphrey was hired to do this. It was a monotonous job that required constant attention. One day as he was watching the valves and wishing that he was out playing, he noticed for the first time that one of the valves had to be opened just as the beam from the engine had dropped to its lowest point on one side and shut as the beam rose to its highest point on the other side. Quick as a flash the idea came to him, why not make the beam do the work ? He quickly fastened strings to the moving beam so that it would open and close the valves, and then he was free to enjoy himself. Humphrey's idea was found to be so valuable that it was soon applied to all steam pumps. Rods were substituted for the strings and the machines worked automatically.

Many coal mines adopted Newcomen's engine, and it was used for almost seventy years. But it was very slow and wasteful of fuel, requiring almost as much coal to run it as was produced by its use. Unless something better than this clumsy, wasteful pump could be found the iron industry could not make much progress. In 1763 James Watt set himself to improve upon Newcomen's engine so that it would not use up so much coal.

James Watt making his first experiment with steam.
(From a modern painting.)

James Watt was born in Scotland. When he was a boy, he was not strong enough to go to school but was taught at home by his mother and father. Even as a small boy James delighted in tinkering with things. He took his toys to pieces, and out of their parts made new ones.

On one occasion when he was stretched out on the floor drawing lines on the hearth with a piece of chalk, a friend of his father's said, " Mr. Watt, you ought to send that boy to school and not allow him to trifle away his time at home."

" Look how my child is occupied before you criticize him," replied Mr. Watt.

Although he was only about six years old, Jamie was busy drawing triangles and curves and trying to solve a problem in geometry. The visitor questioned him and found his answers unusually intelligent.

"Forgive me," he said. "This boy's education has not been neglected. He is no common child."

Not far away lived an aunt with whom James often stayed. One day, the story goes, his aunt found him in her kitchen studying the tea kettle. He bent over it, closely watching the steam as it puffed from its spout. Soon the lid began to rattle and shake. He took off the lid, held a cup over the steam and watched the drops of water into which it condensed. His aunt reproved him for what she thought was trifling, saying : " James Watt, I never saw such an idle boy. Why don't you take a book and employ yourself usefully ? For the last hour you haven't spoken a word, but have just taken off the lid of that kettle and put it on again. Aren't you ashamed of wasting your time that way ? "

As he grew older, James spent much of his time in his father's shop, where supplies for ships were kept and ship repairing done. He had a small forge and a work bench of his own. Here he fashioned cranes and pulleys and learned to work with different metals and wood. So skilful was he that the workmen often remarked, " Jamie has a fortune in his fingertips."

Watt working on a model of Newcomen's engine.

At last the time came for James to choose a trade. His father wanted him to follow his business, but as he had lost a good deal of money it seemed best for his son to choose a trade in which he could use his mechanical talents. So James set out for Glasgow to become an instrument maker. He became a great friend of the professors at the university and cleaned and repaired all kinds of instruments for them.

One day a model of one of Newcomen's engines was given him to mend. In watching *it* at work Watt saw that the alternate heating and cooling of the cylinder made the engine excessively slow and wasteful of steam. With such a loss of heat he felt sure that the engine would never work economically. Too much fuel was needed to keep it going.

Watt became very much interested in the problem. He realized that the cylinder should not be cooled at all but should always be kept as hot as the steam that went into it. But how could the cylinder be kept hot all the time ? From that time on he gave himself to the absorbing study of how to make a more useful engine. For months he worked night and day, experimenting with steam. He hired an old cellar and made a model of a steam engine. But although he spent much time and money, nothing he tried succeeded.

At last, the solution came to him in an illuminating Hash. " I was taking a walk on a fine Sunday afternoon in 1765/' he tells us. " I was thinking about the engine and how to save the heat in the cylinder, when the idea came to my mind that as steam is elastic it would rush into a vacuum. If a pipe were made between the cylinder and an exhausted vessel the steam would rush into it and might be condensed there without cooling the cylinder. I had not walked far before the whole thing was arranged in my mind."

The next day Watt set to work eagerly to convert his idea into reality. Days of hard work and frequent failures followed. Nevertheless Watt felt sure that he was on the right track, and he kept on. For years Watt worked on his engine before he was able to make one that was satisfactory.

Watt's first engine was a very crude affair. He called it Beelzebub, because it puffed and snorted smoke and fire and hissing steam at every point. Finally it blew to pieces. Watt was in despair, but did not give up. Old Beelzebub was shipped to Birmingham and the best mechanics set to work on him. One by one his broken parts were mended, and he was finally made to work successfully. Thus after years of thought and

labour the first steam engine was completed. But even after this, much work remained to make the engine a practical success.

There was living in Birmingham at this time a wealthy manufacturer named Matthew Boulton. He became interested in Watt's work and formed a partnership with him which gave Watt the money he needed to make his engine a success. Mine-owners from far and near came to see it work. It pumped water out of mines as they had never seen an

For many centuries iron was hammered into the desired shape by hand. In 1838 James Nasmyth invented the steam hammer, the forerunner of our modern steam hammers. It was a huge block of steel lifted up by steam. When the steam was let out, the hammer fell on the object to be hammered.

engine do before, and orders for engines came pouring in. By 1783 Watt's engines were used in many mines in Europe.

James Watt lived to a happy and prosperous old age. He kept up his experiments to the end of his life. A little workshop in the attic of his home was his favourite place. There he was content to stay and work for hours. " Without a hobby-horse," he said, ' what is life ? "

The steam engine was invented to pump water out of mines, but it was soon discovered that all kinds of machines could be made of iron and run by steam. England had great stores of iron and machines

and plenty of coal to produce the power to run them. Watt's engine enabled her to make use of these great resources, and the next twenty years saw Watt's engines set up all over England. By the close of the eighteenth century steam had come into general use, and all the leading industries of England were conducted with power-driven machinery. Tasks that had before been performed slowly and laboriously were now accomplished swiftly and with ease. Machinery enabled England to make more goods than she needed, and her exports to other countries increased enormously. Mines and mills, foundries and forges, were humming centres of industry, and England became the workshop of the world. This was the stuff out of which England created the great age of machinery in which we are living to-day.

Watt's engine gave the world a new kind of power. By it the energy of the sun, absorbed by the great forests in the early ages of the earth, was made to work for man. The plants of those early days lived and grew like those we know, thriving in the warm sunshine and taking from the air millions of tons of carbon. Then great upheavals buried the forests, changed them into coal, and concealed them under the surface of the earth for untold ages, until at last the coal was brought forth and made to work for man. Thus the old buried swamps of the early world give the heat and power with which man is to-day re-making the face of the earth.

CHAPTER XVI

THE CONQUEST OF THE WATERS

ALL through the centuries man had been at the mercy of the wind on the water, often held back by calm and storm. After the invention of the steam engine it was only natural that men should attempt to apply it to navigation. There was great need for a boat propelled by steam, and Watt's engine was strong enough to propel it. So the steam engine was scarcely perfected before men began trying to apply steam to moving boats.

One of the first men to propel a boat by steam was an American, John Fitch. He launched a small boat on the Delaware River, propelled by oars which were moved back and forth by a steam engine. Later he launched a steamer propelled by a screw. It ran from Philadelphia to Burlington at the rate of eight miles an hour. This was the longest trip made by a steamboat up to that time. But Fitch's money gave out and he was unable to get help. Although he did not live long enough to see his steamboat a success, he believed in it to the last. " The day will come," he said, " when some more powerful man will get fame and riches, but now no one will believe that poor John Fitch can do anything worthy of attention."

Other men were also working on the problem, but defects in engines or paddle wheels or other parts made these first attempts unsuccessful. So many attempts had been made, and there had been so many failures, that men came to believe that it was impossible to make a steamboat. But now came a man who, after years of trying, finally accomplished the impossible. His name was Robert Fulton.

Robert Fulton was born in Lancaster, Pennsylvania, in 1765. Until he was eight years old he was taught by his mother After that he went to a school kept by a dignified old Quaker named Caleb Johnson. He did not seem to care greatly for books. He loved to visit the machine shops, and he spent all his spare time making things that he

needed or wanted. Fulton was nicknamed " Quicksilver Bob " because he was in the habit of buying small quantities of quicksilver from a near-by druggist for mysterious experiments about which he would tell no one.

When Robert was twelve years old, the second anniversary of the Declaration of Independence came round, and the people of Lancaster planned an illumination of the town by candles. But as the weather had been very dry, they were requested not to light the candles for fear of fire. Robert had prepared for the celebration, but he decided that he would not disobey the law. So he took his candles to a shopkeeper and exchanged them for some powder and pasteboard. The curiosity of the shopkeeper was aroused, and he asked Robert what he was going to do.

" Why," said Robert, " we are forbidden to light our windows with candles. I'm going to shoot mine through the air."

" Nonsense," said the shopkeeper. " That's impossible."

" No, sir," said Robert. " Nothing is impossible."

He made the rockets, which were fairly successful, and astonished the people of the neighbourhood.

Robert and his friend Christopher Gumpf used to go with Christopher's father on fishing trips. The old gentleman had a flat boat, and the boys usually had to take turns poling it to different parts of the Conestoga Creek. One day Robert remarked that he was tired of using that pole. Shortly after this, on a week's visit to his aunt, he made a little model of a fishing boat with paddle wheels turned by a crank. When he got home he told Christopher about it, and they made a set of paddles for the fishing boat turned by a crank while a third paddle revolved on a pivot to steer the boat. The boys were much pleased with their invention, for now they could propel the boat without so much hard work. So it was on the quiet waters of a creek as a fourteen-year-old boy that Robert Fulton began working on the problems of navigation.

When Fulton grew up he took up the study of engineering, and he always had in mind the building of a steamboat. He studied steam engines in England and France, and he learned all he could about the mistakes and failures of others in applying steam engines to boats. He examined a number of plans. Someone had attempted to propel a boat by forcing water through the keel and out at the stern

of the boat. Another had paddles like a duck's feet placed underneath the boat, which opened as they were pushed out and shut as they were drawn in. The boat actually moved, but it was found that the duck's feet could not push hard enough to move heavy loads.

Fulton made experiment after experiment. For nine years he worked hard trying to find the right relation between the size of a boat

When Robert Fulton was a boy of fourteen he made his first experiment with paddle wheels on the Conestoga Creek.

and the power of the machinery required to move it. He calculated the resistance of the water and the force necessary to move a boat through it. When he was in France he built a boat. It was almost ready for its trial trip when a violent storm came up one night and broke the boat in two and it sank to the bottom of the river Seine. The next morning Fulton was awakened by the shouts of his servant who told him that the boat had broken to pieces and gone to the

bottom of the river. Fulton hurried to the river to find that this was only too true. The fruits of many months of labour were lost. But this did not discourage Fulton. On that very day he set to work to raise the boat, working twenty-four hours without food or rest. The boat was finally finished again, and this time it was a success.

The experiment was so encouraging that Fulton ordered an engine from Watt and directed that it be sent to America. He set sail for New York in 1806. Immediately he began building a steamboat, but before it was finished he ran out of money. And he had great trouble finding people who would lend him money for such a foolish thing as a steamboat. But at last he got the funds from friends who asked that their names be kept secret as they did not wish to be ridiculed.

Those who saw Fulton's boat when it was being built doubted whether it would ever run. " Fulton's Folly," they called it. Fulton often loitered unknown near the idle groups of strangers that gathered to make fun of his boat. However, the boat was at last finished, and was named the Clermont.

At noon on August 17th, 1807, she was lying at her dock in the Hudson River, New York. The momentous day for the trial trip had come. The news had spread like wildfire, and a great crowd of curious people gathered to see the strange-looking craft. A tall smokestack rose from the deck, and from the sides there stuck out queer-shaped paddle wheels.

Only twelve 'people took passage for Albany. Few men were willing to trust their lives to this queer craft with a puffing demon inside. Fulton was on deck, surrounded by friends. At one o'clock a long blast was blown on a tin horn as a warning to near-by boats to get out of the way. " God help you, Bobby. Bring us a chip of the North Pole," someone shouted to Fulton. Clouds of smoke belched from the smokestack, there was the hiss of escaping steam and a creaking, whirring, churning sound as the great awkward side wheels began to turn, and to the astonishment of everyone the Clermont moved out from her dock into the stream. Ridicule and joking gave way to silence as the crowds watched her progress with wonder and awe.

After going a short distance, the boat suddenly stopped, people began to whisper, and Fulton could hear those on board saying : " I told you so. It is a foolish scheme. I wish we were well out of it." But Fulton discovered the cause of the trouble, and in a short time the

boat was again on her way. She left the city behind her, passed the Palisades, and made her way up the Hudson River.

She was indeed a strange-looking craft as she moved slowly along. Instead of sails and rigging, which all boats had at that time, the machinery occupied the middle of the deck and creaked and groaned from time to time. Instead of the usual gracefully tapering masts there was the black, ungainly smokestack. The huge paddle wheels rising seven feet on each side, splashed in and out of the water, casting spray high into the air. Dry pine wood was used as fuel, and whenever

The Clermont, the first boat propelled by steam, invented by Robert Fulton, made its historic trip up the Hudson River from New York to Albany and back in August, 1807.

the engineer heaped more wood on the fire, a great cloud of sparks went shooting up from the tall smokestack.

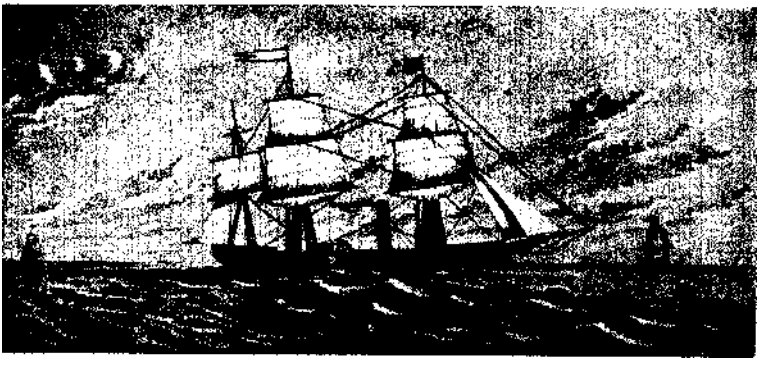
The passage of the Clermont up the river caused great excitement all along the way. At every town the banks of the river were crowded. Hats and handkerchiefs were waved, and the people cheered. As night came on, the crews of boats on the river had an experience they never forgot. They had. never heard of a steamboat, and as the Clermont drew near they saw steam and smoke and sparks bursting from the funnel, and heard the growling and rumbling of the machinery, and the rushing noise made by the great paddles splashing through the water.

Terrified, many of them leapt from their boats and swam ashore, others sought shelter in the hold and drew down the hatches tight. They fell upon their knees and prayed for protection from the horrible sea monster that was advancing upon them, moving on the water in defiance of wind and tide, and lighting its pathway with the flames it belched forth.

Thus the Clermont made her historic journey from New York to Albany and back under her own steam. She covered the hundred and fifty miles to Albany in thirty-two hours and returned in thirty, which was a speed of about five miles an hour. The great experiment had been successful. The Clermont from then on made regular trips and proved to be a paying venture.

It was soon discovered that the steamboat would interfere with the interests of those engaged in the river traffic. Captains and owners of sailing vessels saw in the Clermont a dangerous rival, and she became the prey of other river craft. The captains of other river boats would run into the steamboat and make it appear that the fault was hers, so that she might seem unsafe to travel in. Several times she was damaged by other boats that ran into her.

The possibility of propelling boats by steam had been proved. Thus began one of the great epochs in the world's work. The day of steam navigation had come. Up to this time man had been subject to the wind and the tide ; now he was independent of both. From the



The British ship Sirius, **the first steamer to cross the Atlantic, arriving in New York in 1838.**

time that the Clermont successfully breasted the tide of the Hudson River, other steamboats began to appear in rapid succession. In 1800 the greater part of America was a trackless wilderness except for the trails made by the Indians or the animals. The rivers were the natural highways to the West, and steamboats now began to ply on them, developing the young nation and tying it together. By 1818 steamboats could be seen trailing long lines of smoke up and down the Ohio and Mississippi

An American clipper ship. For quite a while after the invention of the steamboat the clippers, with towering masts and many widespread sails, could outdistance any steamboat. But in the end steam conquered the sail.

rivers. Journeys that had required weeks were accomplished in as many days. By 1823 there were more than three hundred steamboats on American lakes and rivers.

Having triumphed over wind and wave on smaller bodies of water, men now began to think of crossing the broad Atlantic by steam. But at first they did not wholly trust the new machinery. The sailing ship had reached the highest point in its development ; the steamboat was in its infancy. This was the time of the famous Yankee clippers, built

with a high knife-like bow that cut through the water. These long slim beauties, with towering masts and many widespread snow-white sails, were to be seen in every part of the world. In the early days of steam navigation these graceful clippers, with a favourable wind, could outdistance any steamboat. But in the end steam conquered sail.

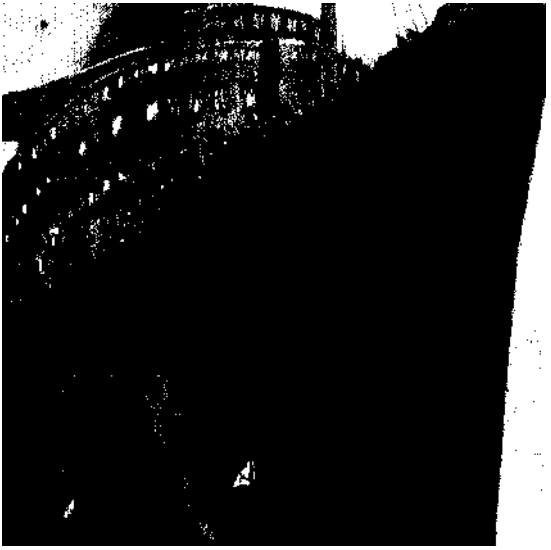
The first steamers to cross the Atlantic were merely vessels with engines. The first, the Savannah, left America on the 22nd of May, 1819, and arrived in Liverpool twenty-six days later. Through most of the trip, sails were used ; only now and then were the clumsy paddle wheels set in motion. The first vessels to cross the Atlantic entirely under steam were the English steamships Sirius in 1836, and Great Western in 1838. The Sirius, a little boat, crossed in eighteen days ; and the Great Western, which was much larger, arrived after fifteen days with ninety passengers. Transatlantic steamship service now developed rapidly, and almost every year after this saw new records made for the crossing.

Up to this time all ships had been made of wood. The idea that boats should be made of material that was lighter than water had come down through the centuries. But wood was becoming scarce in England at this time, and English shipbuilders began casting about for some other material.

Surely such a heavy substance as iron would not be suitable. But the science of shipbuilding was now making great strides, and engineers began making boats of metal. England with her strongly developed iron industry was the first to build iron ships. American shipbuilders, with so much timber, still clung to the wooden ship. The American wooden ship was much cheaper to build and run than the English iron ship. But eventually the iron ship was improved and was found to be much more durable than the wooden ship and able to carry a heavier cargo. So in time the iron ship surpassed the ship made of wood. Later steel ships replaced iron. England developed the steel ship in the early eighties.

The first regular passenger service across the Atlantic was that of the Cunard Line, which was established in 1839 and supported by the English government. From that time, England steadily gained supremacy in the shipping world and American shipping declined.

In 1900 the Germans appeared as challengers of British supremacy on the Atlantic. The steamship Deutschland of the Hamburg-American Line crossed the Atlantic in 5 days, 7 hours, and 38 minutes,

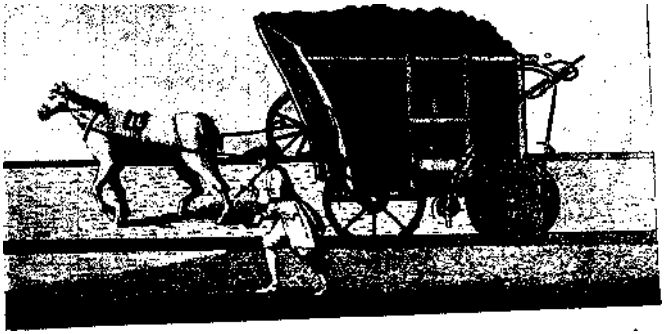


Courtesy North Get

The North German Lloyd motor-vessel Bremen, escorted by tugs, making her way up New York harbour. She has crossed the Atlantic in 4 days, 17 hours, and 42 minutes and holds the world's west-east record.

thus holding the world's record for speed. This led to the building of the British steamships Mauretania and Lusitania, by which time on the fast liners was still further reduced. Germany is now again challenging English supremacy. Two new greyhounds of the ocean, the North German Lloyd liners Bremen and Europa, at present hold the world record for speed in crossing the Atlantic. The Bremen has crossed in 4 days, 17 hours, and 42 minutes and holds the record for the west-east passage, and the Europa has crossed in 4 days, 17 hours, and 4 minutes and holds the east-west record.

The story of man's conquest of the seas is one of indomitable courage. Century after century he pitted his intelligence against the strength of wind and waves. Step by step he made his way to mastery. At length science came to his aid with ships of steel and powerful engines to drive them. And now superb ships make their way over every ocean to every part of the globe, linking up the nations of the world and developing the world's commerce. There does not seem to be much connection between the drifting logs of the early days with men riding astride them, and these floating palaces of wonderful symmetry and grace and strength, but the development can be traced step by step through the ages from the time man first set himself afloat on a tree-trunk.



An eighteenth century coal wagon which ran on rails between the mines and the ships. The front wheels were of iron and the back wheels of wood. This was a step in the development of the modern railroad. (From the *London Magazine,* 1764.)

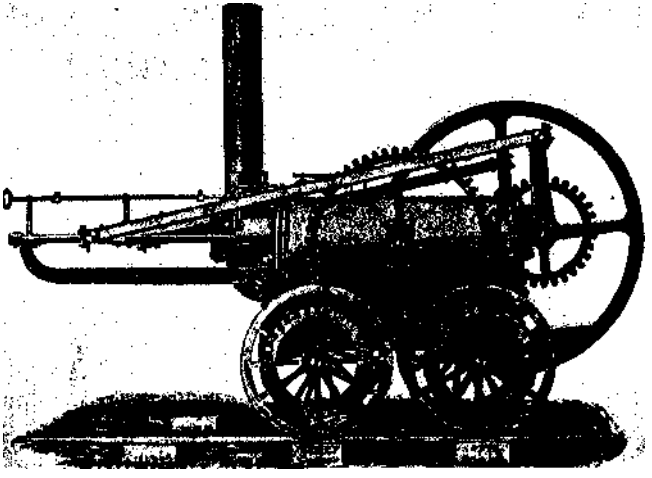
CHAPTER XVII

THE IRON HORSE

ALTHOUGH the steamboat had been perfected by 1807 transportation on land had made little progress with the passing of the centuries. The pack team and the ox- or horse-drawn vehicle were still the best known means of transportation. Even these were impeded by the terrible roads. In wet weather wagons often sank into the mud up to the hubs of their wheels. Goods were usually carried on the backs of pack-horses, and summer and winter, every day, all day long teams of patient horses, heavily laden, could be seen walking single file up hill and down dale behind their leader.

The first improvements took place in connection with mining. With Watt's engines to pump out the water and haul up the coal, miners were digging deeper into the ground and bringing out more coal than ever before. Moving the coal from the mine to the harbour wharf was very slow and expensive. The carts of coal were very heavy and the ruts so deep that rough wooden planks were laid down on the roads to keep the wheels from sinking into the mud. The next step

was to fasten these boards together until a continuous strip was formed. To hold the planks at an even distance crosspieces were laid. As it was found that the wooden planks soon wore out, iron strips were fastened to their upper surface to make them last longer. This was the beginning of the modern railroad track. Next it was discovered that the iron strips wore out the cart wheels, and iron rims were introduced ; and by the eighteenth century iron wheels were in use. The wheels slipped off the edge of the rail, and William Jessop invented



The first locomotive, named Catch-Me-Who-Can, invented by Richard Trevithick in 1804.

in 1789 a wheel with a rim on the inside to keep it from slipping off the track. So the tracks were ready for the steam engine. But through all these changes horses still dragged the great wagon loads of coal along the roads from the mouths of the mines to the coast where the ships lay waiting for it.

So long as the horse remained the best means of pulling a load, neither the weight of the load nor the speed could be increased beyond a certain point. The need for some new means of transporting goods was now clear to everyone.

Scarcely had Watt's engine been perfected when it occurred to thoughtful people connected with mines that an engine which could pump water out of the mines might be made to draw coal carts over the little track. The honour of first applying steam to the hauling of

George Stephenson as a boy studying his engine.

loads belongs to Richard Trevithick, who in 1804 built the first engine on wheels, which he called Catch-Me-Who-Can. He also made an engine which was able to haul a load of ten tons at the rate of five or six miles an hour. For a short time it was successful, but it broke so many rails and ran off the track so often that it was finally given up. The

trouble was with the track and not with the engine. With a little more perseverance Trevithick might have made a successful locomotive, but he did not do much more and other men took up the work.

In 1813 William Hedley built an engine which he named Puffing Billy, capable of hauling fourteen loaded coal wagons at five miles an hour. It did useful work in a coal mine for sixty years.

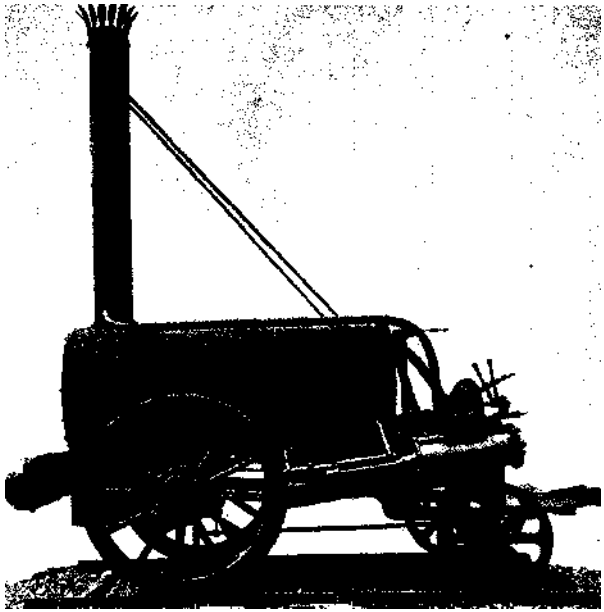
Meanwhile a young man named George Stephenson, who was working in a coal mine, began experimenting with a locomotive. One of Watt's engines was used in the mine where Stephenson's father was employed as fireman. Old Bob, as the villagers affectionately called him, was a great favourite in the village, especially among the children to whom he told stories while he was tending his engine. When George was a little boy he used to carry his father's dinner to him. He loved to see his father stoke the great fire, and hear the engine at work. It was the height of his ambition to work in the mine where his father worked, and as soon as he was old enough he was put to work and began helping his father fire the engine. Here he worked for several years.

George tried to learn as much as possible about the engine, and was so successful that when he was only seventeen years old he was put in charge of an engine of his own in a newly opened mine not far away. His engine was his hobby and he was never tired of caring for it. On Saturday afternoons, when many of the workmen were out spending their week's wages, Stephenson would take his engine apart, clean all the parts and put it together again. Thus it was that young Stephenson learned all about engines.

Stephenson thought that one of Watt's engines might be set on wheels and made to run along tracks carrying several trucks of coal behind it. This was tried and found to be very successful. So Watt's engine was put on wheels and became a locomotive. But although Stephenson's locomotives were in use at his mine for several years, nobody knew much about them, and there seemed to be little prospect that they would come into general use.

Years passed, and Stephenson heard that a tram-line was to be constructed, to run from Darlington to Stockton. There was no thought of using locomotives for it. The hauling was to be done by horses. Stephenson thought it a great pity to make horse trams, when it was now possible to run engines by steam. He had an opportunity

to speak to one of the directors and strongly recommended using locomotives. " One locomotive is worth fifty horses," he said. " Come over to Killingworth and see what my engines can do ; seeing is believing, sir." The director went to see Stephenson's engines, and as a result of his visit it was decided to use them on the new line. Thus

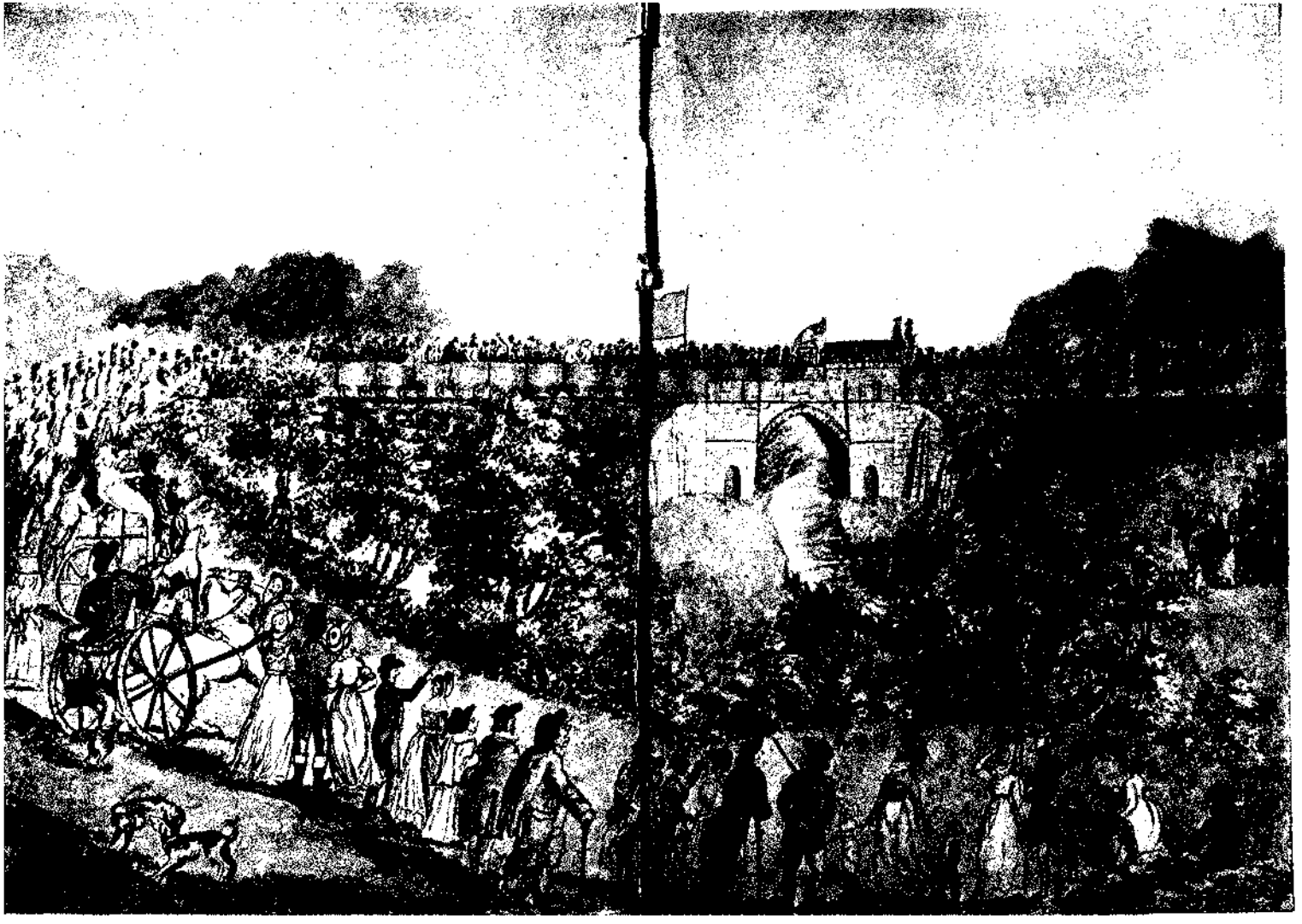


Courtesy Science Museum, London

Stephenson's locomotive, the Rocket, winner of the Rainhill trials.

in 1825 was built the Stockton and Darlington Railway, the first railroad in the world.

September 27th was the opening day. An immense crowd of people came to witness the ceremony. Stephenson himself drove the engine. The train consisted of a coach filled with the directors and their friends, twenty-one wagons fitted with temporary seats for passengers and six wagon loads of coal and flour. A man on horseback rode in front with a banner bearing the words " The Private Risk Is the Public Gain."



Courtesy Science Museum, London

The opening of the first railroad in the world, the Stockton and Darlington, England on September 27th, 1825. "Such was the velocity that in some parts the speed was almost twelve miles an hour," says the report describings extraordinary event. (From a sketch made at the 'time.)

An early train between Manchester and Liverpool. Travelling in those days and thrown on the floor when the train

A signal was given, and off started the procession, with the horseman at its head. The train moved about six miles an hour. Great crowds stood all along the line, and many people ran along to keep up with it. At a favourable place in the road Stephenson decided to try out the speed of the engine and called to the horseman to get out of the way. Stephenson then put on steam, and " such was the velocity that in some parts the speed was almost twelve miles an hour," says the report describing this extraordinary event.

Stephenson delivered his goods in Darlington and returned with about six hundred people in his train or clinging to it like flies, as his little engine rocked crazily along the track, belching forth smoke and sparks that terrified the countryside. It required great courage to ride on that first railroad. The cars were merely stage-coaches and there was no way of protecting the passengers from the smoke and cinders of the burning wood in the engine. The flames from the engine, the jerky movements, and the noise of the machinery frightened all but the bravest.

The success of the Stockton and Darlington Railway encouraged a group of men to build a railroad between Liverpool and Manchester. But there was still a good deal of opposition to the locomotive. It was thought that the engine would run off the track at the curves, and that people might be killed by a bursting boiler. Many of the farmers were afraid that the value of their land would be lowered, and that the sparks that streamed from the smoke-stacks would set fire to near-by farmhouses. They even thought that their hens would take fright and refuse to lay eggs and their cows would cease to give milk if locomotives were to roar past their farms.

was very different from travel to-day. People were often jerked from their seats started or stopped. (From an old print.)

Stephenson appeared before the directors to plead for the locomotive. All sorts of questions were put to him. " Suppose, now," said one member, " that a cow were to stray on the track and get in the way of the engine. Wouldn't that be very awkward ? "

" Yes," replied Stephenson, with a twinkle in his eye, " it would be very awkward—for the cow ! "

" I think you will live to see the day," Stephenson protested, " when railroads will supersede all methods of conveyance in this country, when mail coaches will go by railway and railroads will become the great highway for the king and his subjects."

He was laughed down, called " ignorant," " out of his senses," and " mad." Thus Stephenson, with only his practical knowledge to guide him and his genius to inspire him, battled for his ideas against the most learned men of the day.

The directors finally decided to test the powers of the engine. They offered a prize for the locomotive that would satisfactorily meet certain tests. Stephenson built an engine which he named the Rocket and entered it in the competition, which was held at Rainhill, near Liverpool. A great crowd gathered to watch the trial test of the engines. Four other engines had been entered, but the Rocket was so superior that it outran all the others. Although the Rocket did not run more than thirty miles an hour, that was double the speed of the best coaches of the day. It was declared the victor and won the prize.

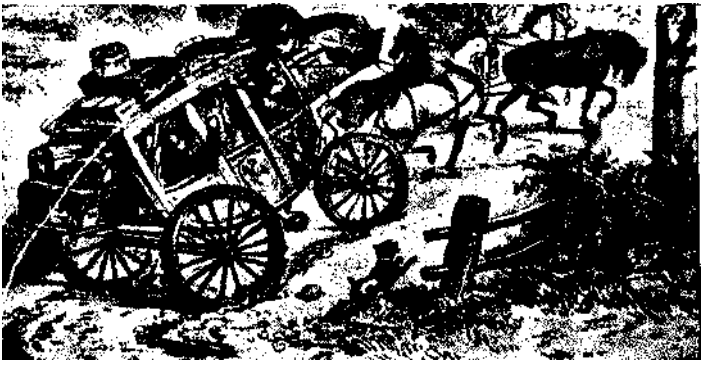
In a very few years locomotives were busy hauling raw materials to mills, carrying manufactured goods to places where they were needed, and taking passengers from place to place. Man now had an iron horse

The Flying Scotsman.

which could carry a load many times that of the live horse at a much greater speed, and which never grew weary. Railroads were built all over England, and by the middle of the century a network of railroads spread all over Europe. The new power had now arrived, and the locomotive was a success.

Travelling in those early days was very different from travel to-day. When we compare our giant modern locomotives with that of Stephenson, it looks like a toy. A description of early travelling tells of people being jerked from their seats and thrown in heaps on the floor when the train started or stopped ; but a long series of improvements which has not yet ended has utterly changed this.

So with the inventions of Fulton and Stephenson our great land and water transportation systems came into being. Where formerly for centuries clumsy wagons and stage coaches drawn by horses toiled slowly over the land and sailing ships subject to the winds made their way slowly over the water, now giant locomotives speed over their iron ways and great modern liners force their way across every ocean carrying goods and people, binding together all parts of the civilized world.



Before the days of railroads the best means of travelling was by stagecoach. If the coach got stuck in the mud, the passengers were requested to get out and walk.

CHAPTER XVIII

HARNESSING THE GREAT EARTH FORCE

As man travelled farther and farther over the surface of the earth he began to feel more and more the need of communicating with others at a distance, and he began working out ways of doing this. In the earliest days he had no better means of communicating with others than his voice. But, no matter how loudly he might shout, he could not make himself heard more than a few hundred yards. Suppose two early hunters became separated. What was more natural than for one of them to cup his hands around his lips to make his voice carry farther as he called to his companion ? This very natural action led in time to the use of the megaphone made of a piece of rolled bark.

Early man also discovered that by exhaling his breath sharply through his lips or his fingers he could produce a shrill whistle that would carry a long distance. Early people also blew through conch shells when they wanted to attract attention at a distance. These were natural trumpets, which man later learned how to imitate in metal. The bugle has been found very useful for signalling from early days down to the present.

The drum was also discovered early. Possibly a woodpecker drumming away on a dead tree stump may have given man the idea that pounding a hollow log with a stick would make a sound that would carry far. Some early thinker improved upon the hollow log by covering the end with the dried skin of an animal. Then man had a tom-tom, or drum, which has been much used for signalling all through the ages.

By all these methods man learned to convey messages over long distances. He also learned to use various visible signals. It was

very early discovered that smoke against the sky can be seen at great distances, and man began to use it to signal to people who were far away. By covering and uncovering the fire with a wet blanket separate puffs of smoke could be made, and these were worked into a simple code. In Egypt columns of smoke were used during the day and beacon fires at night to give warning of the approach of danger. A Greek named Polybius invented a system of smoke and fire signalling by which words could be spelled out. He divided the alphabet into five columns of about five letters each and used a signalling station

Courtesy New York Telephone Co.

The system of signalling invented by Polybius, by which words could be spelled out. He divided the alphabet into five columns of about five letters each. For signalling he used two panels slightly separated. The number of torches on the left panel indicated the column in which the letter was, and the number of torches on the right showed the letter that was intended.

which had two panels slightly separated. The number of torches raised on the left side indicated the column in which the letter was to be found, and the number of torches in the panel at the right showed the letter that was intended. This was used by the Romans throughout the empire. The system worked all right in clear weather, but of course rain stopped signalling.

Another device which used water for signalling was invented by Aeneas Tacticus. He placed cylindrical vessels filled with water on

hills several miles apart. Into each of these a cork was fitted loosely enough to float on the water. To the centre of each cork was fastened a stick marked with lines and numbers at carefully measured distances. When Tacticus wanted to send a message, he raised a torch, and then he and the operator to whom he was signalling started the water

New *York Telephone Co.*

A signalling device invented by Aeneas Tacticus. Cylindrical vessels filled with water were placed on hills. Into each cylinder a cork was loosely fitted. To the cork was attached a stick with numbers marked on it. Each number stood for a message. When a man wished to send a message to another he raised a torch and both men let the water run out of their cylinders. When the number on the stick indicating the message was reached, the first man lowered the torch, and the second man stopped the water in his cylinder and read the message.

running from their cylinders. When the stick in the first cylinder reached the proper place, the first operator lowered his torch and the second man turned off the water in his cylinder and noted the place on the stick. In this way messages were passed back and forth.

The Persians hit upon the reflection of the glare of the sun from a polished shield as a means of sending messages. This is the principle of the heliograph, which has been used down to our own day. But of course it cannot be used on cloudy days.

Semaphores and flags have also been used from the earliest days. In 1690 a French physicist named Amontons got the idea of making signals by means of flags and crossbars on poles that could be read at a distance with a telescope. Another Frenchman, Claude Chappe, almost a hundred years later, developed a most successful system of signalling. He had signal posts with movable crossbars at each end of which was an arm that could be swung on a pivot to almost any angle. Each angle represented a different letter of the alphabet. On clear days these signal posts eleven miles apart could be easily read with a telescope.

After man learned how to write, he began sending messages by fast runners. Most of the ancient nations worked out some such scheme of communication. Darius, one of the great kings of ancient Persia, had a wonderful system of couriers. It was described by the early historian Herodotus : " Neither snow, nor rain, nor heat, nor gloom of night stays these couriers from the swift completion of their appointed rounds."

Young Greeks were especially trained as couriers for the postal service. One of the most famous of these runners was Phidippides, who ran all the way from Athens to Sparta, about one hundred and forty miles, in less than two days to seek help against the Persian army which was threatening Athens. To secure greater speed over a long distance the complete course was divided according to the distance a man could run before fatigue seriously slowed him. At the end of such a run, a fresh runner would be waiting to start on with the message at top speed. So the message was passed along until it reached its destination. Sometimes the messengers were mounted on horses.

As one country after another came under the control of the Romans, they found it necessary to keep in close touch with their wide-spreading territory. Mounted relay couriers became very efficient because Rome

had excellent roads connecting all parts of the empire. Fresh horses were kept at certain points along the roads ready for instant use. The place where the change of horses took place was marked by a post. These posts were the first post offices, and it is from them we get the term post office which we use to-day.

All these courier systems were so costly to keep up that they could

Courtesy AVv *York Telephone Co.*

In the eighteenth century a Frenchman named Claude Chappe invented a most ingenious system of signalling by means of signal posts placed about eleven miles apart. On clear days messages from these signal towers could be easily read with the aid of a telescope and a word could be sent 115 miles in fifteen minutes.

be used only by kings or high government officials. During the Middle Ages couriers were still used to carry messages, and they were persons of great importance whose journey was delayed at peril of extreme punishment. The people quickly got out of the way whenever they heard a bugle and the call, " Make way for the king's mail," as the courier galloped swiftly by. In some countries during the Middle Ages

the use of the mail for private letters was extended by special grant to favoured individuals; but it was a luxury far too expensive for any but the very wealthy.

Fairly early, men began training pigeons to fly to distant places with messages. The Crusaders found this method of communication in use in the East and introduced it into Europe. Medieval knights found pigeons very useful for sending messages from one castle to another. This was the first air mail. So useful have pigeons been

The English scientist Gilbert, showing his electrical experiments to Queen Elizabeth and her court.
(From a modern painting.)

found for this purpose that they have been used ever since. Amazing records of speed have been set up by carrier pigeons. In good weather the older birds can fly about six hundred miles in from seven to nine hours. Dogs were also found useful as message carriers, especially in time of war. Both pigeons and dogs were used until the spread of radio.

Thus through countless ages man struggled against the obstacles of time and space in communicating his thoughts to others. He ingeniously made use of various sounds, fire, water, smoke, the reflection of the sun, the flight of birds and every natural agency he could think of.

But each of these devices had some drawback. It would work all right under certain conditions, but under others it was useless. Sound signals could be drowned out by distance or the direction of the wind. The speed of couriers was limited. Many signals were useless at night or in fog. No method of communication seemed very satisfactory before man learned how to harness the great natural force of electricity for this purpose.

Benjamin Franklin proved that lightning and electricity are identical by experimenting with a kite in a thunderstorm.

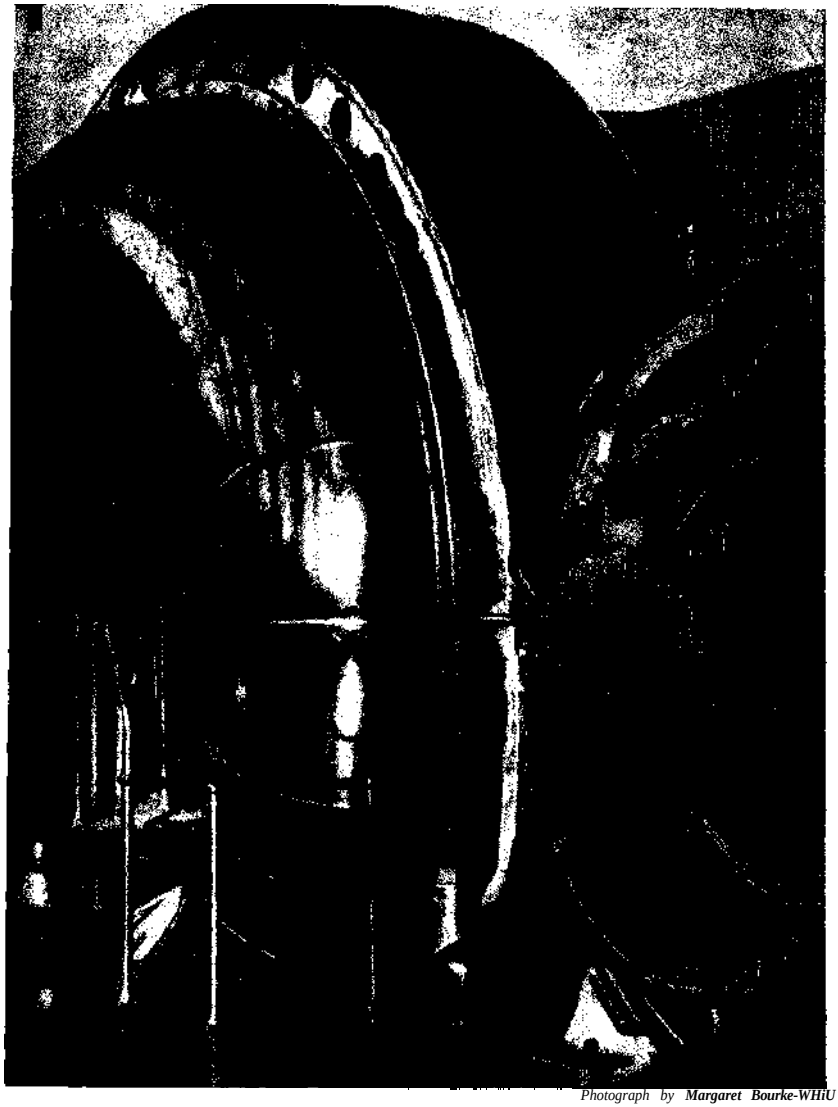
Only in recent times has man begun to brave this great force. Thunder and lightning must have struck terror to the very heart of early man. How he must have trembled as he saw the gathering storm clouds that made the world as black as night, or as he heard the deafening roar of thunder or beheld the heavens split wide open with blinding flashes of lightning ! Here he saw at work a mysterious and tremendous power which he could not understand. As the lightning struck a near-by tree or perhaps killed an animal, he could only crouch shuddering under a friendly overhanging rock until the angry god passed by.

For many centuries man knew very little about this great earth force. But little by little he discovered strange facts about it. As far back as 600 B.C. a Greek named Thales found that a piece of amber rubbed with a cloth would attract hairs, bits of silk, and other light objects near it. But he had no idea what caused this. Amber was called by the Greeks *elektron,* because it seemed to reflect the light of the sun and the Greek name for the sun was *elektor.* Our word electricity comes from the Greek word for amber.

Long before this, people knew that there was a kind of stone to be found in the earth that attracted iron. An old Greek legend tells us that one day a shepherd, while resting, laid his shepherd's staff on the ground by his side. When he tried to lift it up he was amazed to find that the iron end of it was stuck tight to a strange black rock. It was in this way that magnetic iron ore was discovered.

More than two thousand years after Thales, about 1600 A.D., William Gilbert, an English scientist, discovered that other substances as well as amber would attract light objects after being rubbed. He was one of the first scientists to enter this field. By the seventeenth century many scientists became interested, and one after another began making experiments. In 1672 Otto von Guericke, a German, invented the first electrical machine that produced electricity by friction.

Up to the end of the eighteenth century clumsy friction machines were the only means of producing electricity. Then an Italian scientist named Volta made a pile of strips of copper and zinc separated by pieces of flannel soaked in a salt solution. From this pile wires led out, and one had a positive and the other had a negative charge. Thus Volta was able to get a continuous current of electricity instead of the



Photograph by ***Margaret Bourke-WHiU***

A dynamo from a great power plant.

occasional spark made by friction. This was a great step forward. Volta's pile was the forerunner of the electric batteries which are so widely used to-day. His name was given to the unit of electrical pressure. About seventy years before, Stephen Gray had discovered that electricity could be conducted from one place to another by wires.

Even after men had slowly learned about electricity they did not connect it with the lightning of the heavens. Benjamin Franklin by his famous kite experiment proved that electricity and lightning were the same thing. One June day in 1752 Franklin conceived the idea of sending up a kite among thunderclouds. He made a cross of two strips of wood long enough to go to the four corners of a large silk handkerchief. A tail and a string were added, and a sharpened piece of iron wire was fixed to the top of the kite. Part of the string was twine and the part nearest the hands was a silk ribbon.

Franklin and his son went out in a thunderstorm. They stood in the doorway of a shed and from time to time sent the kite up into the air, but the lightning did not reach it. Hour after hour passed, and as nothing happened they began to think that their experiment was a failure. Then suddenly there was a flash of lightning, the filaments on the twine began to stand out. Franklin struck the key with his knuckle and got an electric spark. His experiment proved that lightning and electricity were the same thing.

For a long time the facts known about electricity did not do the world much good, because man did not yet know how to utilize his knowledge. But within the last two centuries men have made electrical batteries and currents do all sorts of useful work.

In 1819 Oersted discovered that if a wire was wound around a bar of soft iron and an electric current turned on, the bar became a magnet. Much use was made of this fact later in the development of the telegraph and the telephone.

In 1831 Michael Faraday, an English scientist, discovered how to make electricity continuously and in great quantities by means of a dynamo. This unlocked for man enormous storehouses of power, and electricity was made the cheap and dependable servant of man. Faraday's work prepared the way for the electrical experiments of the nineteenth century, when the discoveries made through many preceding centuries bore fruit in many marvellous inventions.

So, at last, after many centuries of endeavour, the great mysterious force that so terrified our first ancestors when it flashed through the heavens, has been tamed and made our obedient slave. Man has learned to create lightning at will and to apply it to numberless uses. It is hard to realize that for centuries people lived without its aid. To-day at every turn electricity enters into our lives and contributes in countless ways to our comfort. The dynamo with its soft purring ways is as useful as the steam engine. Steam power and electric power divide the work of the world between them.

CHAPTER XIX

FROM WIRES TO WIRELESS

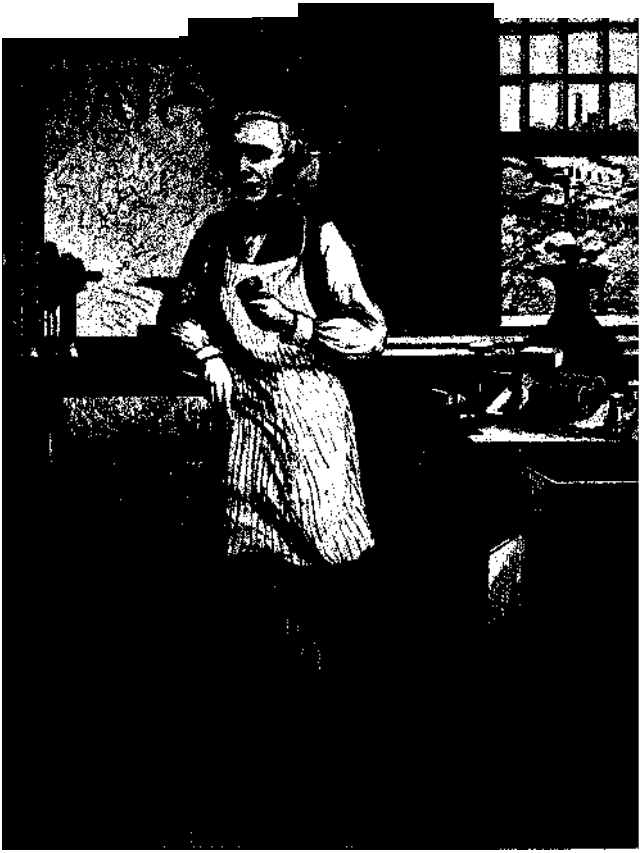
AT the same time that men were learning to use electricity as a source of power, other men were discovering how to use electricity to carry signals over wires.

In October, 1832, Samuel Morse, an artist, was returning to America from Europe on the packet-ship Sully. On the steamer he met a fellow passenger who, like himself, had been studying abroad. But his companion had been studying electricity. He told about the wonderful electrical experiments of Ampere, by which electricity was made to pass a long distance over a wire. This gave Morse the idea that messages might be sent over a wire by means of an electric current. " If the presence of electricity can be made visible in any part of the circuit, I see no reason why intelligence may not be transmitted instantaneously by electricity," said he.

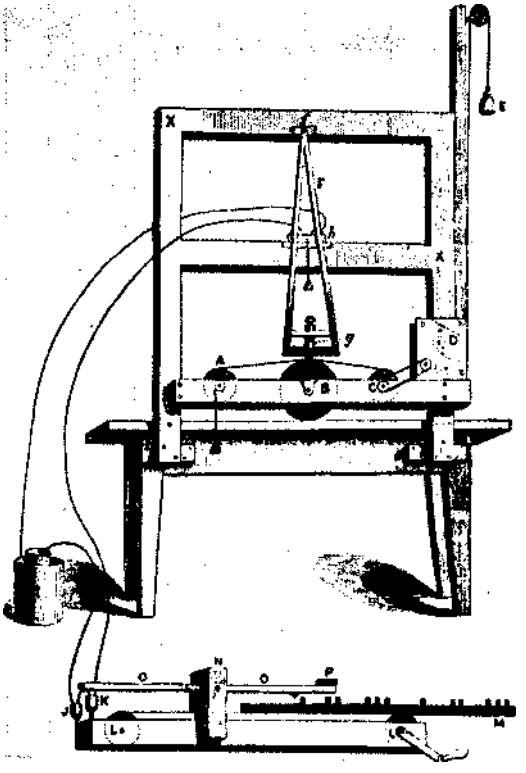
The idea took possession of him. It kept him from sleeping at night. When he left the ship, he said to the captain : Well, captain, should you hear of the telegraph one of these days, as the wonder of the world, remember the discovery was made on board the good ship Sully."

From that time on Morse gave all his time to thinking of a way to signal by electricity. To the end of a wire he fastened a pencil in such a way that the electric current made the pencil mark. " Now," he reasoned, " if I can make a pencil do this over a short wire, why can't I do it over a hundred thousand miles ? " •

Morse was poor, and his difficulties were great For years he lived in a single room, which served alike for studio, parlour, bedroom, kitchen, and workshop. " In order to save time to carry out my invention," he tells us, " and to save my scanty means, I had for many months lodged and eaten in my studio, getting my food in small quantities from some grocery, and preparing *it* myself. To conceal



Samuel Morse at work on the first telegraph instrument.



The first telegraph instrument. Morse, an artist, used the canvas stretcher from a picture and some old clock wheels and other bits of metal and machinery to make it.

from my friends the stinted way in which I lived, I was in the habit of bringing my food to my room in the evenings, and this was my mode of life for many years."

He tried to make his living by teaching art, but his experiments took so much of his time that he had very few pupils. One of his pupils wrote later of this time :

" I engaged to become one of Morse's pupils, and paid fifty dollars for one quarter's tuition. When the second payment became due to him

money did not come from home as promptly as expected and one day the professor said to me, ' Well, my boy, how are we off for money ? '

" ' Why, professor,' I answered, ' I'm sorry to say I have been disappointed, but I expect some money next week.'

" ' Next week,' he repeated sadly. ' I shall be dead by that time.'

" ' Dead, sir ? '

" ' Yes, dead by starvation.'

" I was astonished and distressed and said hurriedly, ' Would ten dollars be of any service ? '

" ' Ten dollars would save my life. That's all it would do.' "

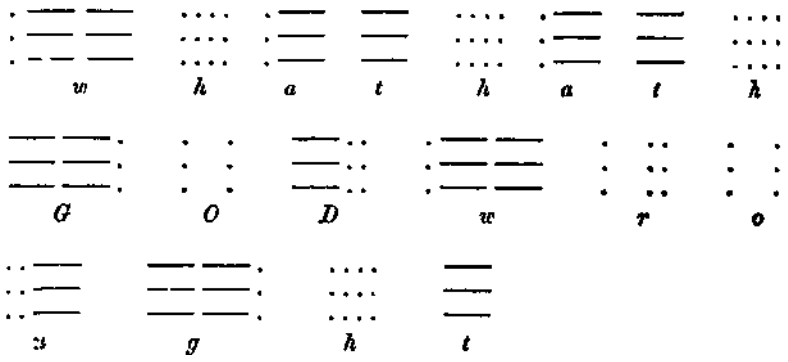
The money was paid, all that the student had, and the two had dinner together. It was Morse's first meal in twenty-four hours.

For years Morse toiled on, and at last he had an instrument that would work. It was a crude affair, made from an old picture frame fastened to a table. The wheels of an old clock moved by a weight carried the paper forward. But it was capable of sending messages.

Morse had worked out a system of dots and dashes to represent various letters. This was the code. The operator in one place tapped out the letters in the words of the message, and they were carried with great speed over a wire through which an electric current was passing. At the other end of the wire was a bar of soft iron with a coil of iron around it. This bar became a magnet while the current was on and drew toward it a piece of iron so adjusted that it clicked. When the current was turned off a spring drew the iron back into place. Thus the message could be recorded at the other end of the wire far away and the code was translated into words.

Morse now went to Washington to ask Congress for thirty thousand dollars to build a telegraph line from Washington to Baltimore to try out his idea. This seemed a large amount of money to spend on an untried enterprise. It was hard for Congress to realize how useful the telegraph would be.

The last day of the session came and there seemed to be little hope that the bill would pass. Morse had spent the whole day in the Senate anxiously waiting for his bill to be presented. At ten o'clock at night, two hours before adjournment, a friend advised him to go home and give up the matter as the Senate was not in sympathy with his project. Morse went to his hotel, counted his money, and found enough to pay



The first message sent by telegraph " What hath God wrought ? "

his hotel bill, buy his ticket home, and leave about thirty-seven cents.

As he was coming down to breakfast the next morning, he met Miss Ellsworth, the daughter of an old friend. She came up to him with a smile, and said :

" I have come to congratulate you."

" For what, my dear friend ? " asked Morse.

" On the passage of your bill," she replied.

" Oh, no, my young friend, you are mistaken."

" It is you who are mistaken. The bill passed at midnight."

For a moment Morse was overcome, and unable to speak. Then he said, " You are the first to tell me the good news, and the first message on the completed line shall be yours."

Work now went forward in earnest, and on the 24th of May, 1844, Morse was ready to put to the test the great experiment on which he had been labouring for twelve long years. He was in Washington and his assistant was in Baltimore. In the room were assembled many of the most distinguished officers of the government. Taking his seat at the instrument, slowly and steadily Morse clicked out the words that his young friend Miss Ellsworth had chosen to be the first message sent over the telegraph, " What hath God wrought ? " The message was instantly received by his assistant in Baltimore, who immediately returned it to Washington. So within a single instant were carried back and forth those inspired words over a circuit of eighty miles.

Within the next ten years telegraph companies sprang up all over the country, and before he died Morse had the satisfaction of seeing his telegraph used in every civilized country of the world.

As the result of Morse's invention electric messages could be carried from one end of the land to the other. But the different continents were separated by wide oceans, and messages still had to be carried from one continent to another by steamship. Wires could not be used

The Agamemnon and the Niagara attempting to lay the Atlantic Cable in mid-ocean. (From *Harper's Weekly,* 1858.)

in the water because water conducts electricity. Some cover for the wire was needed to prevent the electric current from escaping. It was found that gutta-percha, a substance somewhat like rubber, was well suited to this purpose. A number of copper wires, each wire covered with gutta-percha, were twisted together and protected with tarred yarn.

Then the bold plan of laying a cable under the Atlantic Ocean, to make possible telegraphic communication between America and Europe, began to take shape ; and Cyrus W. Field, a young merchant

of New York, undertook to lay such a cable. The idea became his ruling passion, and to it he devoted every ounce of his strength and enthusiasm.

The story of the Atlantic cable forms one of the most exciting chapters in man's struggle with nature. The engineering difficulties were very great because of the great depth of the water. The first attempt to lay a cable took place in 1857. To lay the cable England offered the Agamemnon and the United States the Niagara, two war-ships large enough to carry their bulky load and the machinery with which it could be paid out in the water. The two vessels set out from the Irish coast on their great adventure. When four hundred miles had been safely laid, the cable broke. All the section that had gone overboard was hopelessly lost. Half a million dollars had been sunk in the enterprise. There was nothing to do but give up for the time.

The next year another attempt was made. This time it was decided to begin laying the cable in the middle of the ocean. The two ships set out, each having on board one-half the length of the cable. They met in mid-ocean and the two pieces of cable, one from each ship, were spliced. The plan was for the two ships to part, one sailing east and the other west, paying out the cable as they went. The ships started in opposite directions, but scarcely were they out of sight of each other, when the cable broke. They returned and spliced it again. Again and again the cable parted or else the electric current refused to pass through it. After cutting and splicing many times with indomitable patience they were at last forced to give up the attempt.

Now, surely the attempt would be abandoned. But no, in July they were at it again, and on August 5th Mr. Field was able to report to President Buchanan that both ends of the cable had been safely landed. Everyone was wild with excitement. The Queen and the President exchanged greetings, and the great achievement was regarded as completed.

Then, with the cable a little less than a month old, after about seven hundred dispatches had been sent, the messages grew fainter and fainter and at last ceased altogether. Think of the disappointment to Cyrus Field and the men who had put their money into the enterprise again and again ! Years of effort, thousands of dollars spent, one month of messages —and then only a useless collection of wires running for two thousand miles under water.

People now began to think that a deep-sea cable could never be made to work. Here was enough discouragement to have downed many men ; but Field immediately set to work to raise funds to lay a new cable. In 1865 he was ready for another attempt. Then a heavier cable was made and the Great Eastern, the largest steamship built up to that time, was chartered to lay the cable. This time they proceeded with the most anxious care, and had got two-thirds of the way across the Atlantic when the ship's machinery broke under the tremendous strain and the cable snapped and was lost. Three times they grappled for it in eleven thousand feet of water and three times they brought it to the surface, only to lose it overboard again.

Did Field give up ? Not for a day. A new company was formed, new money was obtained, and in July, 1866, the Great Eastern set sail again and two months later the first cable was laid. July 27th, 1866, was a joyous day in the life of Field. For thirteen years he had tried to lay a cable, and at last his efforts were crowned with success.

The first message sent over the cable was from the Queen of England to the President of the United States, and the next from the directors of the company in England to those in New York in the following words : " Europe and America are united by telegraph. Glory to God in the highest and on earth peace and goodwill to men."

Thus, at last, telegraphic communication was established between the old world and the new, and people were soon receiving every morning news that previously had taken weeks. From that day to this the two continents have been in constant communication under the broad ocean that divides them. To-day eighteen hundred of these under-water pathways for electricity crisscross under the world's oceans in almost every conceivable direction. Over four thousand messages are sent every day to every part of the world, and we are able to receive accounts of events almost while they are happening. Thus through the cable the obstacles of time and space have been overcome, and a new link has been forged in the chain binding the nations of the world together.

The telegraph and the cable transmitted electrical impulses which made sounds at the other end. This method was still a system of sign communication. Those who used it had to be familiar with the code. If it was possible to send signals over wires by electricity, why should it not be possible to send the sound of the voice directly ? Thirty-two

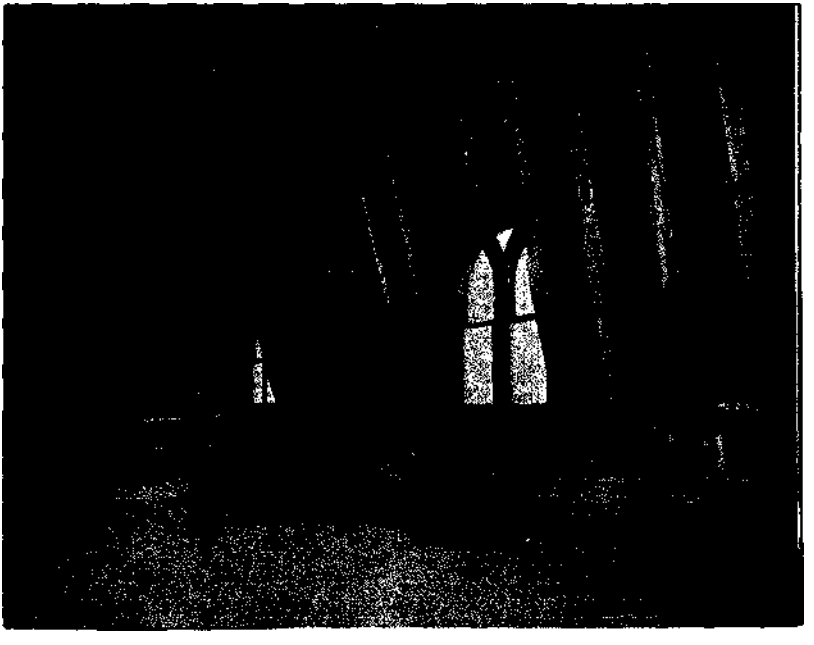
years after the invention of the telegraph Alexander Graham Bell, a young professor in Boston University, was busy at this problem in an attic of a building in one of the narrow streets of Boston.

Professor Bell was a teacher of the deaf and had made quite a study of the effect of the voice on the ear. From early boyhood he had been interested in speech and hearing. When he was a small boy his father proposed to him and his brother that they should try making a speaking machine. It was a fascinating idea, and Alexander set to work to model the mouth, making the tongue and parts of the throat of rubber stuffed with cotton. His brother made the lungs, the throat, and the vocal chords. It was a great day when they put the thing together. One boy blew through the tube that led from the lungs and the other moved the lips of the dummy. Great was their delight when out came the sound, " Ma-ma, Ma-ma." One day they took the machine out to the stairway. The brother blew and there came a sound like that of a regular squalling baby, " Ma-ma, Ma-ma." They heard a door upstairs open, and the boys made the dummy cry for all it was worth. Then, with delight, they heard someone say : " My goodness ! What is the matter with that baby ? "

Bell's long study of how sound affects the ear gave him the suggestion for the telephone. In the ear the tiny disc of the eardrum responds to the spoken word. Bell reasoned that if the eardrum, which is no thicker than a piece of tissue paper, could send vibrations through the heavy bones of the ear, a heavier membrane might be made to vibrate a wire. In a flash the idea of the telephone came to him, and he set to work. He toiled night and day, making experiment after experiment. He was so absorbed that he could think of nothing else. He gave up his professional work so that he might devote himself to his invention.

The story of Bell's struggles is like that of many other inventors. He was forced to endure poverty and ridicule. He was called a crank " who thinks he can talk through a wire ! " One hot June day, however, he was rewarded for all his hard work. He and his assistant Watson were trying one of their endless tests, when he heard a faint, almost inaudible, twang. This was the first cry of the newborn telephone. Bell rushed into the room where Watson was trying to send signals. His eyes blazed with excitement. " What did you do then ? " he cried. " Don't change anything. Let me see."

For a long, long time the telephone could only gasp faintly and give forth strange inarticulate sounds. Then came a great day, March 10th, 1876, when for the first time it really talked. Speaking into his telephone, which was in the attic, Bell said to his assistant : " Mr. Watson, please come here. I want you." Away down in the



The attic in Boston where Professor Bell and Mr. Watson made the experiments that resulted in the invention of the telephone.

basement of the building was Bell's assistant, listening at the other end of the line. Suddenly he dropped the receiver and rushed up the three flights of stairs to the attic, shouting breathlessly, " I heard you, I could hear what you said."

Success at last! You can imagine Bell's joy and happiness. Bell and Watson now set to work feverishly to make the telephone speak more distinctly. The instrument was crude, and the current so feeble

that the voice could scarcely be heard. But from this small beginning have developed all the great telephone systems in existence to-day.

Just two months after this the Centennial Exhibition, America's first great exhibition, was opened in Philadelphia, and Bellwas persuaded to exhibit his telephone. It was at the exhibition a whole month, but no one seemed to be interested in it. One day the electrical exhibits of the exhibition were to be shown to the judges. Dom Pedro, the emperor of Brazil, with a group of gaily attired courtiers, Sir William Thomson, one of the greatest scientists in the world, and other famous people were there. Bell was urged to go to Philadelphia to demonstrate his telephone. But he had no idea of going ; he was too poor. It happened that his young friend, Mabel Hubbard, was going, and Bell went with her to the railway station. As the train started and Miss Hubbard learned that Bell was not going with her, she burst into tears. Without a moment's hesitation Bell leapt aboard the moving train without ticket or baggage.

This trip turned out to be a very important event in Bell's life. The judges were just making a tour of the building. The emperor, Dom Pedro, entered the room where Bell was showing the telephone. He took a seat at a table on which rested the little receiver and was asked to hold his ear to the strange instrument. In another room Bell spoke slowly into the mouthpiece. Suddenly the emperor, with a look of utter amazement on his face, exclaimed, " It talks ! " Then came Sir William Thomson, world-famous scientist. He, too, listened, and then said : " Yes, it does speak. It is the most wonderful thing I have seen in America."

From that time on the telephone became the wonder of the exhibition. " I went to bed the night before an unknown man," said Bell, " and woke up the next morning to find myself famous."

Tireless research of scientists has constantly added to the extension of the telephone since that day. in 1915 the first transcontinental line was opened, and in 1927 a new milestone was passed when telephone service was opened between the United States and Europe.

After Morse's invention of the telegraph millions of miles of wires carried messages. With Bell's invention man could hear the sound of the voice directly over wires. But much more remained to be before perfect communication was achieved, for where wires could not be strung communication was still impossible. Scientists were still

searching for a new way. And then came the marvel of communication without any wire at all. That electrical impulses can travel long distance through the air without a wire had long been known. As early as 1795 a Spanish scientist had explained the possibility of utilizing these currents to send messages through space. In 1887 a German

!

An early public exhibition of the telephone, March 18th, 1877. Bell on a lecture platform in Salem, Massachusetts, is talking to scientific men in Boston several miles away. Some of the chief men of Salem took turns at the telephone to prove to the amazed audience that people in Boston could really hear !

(From *Frank Leslie s Neivspaper,* 1877.)

professor named Hertz discovered how to send electrical waves quite a distance through the ether. But no one was able to apply this knowledge in a practical way. After the publication of Hertz's work the idea was taken up seriously, and every nation tried to be the first to solve the problem.

One of these workers, Guglielmo Marconi, a young Italian only twenty-one years old, carried on a number of experiments in his garden.

In 1896 he came to England, where he was able to receive signals from a distance of nearly two miles without wires. The young inventor pushed quietly and steadily ahead, studying and experimenting, and succeeded in reaching more and more distant points. Finally he was able to transmit wireless messages across the English Channel, a distance, of about twenty-eight miles. But still he was not satisfied. With improved apparatus Marconi next attempted to send messages across

Marconi Beam Transmission Station at Dorchester.

the Atlantic Ocean. In 1901 a very powerful set was erected on the west coast of England ready for the great test. It was decided that three dots representing the letter S were to be transmitted at certain times each day to Marconi, who was in Newfoundland.

Marconi waited in a little shack in Newfoundland. The time for the signal arrived. Everything was in readiness. Marconi sat with the telephone receiver to his ear. Nearly half an hour passed by, and still not a sound was heard. Was the experiment to fail ? Then suddenly, in the intense silence, a faint tick was heard, as the instrument began feebly to work. A moment later came three little ticks—

the letter S ! It had leapt two thousand miles across the Atlantic ! Again and again came the three clicks. Once again Europe and America were united. Here was an instantaneous means of com-, munication which could not be stopped by distance, or mountains, or bodies of water. At last man could use the ether to span the vast barriers of space. Wireless communication soon became general. Powerful wireless stations were built, and messages began to flash back and forth.

But even wireless telegraphy was not to be the final word in the development of communication. No sooner had Marconi perfected the wireless telegraph than men of science began the search for the wireless telephone. Fifteen years after the first wireless message was sent, radio began its matchless conquest of space. By 1914 there was radio communication in every civilized country in the world.

The growth of systems of communication during this century has been little short of miraculous. They have put a girdle round the earth, enabling each part to communicate with every other part and to know what is going on everywhere. The telegraph and the cable enable men to communicate over continents and under seas. With the telephone and radio man has made himself an electric ear by means of which he can hear from the ends of the earth. In television he is now at work trying to create an electric eye which will enable him to see things at a great distance now hidden from his own eyes. When this is perfected, pictures will be flashed through space, and man will be able to look out over the whole world. Thus equipped with universal com-munication, mankind will enter into a new fulness of life.

THE WORLD OF TO-DAY

CHAPTER XX

THE AGE OF GREAT MACHINES

WHILE plenty of iron could be made by the blast furnace it was not strong enough for many important purposes. It was still full of impurities and had to be further purified to make steel, which is stronger. The invention of cast steel was made by Benjamin Huntsman about 1740. Huntsman was a clockmaker. The steel supplied to him for making watch springs was so poor that he tried to make steel of better quality. At last he succeeded. He worked with the utmost secrecy, allowing no one to enter his forge, which he erected in a forest. People tried in every way to find out his method of making steel, and at last they employed a spy. On a cold and snowy night a neighbouring ironmaster disguised himself as a beggar and, pretending that he was lost in the forest, knocked at Huntsman's door seeking shelter. Huntsman unlocked his door and let him in, and thus he discovered Huntsman's secret.

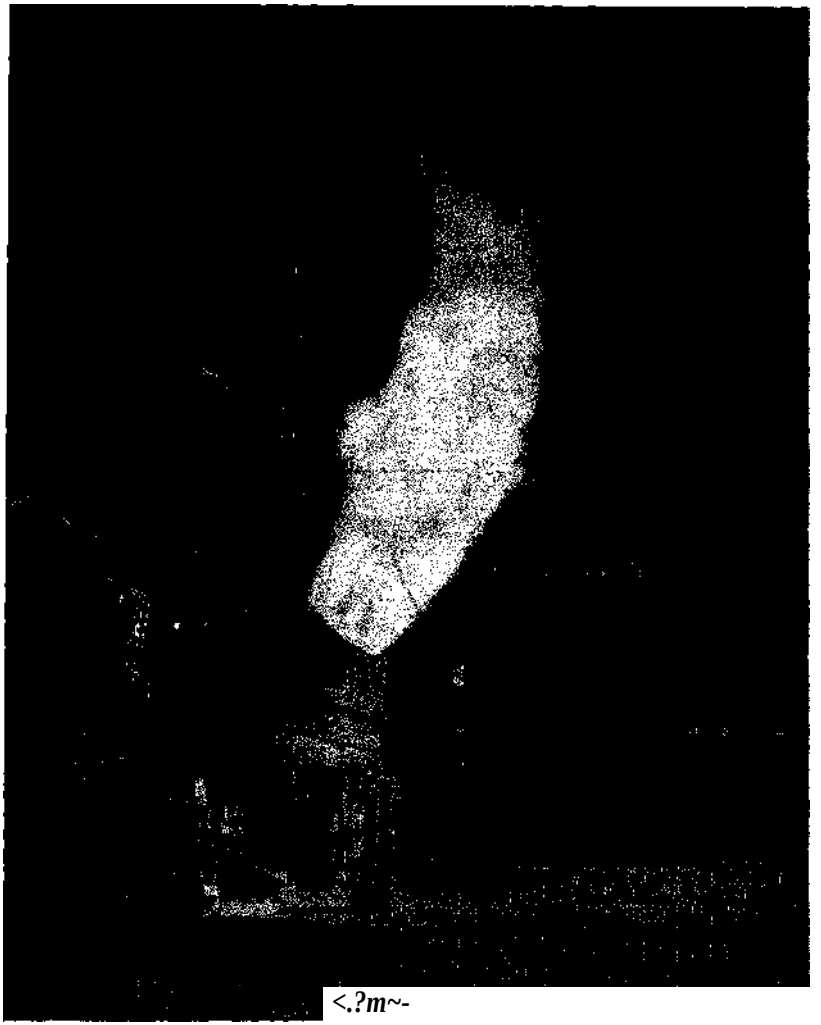
But this way of making steel was slow and expensive. The world needed a new process for making steel in great quantities and thus reducing the cost. In 1855 Henry Bessemer, an Englishman, invented a method of making in thirty minutes steel which was many times stronger than iron. One day when Bessemer was working with his blast furnace he noticed two pieces of pig iron on the inside that did not melt, although the heat of the furnace was great. About half an hour later, noticing that the pieces were still unmelted, he took them out and examined them. To his surprise what he had thought were pieces of pig iron proved to be pieces of steel. He saw from this that, if air

was forced into molten pig iron under great heat, the iron would be changed to steel. Bessemer built a small furnace and proved to his own satisfaction that good steel could be made in this way.

Bessemer next built what he called a converter. It was about four feet high, and around the bottom were six pipes extending inside. The pipes were connected on the outside with a chamber into which air was driven by a forced draught. When all was ready the draught was turned on, and several hundred pounds of molten pig iron was poured into the converter. Except for a few sparks, everything was quiet for a short time. Then startling things began to happen. Clouds of sparks and a roaring flame burst from the top, while hot metal was thrown high into the air and the converter became a young volcano in active eruption. This was a great surprise to Bessemer, and for a time he feared for his life. But in a little while the eruption ceased and all became quiet again. The molten metal was drawn off and found to be steel of ver}^ good quality. This was the Bessemer converter which in time came to be used everywhere for making steel.

Every steel mill has its blast furnaces with their black stacks rising into the air a thousand feet or more, rilled from top to bottom with roaring fire. Into their fiery throats are fed the iron ore and limestone. Here these are kept under heat too great to be imagined for four or five hours, and then from the bottom flow away at intervals two molten streams, one the purified iron, and the other useless slag to be got rid of. Then the iron is poured into the converter, which swings on an axle so that it can be turned and tilted up or down. A terrific blast of air is turned on that rushes like a tornado through the metal. There is a mighty roar and out of the mouth of the converter shoots a mighty blast of orange flame edged with blue. Clouds of brilliant red and yellow sparks leap a hundred feet into the air. The converter is turned on its side, and carbon is poured into the lake of seething white fire within. All this time the impurities are gradually being burned out and the iron is becoming purer and purer.

Then amid the roar and din a whistle shrieks, which means that the converter is going to pour. The monster, looking like an enormous *egg* with its top sliced off, turns over on its pivots and pours into a great



A Bessemer converter blowing on. A terrnu uiasi or air is molten steel in the converter, and with a mighty roar a sheet of flame shoots from its mouth, sending millions of red and yellow sparks high into the air.

ladle its load of steel, shooting millions of sparks into the air. Quickly a man on a platform pushes a lever and turns the converter upside down until all the steel is poured into the waiting ladles. Then he turns it back half-way and picks his way carefully out over a bridge beside it, his eyes shielded by heavy dark glasses, and peers at the bottom of the converter to see whether the inside is satisfactory. Perhaps he hurls balls of clay at holes in the bottom where the lining of firebrick is eaten away. If it is all right he gives the signal and the converter swings up into place again, ready for another load of iron. Thus is iron converted into steel by the Bessemer process.

William Siemens found still another way to make steel. This is called the open-hearth process. An open-hearth furnace looks like a baker's oven. Iron is poured in through the furnace door, and soon there is within a great pool of bubbling white-hot metal, tinted here and there with delicate shades of pink and blue. This is steel cooking. When the process is finished an overhead crane brings a huge ladle and out flows the steel, glowing like a river of fire and scattering a shower of sparks.

When the ladles from the converter or the open-hearth furnaces are full a massive crane swings them over to a platform alongside a train of cars bearing large moulds. One by one these moulds are filled with liquid fire. When the moulds are removed they leave great white-hot bars of steel called ingots. From the ingots the steel can be fashioned into any shape desired. Always moved by mighty cranes, they are beaten by giant hammers, punched by hydraulic punches, riveted with red-hot rivets, or rolled out into thin sheets by great rollers, and finally made ready for the many uses of the modern world.

To-day industry uses steel at every turn. Without steel it was impossible to span wide ravines and rivers. Now great bridges can be built strong enough to carry safely huge engines and trains weighing thousands of tons. The iron ship has given way to the ship of steel. Day and night the work goes on with a roar, month after month, year after year, supplying the endless demand for steel—steel for our great buildings, for railroads, bridges, subways, ships—for all the great structures that require the strongest material that man is able to make

in this day of great machines. At night the huge steel mills of our great industrial centres glow with blue-white light, and the heavens for miles around are bathed in fire from the far-away furnaces making steel for an age of steel.

Artists are beginning to show us the beauty and meaning of the world of work which man has created—vast buildings, supported by their girders, the bridges, the cranes, the factories, the mines. They form a pictorial and beautiful record of the splendours and immensities of the great industrial age in which we are living.

In the early days of man's history the ruling classes of society were released from work by making slaves of other men and using the power of their backs and arms and legs to do work for them. But if you have been able to read between the lines of this chronicle of the past you will have noticed that all through the ages people have struggled for freedom. By the close of the Middle Ages slavery and serfdom disappeared from Europe. Through the invention of the machine man now has a mechanical slave that will perform all kinds of tasks for its human master. The puny power of man's muscles is multiplied a thousand times by the mechanical power of machines run by steam or electricity, that bend and shape and haul things with ease that man by himself could not make budge. They are at the bottom of the mine a thousand feet below the earth's surface, they pump, they excavate, they hammer, they spin, they weave, they print, they turn the soil and thresh the grain, doing the work of the world. How tireless they are ! What faithful workers for man ! Men are needed only to watch and feed them. Like pigmies they stand, watching over all, moving a lever here and there, controlling all, looking almost insignificant beside their giant machines.

Man's life is now bound up with machines, those powerful creatures which he has fashioned out of the materials of the earth to do his work for him. Civilization has passed through many changes, as we have seen, but probably no change so completely altered man's whole way of living in such a short time as the great age of machinery which began in England in the eighteenth century with the inventions of Hargreaves and Crompton and Watt. For hundreds of thousands of years people

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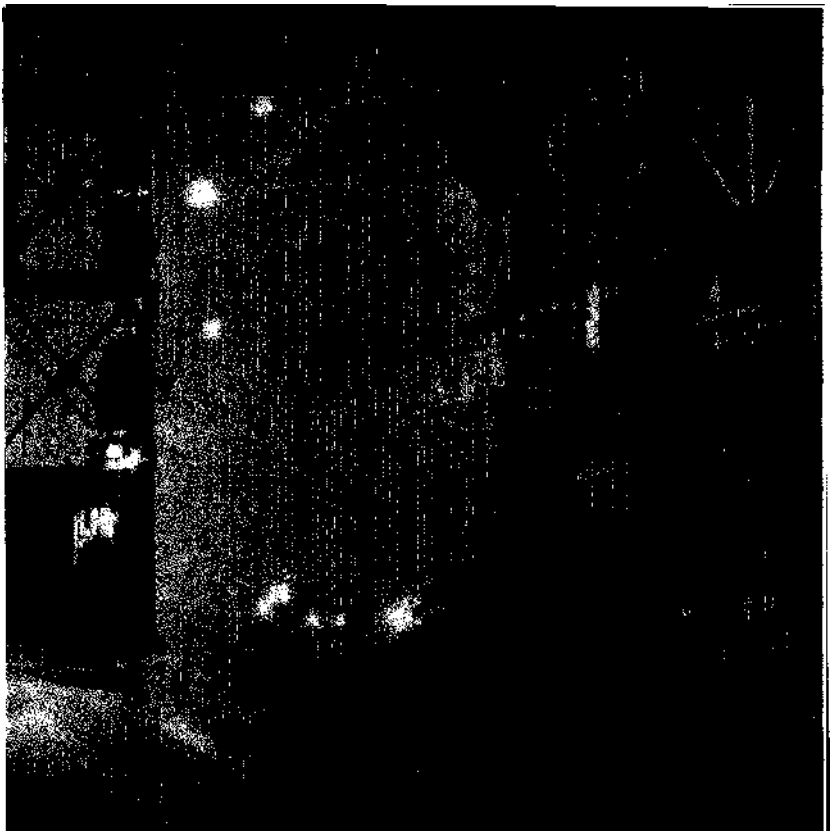


Photograph by Margaret Bourke-Wkite

Dumping slag from the steel ladle into the slag train.
(Taken at the Otis Steel Works.)

had lived without any of these inventions. Then, with startling speed, invention followed invention and created a new civilization entirely different from anything that had ever existed before.

Just think for a moment what the world was like only a little over a hundred years ago. There was not a single railroad in the whole world. There were no steamships, no telegraph, no telephone, no electric lights, not even matches. When people wanted to light a fire they had to make a spark by hitting flint on steel. There were no cities of any great size. Most of the people were farmers growing the things they needed to eat, spinning and weaving the cloth for their clothes and making the other things they needed. What they could not make for themselves, they did without. Travelling was slow, over the land in the lumbering stagecoach and over the water by the sailing vessel. The result was that most people stayed at home, living and dying in the place where they were born and knowing little of the great world beyond.

The invention of machines changed people's ways of living almost immediately. Instead of working at home, as they had done up to this time, they had to go out to their work. The new machines were too costly for a worker to buy, and the homes were too small to hold them. Also they required steam power. Therefore it was necessary *to* erect special buildings for them. All this took a good deal of money, and when a man had to put up a suitable building he found it more profitable to run a hundred machines at once under the same roof. One workman could keep several machines going at the same time. It was in this way that the first mills or factories came to be built. Factories then began springing up everywhere. The craftsman stopped working for himself at home and became a skilled mechanic going to work in a factory for wages. W'orkers in the factories found it more convenient to live near their work. In this way hamlets gradually grew into villages, villages grew into towns, and towns in time became manufacturing and trading cities.

Then Robert Fulton put one of Watt's engines in a boat and made the steamship. George Stephenson set one on rails and made the locomotive. But the steam engine is very heavy and requires a great

Building a skyscraper. Artists are beginning to show us the beauty of the world of work.
(From an etching by Ralph Pearson.)

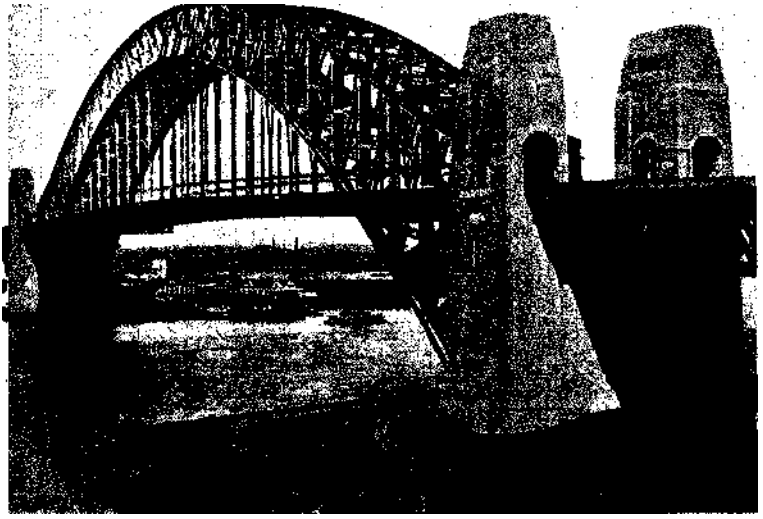
amount of coal. The petrol engine was invented, which is very compact and can therefore be used in smaller vehicles. So the automobile was produced. Thus quick transportation by land and sea was given to the world.

Each country produces the things for which nature has fitted it, and sends over the world its surplus products in exchange for other products which it needs, so that there is a world-wide interchange of products. People no longer depend upon their own neighbourhood for the things they use. Things can be brought to them swiftly and easily from other parts of the country and of the world. Thus every day we draw upon the resources of the whole world. We eat world-grown food, we wear world-made clothes and we use materials from all over the world.

The different industries that supply us have now become so interdependent that they are like an endless chain. We cannot have all the various things made by machinery without factories. We cannot have factories without machines. We cannot have machines without steel. We cannot have steel without iron. We cannot get the iron from the ore without coal. And we cannot get any of these things without railroads and steamships to haul them from place to place. So it is that no family to-day is independent. No longer does a man work alone to supply his own needs. He works with a whole army of other men to supply the world's needs. One person depends upon another. One community depends upon another. One nation depends upon another. The whole world is rapidly becoming one great community in which every member is producing goods and ideas for others and receiving goods and ideas from them in return. Each year this interchange of products increases as the machines produce more and more goods.

Modern inventions have brought the different parts of the world closer together. When the nations of the world were separated by vast stretches of land and water, they did not know one another. But with the railway, the steamship, the telegraph, the cable, and radio, man has put a girdle round the earth that is swiftly uniting all the nations of the world into one great world-wide community, every part

of which can be easily drawn upon for whatever resources it has. And so as a culmination of all man's work through the ages we have the possibility to-day for the first time in history of a single world-wide civilization. Isn't this a thrilling thought ?



The new Sydney Harbour bridge. A view of the wonderful bridge which crosses Sydney harbour, New South Wales, Australia. Took eight years to construct, at the cost of £9,000,000.

The great gift of machinery has been to confer upon the many the benefits that formerly were enjoyed by the few. Have you noticed as we have come down the ages the extension of the benefits and resources of the earth to more and more people ? This new way of producing things in quantity has meant a greatly increased power to satisfy people's wants. The things which people need can be produced quickly and in large quantities by the great machines, and this reduces the cost

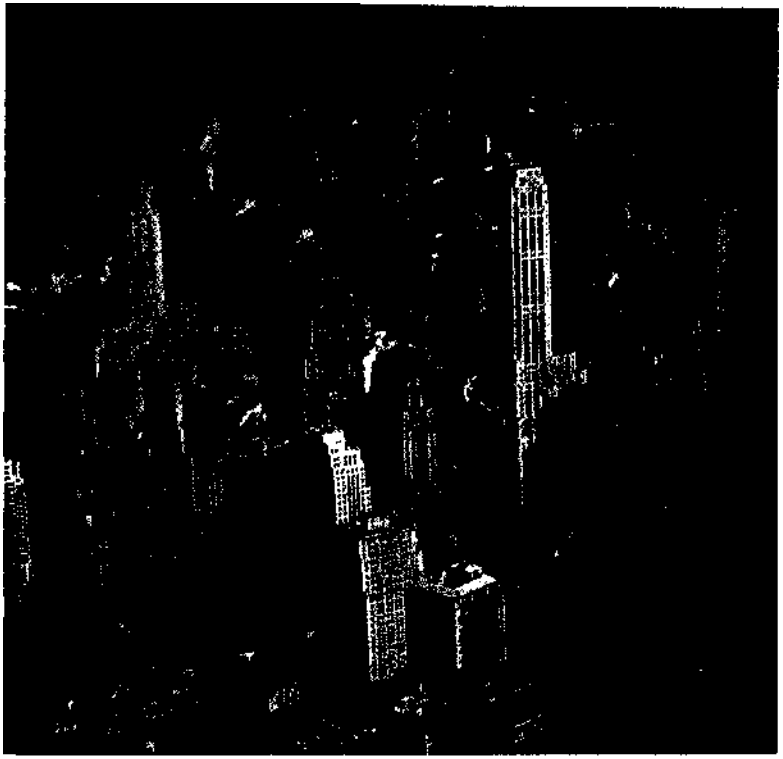
greatly. So people of smaller means can now enjoy many things that earlier were luxuries enjoyed only by the wealthy. The world to-day is a better place for the mass of people than it ever was.

But this new way of living has brought many great problems which are not yet solved. Man is not yet master of the great machines which he has created. He has to keep the machines going, and he still has to do many things that machines cannot do. This has brought about long days of monotonous labour for a great many people. Sometimes it almost seems as if the machines were converting mem himself into a machine, controlling what he shah do as he keeps them going and has to keep up to the pace set by their ever whirling wheels.

The machine affects not only the worker who tends it but everyone who uses its products. The products of the machine are all alike. So everyone tends to wear the same kind of clothes, read the same newspapers, listen to the same radio, and so on. Such standardized ways of living do not satisfy the freedom-seeking adventurous spirit that man has inherited through the ages.

But the machine has come into being only within the last hundred years, and that is a very short time in the progress of the world. Every age has had its problems which man in time has been able to solve, and no doubt we shall in time solve these great problems of our own age. We must, for we cannot turn back again to the old ways of living ; we must look forward to new and better ways. Already the machines have made it possible to produce things with a smaller amount of human labour. The great inventor Edison foresaw the time in the near future when machines not only will make the parts of things as they do now—leaving it to man's hands to put them together—but will also put them together. Books all printed and bound will fall from the presses, and the machine that takes in lumber will turn out finished furniture. If this can be brought about, man will be relieved from many monotonous jobs, and will have greater leisure. This is not merely a dream for the future. Already in an American city completely assembled motor cars ready for the road are being turned out by machinery.

Another recent invention which may point the way to the future is televox, the mechanical man. We have seen how all through the



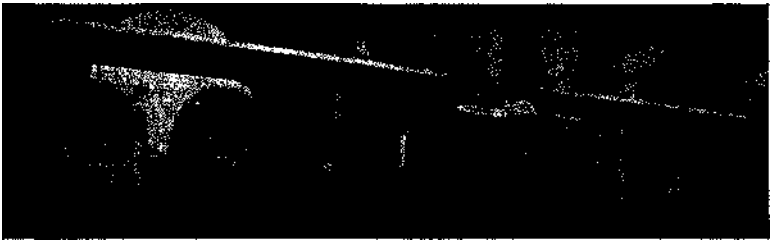
Courtesy Fairchild Aerial Surveys, Inc.

A view of New York City with its towering buildings from an aeroplane.

ages man has multiplied the powers of his own body with external aids. He has learned to make poles which lengthen the reach of his arms, tools which increase the effectiveness of his hands, crushers which will grind things on which he would not trust his teeth, wheels which save his feet, microscopes and telescopes which increase the power of his eyes, and so on. For ages there has persisted in men's minds the idea of a mechanical man that would take over his work and set him free. Recently such a creature has been invented, sometimes called a robot, sometimes called televox. This electrically operated

man can answer the telephone and carry out orders just as a human being would do—even better because he never makes a mistake. He answers questions, takes orders, and does what he is told to do. Some of these mechanical men are now being used in a city reservoir. They answer telephone calls and give accurate information as to the state of the water supply. In some cities they have been tried as policemen to regulate traffic. Who knows what such mechanical creatures may be able to do for us in the future ?

If the work of machines can be greatly extended in all sorts of ways, what a release this will be for man ! No longer will he have to spend hours on the monotonous work of feeding the ever hungry machines. Then man will come to the end of his long search for relief from disagreeable kinds of work. His days, instead of being given up to a ceaseless grind in earning a living, will have the priceless gift of leisure. More people will have time to think great thoughts, to write and act great plays, to paint, to sing, to compose great music, to travel, and use any great gift which may be theirs in the wonder world which man has created on the earth.



Courtesy U.S. National Museum

The Spirit of St. Louis, in which Charles Lindbergh made the first non-stop flight from the United States to Europe in thirty-three and a half hours, May 20th-2ist, 1927.

CHAPTER XXI

CONQUERING THE AIR

EARLY man often watched the birds soaring through the air and envied them their freedom of movement through space. The migrations of large flocks of birds suggested to him new places where food might be plentiful, and he longed to follow them. But whenever he attempted to travel, the heavy undergrowth in the trackless forests, huge rocks, high mountains, large bodies of water blocked his progress. When he came to water he had to build a boat or swim across ; when he reached a hill he had to climb it. All this was very fatiguing. High above him soared the birds, unhampered by any of these obstacles. How he longed for the freedom of those winged creatures! The air certainly appeared to offer a much easier passage-way from place to place if only he could find a way to navigate it.

Many stories have come down to us from early times showing man's interest in flying. He ascribed to the gods and other fortunate creatures the power he desired for himself. Ancient lore abounds in strange tales of magic carpets, seven-league boots, winged horses, and flying gods, who took marvellous journeys through space. Mercury, the swift and faithful messenger of the gods, was pictured with a winged helmet and sandals for flight. Then there is the well-known story of the winged horse Pegasus and Bellerophon, the only person who could put a bridle on him. One time Bellerophon was sent to kill the wicked Chimera, a terrible monster with a lion's head, a goat's body, and a serpent's tail, which breathed forth fire that destroyed men. Sailing through the air

on his winged steed, Eellerophon smote the terrible monster and killed it.

Perhaps you know the Greek story of Daedalus, the first man to attempt to fly. He had been forced to leave Athens and took refuge in Crete, which was ruled over by King Minos. Daedalus incurred the anger of the king, and he and his son Icarus were thrown into the famous labyrinth. Now Daedalus was an ingenious craftsman of an inventive turn of mind, and in order to escape from the prison he fashioned wings of feathers fastened on with wax, with which he and Icarus flew out of prison and far out over the sea. Daedalus had warned his son not to fly high lest the heat of the sun melt the wax that held on his wings. Young Icarus, however, exulting in his flight, forgot his father's warning, and soared high up in the air. The heat of the sun melted the wax that held on his feathers, off they fell, and Icarus dropped into the sea. Such is the well-known old Greek legend.

The ancient Persians had an interesting story of a king who wished to ascend into the heavens for a ride through space. He consulted his wise men, who suggested a way in which his wish might be gratified. They had observed that large birds such as the condor or eagle often stole a young lamb and were able to carry it through the air. If one eagle could lift an animal, several harnessed together, they reasoned, might be able to lift a man. So they took some young eagles and reared them with great care so as to make them very strong. Then they built a square pavilion and to each corner of it they fixed upright a javelin with a piece of meat stuck on the upper point. To each corner of the pavilion an eagle was fastened. The king was seated on it, and as soon as the eagles became hungry they tried to get the meat by flying upward. In this way they lifted the pavilion. As they grew more and more hungry, they flew higher and higher into the air, always trying to get at the meat. But of course the higher they flew, the higher the meat rose above them. At last, worn out by the long and fruitless exertion, their strength gave out and they fell to the ground. In this way the ancient Persian king got his trip through the air.

Man's desire to fly persisted, but for centuries the air remained unconquerable. It was only natural that in his first attempts to make aircraft man should imitate nature's marvellous flying machines, the birds, whose success in the air he so much envied. He reasoned that since birds could raise themselves into the air by flapping their

wings, he, too, could fly if he could only learn to make the right kind of wings. So through the Middle Ages there were many attempts to make wing-flapping devices, worked by muscular power.

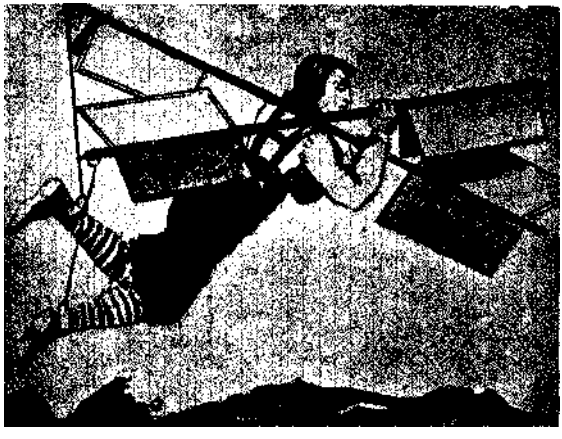
The first actual flying by a human being was that of Besnier, a French locksmith, in 1675. He built a curious machine consisting of two wooden bars that rested on his shoulders. At the end of the bars

According to the old Greek legend, Daedalus, an ingenious craftsman, made wings of feathers fastened on with wax, with which lie and his son Icarus escaped from prison. But Icarus flew too near the sun, his wings dropped off, and he plunged into the sea.
(From an old engraving.)

An ancient Persian king is supposed to have ridden through **the air** in **this** way. (From an old Persian miniature.)

he placed muslin wings arranged like folding shutters, to open on the down stroke and close on the up stroke. He worked these wings, or paddles, with his arms and legs, first jumping off a chair with them, then off a table, then from a window sill. Once he leapt from a second-story window and flew over the roof of a near-by cottage.

One day in the eighteenth century the Marquis de Bacqueville announced that he would fly from his house across the Seine in Paris.

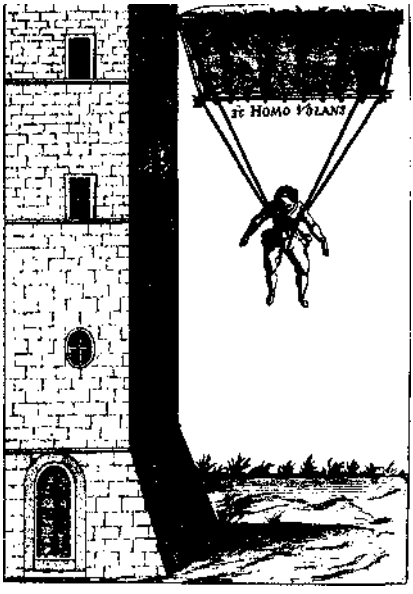


Besnier and his wings. In 1675 he made a number of flights with them.
(From an old print.)

A great crowd gathered to see him. The marquis appeared, with large paddle-shaped wings attached to his hands and feet, launched himself from the terrace of his house and sailed majestically out over the river. Then something happened and he plunged down to the deck of a washerwoman's barge a short distance out on the river.

None of these attempts to imitate the birds was very successful, because of the great weight of a man, and because man's muscles are not strong enough to hold him up in the air. Men are not built like birds. Just to fasten on wings and flap them is not enough.

The clouds, floating gently and peacefully through the sky, also made suggestions to man as a means of travelling through space, and



'The Flying Man," the first picture of a parachute.
(From a woodcut published in 1595.)

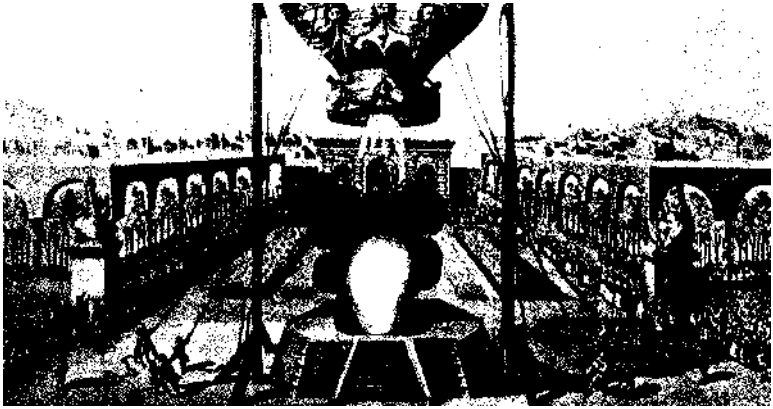
in the eighteenth century men were led to give up the idea of wings in favour of floating bags. If it were possible to surround a cloud with a bag so that it could not escape, it might carry a man. It was not so easy to capture a cloud in a bag, but perhaps a bag could be filled with something else lighter than air and thus made to rise.

In 1782, two brothers named Montgolfier, the sons of a French paper-maker, began thinking about smoke and how it rises. One night, the story goes, one of the brothers, coming home from work, noticed when he opened the front door of his house, that the draught caused the smoke from the fireplace to pour out into the room. It caught up a red petticoat that was hanging on a line drying in front of the fireplace, and ballooned it to the ceiling. This gave him the idea of utilizing smoke. He held a paper bag close to the fireplace, filled it with smoke, and tied it at the bottom. When he let go, the bag floated up to the ceiling. He and his brother then made many experiments with smoke-filled bags.

Encouraged by their success, the brothers decided to try in the open air, and after much experimenting, they decided to have a public exhibition. They issued invitations to a great many notable people to watch the ascent of a great fire-bag, as they called it, in their town on a certain day. The people flocked to the market-place. The Montgolfiers had made a huge bag of cloth lined with paper. It was beautifully painted and decorated with the twelve signs of the zodiac and other designs in gold on a background of deep blue. They dug a pit in the market-place in which they heaped fuel for a great bonfire. They applied a torch, and flames shot up into the air. A dense column of smoke rose and filled the bag with hot air, gradually swelling it out

into the shape of an enormous ball. Eight men were holding it down with ropes. When it was filled, it was tied at the bottom and the signal given to let go the ropes. The great ball shot up into the air and was soon sailing high aloft over houses and trees and up into the clouds. When the air in the bag cooled, it came down again. By this experiment of the Montgolfiers the success of the lighter-than-air craft was demonstrated, but of course theirs was only the first step.

The danger in using **hot air** led some inventors to try to find a better means of keeping a balloon aloft. Henry Cavendish, a great English scientist, had discovered hydrogen gas, which is about seven times as light as air. Professor Charles, a French scientist, made a balloon and filled it with hydrogen gas. It was made of silk varnished all over to keep the very light gas from escaping through the fabric.



The Montgolfiers sending up a great lire balloon from the market-place of their town in 1783.

(From an old print.)

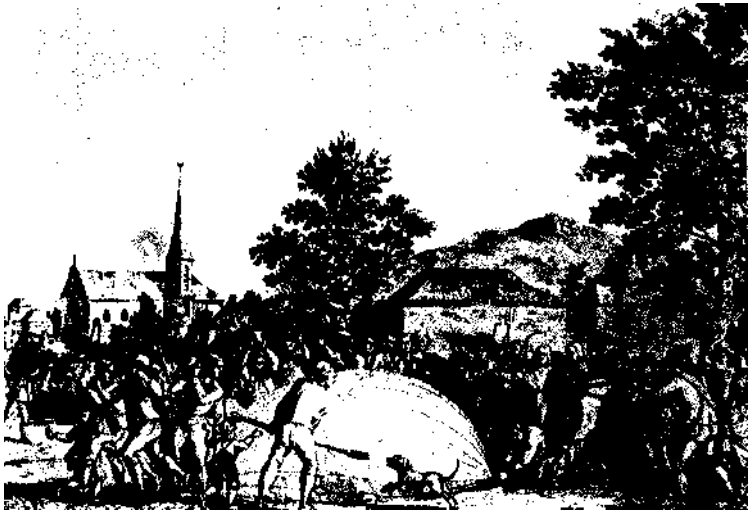
The balloon was launched in Paris and rose in the air to a height of about three thousand feet. After remaining in the air three-quarters of an hour it came down again about fifteen miles away in the country.

Some peasants who were working in the fields saw this strange object approaching them through the clouds. You can imagine their terror at the sight. Never having heard of a balloon, they thought that it must be some terrible kind of monster. Many of them fled ; but the more courageous surrounded the field where the creature had alighted. One peasant who had a gun fired at the monster, tearing a great hole in its side and causing it to collapse with a terrible groan as the gas came out. Thereupon the others rushed upon it, hacking and tearing it to bits with their scythes and pitchforks. When the news of this reached Paris, and a search was made for the balloon, scarcely a fragment of it was to be found. A proclamation was then issued to the people of France, explaining the nature of balloons and telling them not to be alarmed when they saw something approaching through the air.

Up to this time no one had gone up in a balloon. The success of the Montgolfiers encouraged them to build a larger balloon, and in this one they planned to have passengers. But who knew whether the air high up in the clouds was fit to breathe—or, indeed, whether there was any air there at all ? To their next balloon the Montgolfiers attached a little wicker basket, in which they placed the first aerial passengers in the world. And very queer passengers they were, too—a sheep, a rooster, and a duck ! Crowds gathered to see what would happen to the animals. They were carried up fifteen hundred feet into the air, and came down shortly afterward a few miles away. The sheep and the duck were apparently none the worse for their strange experience, but something appeared to be wrong with the cock. It was discovered that the sheep had apparently steppedtm its leg during their trip through the clouds ' Otherwise, it, too, was unharmed.

Having tested the safety of sky travel for living creatures by this experiment, balloonists were encouraged to attempt the next step of sending up a balloon carrying a human being. Who would be the first man to go up in a balloon ? The honour belongs to Pilatre de Rozier, who, with great courage, volunteered to be the first person to go up in the skies. In his first flight a rope was attached to the balloon to keep it from flying away entirely. Later, however, Rozier and

another man made an ascent in a balloon without a rope. They took extra fuel with them and when the balloon began descending they put on fuel and made it go up again, and when it rose too high, they let out some of the hot air and made it come down. Thus they made quite a journey.



French peasants attacking one of the first balloons. They thought it was some kind of monster.
(From an old print.)

The success of the balloon led men to think that it might be useful in crossing bodies of water quickly. Up to this time it had taken more than seven days to get from Paris to London by stagecoach and sailing vessel. On a wintry day in 1785, Jean Blanchard, one of the great pioneer balloonists, and a companion decided to attempt to cross the English Channel in a balloon. Every kind of boat in the Channel was crowded with men eager to see the first balloon venture out to sea. When they were about half-way across, these daring adventurers found that their balloon was going down into the water. They threw out

The first aerial passengers in the world were a sheep, a rooster, and a duck. (From an old print.)

bags of sand which they had taken along for ballast, and the balloon went up again. A second time the balloon began to sink, and the French coast was now only about four or five miles away. Their balloon was almost touching the water. Quickly they threw out everything that they had with them, even some of the clothing that they had on. Lightened by this the balloon rose again, and at last, numb with cold, the travellers came down in a forest. They caught hold of a high tree, and working from one branch to another, brought the balloon into an open space suitable for landing. The gas was let out and they landed safely. Thus was made the first aerial trip over a body of water,

Ballooning now became a popular pastime both in Europe and in America, and people made longer and longer journeys. The great drawback to the balloon, however, was the fact that it could not be steered, and the balloonist was entirely at the mercy of the wind. Men realized that if the balloon was to serve any really useful purpose they must find some means of controlling it. One very natural hope had been that a balloon might be steered through the air by sails, or oars, or by a rudder, as ships are guided over the water. This, however, was found to be impossible. After the steam engine was invented efforts were made to use it in balloons. Henri Giffard, a French engineer, was the first to succeed in doing this. He used a small engine attached to a propeller. In this engine-driven balloon he made a successful flight at the rate of about six miles an hour. This was the first dirigible.

During the nineteenth century certain men began to study scientifically the problem of keeping aloft with gliders capable of carrying a man without using an engine or a propeller. They were made in various

ways, some with batlike wings, others with planes slanted at various angles to catch the wind. One of the pioneers in this work was Otto Lilienthal of Germany. When he was only a boy of thirteen he began making experiments, by flapping wings as he ran down hills, trying to learn the secret of flying. He decided that the reason for man's lack of success in the air was that no one knew enough about the way birds fly. So he spent some years carefully observing young birds learning to fly. His native town with its surrounding meadows gave him ample opportunity to observe birds because many storks made their nests and raised their families on the roofs of barns there.

Lilienthal discovered that even birds, marvellously equipped as they are by nature, cannot just spring into the air and fly. They have to learn how to use their flying apparatus. He noticed that when a young bird began to fly it first determined which way the wind was blowing and then, facing the wind, practised flying. At first it could make only a few short flaps before being overturned by the wind.

For years Lilienthal tried to apply his knowledge of the flight of birds. He built a pair of large, light, fabric-covered wings, with space between through which he could thrust his head and shoulders, and at the back a balancing tail. This human bird would go to the summit of a hill with a gently sloping side, and facing the wind, would run forward until the wind sweeping under his wings enabled them to support his body while he glided through the air to the bottom of the hill.

They came down safely, none the worse for their strange journey.

Lilienthal found great difficulty in balancing himself in the air. He steered and balanced his machine by swinging his body backward or forward or from side to side as it was tipped this way or that by the air. He made many experiments, discovering new facts about wind currents, experimenting with wings to determine

the best size and shape, and inventing a system of levers and flaps to control the wings. Lilienthal was the pioneer glider. He made a great contribution to man's knowledge of flying by his experiments.

In the United States a number of men were working on these same problems. A great American gliding pioneer was Octave Chanute. He studied Lilienthal's experiments and in 1896, with a small band of helpers, he designed and operated many gliding machines on the dunes of Lake Michigan. His greatest success was with a double-decker, in which he made a flight of 359 feet.

Two brothers, Wilbur and Orville Wright, had heard about the gliders of Lilienthal and Chanute. For years they had spent much of their time making kites and gliders and experimenting with them. When they were boys their father had given them a toy flier, and from that time on the thought of flying was constantly in their minds. Through their experiments they developed original wing surfaces, propellers, and methods of control. Finally they succeeded in placing a motor in a biplane with two propellers. On December 17th, 1903, they were successful in launching and flying their machine at Kitty Hawk, North Carolina. Four successful flights were made. On the first flight the airplane remained off the ground twelve seconds, and on the last it stayed in the air fifty-nine seconds and travelled a distance of 852 feet. This was the first time that a heavier-than-air machine had remained in the air under its own power. Thus was written a new chapter in the history of man's conquest of the air.

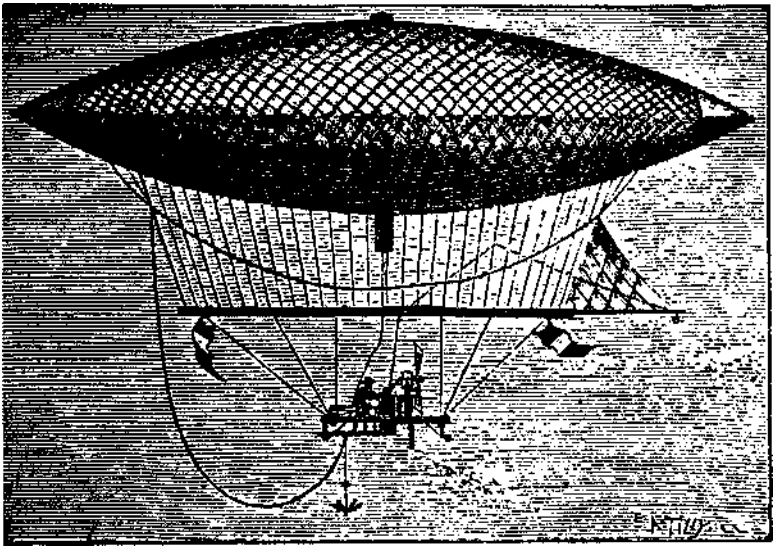
Following their first successful flight the Wrights continued their experiments, improving their motor and various parts of their machine. By 1904 they succeeded in flying for five minutes and four seconds. By 1908 they were able to remain aloft more than an hour.

The success of the Wright brothers stimulated experiments in other countries. Louis Bleriot, a Frenchman, designed a mono-plane in which he flew across the English Channel in 1909, the first man to do this in a heavier-than-air machine.

In spite of all these advances, up to 1914 aircraft were regarded as a novelty. Then came the World War, and aviation took a great leap forward. Every nation set its engineers to work improving aircraft, and many men were trained as expert pilots.

During the war Germany began taking an interest in lighter-than-air craft. As early as 1898 Count Ferdinand von Zeppelin had begun

building airships, making many improvements in them. Instead of making one collapsible cloth bag, as in the old balloons, he constructed a long pencil-shaped craft with a rigid aluminium frame to hold sixteen separate bags of gas, the whole covered by a thick fabric. This made the airships much larger, and stronger, and safer. His huge rigid airships, so graceful and beautiful in flight, soon surpassed all others, and became more and more serviceable in long-distance flights.



Courtesy U.S. National Museum

In 1852 Henri Giffard, a French engineer, made a flight in an elongated balloon steered by a rudder and propelled by a steam engine. This was the first dirigible.

After the war interest in aviation spread rapidly and great advances were made in winning power in the air. This developed a desire to cross the Atlantic, and now begins the period of big-water spanning. In 1919 the London *Daily Mail* offered a prize of £10,000 for the first non-stop flight across the Atlantic in less than seventy-two hours. A number of aviators attempted this, among them Captain John Alcock and Lieutenant Arthur Brown. They took off at St. John's, Newfoundland, on June 14th, and arrived safely in Ireland the next morning.

Thus about four hundred years after Columbus, the Atlantic Ocean was crossed for the first time through the air.

Not for eight years after this was the record set up by Alcock and Brown challenged. This time it was by a young American whom we all know and honour—Charles Lindbergh. Although Lindbergh's was the eleventh crossing of the Atlantic by air, it was the first non-stop solo

Lilicnthal in his biplane glider, in which he was able to fly 300 feet.

flight between the United States and the continent of Europe. The first east-west aeroplane flight across the Atlantic was made in the monoplane Bremen on April 12th, 1928, by those intrepid airmen, Captain Koehl, Baron von Huenefeld, and Captain Fitzmaurice.

After the war Germany continued the work of Count Zeppelin in building dirigibles. She built the Los Angeles for the United States, and, sheer silver in the light of the sun, it sailed through the skies from Germany to Lakehurst, New Jersey, in 1924, in eighty-one hours, which was at a rate of about sixty miles an hour. Later in the giant

hangar at Friedrichshafen was built the Graf Zeppelin, the world's largest airship. After a number of test flights it flew to America with passengers and mail, and then circumnavigated the globe, under the hand of the master pilot, Dr. Hugo Eckener. This marked another stage in man's conquest of the air.

One of the most important practical uses of the aeroplane is for carrying the mail. As early as 1918 the United States established the first regular aeroplane service in the world, between New York and

Courtesy U.S. National Museum

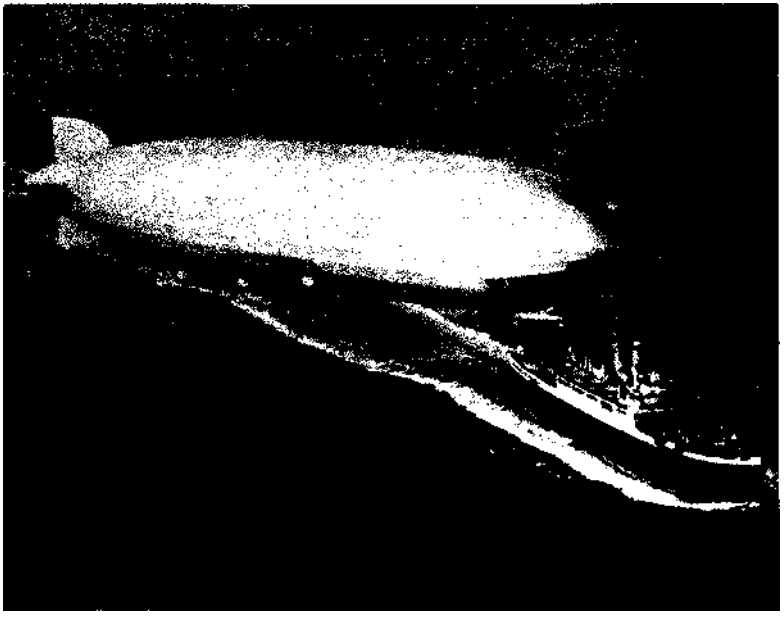
The flight of the Wright brothers at Kitty Hawk, North Carolina, December 17th, 1903. This was the first flight in a heavier-than-air, motor-driven plane.

Washington (220 miles), and in the following year British air-routes were in operation to most of the nearer capitals of Europe.

Aeroplanes need well marked routes and convenient landing places. Routes have been carefully charted and fields established along the way so as to lessen the danger of a forced landing. Lights have been invented which pierce through storm and fog, and the whole route from start to finish is lighted. The air stations give the aviator the latest weather reports by radio, so that he can change his course so as to avoid storms.

Ten years ago we had no air mail. To-day there are more than 23,000 miles of airways in the British Empire alone, and other airways

stretch over every part of the world. In 1930 the world's mail and passenger carrying planes flew nearly sixty-four million miles, equal to over two hundred and sixty-seven trips from the earth to the moon ! What a change in ten years ! With the valiant work of the aeroplane



Courtesy Hamburg-American Line

The Graf Zeppelin flying over the steamship New York on her trip around the world. The New York is 633 feet long and the Zeppelin 775 feet.

pilots the ancient Greek motto adopted by our post office takes on new meaning :

" Neither snow, nor rain, nor heat, nor gloom of night stays these couriers from the swift completion of their appointed rounds."

With the appearance of the power-driven aeroplane capable of sustained flight and the evolution of the modern airship, the conquest of the air is assured. So we see that although all through the ages men have been trying to fly, travelling by air has been accomplished only in the twentieth century, and even now is just beginning to take the

place held so long by the steamship on the water and the railway on the land. From London to Paris in three hours, from England to India in seven days ! What a contrast to the slow, laborious travel of early man ! A man can run only at the rate of twenty-one miles an hour, a horse can make thirty-nine miles an hour, the fastest railway train runs 120 miles an hour, and a high-powered aeroplane makes 400 miles an hour! It took Magellan's men thirty-seven months to sail around the world ; the Graf Zeppelin made the journey in twelve days ! Man is becoming master of the air, and the day is not far distant when he will soar with ease over mountains, over valleys, over seas like a great mechanical bird winging his way through space.

Such, in brief, is the story of man's conquest of the air up to date. As we look back over the past we can see how, link by link, the chain of progress has been forged. Man's effort to conquer the air is one of the most romantic stories of human endeavour, engaging the imagination and faith and dauntless courage of many men, and asking of many the sacrifice of life itself. Because of the work of these pioneer birdmen, man's dream through the centuries is to-day beginning to come true. Travel through the air will bring the peoples of the earth into closer relationship with one another. It will spread knowledge and understanding and friendship among the nations of the world, and so, we hope, help to bring about that greatest ideal of mankind throughout the ages—peace on earth and goodwill to men.

CONCLUSION

HEIRS OF THE AGES

AND now we have followed the long, long climb of man from his life in the beginning which was little better than that of the animals who shared the earth with him, to the magnificent achievements of the man-made world of to-day. How far we have travelled in our story since the days when our first ancestors, weak and shelterless, crept through the primeval forest, seeking a living wherever they could find it, and trembling in terror at the roar of Sabre-tooth, or the tread of other giant animals ' How stupendous have been the changes that man through his efforts has brought about in the world '

We have seen that everything man needs comes from the earth, or the water, or the air ; but this is a workaday world, and it is man's ability to make use of these things that marks the various stages of progress, or what we call civilization. Beneath the feet of early man lay all the wonderful treasures of the earth; around him stretched undreamed-of expanses of land and water. But, ignorant of all the great resources of nature, all that he got for his daily living he gained through slow, wearisome toil—through the work of his own hands, and feet, and muscles.

We have seen how, age after age, man struggled to better his condition, and how, little by little, he discovered the secrets of nature and learned to utilize them. He began supplementing the powers of his body with simple tools. He learned how to make fire serve him. He subdued the wild beasts and made them feed him and clothe him and carry him from place to place. He made the earth bear such plants as he wanted. He conquered the winds and the waters and forced them to do his bidding. He burrowed into the depths of the earth and made the vast storehouses of mineral wealth yield him their hidden treasures. He solved the mysteries of steam and electricity and made them his obedient slaves.

HEIRS OF THE AGES

Age after age, man, the inquirer, the inventor, pushed on, overcoming obstacles, learning by experience ; each age adding something to what was known before. Gradually from his first chipped stones he learned to make the giant machines that work tirelessly for him, doing the work of the world. From his two logs lashed together he learned to construct the great liners that now make their way over every sea, safely outriding the fiercest gales. From his first rude carts set on the trunks of trees have developed the modern railroads that make a network over all the land areas of the earth. From the pictures on early cave walls has come all the wealth of written records in the world to-day. From a few huts placed near together for protection have risen our towering modern cities, and out of the early crude ways of community living have developed our present great states. Man is at last coming into his own in the conquest of the earth.

What is the meaning of it all ? What is the meaning of these ceaseless activities in which man has been steadily engaged ever since he has been on the earth ? Is it merely a struggle to get food, and clothing, and shelter ? Or is it not man's effort to make his age-long dreams of the good, the true, and the beautiful, living realities upon the earth ? Surely this is the great lesson that history teaches us. Man, with his great creative and inventive gifts, can change conditions on the earth so that his life in the world may be better and finer. It is this ability of man that has made human progress possible, and has gradually brought about the world we live in.

Such is the world we have fallen heir to. What an age in which to live, with its centuries of stupendous accomplishment behind us, and before us a future the greatness of which we can scarcely imagine ! For the tale of progress is a continued story never fully told. Each generation of people on the earth is but a part of the great onward swing of evolution. When we are born into the world we naturally inherit the results of the labours of the millions of people who have lived here before us. In this inheritance we find many good things, many not so good, and many still unfinished. To-day, we adults of the present generation are working on the problems left us by the generation that preceded us. In the course of time we shall " join the immortal company " of those who have gone before us, and you, who follow us, will inherit the world with its splendid achievements and its great problems.

What will you do with it ? Will you work out new and happier ways of living and working together ? Will you learn good uses for the greater leisure which the work of the great machines will bestow upon you ? Will you utilize the closeness of the nations of the world to increase the possibilities for quarrels, or to multiply the opportunities for making the life you live in the world a fuller and a fairer thing ? These are the questions which you, the latest comers on the earth, will be called upon to answer when you grow up. Yours will be the task of forging the next link in the long chain of man's progress. This is the task which past ages have set you. They have given you their gifts. How will you use them ?

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