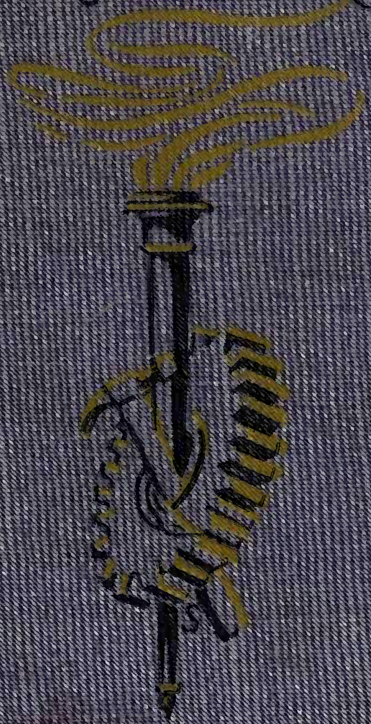
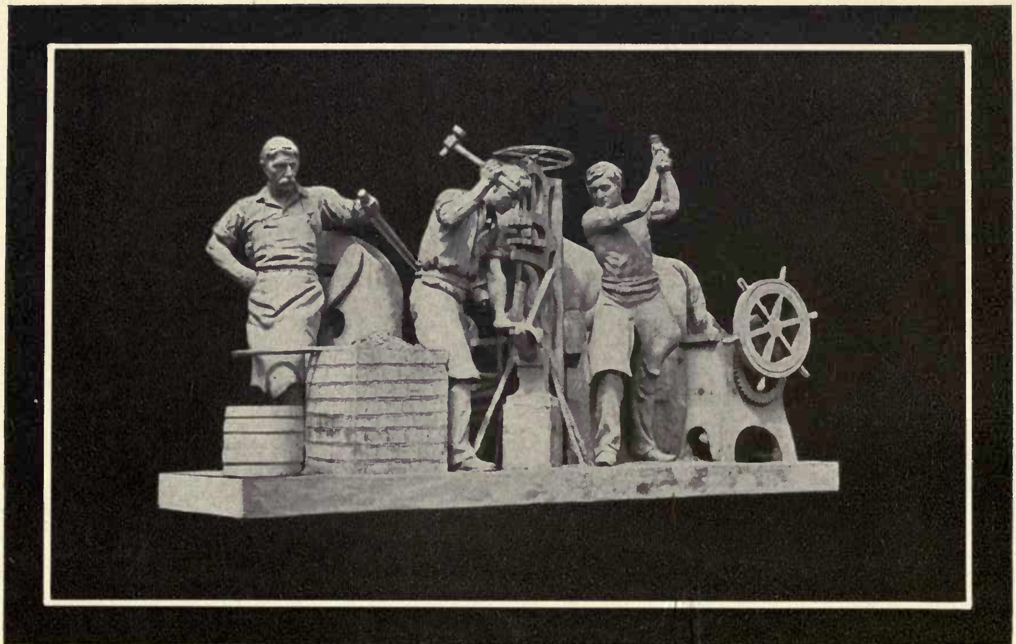
TOOLS AND MACHINES

BY CHARLES BARNARD.



SILVER BURDETT & COMPANY



THE WORKERS IN METAL

TOOLS AND MACHINES

TOOLS AND MACHINES

BY

CHARLES BARNARD

EDITORIAL CONTRIBUTOR TO "THE CENTURY DICTIONARY"

ILLUSTRATED

SILVER, BURDETT AND COMPANY

NEW YORK BOSTON CHICAGO

CONTENTS

ILLUSTRATIONS

INTRODUCTION

One of the greatest pleasures in the world is to use a fine tool in doing good work. A tool extends the power of the hand. It enables us to do things we could not do without such aid. A needle is a tool that every girl should be able to use with skill. A sewing-machine is a needle in a machine, and it extends the power of the hand by enabling a girl or a woman to do more needle-work in less time and in a different manner than she could do with the needle alone. An oar is a tool every boy should be able to handle with precision and power. It is a tool of transportation. To steer a naphtha launch and attend to its little engine is to use a machine for transportation. With an oar a boy can row a boat with one passenger a mile. With a launch he can carry twenty passengers ten miles with less labor. He can learn to row in one lesson. To manage a launch may take a month's instruction and practice. To row a boat is to use the boy's own unaided strength. To manage the launch implies a knowledge of the control of an engine that develops power, and this implies a knowledge of navigation, that the launch may be steered from port to port in safety.

The hammer, the saw, the knife and the needle are tools that have come down to us from men who lived long centuries ago in unknown lands. Somewhere in the dim past, when men lived in trees or in caves, some poor savage tried to defend his children from wild beasts, some mother tried to shelter her babies from storms and cold. With their hands alone they were almost helpless against storms and wolves. Out of their dangers they developed arms. In their starvation, cold and misery they invented tools. Ages passed, and little by little the first rude tools were improved. Other men saw new and better methods of using the old tools, and very slowly men learned to use tools in still other and more useful ways, and machines were invented.

Once all men and women were obliged to work hard through long days and nights to get a little food, a few poor clothes, and a miserable home. To-day they can have more and better food and clothing and more comfortable homes. There are more things in the world, and yet there is less labor. We can hardly comprehend the suffering, hunger, cold, danger and misery of those poor half forgotten people who had no tools. They were hardly men at all. There were no children, only little old men and women toddling about in the woods, eagerly searching for a fallen nut or wading in the water in search of an oyster or a clam. And when they found an oyster they had no knife with which to open the shell. They could only smash the shell with a stone and tear out the fish and eat it raw, for there was no fire by which it might be cooked, not even a tool wherewith to make a fire. When danger and starvation compelled men to invent tools, they laid the foundations on which rest all the safety, comfort, convenience and pleasure that we enjoy to-day. We can, therefore, find no more interesting and attractive study than the names, history and use of the grand things we call tools and machines.

To use a good tool is a pleasure because it enables us to make something that shall be useful and beautiful, for any article that is rightly made and that will do good work has a real beauty of its own. A good tool, rightly used, enables us to express ideas in things so that when others see these things they will comprehend the ideas we have put into our work. To express ideas is one of the greatest of pleasures, and a tool is a mode of expression; thus its very use is a pleasure in itself.

A young boy or girl may wish to make a picture frame, a box, a net, or a rolling-pin that will be useful in the kitchen. The young designer may have a correct idea as to the future appearance of the thing to be made and yet be unable to make others understand exactly how the thing is to appear when finished. The first step thus implies the use of a tool, and this is a pencil. The pencil is a tool with which a sketch, plan or drawing can be made. The pencil is a tool that enables the designer to express his ideas so that others, on seeing the design, may with the right tools make the thing illustrated by the drawing.

A boy may have a design for a picture-frame or a

TOOLS AND MACHINES

CHAPTER I.

TOOLS, UTENSILS, INSTRUMENTS, IMPLEMENTS, APPARATUS AND MACHINES

A MAN sees a ripe apple on a tree and he pulls it from the tree with one hand. He may see another apple that is higher up and beyond his reach. He picks up a broken branch fallen from some tree and with it pulls the bough of the apple tree down until he can reach the apple. In the first instance he used his unaided hands; in the second he used a tool.

A man sees a stone partly buried in the ground. It seems to be a good stone to put in the wall of a house. He tries to lift the stone, but cannot, and he looks about for a stout stick with which to pry it up. The stick is a tool. He sees a bunch of ripe grapes on a vine and he finds a flat stone with a sharp edge that he can use as a knife to cut the stem of the bunch of grapes. The sharp stone is a cutting tool. A girl sewing is using a tool. A man spading up a garden or uprooting weeds uses a tool. An artist using a brush, or a sculptor a chisel is doing work with a tool. Such work, whether done by a laborer, a gardener, a painter, or a sculptor, is mechanical work. Tools are things used in mechanical work. A tool, in one sense, may be anything with which work may be done. A writer may call his books, his pen and his paper the tools of his trade. The captain of a coast-survey steamer may call his ship a great tool. These wider meanings of the word need not now concern us; we will confine our attention to those special things used in mechanical work and commonly called tools.

A girl breaks an egg into a bowl, and, holding a fork in one hand, beats the yolk and white of the egg until she has a mixture of the two. She has used a tool in doing mechanical work, and has made a mechanical mixture. She then pours this mixture into a pan that has been prepared for it and places the pan on the stove. The egg is now submitted to a high temperature and, in a few minutes, is entirely changed in appearance and character. This change, imparted to the egg by the heat, we call a chemical change. We say the egg is cooked, or has been submitted to the chemical action of heat. We see at once that this is entirely different from the mechanical action of beating the egg with the fork.

The girl beats another egg and pours the mechanical mixture into another pan and places it upon the stove. She then stirs the mixture with a spoon, which is a tool, while the pan remains on the fire. Chemical action proceeds as with the first egg, but to this action is now added the mechanical action of the stirring.

The result of this combined chemical and mechanical action is quite different from that obtained by the chemical action alone. In the first instance the egg became an omelet, in the second a scrambled egg.

In cooking the egg the girl used another tool. The pan in which the egg was placed was a tool, because it did the mechanical work of holding the egg while on the stove. We do not, however, call a pan a tool, because tools are used in mechanical work, and the mere holding of the egg is not regarded as work with a tool. We, therefore, call the pan a utensil. Pots, kettles, skillets, frying-pans, griddle-irons, and boilers are kitchen utensils. Knives, forks and spoons are sometimes called utensils, but they are really kitchen tools.

When a man uses a hoe to mix sand and cement he uses a tool to make a mechanical mixture. If he then adds water to the mixture, chemical action will begin, and in a few moments the sand and cement will have turned into a hard, stone-like material that is unlike sand or cement. If, before the water was added and before the chemical action began, the man had wished to separate the sand from the cement he might have done so by sifting them through a fine sieve. He would then have had sand and cement. After the water was added and chemical action began, and after the mechanical mixture of sand and cement had turned into the new chemical compound called concrete, the man could not separate the sand from the cement. He might grind up the material into powder, but it would be only powdered concrete. These two experiments show us the difference between chemical and mechanical action, and enable us to understand that tools are things used in doing mechanical work.

Now, while things used in mechanical work are tools, they are not all called by that name. The surgeon uses a saw, which is a mechanical tool, yet he prefers to call it a surgical instrument. An instrument may be anything used to accomplish a certain end. A pair of forceps or a drill or a file used by a dentist may be called dental instruments. Yet both surgeon and dentist are really using tools, though, for convenience, they will call all their tools instruments. The word instrument may have even another and a wider meaning, as when a sheet of paper, on which is written a deed, a will or other legal statement of facts, is called an instrument. However, for our purposes, we will recognize that tools are, in some cases, called instruments, and that all instruments used in doing work are also tools.

A farmer may use a hoe, a spade or a rake in doing mechanical work, and may even tell us that he keeps them in his tool-house. If we go to the maker of such tools we shall learn that he calls them, not agricultural tools, but agricultural implements. The surgeon carries his tools in an instrument case; the farmer never mentions his implement-house. Instruments and implements may be tools of a trade, as a flute or violin, yet the musician would call them his instruments. An organ is really a great mechanical machine. It is called a musical instrument.

A girl in beating an egg may prefer to use, in place of a fork, a little machine called an egg-beater. She might tell us that it was an egg-beating apparatus. A chemist may have some sea-water and may wish to separate the salt in it from the water. He can do this by using two bottles, a small lamp, and some glass tubes, and such a collection of things he calls a distilling apparatus. The engineer of an ocean steamship wishes fresh water for his boilers and he, too, uses a very large apparatus to distill fresh water from the salt sea-water. The fireman calls his steamers, hose-carts, chemical tanks, ladders, trucks, hooks and nets his fire-apparatus. An apparatus may be any assemblage of parts, tools, machines, or appliances designed to do work or accomplish a certain result. The electrician may also call his telephone or telegraph electrical apparatus.

A machine is an assemblage of things, some one or more of which are tools, and used to do mechanical work. The girl would be correct in calling her egg-beater a machine, and the chemist is right when he calls his bottles and tubes a distilling apparatus. A girl in cooking may strain her soup or jelly through a cloth tied over the mouth of a jar, and tell us she is using a straining apparatus. The girl may put the strained jelly away to cool under a block of ice. The ice is placed in a tight box, and in melting it chills the air in the box, and the girl calls her refrigerator a cold-storage apparatus. A man making ice or preparing brine for use in a cold-storage warehouse does not call his great plant an apparatus. He says he uses an ice-machine; yet his warehouse itself, with its cold rooms and glittering, frost-covered pipes, is nothing more than a very large refrigerating apparatus. To distinguish, however, his ice-making plant from his cold-storage house he calls it his ice-making machine.

A fisherman uses hooks, floats, sinkers, rods and lines as tools in his trade, and calls them his fishing tackle. Ropes and blocks used in hoisting sails on a ship or in raising weights are often called hoisting tackle.

Tools, utensils, instruments, implements, apparatus, tackle and machines are terms used to designate tools, machines and things used in work. It may not all be mechanical work, as we have seen in the case of the refrigerator and the omelet pan and in the making of concrete. For our purposes we will select the two terms, tools and machines, for utensils, instruments and implements may also be tools or may be parts of machines, while in many instances some apparatus may be also machines.

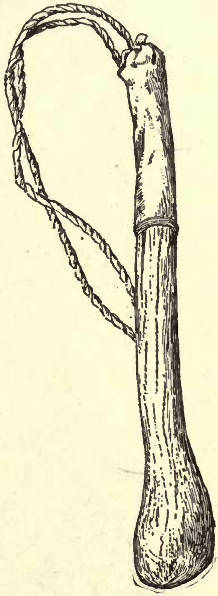
Tools are simple; machines are complex. Tools were invented first and were used for thousands of years before the first machine was made. Machines grow out of tools, and do on a large scale and in a large way the work that can be done with hand tools in a small way. Tools may be used slowly; machines may be used at a very high speed.

A hammer is a hand-tool; a steam hammer is a machine. A needle is a tool; a sewing-machine is a thousand times larger than a needle, and yet does the same work. A chisel is a tool; a lathe is a machine, and both are cutting tools. A gimlet is a tool used in boring a hole; a gang-drill is a great boring-machine that bores many holes at once. A saw is a tool; a sawmill is a great sawing-machine. A rolling-pin can be used to spread a sheet of dough; a rolling-mill may spread out tons of steel into great sheets fit for the sides of a ship. A rubber stamp may be used to print fifty letters at once; a printing-press may print fifty thousand letters at one time.

CHAPTER II

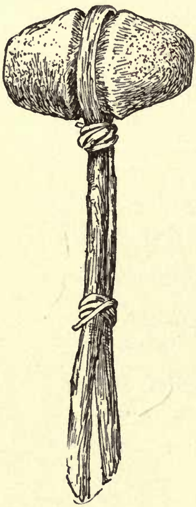
THE HAMMER

To understand the very beginning of tool-making we should endeavor to imagine how it happened that men first used a tool. This was centuries ago, long, long before men had any means of making a record of the things they saw or did, and we can only make a picture, as it were, of the unknown man who first used a tool. He was a poor, helpless savage, living in trees. He had never even dreamed of a bow and arrow. He could not imagine such a thing as a spear or a knife, and yet the woods were full of terrible wild beasts. He knew only that if a wolf appeared he must scramble into the nearest tree to save his life. Perhaps this man was one day in an open space in the forest when a wolf attacked him. There was no time to reach a tree. He must fight or be torn to pieces by the wolf. A limb of a tree, broken off by the wind, lay near him, and in his desperate need he picked it up to defend himself. It was a club—a tool, and with it he struck the wolf on the head. To his amazement, the blow killed the beast. The broken limb was a hammer, and with it he had cracked the wolf's skull. With what wonder he must have looked upon the stick. It was a precious thing—a weapon and defense against wolves. He would keep so valuable a thing, keep it for his sons and his sons' sons as something to be preserved and treasured with the greatest care. It must have been some such desperate necessity that led to the invention of the first tool, and it is quite probable that this first tool was a club or a hammer.



Prehistoric War Club

The use of clubs would, in time, spread from man to man until everyone would own and use a war club. Perhaps, long after, some other man carrying a club would find a plant whose roots were good to eat. The club, he might discover, would be useful in prying the plants out of the ground to get the roots. Another man or woman, perhaps long after, and in some other country, might find the club very useful in cracking the bones of animals to extract the sweet marrow, or to smash an oyster shell to obtain the fish inside the shell. We may never know where or when these first



Stone Hammer with wooden handles bound together with cane experiments were made. We can guess only that in some such way men first learned to use tools. The search for food and defense against wild beasts was the inspiration; common things, like the limb of a tree or a round stone, were the things that suggested the means to an end. What was wanted was something that would strike a smashing blow. A man's fist could deliver a blow, but in giving the blow the hand might be injured. A stick or a hard stone held in the hand would do the work without injury to the hand. It is quite possible that a club or a stone used as a hammer was the first tool, and we may well begin our studies with the ancient tool that we now call the hammer.

To study a tool we must see it; we must make experiments with it, because in an experiment we try things to see how they behave under certain conditions, and from their behavior we learn the laws governing their use. Get a nail, a small piece of soft pine, a brick or flat-iron and a carpenter's hammer. The hammer consists of two distinct parts, the head and the handle. The handle is of hard wood, beautifully moulded to fit the hand, just large enough to be grasped firmly, slightly tapering, to prevent the hand from slipping, and of just the right length. The steel head has a face or striking surface with which to strike the blow. It has also a claw, the use of which we shall observe presently.

Now place the wood on a bench or some firm support about three feet from the floor, and with the left hand hold the nail upright on the wood. Grasp the hammer firmly in the right hand about one-third of the length from the end and rest the hammer head on the nail. Nothing happens. The weight of the hammer produces no visible effect on the nail. We may even press upon the hammer with all our strength, but beyond a slight dent in the wood just under the point of the nail there is no effect, certainly no useful effect. Next, resting the face of the hammer squarely on the head of the nail, raise the hammer a few inches and then put it gently back again. This trains the eye and hand to guide the hammer in striking a quick, hard blow on the head of the nail. Strike one blow and observe that the nail sinks into the wood and stands upright. Strike another blow and it sinks deeper. We observe that the hammer is a tool for giving a sudden impact or driving blow, therefore we call it a tool of percussion.

The experiment teaches us that there is a difference between placing the hammer slowly and gently on the nail and the quick blow. Under the mere weight of the hammer resting on the nail the particles of wood immediately under the point of the nail resist the pressure and hold up nail and hammer. Under the quick blow they give way and the nail sinks into the wood. The experiment shows that there is another matter to be considered, and this is time. Under the slow pressure the particles of wood had time to adjust themselves to the pressure; under the quick blow they broke and gave way. We can lay the hammer on an inverted teacup and the frail china ware will support it unharmed. Drop the hammer suddenly on the cup and it breaks. Place two inverted glass tumblers upon the floor and you can, if careful, step upon them and they will sustain your weight. Drop one glass on the floor and it will break with its own weight. We may press with all our strength on the glass and not break it, yet we can easily smash it with one blow of the fist. Clearly, there is a difference between a pressure and a quick blow—a useful bit of information in carrying eggs.

These experiments teach another matter. Should we attempt to break the teacup or glass with the hand it is quite possible we might cut or injure the hand. The hard steel face of the hammer head saves us from this injury. Now hold a nail upright on a brick and strike it with the hammer. Be careful in this experiment that the nail does not fly off and do some harm under a bad blow, or that it does not bend or give way and injure the hand. Next, strike the hammer on the bare brick. Observe that in both cases the hammer accomplishes nothing, or recoils as if it had received a return blow. It meets with resistance, and no useful effect is accomplished.

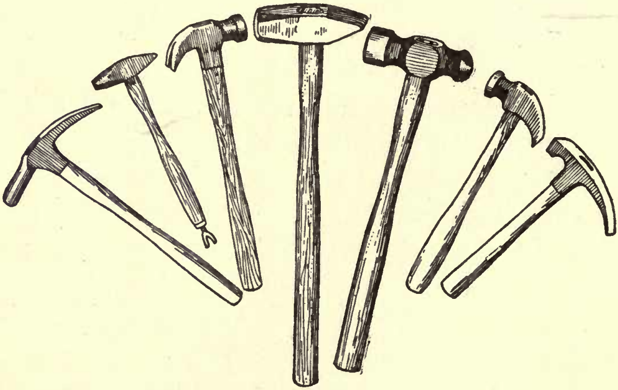
Hold a nail upright on a piece of wood and try to drive it in by using another piece of wood as a hammer. We see that such a wooden hammer is dented or split, and the nail is hardly driven in at all. Clearly, the resistance affects the wooden hammer, and the force spent in the blow is wasted in part on the hammer.

Go on striking the nail until it sinks into the wood up to the head. The last blow "drives it home" or sinks it until the top of the nail is level with the surface of the wood. It requires great skill and long practice to do this, and we shall probably find that the last blow has left an ugly scar on the wood. This is bad work. The nail must be "sent home" and the wood left uninjured.

We observe that the carpenter driving nails in handsome wood or in wood exposed to the weather never mars the wood with hammer marks. He omits the last blow and then places a small, slender piece of steel, called a "nail-set," upright on the head of the nail and strikes the blow on the end of the nail-set. This drives the nail home without injuring the wood, beyond the small hole made by the nail itself. These experiments show us that even such a simple thing as driving a nail is an accomplishment well worth learning.

The carpenter's hammer is sometimes called a claw-hammer. Opposite the face is a double toe, or claw, curved back towards the handle. The inner edge of the slot between the claws is beveled, and the slot is narrow at the bottom and wide at the top. Suppose we wish to draw out a nail that is half driven in the wood. We put the claws over it and observe that the head of the nail is wedged in between the claws. By bending the hammer backward as it rests on the wood we use it as a lever to pull or draw out the nail. The claw-hammer is thus a compound or double tool—hammer and nail-puller.

Of all the many kinds of hammers, only a few are single tools for striking blows only, and such hammers have usually two faces—one at each side of the head. A blacksmith's hammer and the mason's stone-breaking hammer are examples of these simple hammers with double faces. Compound hammers have a face at one



Types of Hammers

side of the head for striking a blow, and the other side, called the "peen," is quite another kind of tool. The peen may be a claw, a pick, a wedge, a shovel, a chisel or an awl. The peen may thus become a second tool used with a hammer and having the same handle.

There are about fifty different styles of hammers, each one having a trade name. They are of every size, from a tack-hammer, weighing a few ounces, up to the blacksmith's great straight-handled sledge-hammer, weighing twenty pounds or more. Many are named after the trade in which they are used, as bricklayer's hammer, miner's hammer, gold-beater's hammer, etc. Some are named after the work in which they are used, as creasing-hammer, chasing-hammer. A man laying paving blocks uses a short-handled hammer called a paver's hammer, with a heavy head and a peen shaped like a curved, sharp-edged hoe. A bricklayer's hammer has a peen shaped like a small ax that can be used to "dress" bricks into shape.

Mallets

A ramrod is a long-handled hammer with the face in line with the handle. It is used to load a muzzle-loading gun. A paver's rammer is a heavy iron hammer with two handles near the top. It is lifted in both hands and let fall on its end, or face, to drive home a paving block. A long-handled wooden hammer used in tamping soil round a post set in the ground is also called a post or trench-rammer. A mallet is a wooden hammer with a short, straight handle and large, round wooden head. It is used in fine stonework and sculpture. A long-handled hammer with a small wooden head, and used in the game of croquet is also called a mallet. A billiard cue, a baseball bat, a tennis racket, all the instruments used in golf, are hammers. A maul or beetle is a large hammer with a wooden head, used in driving a wedge, in splitting logs or driving down a stake, or in driving sheet-piling to protect an embankment. A woodchopper's maul has a wedge-shaped peen and the railroad spike maul has one large face and one small face. A gavel is a small hammer used by the presiding officer of a meeting as a signal to attract attention. A drumstick is a hammer, and the strings of a piano are struck by felt-covered hammers just as the hammers of a pianola strike the keys of the piano itself. The tongue of a bell is a hammer. The rolling ball that sounds a fog-bell is also a hammer. A girl beating a carpet is using a hammer, though it may look like a wicker fan on a long handle. The men at Bunker Hill used flint-lock guns that were fired by a spark struck from a flint by a hammer, and in their canvas haversacks they carried bread made from wheat threshed out by a flail—a curious hammer with a long wooden head, called a souple, affixed by a swivel joint to a handle.


A Hammer for Play

The stone-mason, millstone dresser and marble-worker use hammers with compound faces. A bundle of rods with sharp points or a bunch of flat, sharp-edged steel plates may be clamped together or wedged together in a box to form a hammer-head. Such multiple-faced hammers strike many blows at once and are excellent for finishing or dressing stone surfaces. Blacksmiths, machinists, coopers, jewellers and plumbers use many different hammers of varied shapes and sizes and bearing special names. For instance, a goldbeater uses a commencing-hammer, a spreading-hammer, and a finishing-hammer, according to the progress of his work.

A carpenter, having only one arm, finding it difficult to drive small nails with one hand, thought of the idea of magnetizing his steel hammer-head. With such a magnet hammer he could pick up a tack by its head and with one blow drive it into the wood hard enough to make it stand alone. Then he could drive it home. Such magnetized hammers for driving brads and tacks are now used in many trades.

A blacksmith heats a bar of iron in his fire until it is soft. He then lays it upon some firm support, and with his hammer beats or forges it into the shape he requires. This support he calls an anvil. The blacksmith's anvil is a square block of iron or steel, having a smooth top or face. At one side there are holes of different sizes and shapes, and on the opposite side is a projecting beak or horn. By means of these holes, the beak and the flat face, he works his hot iron into a great variety of useful forms, and will forge almost anything from a horseshoe to a pot-hook. So we always speak of the hammer and anvil as the two tools that go together. All work done with the hammer, all shaping, bending, twisting, spreading or welding metals by blows must be done on some form of anvil. The hammer blows fall, not on the anvil, but upon the work that rests thereon, and the shape of the anvil determines the form of the finished work. The anvil is hard, and resists the impact of the hammer, but red-hot iron is relatively soft, and between hammer and anvil takes any shape the skillful workman wishes. So we shall see, with nearly every hammer, be it great or small, some form of anvil.

All the great family of tools used as hammers have come from the club or the stone tied to a stick, used by primitive men. All have assumed their present varied forms through the efforts of thousands of unknown and earnest men, who sought, through trial and experiment, to learn what is the best shape for a hammer in doing any work. The more complex and varied the work the more varied the hammers, so that to-day the hammer is a specialized tool of the very highest value and efficiency.

We have only to look about and we shall see in every art, trade, and manufacture many varied forms of this ancient tool. Even a bird may know the use of a hammer, as when a crow steals an egg and, wishing to break it, lifts it in its claws, and flying up in the air, lets it fall, and then with a proud and thankful "caw" flies down to the dinner so cleverly obtained. However, there was once a tame crow who stole a porcelain nest-egg and tried this hammer method of cracking the egg, only to be puzzled and disappointed at the result.

To-day the American hammer, whatever its name or use, is a splendid tool, admirably designed for its special work. It is the finest tool of percussion ever made —a tool that it is a pleasure to see and to use. To the eye trained to see the true, the useful, and effective, a good hammer is a handsome tool. Never before were such fine tools made, never before were they used in so many different ways, and never before was it so important as now to know and understand the use of good tools.

In using this grand tool, we train the eye, the hand, and the mind. The eye must guide the hand and the mind guide the work, or we may break the nail, dent the wood, injure ourselves, or, what is far worse, spoil the work. We can mend broken skin with courtplaster, but a beautiful piece of maple injured by hammer marks can never be repaired.

To drive a nail seems a simple thing, yet no one can do it well the first time. Just how to hold the nail that it shall not split the wood, to drive it home, straight and true and just far enough without injuring the wood, is a little accomplishment which no one need be ashamed to acquire. Skill comes with practice, and it is the practiced hand, using a fine tool, that produces the finest results, be it at a bench or a piano. It is not the driving of the nail, but the skill, the knowledge, the training in good work it brings that is valuable.

No one can afford to say that he need not learn to use this ancient tool.

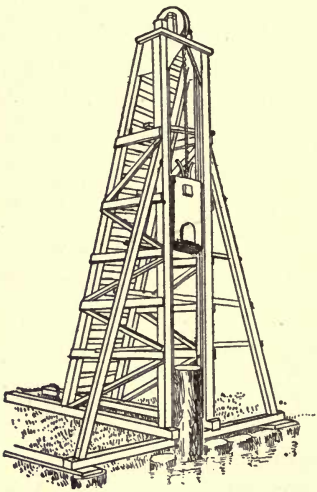
On other pages will be seen drawings of some of the many forms in which hammers are now made, and it will be well to examine them all with care, that we may be able to recognize their names and use them with skill.

CHAPTER III

THE POWER-HAMMERS

A MAN may wish to drive a long, pointed log, called a pile, on which to rest a bridge or wharf, into the mud or sand of the seashore or into the bed of a river. The pile may be twenty feet long, and while with the proper tools he might manage to set it upright in the mud, he could not drive it into the mud with the largest maul that he could handle. He therefore uses a machine-hammer or power-hammer called a pile-driver.

A pile-driver consists of two tall uprights of wood, properly braced and held in position upon a scow or upon a platform erected over the place where the pile is to be driven. These wooden uprights serve as guides for a very large and heavy hammer called a "monkey." The monkey is fitted with iron lugs or wings at the sides that just fit the two guides, so that, while it is free to slide up and down between the guides, it cannot escape on either side. At the top of the hammer is a ring, and in this may be caught a double hook or tongs to which is fastened a long rope. This rope leads up between the guides to the top, where it turns over a small wheel resting on the top of the guides and then runs down to the ground where it passes through a block securely fastened to the ground. The end of the rope is fastened to a wooden bar secured to the traces of the harness of a horse. Just under the wheel, at the top of the machine, there are two triangular pieces of wood placed between the guides, the rope passing between them. Suppose, now, a tall pile has been placed between the guides, ready to be driven into the mud, the monkey hanging suspended above the pile. When all is ready the horse steps forward, pulling on the rope and lifting the hammer to the very top of the guides. Here the triangular pieces pinch the tongs and the claws open, letting the weight fall on the head of the pile and driving it home by a series of falls on its head.

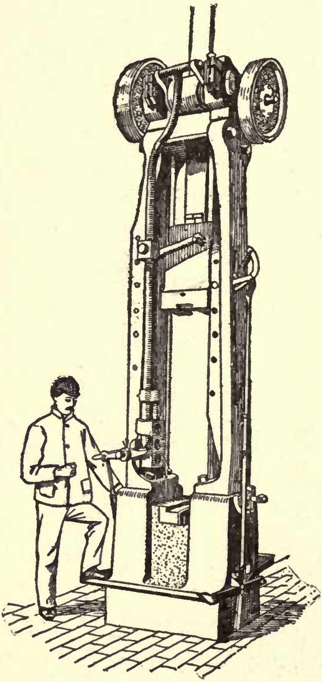


A Pile-driver

Here is plainly a machine-hammer, operated by the power of the horse. When the weight has fallen the horse backs, the rope slips down till the tongs again bite the ring in the weight, and then the horse moves forward, lifting the hammer until it is again released and delivers another blow. A pile-driver operated in this way is said to be operated by horse-power. The hammer might also be raised by men turning a windlass, but the work would be slow and expensive. A steam hoisting-engine is usually used with such pile-drivers, and such machines are said to be operated by steam-power. We can also properly say that such a machine is a power-hammer, to distinguish it from a hand-hammer.

A man may wish to forge some small piece of iron, a bolt, a hook, or a part of some machine. He can heat the metal in a fire and then forge it into the required shape with a hammer on an anvil. This might be all right for one piece, but if he wanted a thousand pieces, all exactly alike, this method would take too much time and labor. The thousand pieces would be so costly that people could not afford to buy them. That would not be good business; he must use a power-hammer that will do the work quickly and cheaply, and that will turn out each piece exactly like every other piece. We say he must manufacture the pieces with a power-tool, and the tool he will select for this work will be a drop-press.

A drop-press is a machine having two upright guides placed over a fixed anvil, with a weight or hammer suspended between them over the anvil. By the use of simple machinery the weight can be raised above the anvil and made to fall upon it. The face (bottom) of the hammer is cut into the exact shape of the object to be made by the drop-press. The anvil may also have a face of the shape of the object. The man operating the drop-press has a supply of pieces of metal called "blanks," and as the hammer rises he has time to lift a blank in his tongs and place it on the anvil. The hammer falls, and at one blow the metal is struck or forged into the exact shape cut in the faces of the hammer and anvil. The blank, when the hammer again rises, may be removed from the anvil and another blank put in its place. All such pieces will be exactly alike, and as they are forged in a drop-press they are called drop-forgings. Such a power-hammer works faster than any man with a hand-hammer, and it does better work at a great saving of time and labor, and as these cost money, at a less cost of manufacture. There are many different styles and sizes of these drop-forges. We need not stop to examine them all in detail, as our aim is to understand what is meant by a power-hammer. The monkey of a pile-driver may weigh a thousand pounds and the hammer of a drop-press used in a factory may weigh only ten pounds, and while the two machines only slightly resemble

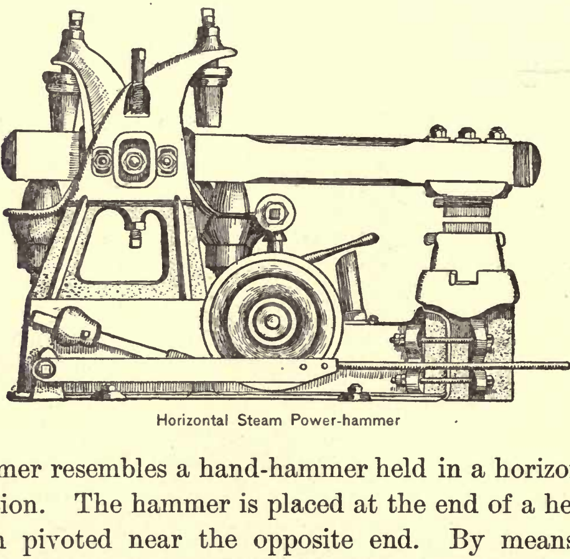


Drop-forging Hammer

each other, yet were we to see them we would recognize that each is a power-hammer.

In mining it is often necessary to extract the gold or other metals embedded in the ore-stone by pounding the stone into powder. This can best be done by a smashing blow from a hammer. As such work could not be done by hand, except at very great expense, we find at such mines great machines called stamp-mills. A stamp-mill consists of a row of heavy wooden beams shod with iron, standing between guides upon massive anvils. By the use of simple machinery these beams, called stamps, are lifted above the anvils and let fall upon them, while a stream of the rock slides down upon the anvils. The ore is said to be "fed" to the stamps, and under the terrific, crashing blows of the huge stamps it is rapidly crushed to powder. It is afterwards a comparatively easy matter to extract the gold from the powdered stone. A row of stamps is called a battery, and such a battery of stamps represents the largest and most powerful power-hammering machine except one, in the world.

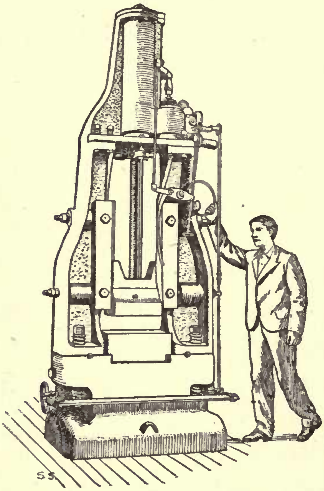
As long as all hammers were used by hand, men had to confine their work to small things. A blacksmith could make a nail, a horseshoe, or a crane for a fireplace, or the links of a small chain. When the locomotive was invented it was found that we must use larger and more powerful hammers to forge the axle of the new engine. This, and the demand for other work like it, led to the general use of the oldest and the most simple of the power-hammers—the trip-hammer. This useful machine was invented before the locomotive, but it was the invention of the engine, and more particularly the invention of the steamboat, that led to the general use of the trip-hammer. Before that time it had been used in a small way for heavy forgings. Now it became exceedingly useful, and it was at once greatly increased in size and power. A trip-



Horizontal Steam Power-hammer

hammer resembles a hand-hammer held in a horizontal position. The hammer is placed at the end of a heavy beam pivoted near the opposite end. By means of simple machinery the handle was raised and then "tripped" or let fall, when the hammer-head delivered its blow upon the anvil. All these tripping or tilting hammers were, at first, operated by water-power, and in the first half of the last century, in New England, did much to make the forging of shovels and other large tools cheap and rapid. Later they were operated by steam power. They are still used in forging many comparatively small pieces of metal work, but have in many shops been superseded by the drop-press and by their great rival, the steam-hammer.

The first step in the evolution of the steam-hammer came from an attempt to improve the common trip-hammer. The plan was to place a steam cylinder under the handle and to use the expansion of steam to lift the hammer. The idea was good, but it did not prove to be very practical, and is only interesting as showing the first attempt to use the direct expansion of steam to move a hammer. In 1838, Nasmyth, of England, planned his really great invention—the steam-hammer. His idea was to use the piston-rod of an upright steam-engine as the handle of a hammer that could move up and down between vertical guides. The valves of the engine were to be operated by hand to admit steam above or below the piston. When steam was admitted below, the piston would rise and lift the hammer. Then, on letting the steam escape, the hammer would fall upon the anvil below. By admitting steam above the piston as it fell, the force of the blow would be enormously increased. By admitting steam both above and below the piston at the same time, the hammer could be hung suspended over the anvil or be made to deliver light or heavy blows, quick or slow blows, at the will of the operator Nasmyth's idea was one of the greatest of modern conceptions, and when carried out in actual practice it gave us the most powerful and most costly machine-hammer in the world. Steam-hammers are now made in many sizes, from small machines for forging the ironwork of a carriage or other light work, to the giant labor of forging the shaft of an ocean steamship. So perfect is the operation of one of these Titan hammers that the engineer can crack an egg with it, or deliver terrific, smashing blows that will mold a ton of iron into any shape he wishes.

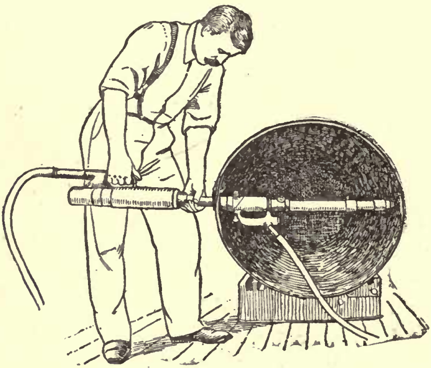

Vertical Steam-Hammer

The steam-hammer and the drop-press are types of all the most common and useful power-hammers. The smaller machines are called dead-stroke hammers, drop-hammers, pig-iron breakers, etc., and all use a hammer moving between vertical guides and operated by means of lifting machinery or by the direct expansion of steam. Some deliver blows at a regular speed, others at variable speeds, or at the will of the operator.

In addition to these machine-hammers there are other machines that, while given other names, are really power-hammers. In the carpet-beating machine wooden rods arranged in a battery beat or strike the carpet as it passes under them. It is thus a form of machine-hammer. A batting-machine or scutching-machine, employs beaters that slap or thrash raw flax or cotton to beat out the dirt and dust, and it is thus a form of machine-hammer. In the manufacture of shoes, pegs, brads or small nails are driven into the shoe sole, and a pegging-machine is properly a variety of machine-hammer. A box-nailing machine that will drive eight nails at once into the corners of a box is clearly a gang-hammer, or small battery of hammers operated by machinery. Such a machine is called a nailer, and its principal work is nailing shoe or other packing boxes.

After the invention of the steam-hammer it was thought that compressed air could be used in such machines in place of steam. Such pneumatic hammers did not at that time come into general use. We did not then understand the use of compressed air, and these atmospheric hammers, as they were called, were soon forgotten.

With the invention of larger and more powerful compressors, compressed air came to be better understood, and many new tools were invented for employing this very convenient method of distributing power. Among these new tools was the rock-drill, and from the rock-drill came the latest and finest of all the power-hammers, the pneumatic hammer. This new and remarkable machine sprang from the demand for a small, self-acting hammer, which would deliver blows of moderate power at a very high speed. A pneumatic hammer consists of an iron cylinder designed to be held in the hands, and containing a piston with its rod and the proper valves to operate the piston as a little engine or motor, using compressed air in place of steam. This little reciprocating engine, when supplied with air under pressure, delivered through a hose, will run at a very high speed, and we can easily see that if the piston-rod has a hammer-head at the end, we shall have a power-hammer. Such a hammer, held in any position before any anvil or any work placed upon an anvil, will deliver a blow at every stroke of the piston-rod, and with sufficient air-pressure will give from 200 to 1,000 blows a minute. Such a swiftly moving hammer would be useless in driving nails, but for long and heavy work in iron, such as "caulking," beating down the seams between the plates of an iron ship, or in forging rivets into place or in dressing stone or marble it is an exceedingly useful tool.



Pneumatic Hammer

The pneumatic hammer is so new that we do not yet know all that it can do. It is one of the finest of modern machine tools, and every month new uses are found for its swiftly flying hammer. In the foundry the foundryman in making his molds rams the soft, loamy sand into his flasks with a mallet. The pneumatic hammer will do the work far better and twenty times as fast. A large pneumatic hammer resembling a paver's rammer will ram down paving-blocks or level the sand in great molds in a foundry. The stone-mason and the sculptor have found it to be a new and wonderful kind of mallet in their beautiful work of dressing building stone or carving statues or in making the many useful forms of marble used in our homes, churches and office buildings. We shall examine this splendid new power-hammer again when we come to examine that ancient tool, the chisel.

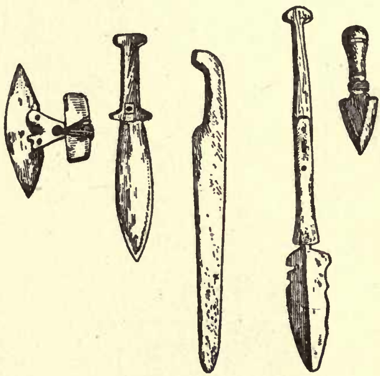
We have seen that to use a hand-hammer requires skill, and that its proper use is a real training for hand and eye. To use these grander tools, the great power-hammers, and this new and wonderful machine, the pneumatic hammer, teaches even more, for to use them requires a higher skill and a greater training. A man may earn two dollars a day driving shingle nails on a roof. A man may earn five dollars a day controlling some gigantic steam-hammer. A sculptor with his chisels and a mallet and aided now by a pneumatic hammer, may earn ten thousand dollars in one grand piece of work by making a beautiful marble statue.

CHAPTER IV

THE KNIFE

Long centuries ago some savage hunters may have killed a bear. The bear's tough, hairy hide would be, in their eyes, very valuable as clothing and as a cover for a shield. The difficult thing to do would be to get the bear's hide off. Without some kind of cutting tool it would be impossible. If it were near the seashore the hunters might readily see that the sharp edge of a clam shell would make a very fair kind of cutting tool. Perhaps the hunters had seen among the mountains thin flakes of a glassy mineral that we now call natural glass or obsidian. They perhaps found flakes of a very hard stone, to-day called flint, and such flakes of flint or obsidian would make rude cutting-tools with which they might cut and strip off the hide of the bear. We can easily imagine that it was perhaps in this way men first learned to make and use a knife. Then, perhaps, long after, some bright man thought of the idea of tying or fastening in some way such a stone blade to a wooden handle, and then he would have a tool composed of two parts, a cutting-blade and a handle, and this would be a real knife. Such obsidian knife-blades, bored with holes for the cord to pass through, can be seen at the New York Museum of Natural History.

The history of the knife is a long story. It began with shells and sharp stones, or with bits of hard wood, centuries before men learned to write, so we may be sure it was a tool in universal use long before history began to be recorded. When men learned to use copper and iron the shell and flint knives disappeared, for a metal knife could be made much sharper than any of the old stone ones. To-day all knife-blades are made of steel, excepting a few where a sharp edge is not so important, as the ivory blade of a paper-knife.


Prehistoric Knives

Get your pocket-knife, and let us examine it. This pocket-knife is the boy's handy tool. Every boy and every girl should have one, and should know how to use it with skill and in safety. It consists of a steel handle covered with bone. This bone is rough, so that the fingers have a firm, strong hold upon the handle. There is a blade hinged at the end by means of a little pin passing through a hole in the thick end of the blade and securing it to the handle. On examining the blade we see there is a little channel or nick near the back of the blade, and by putting the thumb-nail into this nick we can easily pry the blade up out of the place where it rests in the handle. Then we can bend it back until it is in line with the handle. We say we have opened the knife. Just as the blade comes in line with the handle we hear a slight click, and then we find that the blade is held quite firmly in its place. We examine the knife and find that there is a spring in the back of the handle, and it was this spring that caused the little click and that holds the blade firmly in position. When we wish to close the knife we press on the back of the blade and again we hear the click of the spring as the blade slips back into its place. We see that the spring serves a double purpose, in holding the blade steady when the knife is open, and in keeping it safe and snug in the handle when not in use, and thus preventing the knife from doing any harm when carried in the hand or the pocket. If there are other blades in the knife we find they all work in the same way. Three blades is the usual number—a large blade, a small one and a little finger-nail file with a very small blade at the end. With such a pocket-knife we can do a great variety of work and make various useful things. Many pocket-knives have more blades or have other attachments, such as a screw-driver, a hook, a corkscrew and other more or less useful things. Such knives, however, are heavy and troublesome to carry, and are chiefly useful in camping, or in the country where it may be important sometimes to have a hook to pull a stone out of the horse's shoe or to cut a hole in a strap to fit the tongue of a buckle.

Let us get a stick of soft pine and see what we can do with our pocket-knife. Open the large blade and hold the knife in the right hand and the stick in the left. Now be careful. We are to use an edge-tool and there is a wise old saying about the danger of "playing with edge-tools." Should we hold the wood in the left hand and with the right hand draw the knife-blade towards us we might very soon find out just what the old saying means. Hold the blade against the wood and push it away from you. Then there is no danger that the knife will slip and cut the hand or strike the body. This seems a simple rule, and yet we shall see that is the one almost universal rule in using all kinds of cutting-tools, the exception being the spoke-shave, or draw-knife. Always keep the back of the blade facing in the opposite direction to the cutting stroke. Hold the knife firmly, with the blade resting nearly, but not quite, flat on the wood. See exactly what you mean to do and then make one swift, sharp stroke outward along the wood. A long, thin shaving flies off, and we see that the stick has a new shape. This is the work of the knife—to give a new shape to the stick. The stick may be square, and by taking off a piece from each corner you give the four-sided stick eight sides. By repeating the strokes you can easily change the square stick into a smooth round one. Thus we see that the knife is a shaper or shaping tool. The stick may be round, and we can cut or whittle it into a triangular or a square shape, or give it this shape for part of the length and another shape for the remaining length. We can whittle out of a round stick a boom for a miniature sailboat or make a ruler or a paper-cutter or a salad spoon. We can even whittle the stick up into toothpicks. One thing we will not do, and that is idly and aimlessly to whittle it to pieces and make nothing at all. That would be very unwise, for thereby we should learn nothing new and waste a good piece of wood. Whatever you do, decide beforehand just what you intend to make—and make it.

Once there was a young man who wished to marry a farmer's daughter, so he called on the father to get his consent to the marriage. The farmer was at work in the barn, and the young man sat down and began to whittle. After he had said all he wished, he threw away the stick he had been whittling. "Now," said the farmer, "I noticed that while you were asking for my daughter's hand you were using your pocket-knife. I thought you meant to make something. Instead of that you spoiled a good piece of wood and made nothing at all. I guess, young man, you are not the right husband for my daughter."

A pocket-knife is a grand tool for any boy or girl who wishes to make things. It is wonderful how many things can be made out of a piece of fine wood; not merely pretty or curious things, like a ring in a bottle and other odd objects that cost time and work and that when finished are not worth the labor spent upon them. Make something useful or beautiful, for a really beautiful thing is always valuable. Always decide in advance just what you intend to do. Have a clear idea of the shape and dimensions of the object. The best plan is always to make a drawing of the thing to be made and then to reproduce the drawing in wood with your knife.

A good plan is to begin with some simple thing like a ruler or paper-cutter. Learn to cut true and square, making everything exactly according to pattern. Learn to use the large blade for rough shaping out, and the small blade to give a fine, smooth, accurate finish. Endeavor to make things that you will care to keep and use, or things that you will be proud to give to friends as samples of good work and that your friends will be glad to receive, because it is your work and because it proves you know how to do good work. This is the lesson of the knife—to be true, square, exact, accurate.

Typical Knives

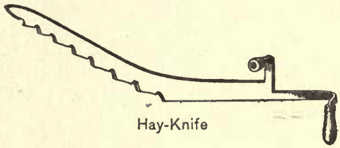
The moment we look about we find that there are a great many different kinds of knives. On the table there is the butter-knife, the carving-knife, the bread-knife, the fruit-knife, the fish-knife and the table-knives.

In the kitchen we shall also find the chopping-knife. Each has a blade and a handle, and they differ only in size or in the shape of the blade, and we see that each is adapted to its particular use, and that it would be very unwise to try to carve the turkey with the butter-knife or to pare an apple with the carving-knife.

A young man was once eating his lunch in a railroad car when the train ran off the track. He had just put his knife into his mouth when the shock of the accident caused the knife to cut his mouth. He sued the railroad company for damages, but the judge said he had no case.

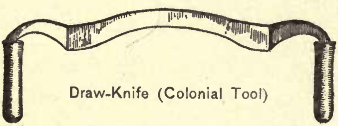
When we go out among the men who use tools we see that knives are used in every art and trade. The surgeon has a great variety of beautiful knives for his delicate and important work. The carpenter, the shoemaker, the butcher, the dairyman, the gardener, the glazier, the harnessmaker each uses a number of different knives adapted to his special work and all having specific names. The gardener has his pruning-knife, his grafting-knife, and his budding-knife; the grocer, his cheese-knife; the butcher, his butcher-knife; the fishman, his oyster-knife, and so on through every craft and art. Some knives are very small, like the lancet, others are very large, like the planter's cane-knife. Some have sharp points, some have rounded points.

Some knives have the handle placed at a right angle with the blade. The farmer in cutting hay from the haymow in his barn uses a large knife with such a right angle handle. He calls it a hay-knife. The gardener in trimming the edges of his lawn may use a large knife with a curved blade. He calls it a grass-knife. In old times all grains like wheat or oats were cut down with such a curved, crescent-shaped knife, called a sickle. This is one of the oldest knives of which we have any record. The ancient Egyptians used sickles in their rice and wheat-fields; sometimes such sickles had a straight handle at the end of the blade, and sometimes a bent handle or a handle placed at an angle with the blade. The new moon is sometimes called a sickle, because it resembles the blade of a sickle or grass-knife, and there is a cluster of stars in one of the constellations also called by that name.



Hay-Knife

One very useful knife has a long blade with a cutting-edge on one side, and a handle at each end, placed at a right angle with the blade. Sometimes the handles are hinged, so that they can be held in any position desired, and can be kept in such position by means of a set-screw. Such a two-handled knife is called a draw-knife, because it is used with both hands and is pulled or drawn forward in making a cut with the blade. Another two-handled knife is the shave, and the wheelwright uses a two-handled knife which he calls a

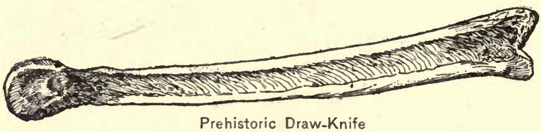


Draw-Knife (Colonial Tool)

spokeshave, in shaping the spokes of a wheel, and that suggests a plane, as we shall see in studying that tool.

This form of two-handled or drawing knife is very old, for, in the Museum of Natural History, we can see bones split open to give two cutting edges. Such bone knives were used by prehistoric people.

A half-moon knife has a crescent-shaped blade with two handles. It is used by the currier in dressing hides, and is sometimes called the currier's knife. A double or parallel knife has two blades placed side by



Prehistoric Draw-Knife

side. It is used to slice off very thin sections or slivers of any soft substance. In some knives the blade is pivoted at one end and has a handle at the other end. These are used in cutting paper or tobacco. The cutting-edge is on the side of the blade, and makes what is called a shearing cut. A razor is a very sharp knife having a hinged handle. This is one of the oldest of tools. A race-knife has a bent cutting-blade for marking or scribing. It is more of a marking-tool than a knife, though it has a little cutting or scratching blade.

The largest of all the knives is the scythe. It is a very old tool, and yet the finest scythes in the world are to-day made and used in this country. We have fine grassland, and the scythe is the hand grass-cutter or mower. The blade is long and slender, sharply curved and ending with a sharp point. It has a long, curved handle called the helve, placed at a right angle with the blade. It is used in both hands by grasping small handles on the helve. The mower swings his scythe in a great sweep through the grass, mowing a wide swath or path through it. It is a grand sight to see a good mower cutting grass, and it is a fine thing to be able to swing a scythe in the hayfield on a July afternoon. Scythe-blades are made of different sizes and shapes for different work. A grass-scythe has the longest blade. The clover-scythe has a shorter and wider blade. A scythe for cutting weeds or brambles has a still shorter blade, and the kind used for mowing down small bushes has a very short, stout blade. A grain-scythe has a long but thick blade, and is the heaviest of all.

The knife has given its name to a number of other things, as a knife-file, or a file resembling a knife blade; a knife-rest, which is a glass or metal holder for a table-knife. Anything with a sharp edge may be said to have a knife-edge, like the sharp-edged support of the balance beam of a weighing scale. A wooden slicer for cutting ice-cream is called a cream-knife, and is, like the paper-folder or paper-cutter, a dull-edged knife. Some ancient war arms having a blade and a handle were called battle-knives, such as the sword, the halberd and the dagger. However, these are arms, and are not tools at all.

The surgeon uses a number of small and very beautiful knives that have curious shapes and more curious names. His knives are made of the finest steel and are the sharpest knives in the world. He keeps them in beautiful order in his instrument case, for when he uses them it may mean life or death accordingly as they are or are not in perfect order.

Primitive Africans Forging a Knife

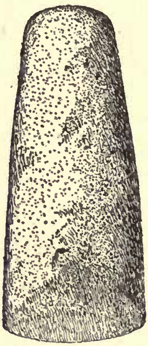
CHAPTER V

THE CHISEL

In studying the hammer we observed that a great number of tools grew out of the simple hand-hammer. In the same way, from the original shell knives have come many useful and interesting tools that are not called knives, and yet are cutting-tools. At the department store, we shall find that the table-knives and many small knives, like the pocket-knife, are called cutlery. Other and larger cutting-tools are called edge-tools. The gardener uses a pruning-knife to trim his pear trees, and buys it of the cutler at the cutlery department. The lumberman cuts down a great tree with an ax, a carpenter uses a chisel, and the shipwright an adz, and all three are using edge-tools that they buy at the hardware store.

At such a store we may ask to see edge-tools, and the store-keeper will show us a large collection of beautiful and interesting tools, each one having some form of cutting-edge. One, the dealer tells us, is a chisel. We find it has a long, narrow blade, fastened to a wooden handle, blade and handle being in one line. The end of the blade is cut off at an angle. We say it is beveled, or has a beveled edge, the lower side being very sharp. This beveled edge is formed by grinding the blade, and it is called the bezel. The head of the handle is flat and suggests an anvil, and shows that the tool is to be used with a hammer. As it is of wood, the best plan is to use it with a wooden mallet, because a steel hammer might mar the handle.

The chisel is one of the oldest tools in the world. Chisels have been found buried in mounds that were made by men who lived in our country before history began to be recorded. Pictures on old monuments show plainly that the ancient Egyptian carpenter had a chisel in his tool-bag, and used it with a mallet.

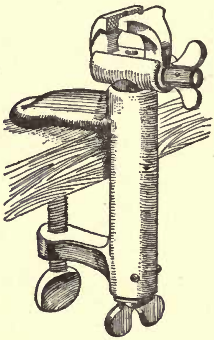


Prehistoric Stone Chisel

We decide to take the chisel, and we purchase at the same time a foot rule and a pencil, and, unless we already have one, we buy also a wooden mallet. On reaching home we place a small piece of pine board on our work-bench and lay our purchases beside it. A good, folding foot rule, that will fit an inside pocket, is one of the first things a boy or girl should own. It is the universal standard of simple measurements, and our best plan is to keep one in the pocket, for we shall soon discover that we need it every day, and often a dozen times a day. It is a guide in mental arithmetic, for it enables us to learn to add and subtract in inches and fractions of inches. It gives us accurate ideas of the sizes and dimensions of things, and in using it we train ourselves to be exact and accurate in our work and our statements concerning work and things.

Lay the piece of board on the bench, and with the rule and pencil mark off upon it at one corner a square of one inch each way. Turn the board over and repeat the inch marks on the opposite side and then join the marks together across the side and end. Now hold the chisel upright on one mark, with the bezel facing outward, and with the mallet in the right hand strike one sharp blow on the handle of the chisel. The chisel sinks in the wood, making a mark that is sharp on one edge and bent or beveled on the other. Move the chisel along on the mark and repeat the blow. Do this along all the marks, except those on the end. The angular cuts form with the corner of the board a square, one inch each way. Lastly, hold the board on edge, sidewise, and make one cut across at the ends of the pencil marks.

Next we set the board upright on end (the grain of the wood being vertical), and prepare to make the next cut. Just here we discover that it would be very helpful to have some means of holding the board upright. Some one might hold it for us, but this is not a good plan, as the person holding the board would be in the way, and might be hurt should the board slip. We are using an edge-tool, and the first thing to consider with edge-tools is safety, both for ourselves and for others. The board should be placed in a vise. A vise is an apparatus for holding any material on which work is to be done. A carpenter's vise, such as would be used with his work-bench, consists of two parts just alike, and called the jaws. One jaw is fixed to the bench and the other is movable, and the two are joined together by means of a wooden or a metal screw. When the screw is loose the piece of board we are using can be slipped between the jaws in any position we wish. Then, on turning the screw, the jaws come together and bite or hold the board firmly.


Hand-Vise Clamped to Bench

Whatever work we do we should use the best tools. We can get along without a vise for holding our work, yet in doing the best work we shall find it most valuable. In metal work we can hardly do without one, and we will stop just a moment to examine a good vise. The accompanying picture represents a small and convenient vise clamped to a bench. The clamp has two horizontal arms at the side, the lower arm carrying a screw that, by means of the handle, can be screwed up tight against the under side of the bench. The vise itself rests in the hollow clamp and is kept firmly in place by a set-screw below, as shown by the two wings of the handle. The vise is of steel and has two jaws having roughened faces to give a good bite or hold on the work when placed between the jaws. A screw, with winged handle, draws the jaws together or pulls them apart at will. The vise can also be used in the hand to hold metals, wire or small woodwork. The clamp itself, even without the vise, is a handy thing to have on our work-bench. It will come into use in a dozen different ways in using our tools.

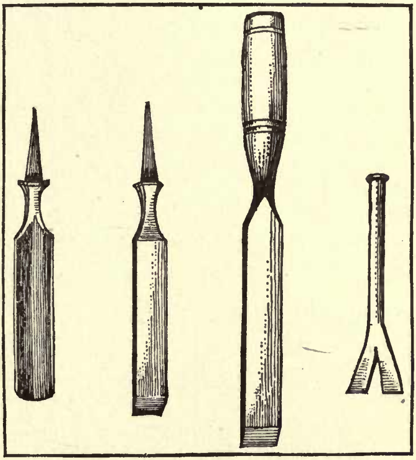
Place the board upright in the vise, with the end about waist-high or in convenient reach. Place the chisel upright, close to the edge of the board, the bezel facing out, on the upper end. Give it a light tap with the mallet, and a thin chip splits off down to the chisel cuts on the sides of the board. Repeat this till a square piece or shoulder is cut out of the board. Now we see the value of the chisel. It is a cutter or shaper. It cuts to shape, and does far more than could be done with a knife. We can use it to cut wood into many useful forms or shapes; for this reason we call it a shaping-tool. We also see now the value of the pencil marks on both sides of the board, as they guide us to a correct cut.

Mark, with the rule and pencil, a square near the middle of the board, one inch each way. Cut with the chisel all round this mark, holding the chisel upright, with the bezel facing the inside of the square. Now, hold the chisel at an angle in the upper or lower cut, not side-cut, and strike a sharp blow. A chip flies out of the square. By repeating these two kinds of cuts, straight and at an angle, alternately we can cut a square hole quite through the board. Such a chisel hole is called a mortise. The chisel is thus a mortising tool. We observe, also, in making these splitting-off cuts, that we cut across the grain and split the wood with the grain.

Next, get a smaller piece of board, three inches wide and six inches long. Place it upright in the vise and mark off one inch on each side of the end. Then cut off each corner, leaving a square point in the middle. This center projection is the tongue or tenon, and the two side-cuts are the shoulders. If the work has been truly done and every measurement is exact, the tenon will fit into the mortise. You have now made a mortise and tenon joint. You have done a piece of joinery. This mortise and tenon joint may be used in almost every kind of work where one piece of wood is joined to another. The carpenter uses this joint in many ways, and for this reason he is sometimes called a joiner. The carpenter, cabinet-maker, ship-builder, sash-maker, carriage-maker, box-maker, cooper and trunk-maker all make such joints as this. You see what an immense variety of work can be done with a simple hammer and chisel. A series of tenons and cuts on the edge of a board makes what is called a dovetail, and by fitting two dovetailed boards together we make a dovetail-joint.

Not only is the chisel used in all kinds of wood-working, but it is useful in working stone, marble and metals. It has many other uses besides making joints in wood, and, in the hands of the wood-carver and the sculptor, it becomes one of the finest of all the tools. Through its use men and women have made the most beautiful things we see in our homes and churches, our museums and art galleries. To understand this splendid tool, let us examine the different kinds of chisels and then see how they are used by stone and metal-workers.

The chisels used in woodwork range from the large, heavy house-builder's chisel, two feet long, used in framing timbers together, down to the delicate little chisels, six inches long, used by the wood-carver in cutting flowers and foliage upon a newel-post or mantel-piece. They are divided into two classes: socket chisels, in which the handle is fastened into an opening or socket at the end of the blade, as in a joiner's framing-chisel; and tang-chisels, in which the tang, or pointed end of the blade, is fitted inside the handle. All the smaller chisels are tang-chisels. A carpenter may use a dozen chisels all exactly alike, except in size. He may also use chisels with blades of different widths for doing large or small work. He gives names to these according to their use, such as sash-chisel, mortise-lock chisel, paring-chisel, etc. For certain work he may use a chisel



1. Tang-Gouge 2. Tang-Chisel 3. Framing-Socket Chisel 4. Box Chisel

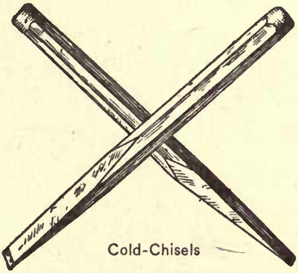
having two narrow blades with a blank space between them. He may use a chisel with an oblique cutting-edge, or one with two blades placed at right angles, and called a corner-chisel. His diamond-pointed chisel has two bezels, meeting at a point in the middle.

One class of wood-cutting chisels has been given a special name. Where a chisel has a hollow or round blade, it is called a gouge. A flat chisel gives a straight cut, and the chips are flat. A gouge gives a hollow cut, and the chips are curved or crescent-shaped. With the first the material is chiseled out, with the second the work is called gouging. Gouges have different curves; some are a true half-circle, some are crescent-shaped, and all are made in many different sizes. Some gouges have a pointed cutting-edge, like the diamond-pointed chisel.

Some chisels for cutting wood have two bezels, one on each side of the blade, as in the gardener's grafting-chisel. Such a double-faced chisel is used for splitting open the limb of a tree, and we shall find in other work that there are many of these splitting-chisels. Anything having two faces to its cutting-edge, and used with a hammer, is said to have a chisel-edge, as the gardener's grafting-knife, which is a chisel having a bent blade and two bezels.

The blacksmith, machinist, shipwright, plumber, and jeweler all use chisels. These metal-cutting chisels are of very hard steel, and usually have no handles, the top of the blade acting as the anvil on which the hammer strikes. Good examples of the metal-working chisels are shown in the accompanying picture.

The cold-chisel has a round or hexagonal handle with a round head and long, tapering blade and double bezel. It is given the name of cold-chisel because it is used to cut or chip metals when cold. Iron-castings, when they come out of the iron-founder's molds, are usually rough and uneven, and often are not exactly the right shape or size. The cold-chisel is used to smooth such castings, and also brass and other metal castings, or to trim them to exactly the right shape. This work is called chipping. The chisel is held at a slight angle, and at every blow a small metal chip is cut off. Should you go to a technical school, one of the first lessons you would be taught would be the use of a hammer and a chipping-chisel in cutting metal to pattern, or in reducing a rough surface to a true and even one. A large clipping-chisel is sometimes called a flogging-chisel.



Cold-Chisels

Among the chisels used by workers upon hot or cold metals we shall find a great variety of tools of all shapes and sizes, according to the work to be done. One of these is the bolt-chisel, which is a cold-chisel having a long blade and narrow edge, and used for cutting off bolts or any round piece of metal. A cold-chisel with a sharp-pointed edge, used for denting or marking metals, is called a center-chisel. It is used to mark the exact center of any round pattern marked upon metal, such as the mark where a hole is to be cut through the metal. A cross-cut chisel has a very narrow edge, and is used as a cold-chisel in making a narrow groove or cross-cut in metal where a part is to be broken off.

This leads us to a very curious thing about cutting cast iron. If the gas-man or plumber wishes to cut an iron pipe, he chisels out a shallow groove all round the iron. It is just as if he cut the skin of the iron. The iron pipe, after this groove is cut, is so much weakened that it can be easily broken with a hammer, the break coming just where the cut is made. Without the cut, the pipe would break with a ragged fracture, and there could be no certainty where the break would come. By means of the groove cut with the cross-cut chisel, the pipe can be broken at any place we wish, or according to measure. Sometimes a blacksmith wishes to cut off a rod of iron while red hot, and he uses a thick, short chisel on the end of a rod, or fastened to a long wooden handle, and he calls it his rod-chisel.

The chisel is useful in many trades. The plumber, jeweler, and machinist, the brass founder and railroad man all use chisels suited to their special work. Each gives his tool names according to its work, and often to his fancy and for no particular reason, such as the silversmith's chasing-chisel, or the shipwright's marking-iron and calking-chisel, or the blacksmith's hardy and splitting-chisel.

The dentist uses a number of very small chisels, and often in his tiny little forge hammers out a chisel to suit this work, and gives it a name to suit his fancy, as burr-chisel, triangular chisel or dental chisel. The ice-man, harvesting ice in the winter, uses a number of giant chisels as tall as a man, to split off the cakes of ice floating on the surface of the water. A boy may use an ice-chisel to clean off the sidewalk after the snow is hard, or the cook may use a chisel to chop off a piece of ice for the water-pitcher.

The wood-carver uses some of the carpenter's chisels, but nearly all of his work is done with small chisels, made in a great variety of shapes to fit the work he has to do.

In decorative work, like wood-carving or stone-carving, or in sculpture, we discover that the mason, sculptor and wood-carver use the chisel as their best and finest tool. So true is this, that the word chisel is used to express quite another matter, as when we say a beautiful girl has a finely chiseled face. We do not mean that a chisel has been used upon it, but that her face is as finely molded as the chiseled face of a beautiful statue. A sculptor's work is known by the marks of his chisel, so we sometimes say a good workman is known by his chisel-marks.

The stone-mason or stone-carver uses about a dozen chisels in his beautiful work of dressing and decorating stone. All stonework used on the exterior walls of buildings is "dressed" or given a fine finish, to shed rain and dust, and stone-dressing is largely done with chisels. Sometimes the dressing is only along the edge of each stone, the center of the block being left undressed, or roughly chiseled over to trim it into shape. Carved stonework is a more highly finished or decorated work, done with chisels on the stone. Many buildings have dressed stone walls with carved stone ornaments, and if it is the work of a master workman, we can find his fine chisel-marks over it all. Look at any stone building near your home, and you will soon see with what skill and care the stone-carver and stone-dresser use their fine chisels. Every cut tells, every mark is true, exact, and beautiful, and we cannot fail to see what a grand tool is this plain little thing we call a chisel.

When the mason, the stone-dresser or the sculptor begins work upon a block of stone or marble, he uses a wide-bladed chisel called his boasting-chisel. With this he can chip off the first large flakes and chips of stone, to bring it into something like the shape he wants. He then uses a variety of chisels, some with very sharp points, or narrow chisels, and chisels with two cutting-points, or a flat chisel having a number of sharp points or teeth, and called a marteline-chisel. He uses chisels with rounded edges notched with fine teeth, and many others of curious shapes and strange names. He uses with all his chisels wooden mallets of various shapes, but chiefly a round-headed mallet with a short, straight handle.

The sculptor uses all the finer chisels of the stone-mason, and special forms of chisels suited to the fine material in which he works, like the entering-chisel or spoon chisel. The most beautiful things that have come down to us from the past are the marble statues carved by the great sculptors of ancient Greece and Rome, and all of these grand pieces of work were cut out of the solid marble and given their splendid forms with a simple mallet and chisel. But then, simple as were these tools, they were in the hands of master workmen. Men will always respect their memory and admire the work of their hands. If these men could use a chisel to such noble purpose, we, too, need not be ashamed to use their tools. We may never do as grand work, but it is something that we can learn to use the tools they used, something that we can do good work, so that, perhaps long after we have passed away, men may see our chisel-marks and say, "Here is the work of a skillful user of tools."

With the invention of the new pneumatic hammers every one asked if they could be used with a chisel. It was soon shown that the swiftly moving power-hammers could be easily adapted to the use of the stone-cutter and sculptor. It was necessary only to affix a chisel-point to the piston-rod of the little motor, and the tool was changed from a power-hammer to a power-chisel, and the sculptor had a new and wonderful tool that gave him an entirely new method of carving marble. With a chisel and mallet he could strike thirty blows a minute; with the new tool he could strike a thousand a minute.

All the labor of striking the blow was performed by the flying piston-rod. The sculptor's hand and mind were released from all the labor and thought given to the work of striking the chisel. He could now give his entire attention to the business of guiding his chisel to the work. With a mallet he slowly chipped off one flake of the stone at a time. With the pneumatic tool his chisel cut away a very small piece at each blow, the little grains falling in a dusty shower from the chisel-point. The gain in time and labor is so great that to-day we find pneumatic tools, having many different styles of chisels, used in marble and stone-yards, and in sculptors' studios. The different chisel-points are easily affixed to the piston-rod, and the workman can use the same motor for many kinds of work. These pneumatic tools are used also in all kinds of metal cutting, chipping and shaping, or dressing. They range in size from small motors for the use of marble-workers to large and powerful motors used in shipyards and

Pneumatic Chisel

bridge and boiler-shops. The pneumatic chiseling-tools are justly regarded as the most important power-tools recently invented, and as they have a wide field of usefulness before them, we shall find it well worth our while to endeavor to understand their construction and their use in the arts. One of these grand new tools used in chiseling iron is shown in the accompanying picture.

CHAPTER VI

EDGE-TOOLS

Sometimes the carpenter or wood-carver may use the gouge without a hammer. Holding it in his hands, he may push or slide the point of the blade over the wood and plow out a long, shallow groove. With hammer and gouge he strikes out chips. With the gouge used in this way he plows up a long, slender shaving. When we examined the drawing-knife we saw that it is used with a swift, sliding motion over the wood in cutting a long, slender, curling shaving. The spoke-shave is a drawing-knife in which the cutting blade is fixed in a frame or carrier. This carrier holds the blade in a fixed position, and as it slides over the wood it causes the blade to make an even, uniform cut. This idea of placing the cutting-tool in a sliding carriage brings us to another and most interesting class of tools. The ancient Roman carpenters understood this idea of placing a knife in a carrier, and had a tool they called a runcina. Could we see a picture of a Roman runcina we should recognize it as a plane.

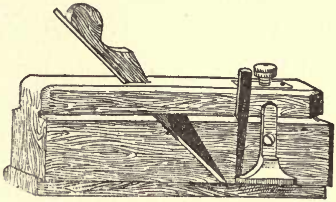
A plane is a tool having a sliding carriage and carrying a broad-bladed chisel. The carriage part is called the stock, and it has a smooth bottom that is called the sole. On the upper side of the stock is sometimes placed a handle whereby it may be pushed or slid along over the material to be planed. This handle is sometimes called the toat. The word handle is, however, better, because some planes have two handles, and in some planes they resemble the handle of a saw. In the stock is an opening, wide at the top and extending through the stock to the sole, where it is reduced to a narrow slot. In this opening is fixed the cutting-tool, carried by the stock, the cutting-edge projecting slightly below the sole. The cutting-tool is called the bit, or iron, or, sometimes, the plane-iron.

Place a piece of board upon the workbench, pushing one end against the little piece of iron set in the top of the bench, and called the stop. This will prevent the board from sliding on the bench when we use a plane upon it. Place a plane upon the board and strike the end with a hammer. Next, holding it by the right hand (by the handle), push it slowly along the board. Nothing happens. It is clear that the plane is not a tool to be used with a sudden blow or by sustained pressure. Now, standing by the bench and facing the stop, press upon the plane and give it a smart, quick push. It at once slides easily along the board, and out of the opening of the stock curls a long, thin shaving. We see that the plane is a tool in which speed or time is an important element of the work. There must be pressure, with a rapid, forward motion. We examine the wood and find that the plane has left a smooth path on the surface. The plane makes smooth. It is a surfacing-tool.

With a chisel and hammer we can make a mortise and tenon-joint, a dovetail-joint, or we can shape wood into many useful and beautiful forms. With the plane we can make rough wood true, smooth and beautiful. The name plane, perhaps, comes from the work it does, for it is used to smooth or reduce wood to a true plane. Chisel and plane are useful each in its own way, and our best plan is to use both tools with care and skill, knowing well that even a smooth, true surface is both useful and beautiful.

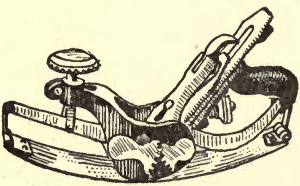
The carpenter, cabinet-maker and cooper use many different kinds of planes in their work, each one with its special trade name. Some of these names describe the work designed to be done by the plane, as smoothing-plane, sash-plane, edge-plane, hand-rail plane, and panel-plane. The other names are often local, or known only in one country or one part of one country. All are, however, known in a general way as wood-working planes. The house carpenter uses a number of planes of different sizes, and employs each in special work. Among these are the jack-plane, long-plane, fore-plane, try-plane, etc. In bringing a rough board to a fine surface he uses first the jack, then the try, panel and smoothing-plane, in this order. His planes cut a path varying from three-fourths of an inch to three and a half inches wide.

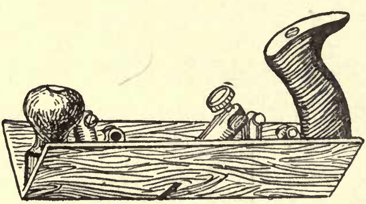
The carpenter sometimes wishes to make a tight joint between two boards. To do this he makes a groove in the edge of one board and a continuous tongue upon the edge of the next board. The two boards can then be joined together to make what is called a matched, or tongue and groove joint, and when put together in this way such boards are called matched boards. To do this work he uses a tonguing-plane and a grooving-plane. The first has two bits, side by side, with a blank space in the stock between them. Such a plane used on the edge of a board cuts two shoulders on the edge of the board, leaving the raised tongue between them. The grooving-plane is the reverse of this, and plows out of the edge of the board a central groove that will just fit over one of these tongues.



Side-plane

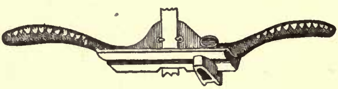
The cabinet-maker, stair-builder and decorative woodworker use still other planes called fluting, fillet, ogee, astregal, hand-rail and ovolo or quarter-round planes. These names describe the sole of the plane and the edge of the bit, and the tool cuts the wood into these various shapes. A double rounded sole gives a double





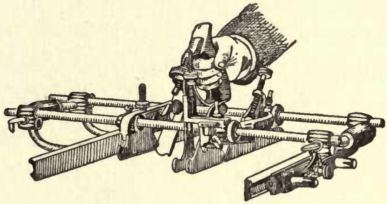
Circular and Core-box Planes

curved, or ogee shape, and a curved-sole-plane will cut a strip of wood into the rounded form of the hand-railing of a stairway. In some planes the bit and the opening are placed at the side of the stock, the sole being blank. Such planes are called side-planes, and are useful in planing in corners where it would be difficult to use an ordinary plane. Some planes have narrow soles and bits for making deep grooves. They are often called plows. In sash-making, when a shoulder or rabbet is to be formed on a sash-bar, a rabbet-plane is used. Others have wide soles, and are used to cut thin, wide splints or veneers from wood. In one form of plane the bit is placed upright in the stock, and its edge is notched or serrated or cut into sharp joints. Such planes are called scratching, marking or scraping-planes. In addition to the ordinary wooden stock planes there are many iron planes, some having thin, flexible steel soles for working in curved corners. They are called circular planes.



Universal Hand-Beader

The many intricate decorations designed by the ancient Greek and Roman architects, and cut in stone by their builders and stone decorators, naturally suggested to our own house-builders many beautiful designs to be reproduced in wood. We can see examples of this work in old colonial houses. The desire to reproduce in wood these old stone ornaments led to the invention of a great number of plane-bits, and the use of these bits naturally inspired our tool-makers to devise a plane in which many different bits could be employed. Such universal planes are exceedingly ingenious, and well worth careful study. One, figured in the accompanying illustration, will plane wood into fifty-two different forms by simply changing the bits.



Universal Plane

All the beautiful decorative work we see in colonial houses was done with chisels and planes, and while we must admire its beauty, we can see that such fine handwork must have taken a great deal of time and labor. There is much fine hand-work done now, but the cost of labor is to-day so high, and hand-work demands such high pay, that we now use other methods and other tools. At the planing and molding-mill we shall find many fine machine-tools that reproduce in wood all the beautiful planed work once done by hand. These wood-working machines have made it possible to decorate even the smallest and cheapest houses with perfect copies of the planed moldings, railings, window-casings and panels of the old colonial mansions. These machines are described in the next chapter.

Every trade using wood employs planes of some form, so we find the cooper using a plane, called a jointer, having a very long stock. The sole is on the upper side, the plane being held in a fixed position and the wood drawn over the edge of the bit. He uses also other planes that he calls his whisk, his howell and his over-shave. In city skating parks and on frozen rivers where ice is being harvested, large planes, drawn by horses, are used to plane natural ice down to a clean smooth surface fit for skating or harvesting. They are called snow-ice planes. The confectioner also uses a small hand-tool, called an ice-plane, in shaving ice for cooling a glass of soda water.

In all ordinary work we may wish to do upon our home bench three or four simple planes will answer all practical purposes, and our best plan is to leave their selection to the dealer at the hardware store. Using a plane is a capital exercise, and we may all be glad to learn this simple accomplishment of planing. To use a plane means that we wish to give to whatever work we do a smooth, true, and handsome finish. A plane teaches us the value of fine, accurate work, teaches us neatness, and shows us that even so simple a thing as a wooden box may have a real beauty of its own.

We have seen that the knife may have suggested the chisel, and the chisel may have led to the invention of the plane. In the same way we can easily imagine that a knife with a long handle may have led to the invention of that fine old tool, the ax, and its little brother, the hatchet.

The hatchet must be a very old tool, for stone hatchets have been found in the graves of the oldest men of whom we have any trace. These ancient men, whose very names are lost, had not learned the use of metals, and they laboriously cut their heavy and clumsy hatchets out of hard stone. It was this use of stone-bladed tools that led the students of these old peoples to call them the Stone Age men, or the men who used stone tools. The Stone Age men evidently tied the blade to the helve with cords, for we can still see the groove cut in the stone for the cords. Even after men learned to make iron hatchets, they still tied the blade to the helve, and it seems to have been a very long time before any one thought of making a hole or socket in the blade and fitting the helve in the socket.


A Prehistoric Ax

The North American Indians had a rude kind of stone hatchet, and when white men came in their ships the Indians were glad to buy iron hatchets of the traders. They did not wish the hatchets as tools, but as weapons in their wars, and as the metal hatchets were far better than their own stone hatchets, they eagerly exchanged furs and tobacco for the white man's tools. They called their stone hatchet a tomahawk, and it was really only a war hatchet. At the top of the blade of the tomahawk was (in place of our hammer) a hollow pipe-bowl, the handle being hollow, and serving as a pipe-stem so that they could use the tomahawk to smoke tobacco or kill their enemies. They had a curious custom of burying one of these tomahawks in the ground at the end of one of their little wars, and cheerfully digging it up again the next time they started out on the warpath. It was from this our expression "to bury the hatchet" or to have peace, came.

The best tool for a study of the ax and hatchet is the carpenter's shingling-hatchet. It has a large flat blade with a straight edge. At the back is a peen or hammer-head, and in the middle is a socket for the handle or helve, the blade and helve being in one line. We see that it is a combined knife and hammer with the same helve. We see also that on the side of the blade there is a small notch, and this enables us to use the tool as a claw in pulling a nail. This idea of making a tool that can be used to do three different pieces of work in the same trade has been carried to great perfection by our American tool-makers. Time and labor are so costly that we cannot expect a man to carry to the roof three tools, one to split or shave a shingle to the right width, another to drive a nail, and still another to pull out a nail when put in the wrong place, and this shingling-hatchet combines all three in one.

Lather's Hatchet

The hatchet, like a knife, is a handy tool for the workroom. It is useful in sharpening a stake for a tennis net, or in making a pin for a tent. The city boy uses a hatchet for roughly shaping wood ready for the knife, and for various pieces of work at the bench. For the country boy the hatchet is, next to the knife, the most useful thing any young man can own. With a hatchet he can cut down small trees for a camp in the woods, make stakes and pins of all kinds, chop wood for the camp-fire and for his mother's cook-stove. With his hatchet he is ready for fun in the woods or for good solid work in the barn or at the sugar-camp. It is his all-around tool, useful every day in the year. There have been boys who did not like chopping kindlings in the woodshed on baking day. They would prefer to go fishing. Such boys never really understand the connection between pies and a hatchet. They are ready to eat mother's pies, but unwilling to swing a hatchet at mother's woodpile. This shows what curious ideas a boy may have concerning this fine tool we call a hatchet.

Hatchets are used for many purposes. The man putting on laths in a new house uses a hatchet with a narrow blade and a straight hammer-head having a rough face. The carpenter may have a hatchet having claws at the side of the hammer, or a broad hatchet with a wide blade and a short head or poll. A hunter's hatchet is a little hand-ax. A cooper uses a hatchet having a curved cutting edge. An iceman's hatchet has a narrow blade with rounded edge and a sharp pick or point for moving blocks of ice. A bricklayer's hatchet has a heavy head with a square hammer-face, and a blade with curved sides and a straight, but dull edge. It is used to cut bricks and to tap them into place in the wall. Another style is more like a paver's hammer; the handle is long and the top is like a chisel.

Of all the edge-tools, the American ax is perhaps the finest hand-tool in the world. Next to the hammer, it is the most common tool to be found in this country. This is a land of forests. The very first thing the colonist was obliged to do was to build a log house. The Pilgrims in Massachusetts Bay, the Dutch in New York, the Spanish and French in Florida and Canada could all use an ax. Each began his settlement by felling trees. So, from the very start, the American has been a woodman, and the American lumberman is the finest ax-man in the world. Naturally he wants the finest tool. The American ax has a large blade gently tapering to the cutting edge. The edge is slightly rounded, the front being a trifle longer than the back. The head, or poll, is short, with a slightly rounded face. The helve is fitted to the eye with a wedge, and is beautifully curved, and has a slight projection at the end to prevent the hand from slipping. Altogether, it is a graceful and handsome tool, worthy of the master-hand that uses it. Every lumberman seems to prefer a special kind of blade for his particular work. The Maine woodman wants one style, the Ohio man another, the Michigan man still another, the Kentucky man wants his own ax, and the Georgia man in the piney woods, and the turpentine gatherer, each wants a particular ax suited to his work. The swamp lumberman wants a double-bladed ax, and many others prefer a double ax for their work, wherever it may be. In peeling bark for the tanner the woodman calls for a double ax with a broad, gently rounded blade. There is even a special ax for young lumbermen, called the boy's ax.

The finest piece of woodcraft to be seen in the world is the felling of a great tree by two expert lumbermen. The two men stand on opposite sides of the giant stem and strike alternate blows, swinging their gleaming axes in their arms with a freedom of motion that puts the trained athlete to shame. The blows ring quick and fast, the chips skim through the air as if shot out of the tree. At last, the towering giant quivers and bends, and then with a terrific crash falls to the ground just where the ax-men decided it should fall. Old woodmen used often to chop a dozen trees till they were just ready to fall. Then, skillfully chopping one tree, they caused it to fall against the others, and all went down in one prolonged and thundering uproar that startled every wild beast for miles through the woods and sent the eagles screaming and wheeling through the air.

The trees once felled, the woodman takes another ax to trim the great logs into convenient length and shape. For such work he uses a broad-ax. The New England woodman and ship-builder use a broad-ax with a wide blade that is gently rounded on the edge. The Canadian, the western and the southern man use broad-axes having very wide blades with a straight edge. In all these axes, whatever their names, experience seems to show that each is exactly adapted to its work and the kind of tree on which it is used.

In the railroad cars you will often see, enclosed in a glass case, a number of tools. These are wrecking-tools, to be used in case of an accident on the road. Among these tools is a fine ax with a narrow blade. In place of a poll, it has a sharp pick. This is the fireman's ax, one of the most useful tools ever made. The iceman uses an ax to divide his ice blocks, and in handling the blocks that are too large to lift in his tongs. It has a long, narrow, wedge-shaped blade resembling a chisel, and a pick at the head of the blade.

Type of Adz

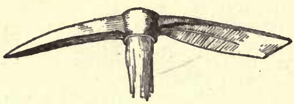
Before the days of sawmills the lumberman, the house-builder and the carpenter made the posts and beams of a house by cutting them out of logs. The log-house can be built with an ax. In building a frame-house the old builders had a tool resembling an ax and called an adz. This is a wood-cutting tool with a curved blade and a straight cutting-edge, with a bezel like a chisel. The helve is fitted to the eye at a right angle with the blade, and there is a poll or head at the top of the blade. It is used in squaring a log by standing on the log and swinging the adz in both hands between the feet.

With a good adz the adz-man can cut from a round log a square beam with smooth, straight sides.

Old Henry Hudson, in exploring the Hudson River in 1609, sent his ship-carpenter ashore near the Catskills to get a new boom for the good ship "Half Moon," and, no doubt, the carpenter used an adz in shaping the boom. The builders of old colonial houses were famous adz-men, and we can still see the marks of the adz on the floors and beams of old New England houses. The adz is a very old tool, for we know it was used by the ancient Egyptians, though at that time it was smaller than our tools. The colonists also had a short-handled adz.

The ship-carpenter uses an adz in shaping the ship's ribs and knees. His adz has a long, narrow poll and a straight blade, though for some work he uses an adz with a hollow blade resembling a gouge.

The stone-ax is a small ax with double blades and a straight handle. Another style of stone-ax is called the cavil or jedding ax. The slate-roofer uses a small ax with a narrow blade and having a sharp spike at the head with which to make the nail holes in the slates. The butcher uses an ax with a very long sharp blade, called a cleaver. The gardener uses an ax having a curved blade with a long cutting-edge and a sharp point. It has one, and sometimes two, sockets at the back for a long handle, and is called a bush-hook. Sometimes the long blade has a slightly hooked cutting-edge and a socket for the long handle at the end of the blade. Such cutting-tools are called bill-hooks and, like the bush-hooks, are used in trimming trees, shrubs and hedges. The farmer also uses long-bladed, short-handled cutters called corn-knives and hedge-knives, or hedge-trimmers. The farmer uses another ax in grubbing up and cutting off the roots of trees, called a mattock. It has a narrow blade like an adz, but in place of the poll it has a narrow ax-blade and sometimes a point like a fireman's ax. A railroad man uses a narrow adz with a long, sharp pick. A pick is not an ax, but a double-pointed tool with a straight handle, used to pick up or loosen the ground. It is like a double-pointed mattock.

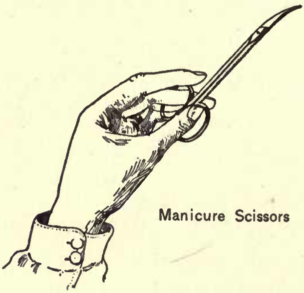

Pick Mattock

In old wars, before the invention of firearms, the fighting men used an ax as a weapon. Even the Stone Age man had his rude battle-ax. A long-handled war-ax was called a pole-ax or halberd. Another, having two blades and a spear point at the end of the handle, was used by soldiers, but all these war-axes quickly disappeared the moment men learned to use a gun.

We now come to another very large class of edge-tools, in which the cutting-blade is fixed to a pivot. We do not know where or when men first learned that, if a knife-blade is fastened at one end to a pin on which it can freely turn as on pivot, we have a cutting-tool that will act as a lever. The household meat and potato-slicer and the cigar-dealer's tobacco-cutter are examples of such pivoted knives. On the farm we may see this idea of a pivoted knife-blade applied to the cutting of hay and cornstalks in the lever feed-cutter. From the invention of the pivoted knife it was only a short step to the invention of the double-bladed pivoted knives.

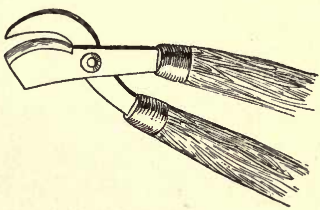
Lay a visiting-card on the bench and with your knife try to cut it into two pieces by pressing the knife-blade down upon it. It is not easy to cut it in this way, because the whole of the cutting-edge of the blade is used at once. There is another and better tool for such work, called a pair of scissors. Hold the card in the left hand and the scissors in the right. We see that we now have a double acting pivoted cutting-tool, and we observe, in using it, that the blades do not press upon the card through their whole length. The card is separated with a moving or progressive cut. We say the pivoted blades give a shearing cut. This progressive or shearing cut enables us to do work that would not be possible with a single-bladed cutting-tool, and we shall find the principle of the shearing cut applied to a great number of cutting-machines.

The ancient men who first used a clam shell or a flake of obsidian as a knife had no idea of a double-bladed knife. They could not imagine how a pair of scissors would work. Double cutting-tools or shears were not invented until long after the men who used stone knives had disappeared. The earliest shears of which we have any trace were simply two iron knives joined together at one end by a spring formed of a strip of elastic metal. Such a tool was held in the hand and the blades pinched together. They were first used in clipping the wool from the backs of sheep, and were called sheep-shearing tools, or simply shears. Before their invention all the wool was cut off with rude stone or flint knives. As the knife would cut only one little flock of wool at one stroke, the shears must have seemed to be a truly wonderful improvement. No doubt, even the sheep thought the shears were better than the terrible dull stone knives.



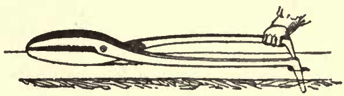
Manicure Scissors

The invention of scissors came long after the invention of shears, and they were no doubt welcomed as a very great improvement over the older tools. At first scissors seem to have been small, awkward things, with straight blades and handles. Now they are made in many different styles, shapes and sizes, and are adapted to a great variety of uses. Some have bent blades, others curved or bent handles, some are long, some very thick and short, some have rings for the fingers or thumb.



Pruning-shears

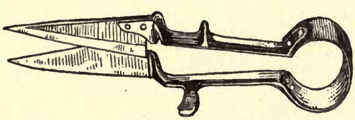
The newspaper man may use a pair twelve inches long, and the dressmaker or the salesman at the ribbon counters may use a pair that will slip into the pocket. The surgeon has a number of very fine scissors for his delicate work. The button-hole maker uses a pair of scissors with a blank in the blade to prevent cutting through the edge of the cloth. The florist and gardener use scissors with a curved blade for pruning, and a delicate pair for gathering flowers, and large shears, called pruning-shears, for trimming hedge plants.



Tinsmith's Shears

Before the introduction of gas careful housekeepers used a curious pair of scissors, called snuffers, to trim the wicks of candles. These snuffing-scissors had a tiny box on one blade and a cover on the other, so that when the blades cut off the burned wick, the black bit of charred wicking was pushed into the box and prevented from falling on the clean table-cloth. Such snuffers were often made of silver, and were kept on a silver tray on the parlor mantel. Snuffers are sometimes used in country houses to trim the wicks of lamps.

Large scissors, such as we see the tailor use, are called shears, though ordinary clipping sheep-shears are not in any sense a pair of scissors. These simple shears have no pivot on which the blades turn, though all the large shears used in cutting heavy cloth, paper and metals are really scissors. For convenience we call the tinman's great cutters shears and his smaller hand-tools



Sheep-shearing Shears

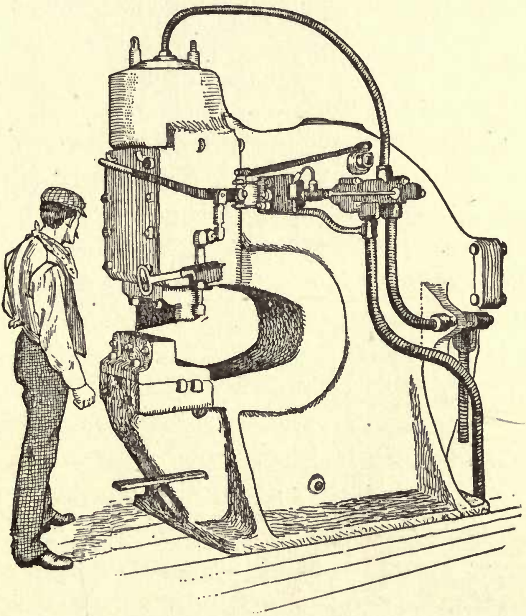
snips. A bench-shears is a tool with two short, stout blades and very long handles, one of them being fitted with a point to hold the shears firm on the bench.

A little observation will show us that the principle of the shearing cut has been applied to a great variety of cutting-tools. In the kitchen we can see that the slaw-cutter and potato-slicer is like an inverted plane with the sole uppermost. The cutting-blades are set in the wood at an angle, or skew, and on drawing a cabbage over the blades it is cut into thin strips with a shearing cut. The old meat-choppers, using a blade resembling the common hand meat-chopper and operated by machine, have been recently supplanted by the new meat-choppers having revolving knives with a shearing cut. Some of the new cutters are very handy tools in every kitchen where the cook wishes to make cracker crumbs, or to dice carrots for soups, or prepare meats for Hamburg steak or for hash. All the many forms of apple and potato-parers and slicers employed

Wood-cutting Tool

in kitchens and canneries use knives, either fixed or revolving, with a shearing cut.

At the shops of the printers and book-binders we may see powerful machines for cutting paper. An-



Hydraulic Shear for Cutting Metal

other powerful cutting-tool is the jeweler's lever bench-shears. In wood-working there are a number of fine tools used in cutting wood, in which a single or double shearing blade is used. In cutting ship and boiler plates powerful hydraulic shearing-machines are used that will easily cut through an iron plate three-eighths of an inch thick.

CHAPTER VII

THE GREAT CUTTERS

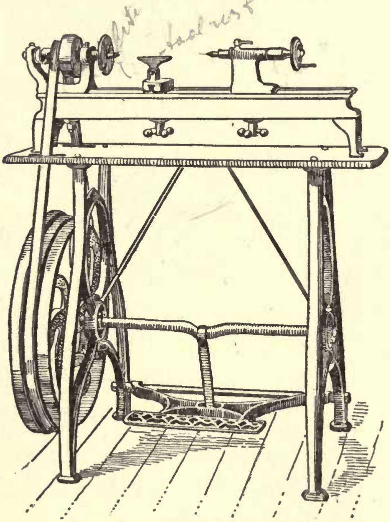
There was once found among the ruins of an ancient temple in Egypt, a curious picture. The Egyptians had an idea that the first man was made by one of their imaginary gods out of a lump of clay, and what was more natural than to think the god must have made use of a machine used by potters in making a vase or bowl. This picture represents the god seated before a small round table, on which was placed a lump of soft, wet clay. The aim of the picture was to show that the god used a potter's tool in making his clay man. How the clay man was turned into a live man the Egyptians could not explain.

The picture is of interest to us because it proves that the machine now called a thrower, whirling-table or potter's wheel was known in Egypt long centuries ago. It is so old we do not know who invented it or where it began its long career of usefulness. The potter's wheel consists of a small round table, supported by an upright shaft that rests on a pivot below. By the use of suitable machinery, a belt being preferred, the table may be made to turn or whirl round swiftly. In old tables the workman sat before the table and caused it to turn by pushing it round with his feet. Modern machines are made to turn, either by a man or boy turning a crank, or, better still, are connected with some steam-engine or other motor.

In making a plate, bowl, cup, pot, vase, saucer or other stone or chinaware vessel, the potter, sitting before the whirling-table, places or "throws" upon it a lump of soft, wet, plastic clay. The clay sticks to the table and whirls round with it. While it is thus in rapid motion, it is easy to mold it into any form the potter desires. Pressing his hand down upon it, the clay spreads quickly out into a dish-like, circular form.

Pressing with both hands upon the plastic clay, he causes the sides of the dish to rise, and it becomes a bowl. Every touch of the hand or fingers causes it to assume new shapes, and all the shapes will be circular in form. To see a well-trained potter mold his plastic clay on his whirling-table is most interesting. The soft clay seems to spring up into new and beautiful forms as by magic, and we watch the interesting work with a feeling of admiration for the unknown master workman who first invented such an exceedingly useful machine. When the potter has given his vessel the shape he wishes, and particularly when the clay begins to dry and become hard, he sometimes uses a chisel to smooth and finish the vessel and give it a better surface. The potter's wheel thus enables him to use our old friend, the chisel, in an entirely new way. With the hammer we used the chisel to shape a block of wood, the wood itself being at rest. Here the chisel is used to shape a mass of clay, the chisel being at rest, and the clay in rapid motion—exactly the reverse of the usual way of using a chisel.

If we look about the house we observe that the legs of tables and wooden bedsteads are often round and ornamented by circular grooves or circular moldings. We see the same thing on the banisters of the stairway and on the newel-post on the last step, and even on the posts of the piazza. On examining these things, we see at once that it would be very difficult to make such things with any of our ordinary wood-working tools. They must be formed by a machine in some way related to the potter's wheel. This machine is one of the oldest of all machines, and is now one of the most useful as well as one of the largest machine-tools in the world. We call it to-day the lathe.



Foot-power Wood-working Lathe

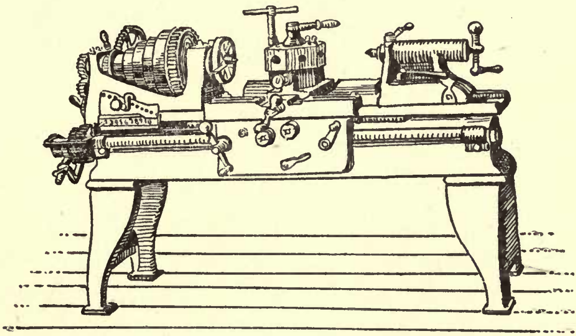
There are two great classes of lathes, the wood-turning lathes and the metal-turning lathes. A simple wood-turning lathe, such as any young boy or girl should be glad to own and use, consists of a long and narrow table, supported on four stout legs, the whole being usually formed of iron and made very stiff and strong. On the table or bed are two supports called the heads, one being fixed to the bed near one end, the left end, and the other on the right being free to slide along the top of the bed. The fixed head, called the "live head," carries a horizontal shaft, or spindle, and by means of a chuck or other device, a block of wood may be securely fastened to this spindle. The free, or "dead head," carries a sharp point, projecting towards the center of the spindle, and as it is free to slide on the bed, or table, this dead head can be pushed to the left until the sharp point touches the wood secured to the spindle.

The wooden block is now suspended between the two heads and free to turn with the spindle. By means of suitable connections the spindle can be controlled by a belt extending to a large "fly-wheel," or balance-wheel—so called because of its weight—that, when the wheel is set in motion by means of a foot-treadle, serves through its momentum to keep the wheel balanced or flying evenly through the varying motion of the foot-treadle. At one side of the bed, between the two heads, is an iron support called the tool-rest. This is free to move on the bed, and may be clamped directly in front of the block of wood.

When all is ready we may take a sharp chisel in the right hand and stand before the lathe with one foot on the treadle. A little pressure on the treadle sets the lathe in motion, and the block of wood revolves rapidly between the two heads. We rest the blade of the chisel on the tool-rest with the sharp edge towards the revolving block. Push it close to the wood and a stream of chips flies off, and, to our surprise, the block of wood seems by magic to take on a new shape. We stop the lathe and find that a part of the wood has been cut to a true circle. We say the wood has been "turned" into a new form. This is the fine art of turning—one of the most fascinating accomplishments any young man or woman can acquire. We discover that under the slightest turn or twist of the wrist the chisel can give the rapidly moving wood a new form.

We can turn a square block into a perfect sphere, or into an egg shape, or turn a square rod into any of the hundreds of beautiful shapes we see in banisters, chair and table legs, newel-posts, gate-posts and round columns for piazzas and balconies. Moreover, a skilled wood-turner will put stick after stick into his lathe, and with his different chisels turn them into many different shapes, or put in a hundred stair-rods and turn them all out exactly alike. Moreover, so perfect have these wood-working lathes become that we find them automatically making strange and intricate forms, like the stock of a gun, a piano-leg, or a shoe-last, each lathe making continuously the exact form decided by a pattern put in the machine. Such machines seem to do everything but think.

While the lathe has been used for hundreds of years, it was brought to perfection only in our own times. It is now one of the great tools of the world, is made in many forms and sizes, from the tiny lathe on the jeweler's work-bench to the giant machines for turning the shaft of a steamship or turning a marble column for some grand cathedral. At first lathes were only used in turning wood. Now we have wood, brass, iron and marble-turning lathes. We shall find lathes in every machine-shop in the world, and so valuable have these tools become that countless improvements and additions have been made to them to fit them to



Large Power-lathe

every possible variety of work. Lathes are used in every industry, and through them we are enabled to make a thousand beautiful things that, if made with hand-tools, would be so expensive that very few of us could afford to own them.

It would require too much time to examine in detail the many forms of lathes used in our shops and manufactories. All we can now do is to try to understand the general principles upon which all are made, so that when we see a lathe we shall be able to recognize it and to understand how and why a trained lathe-man is enabled to do such wonderful work in wood and metals.

In the wood-turning lathe a shower of fine chips and dust flies off under the turner's skillful chisel. In the metal-cutting lathe the sharp, strong cutting-tool plows off a thin, curling shaving as the metal slowly revolves before it. In making tools and machines, and parts of machines, in making parts of a ship, a locomotive or a building, the piece, whatever its name, is first cast or forged into shape. It is of the right shape, but is not accurately finished, and, if it is of a circular form it must go to a lathe to be finished to a true or perfect circle. A fine lathe will enable a skillful lathe-man to turn or finish a hundred such cast or wrought pieces to exactly the same form, so that, when all are finished, there will not be the difference of one hundredth of an inch between any two of them. All lathes employing steam or water-power are called power-tools, the larger and more complicated metal-working lathes being often called machine-lathes.

When, about a hundred years ago, we began to use water and steam-power in operating these large cutting-tools, people naturally asked if it were not possible to use power in planing a board. This was a land of forests, and there was a great demand for fine woodwork. The skillful wood-workers of those early days could make many beautiful things with hand-planes, but such work was always expensive. If the lathe could make a smooth, round stair-rail, why could not some machine be used to smooth and finish flat surfaces? At first large sliding-planes were tried, but they did not prove to be very useful. Then came a modification of the lathe idea. In the lathe the material revolves and the cutting-tool is at rest. Why not make a knife revolve rapidly while the material (wood) passes under it? Upon this idea was based a multitude of remarkable wood-working machines. The number of these tools is so great that all we can do is to examine the few general principles upon which all are built, so that when we go about among the great wood-working shops we shall recognize them and understand and admire the wonderful work they do for us.

The first of these machines is the wood-planer. It is used to plane down the rough boards that come from the sawmill, and make them ready for the carpenter, cabinet-maker and builder. Two types of these planers were invented. In one a number of knives were fastened to a spindle suspended over a table. When the spindle was set in motion the knives revolved in a horizontal position, and a board pushed under them, on the table, would be shaved or chipped by the whirling knives. The table was adjusted to just the right height to enable the knives to shave off thin shavings, and by suitable machinery the board was pushed along under the knives as fast as planed down by the knives. In modern planing-machines cylindrical knives revolve in a horizontal position over the board as it passes under them, and skim or shave off the surface, leaving it beautifully true and smooth. These great wood-planers, when at work, send up a cloud of dusty shavings and, in the best shops, an air (suction) current sucks them up as fast as they are made, and sweeps them away to a distance where they may be safely burned to make steam. A large planer, when at work, gives out a loud, purring sound that once heard will never be forgotten. It is between a moan and a sigh, and makes us feel that the poor dead tree passing through the machine sighs for its lost life in its home in the calm and happy forest.

With our vast wealth of lumber, now, through our own greedy folly, passing rapidly away, our toolmakers early saw that the idea of the swiftly revolving knife could be applied to many other styles of woodworking beside planing. With abundant material and a lively demand for cheap and beautiful woodwork, there was a demand for power-tools of many varied forms. These machines are called shapers and molding-machines. In one type of these machines a spindle called the "cutter-head" is placed upright at the center of a smooth table, being supported below the table. To this cutter-head may be fastened sharp cutting-tools, or knives of various forms. When by means of the proper machinery the cutter-head is made to revolve, the knives whirl round so swiftly that they appear like a single shadowy knife. If now we lay a piece of board, having square edges, on the table and push it against the cutter-head, we see that the edge is shaped or molded into the exact form of the knives. By sliding the board about on the table we can in a moment or two transform the square-edged board into one having a finely molded edge on every side. By changing the knife we can change the shape of the molded edge cut on the wood. For this reason, such a machine is called a shaper. By changing the position of the cutter-head, and presenting the knives at different angles or by inverting the cutter-head, and by using knives of different shapes, we can shape or mold wood into scores of beautiful and useful forms. We can also use the shaper to cut or rout out sunken panels, make the large wooden letters sometimes used in printing-presses, and carve bas-relief decorations in wood. The cutter-head and its knives are sometimes supported on brackets or movable arms over the table, and then the work is kept at rest, by clamping it to the table, and the workman guides the cutter-head to its work. Such a machine is called a router or routing-machine. The large machines for making the long moldings or "trim" used in decorating houses are called molding-machines. They form a class by themselves, and will repay careful study, for they are the expression of the highest art of the maker of wood-working tools.

Many people look back with regret to the old colonial days, when there were no molding-machines. They wish we could have nothing in our homes, schools, and public buildings, but the good, honest work of the long dead master workmen, who used the hand-tools of the colonists. Now, in point of fact, the tools made to-day are infinitely superior to the old hand-tools used before the Revolution, and just as fine workmen live to-day as then. We can have just as honest and artistic work as our fathers if we are ready to pay for it. We all like to see the beautiful work of a real artist. The very term "hand-made," implies an added value in any work. Hand-work has a beauty and value of its own, and many are glad to purchase such work, whatever its price. At the same time, there is a real and honest beauty in this overflowing abundance of cheap machine-work. It may be that much of it is exactly like much more, and to see a great mass of it together may seem to many of us tiresome and monotonous, yet this rarely happens, for it is soon widely scattered, a little here and a little elsewhere.

One chair may be exactly like a thousand others in the same factory, yet it is better that good, handsome, well-made chairs should be in a thousand homes than that one fine chair should be in one house, and nine hundred and ninety-nine families have only a three-legged stool or no chairs at all. The machines make beautiful things cheap. Hand-work alone without machines would make every beautiful thing exceedingly costly. Hand-work and machine-work combined give us two kinds of beauty, and make it possible for all of us to have beautiful things in our homes.

Up to the time of the invention of the steam-engine and the introduction of steamboats and railroads, all ironwork was cast or forged and finished by the aid of hand-tools. With the demand for larger pieces of metal, it became necessary, as we saw in our study of the great hammers, to invent machines for handling iron in larger masses. Blast-furnaces and forges made it possible to make large things, like the parts of engines, but none of these things could be used in their original condition, as they came from the molding-sand or the anvil. They were of the right shape and size, but not accurately finished, and every piece required more or less hand-work to fit it exactly to its place and purpose. This involved a great deal of hard labor, and our master machinists saw that we must have machine-tools to do this work. To-day we have in use a vast number of the most remarkable metal-working tools, and when we examine them we wonder how it is possible that men could have invented and brought to perfection such giants of steel and iron, such complicated and delicate mechanisms, all designed to save labor in metal-working. We have only to imagine what it would be to go without the telegraph, the steamship, the locomotive, the telephone, the electric car and the electric lights and gaslights, and ten thousand things that so add to the value of human life, to see what the world would be without these multitudes of iron-working machine-tools.

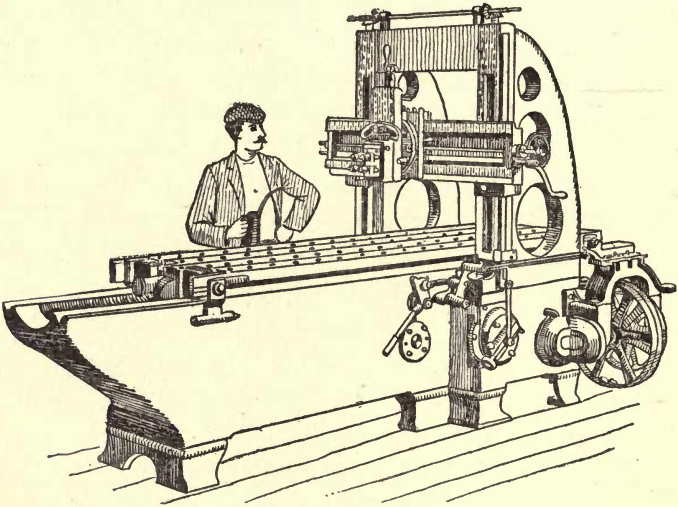
We sometimes meet singular people who say that they never saw the inside of a machine-shop, and that they do not care for machinery. Such persons miss a great deal that, did they give a little thought to the subject, would open their eyes and minds to new sights and wider knowledge, and give them a new interest in life. A visit to a machine-shop may seem, at first, to be disagreeable. The place is dark, black, often very dirty, ill-smelling and noisy, and the multitude of machines seems perplexing and confusing. Now this description of a machine-shop is only partially true. The best modern machine shops are clean, bright and pleasant; many are large, handsome halls, in which it is a pleasure to work. As for the machines, they are easily understood when we arrange them in a few simple classes according to their method of doing work.

All the grand tools used in a machine-shop, both great and small, can be divided into three great groups: the cutters, the borers and the grinders. The borers and grinders we will examine later, and give our attention to the great cutting-machines. These metal-cutting machine-tools are divided into two great classes—the lathes and the planers.

The metal-working lathe in general appearance resembles the wood-working lathe. There is, however, this difference: in the wood-lathe a comparatively soft material is cut or turned at a high speed. In the metal-lathe a very hard material is made to revolve at a slow speed, but with great power, before very hard, sharp steel tools. In the wood-lathe the shavings fly off in a fine, dusty shower; in the metal-lathe a thin, curling sliver or shaving is pared or shaved off by the strong, firmly held cutting-tool. The wood-turner can hold his chisel in his hand, using the tool-rest to steady the tool. The man using the metal-lathe must clamp his tool firmly to the machine, for no human strength could resist the terrific strain on the point of his tool as it plows its way over the smoking iron in the lathe.

When we examined the wood-molding machine or shaper, we saw a rapidly revolving knife, used to carve or mold wood. So we shall find in every machine-shop a large number of most interesting machines employing the same idea in the same way, but at a slower speed. These tools are called milling-machines, and in all of them we shall observe the use of revolving cutting-tools, supported in various positions, horizontal, vertical or at some angle between these directions, and used to cut or chip metals held firmly against their steel teeth. Milling-machines are comparatively new, and they sprang from the demand for tools that would cut out of iron the novel and curious forms used in making typewriters, bicycles, sewing-machines, and the thousand useful things used in the arts and manufactures. They are of wonderful interest, for they are exceedingly ingenious in design, and do their work with remarkable speed and precision. All are, as far as possible, automatic, the machine itself performing every operation in turn with the least possible attention from the workman.

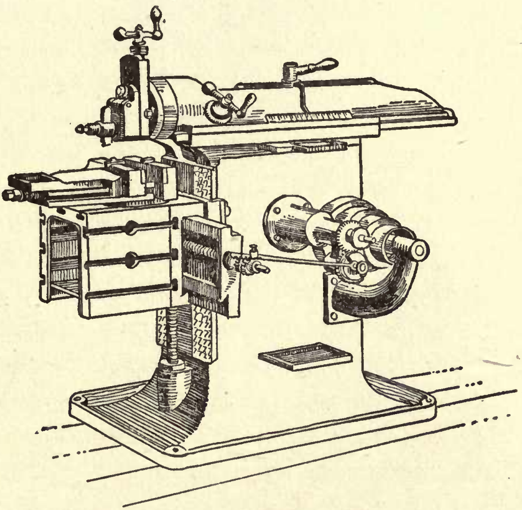
In the wood-planer we saw the use of rapidly moving knives upon wood that was caused to pass under the knives. The metal-planer employs a fixed cutting-tool, supported upon a strong frame, and cutting a thin and narrow shaving from a block of metal that is pushed with great force against it. The tool is held rigid over a moving table, and the iron to be planed is firmly clamped to this table, and it is the forward motion of the table that causes the steel tool to plow its way over the iron. The advance of the table towards the tool is slow and very powerful. The moment the tool has passed over the iron and planed off a thin sliver, the table quickly returns to a new position



Iron-planer

to be ready for the next slow-working stroke. This slow advance and quick return, we shall find, is characteristic of all the metal-planing machines, both great and small.

Closely related to the planer are two other metal-working machines, called the shaper and the slotting-machine. In these machines the metal to be cut or shaped is firmly held in position, while the cutting-tool moves over it. The shaper, which slides forward to its work, is more like the original hand-plane than the planer, yet it differs in this, that the forward stroke is very slow and powerful, and the backward stroke, or return, is swift. The cutting-tool in the shaper usually moves horizontally. In the slotting-machine the move-



Shaper

ment of the cutting-tool is vertical, the effective stroke being downward. All these machine-tools are essentially planers. They can be found in every machine-shop in the world, and are often given special names, according to their work. All are provided with many interesting appliances for increasing the speed of the work and for enlarging the field of their usefulness. We can well afford to pause and examine them with the greatest care, for they are all worthy of our highest respect and admiration. To pass them by as uninteresting or unworthy our attention is to confess our own ignorance of the wonderful scientific progress of our modern master builders of tools. Better to know less of the weak and silly lives of dead kings or imaginary gods and goddesses, and know something of the men who make and use these splendid machine-tools. Kings and generals have, perhaps, done a little good in the world, but greater than them all is the man who invents a new machine-tool that by its giant labors makes all our lives safer, more useful, more worth living.

Among the oldest of the knives is the sickle. For thousands of years men gathered wheat by cutting down a few stalks at a time with this crescent-shaped harvesting-knife. So, also, in cutting grass, men used the scythe, but long ago they saw that both scythe and sickle were slow and inefficient. For years many attempts were made to make some kind of machine that would harvest grass, wheat and oats. All these machines failed, and it seemed, up to our own times, as if all harvesting must be done with hand-tools. This could not continue, because, as more and more people learned to use machinery, more and more people lived in cities and followed other trades than the growing of food; necessarily there must come a time when the cost of harvesting our crops would be so high that food itself would be high, and all the people would suffer because of the high cost of a loaf of bread. This critical time came early in the last century. Our cities were growing rapidly, the railroads, factories, and mills were calling so many people from the farms that, in spite of the emigration of millions of people from Europe, our farms were short of "hands." It became useless to raise great crops, for there were not men enough to gather them. Machinery had reduced the cost of making flour, and the railroads and steam vessels had reduced the cost of transporting it, and machinery must be used on the farm or the price of every loaf would be high. Out of this state of affairs came one of the finest machine-tools in the world—the harvesting-machine. We cannot afford, as Americans, to be ignorant concerning these great inventions.

The first of these harvesters is the mower, the most simple machine being the common lawn-mower we see in every front yard. The moment we examine it we see that it is really a machine-knife. It has a roller and a knife-blade bent into a spiral form. Both are supported in a little carriage, and by means of simple connections the spiral knife can be made to revolve, the cutting-edge being at all times close to the roller.

As the machine is placed on the grass we see that some of the blades of grass stand up between the roller and its spiral knife. On pushing the machine forward over the grass we observe that the blades of grass caught between the knife and the roller are cut off with a shearing cut, precisely as if the machine were a pair of shears having a continuous cutting motion, all in one direction. The surprising thing is the extreme simplicity of the machine, and yet we see that it does its work with speed and precision. These grass-cutters are all comparatively small, the largest used in city parks being drawn by a horse, and their work is merely to shave or trim the grass. To cut grass for hay is quite a different piece of work, and demands a larger and very different machine. It must be large enough to cut a wide swath at a good speed. It must have a carriage, with its pole and harness for the horses, and carrying the machinery used to convey the power generated by the forward movement of the horses to the cutting-machine. At one side of the carriage hangs an arm or bar, projecting at a right angle with the advance of the carriage. This bar is suspended a few inches above the earth, and along the forward edge is arranged a series of hollow fingers or steel teeth. Within these fingers is a series of lancet-shaped or double-edged knives attached to a bar that, by suitable connections with the carriage, can be made to vibrate from side to side. The man seated on the machine guides his horses up to the edge of the hay-field, the bar supporting the fingers and knives projecting over the grass to be cut. On starting the horses forward, the motion causes the knife-bar to vibrate between the fingers, and at each vibration the stalks of grass caught between the fixed fingers and the moving knives are sheared off. The work is done as fast as the horses can walk, and not a single blade is missed, the grass falling in a continuous shower as the machine passes over it.

This single idea of the vibrating lancet knives between fixed hollow fingers is one of the most important and valuable of all modern inventions. It has been employed in many ways, and is used every year in a million machines. So important and valuable is the mowing-machine that it has spread all over the world, and has been so improved and developed that it is now used to cut wheat, bind it into sheaves and tie each bundle up and leave it lying upon the ground ready for the harvest wagons. When a mowing-machine is used to cut wheat, gather it into bundles and bind it up, it is called a reaper or harvester, or sometimes a reaper and binder. When used to cut grass for hay it is usually called a mower or mowing-machine.

8

CHAPTER VIII

THE SAW AND THE SAWMILL

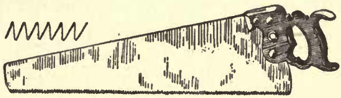
We observed in our studies of the knife that the blades of all good knives that are in proper condition for cutting have a continuous, unbroken edge. Centuries ago men noticed this and took pains to keep their knife-blades free from nicks or notches. We do not know who first observed the fact that if a knife-blade have many nicks or notches along the edge it will behave in a very different manner from a straight-edge knife, and can be used in a wholly different way and for different purposes. We can only imagine that this early observer tried his nicked knife as a cutting-tool for tearing apart a cord, a grapevine or the small limb of a tree, and found that it worked very well as a dividing or separating-tool.

A knife can be used to cut a piece of wood by pushing it along the wood, as in whittling a stick. A knife with a notched edge can be drawn across the wood and it will soon separate the wood into two parts. With a notched knife we make, not shavings, but sawdust. We recognize that any notched or serrated cutting-blade is a saw. The origin of the saw is lost in the long-forgotten centuries, yet we may feel sure that the saw is quite as old as the knife. The ragged edge of an oyster-shell or the curious weapon carried by the saw-fish may have first suggested the saw. However it may have been originated, we readily see that it is one of the most ancient and most useful of all the tools.

We take up a common carpenter's saw and examine its edge, and see that it consists of a series of serrations or notches, all of the same size and all having a little cutting-edge on each side. Looking along the edge we see that each tooth is bent slightly to the right or left. It is said to be "set" in that position, every alternate tooth being set to the right and the others set to the left. Each tooth is a tool, and when the saw is used each tooth acts as a tiny cutting-chisel that chips out the small bits of wood we call sawdust. As the saw may have a hundred of these little chisels, we can easily see that a dozen or more may be at work at the same instant, each cutting out tiny bits of the wood and rapidly dividing the block of wood into two parts. When we use a knife to cut wood, we separate it with a clean cut. With a saw we destroy a portion of the wood and turn it into sawdust. Each tooth cuts off a bit of the wood, and soon the saw-cut or "kerf" is filled with this waste sawdust. Were the teeth not set alternately to the right and left, the sawdust would fill and choke up the kerf, and the saw would jam or stick fast in the kerf. The setting of the teeth cuts the kerf a trifle wider than the saw-blade, and this leaves room for the sawdust to escape. We see that at every stroke of the saw some of the sawdust is pushed out of the kerf. This setting of the teeth seems to have been invented thousands of years ago. In using the saw we observe, also, that it does its work upon both the push forward and the pull backward, or, as we say, at both strokes. Some ancient saws were made to be used only upon one stroke, and in some countries they are still used in that way, but it is plain that two effective strokes are better than one effective stroke and one idle stroke alternately. That is too slow for our times.

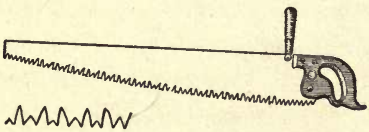
Get a small piece of board and a hatchet. Hold the board upright and strike it upon one edge. We at once discover that striking either one of two edges produces no effect, except to dent the wood, while striking either one of the two other edges splits the wood apart. To understand this we examine the wood, and see that it is built up of bundles of woody fibers placed side by side and fastened together. These are called the fibers or grain of the wood, and our experiment proves that the wood is stronger across the grain than along the grain. The fibers are tough and strong and resist the blow of the hatchet, while they are but loosely held together and readily split apart when struck in line or with the grain. Every piece of wood shows the fibers of the wood in one direction and the ends of the fibers in the other. It is this that led, no doubt, to the expression "against the grain." A boy may be asked by his mother to split some kindlings for the kitchen stove and say that the request "goes against the grain," or against his inclination, while he will split the wood itself "with the grain," which, we see, is a very pretty paradox.

Now, in preparing firewood, a boy can do very little with the hatchet alone, for the wood, as it comes from the tree, is too long for the stove. Then he learns the value of the saw, for he uses it to saw the wood apart, "across the grain," into short pieces or "stove lengths." Sawing is much harder work than splitting with a hatchet. "I'll chop and you saw," said the country boy to his city-boy visitor as they went out to the woodpile. "No, sir," said the city boy, "I've read about sawing and splitting, and we will take turns at the chopping-block, or I will not play."



Rip-saw

The writers of story books sometimes tell us that their heroes carried a "Damascus blade" or a "Toledo blade," meaning a sword of such fine steel that it could be bent into a circle without breaking, and carry an edge like a razor. A good American saw is as fine a piece of work as the most famous sword ever made. Look at one in the carpenter's kit. It is strong, elastic, sharp, and beautifully polished—a better thing than any sword. All our carpenters carry two chief saws, one adapted to sawing across the grain, called a cross-cut saw, and

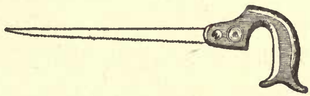


Cross-cut Saw

one for sawing along or with the grain, and called a rip-saw. Saws, whatever their size, shape or use, are usually divided into these two styles—the cross-cut and the rip-saw. The trained user of saws examines every piece of wood he wishes to saw to ascertain the grain of the wood, and selects the right tool to fit the grain. Every user of tools sees also that his saw is sharp and properly set.

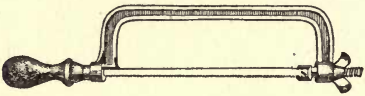
When the Pilgrims landed from the *Mayflower* they brought ashore an ax and an adz, and with these it was possible to cut down trees and build log-houses. They brought also a saw, because the Pilgrim house-mother wanted shelves in her buttery and panels in the wainscot and closets for her linen and china, and these things could only be made by sawing up the big logs into thin boards and sawing the boards into the proper shapes and sizes. To make these sawn boards the colonial carpenters first dug a pit in the ground and laid rough planks over the open mouth. A log was then laid on these and one man climbed down into the saw-pit, while another stood over his head on the planks. The man below was called the "pit-sawyer," the man above the "top-sawyer." To saw the log they used a big, two-handled rip-saw, pulling and pushing it up and down between them. In this way the two sawyers sawed fine boards out of big logs. The top-sawyer used the most skill, and was thought to be the best man. Hence, to call a man "a regular top-sawyer" was to pay him a high compliment, and the expression still lingers in New England, a hundred years after the last saw-pit was filled up and abandoned.

From the great pit-saws and the carpenter's rip-saw and cross-cut saw, have sprung the hundred different kinds of saws now in use. The lumberman and builder still use double-handled saws eight feet long, and large cross-cut single-handled saws from four to six feet long. Hand-saws range from fourteen to twenty-six inches in length. Saws for fine woodwork are often made with stiff blades strengthened by a thicker piece of steel at the back of the blade. Such saws are often used in fine joinery and cabinet-making with a "miter-box" or guide-box for cutting wood at an angle. Narrow, flexible saws, like the compass-saw and keyhole-saw, are used for making circular or curving cuts.



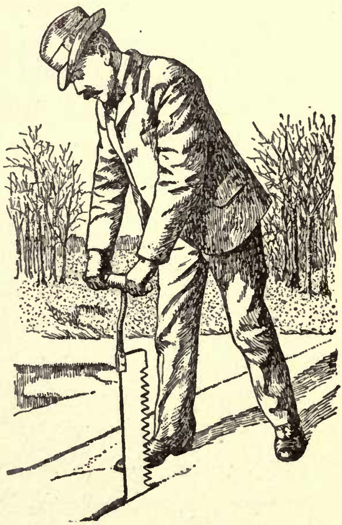
Keyhole-saw

In the kitchen the cook uses a meat-saw, having a narrow blade set in a frame. We see larger saws of the same kind at the butcher's shop. There are many kinds of these frame-saws used in sawing wood and metal, the most common frame-saw being the wood-saw that hangs in every woodshed in the land. It is the farmer's handy saw, and every farmer's boy has used one. Wood-sawing is good exercise, and many a country boy now a city man owes his strong arms, good lungs and fine health to the practice he had with a wood-saw in the old home. The machinist, plumber, and railroad man use frame-saws called hacksaws, some of them having blades that can be adjusted to any angle in the frame. The surgeon uses the finest saws that are made, and in every art, trade and handicraft we shall find saws of some kind. Even the ice-harvester uses a saw to cut his crystal blocks apart, and the retail ice-dealer carries a saw to cut his ice into blocks for the refrigerator. It would be difficult to find any people the whole earth around who do not use some form of this ancient tool.



Hack-saw

We do not know who first thought of using a water-wheel to drive a saw. Some crude machines for sawing wood by water-power were used in Spain as early as A.D. 1420, and a hundred years later they were quite common all over Europe. They were called sawmills, probably because the first water-wheels used to move saws were also used in grinding-mills. In 1596 a sawmill that would cut two boards at once was built in Holland, and in 1663



Ice-saw

a man from Holland tried to erect a sawmill in England, but the English sawyers would not let him use it, for they said it would ruin their business. Another mill was built in 1767, but the sawyers burned it down. In our own country a sawmill was built at Natchez early in this same century, but even our southern sawyers thought such a mill would injure the sawing business, and promptly destroyed it. However, the sawmill was too valuable to be neglected, and they soon increased rapidly, in spite of the pit-sawyers. People wanted lumber to build homes, but the hand-sawn boards were too costly, and it took too long to saw them. Sawmills made better boards, in larger quantities, in less time and for less money. The more boards made, the more carpenters to be employed, and the cheaper the houses the more families could find new and comfortable homes. All the pit-sawyers were Americans, and in the American fashion quickly gave up a hard, laborious, ill-paid business for cleaner and more profitable employment. To-day there is not a man in the country who would go back to this miserable trade, and yet the old sawyers burned down the early sawmills—which to us to-day seems very curious and very foolish.

At first, all the sawmills used straight saws resembling the pit-sawyer's rip-saw, simple machinery being used to drag the saws up and down as the log was pushed against them. At first, one saw only was used, but it did not take long to discover that one water-wheel would supply enough power to move two or more saws. These saws were set in frames side by side or, as the mill-men expressed it, "arranged in gangs," the frame being moved up and down by the water-wheel, and the saws working side by side through the log, the space between the saws regulating the thickness of the boards.

The first great improvement in the sawmill was the invention of the circular saw about a hundred years ago. A steel disc with teeth upon its edge could be set up on edge and driven rapidly by a water-wheel or steam-engine, and such a revolving saw would cut a log at much greater speed than any form of reciprocating saw. Since the invention of the circular saw our builders of sawmills have made many improvements in their great machines, and they may now be regarded as among the very largest and finest wood-working machine-tools in the world. One common form of circular sawing-machine has a saw suspended upon a swinging frame hung from the ceiling of the mill. It is very useful in sawing firewood and in cutting short lengths of wood in box-making and cabinet-work. Another useful machine consists of a table having a circular saw hung just under the top of the table, a small segment of the saw projecting above it. Such a sawing-table is very useful in every shop, and we shall find them in every plant using power to saw

Circular Saw

wood. At first all circular saws had teeth cut in the edge of the disc. Now all large circular saws have adjustable teeth, each tooth being fitted and locked into its place on the edge of the disc. The advantage of this is that, if a tooth is broken, a new tooth can be easily fitted into its place and the saw can go on with its work without delay.

The most novel and certainly the most interesting of all the sawing-machines is the band-saw. It consists of two large wheels placed in an iron frame, one over the other. Round the faces of the two wheels is stretched a thin ribbon or band of flexible steel, having one edge cut into saw-teeth. The ends of the band are brazed together to form a continuous band from wheel to wheel. A table is placed over the lower wheel and under the upper wheel and having a slot through which the band passes from wheel to wheel. There are arrangements for keeping the saw-band stretched tight at all times, and when power is applied the wheels turn rapidly, and the saw-band moves swiftly in one continuous direction through the slot in the table. A block of wood placed upon the table and pushed against the flying saw is quickly cut into any shape desired.

For small work at home there are a number of very useful little sawing-machines called jig-saws and fret-saws. They use a short saw-blade supported in a frame, and have a rapid up and down motion over a small table. They are usually operated by a foot-treadle, and any boy or girl, wishing to use a capital little sawing-machine, will find it well worth the time and labor to learn to use one of these fret-saws. Such machines are very useful in making picture-frames, paper-pockets, bookracks and other pretty and handy things. Such things, being the work of their own hands, make the very best and most acceptable presents for their friends.

CHAPTER IX

THE BORERS

Should we ever be so fortunate as to see a real Indian birch-bark canoe, we might, perhaps, be surprised to find that the thin sheets of bark covering the canoe are stitched together by strong cord sewn through small holes in the edge of the bark. We can see the same thing in every iron steamship, each plate and beam of metal having small holes in the edge through which are secured bits of iron called rivets, the rivets binding plate to beam in every direction. Clearly, these holes in the birch bark and in the pieces of steel must be made by some form of tool. In the Museum of Natural History we shall find among the most ancient of all tools curious sharp-pointed bones or teeth. Evidently the old workmen made these things for the work of boring holes, and we call to-day such a hole-maker an awl. We shall find an awl on every shoemaker's bench and in every carpenter's kit. The carpenter's awl is a slender rod of steel, having a fine, sharp point, and fitted with a convenient wooden handle. The shoemaker uses an awl to make the holes in

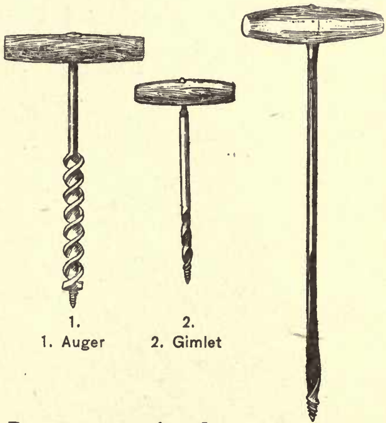
Prehistoric Bone Awl or Borer

his leather, the sailmaker uses a curved awl to make the holes in the heavy canvas he sews together for sails, and the carpenter uses his awl to make a hole for a screw. The awl is thus a piercer or hole-making tool. It is used with a sharp push or thrust, and it breaks or tears its way through the material, whether it be bark, a fabric, leather, wood or thin sheet-metal.

In using an awl it is often necessary to move or twist it about in order to make a larger hole. This must have been observed long ago, for men early discovered that if an awl had a cutting-edge on the side or shank of the tool, it could be twisted and turned about to make even larger and deeper holes than could be made with a simple awl. Such a tool would not be a piercer, but a borer. So, from the awl, an exceedingly ancient tool, came the first of the simple boring-tools—the gimlet.


Carpenter's Awl

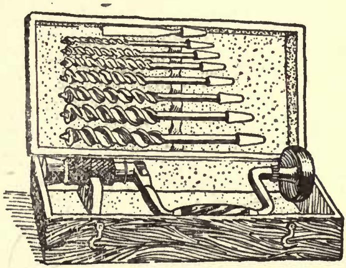
The gimlet is the smallest and oldest of a great family of wood and metal-boring tools, and if we understand it we can easily understand the larger tools and machines that belong to the same family. The gimlet has a round steel shank with a "cross-head" or handle at the top. The lower part of the shank is hollowed out, the cut-out part having a spiral or twisted form, and called the pod (from its resemblance to a pea-pod). At the end is a spiral point resembling the tip of a wood-screw, and called a gimlet-point. In using the gimlet the handle is firmly grasped in the hand, and the sharp point is pressed into the wood at the exact spot that marks the center of the hole we wish to bore in the wood. It is now given a rotary motion combined with a downward pressure. We see that the point is thus screwed or pressed spirally into the wood. When the lip of the pod reaches the wood it cuts out a spiral shaving. As the gimlet sinks deeper, the sharp edges of the pod cut into the wood and shave off the sides of the hole. The waste wood is pushed up as fast as it is cut off, and falls out upon the surface. When the hole is as deep as the tool will conveniently go, we have only to reverse the motion of the handle, and the gimlet easily rises out of the hole. It seems a simple little tool, and yet we see how much thought has been expended upon it to bring it to its present perfection.



1. Auger 2. Gimlet 3. Electric-Wiring Auger

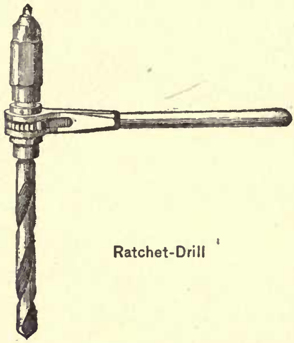
Awls and gimlets have been used for a long time to prepare the holes for screws, and without them it was very difficult to put a screw into wood. Then came, in quite recent times, the invention of the gimlet-pointed screw, and now every screw is its own gimlet and bores its own hole as it is screwed into the wood. No single small invention has proved of greater value in wood-working than this simple Yankee notion of putting a gimlet-point on every screw, for it saves all the time and labor of boring the holes. One tap of a hammer on the screw-head and it is started, with one of the improved screw-drivers it is quickly and firmly screwed "home." While the new screw saves all the labor spent on boring screw-holes—except in fine cabinet-work, etc.—and puts the gimlet out of commission, we shall still find it a handy tool to have in our tool-box.

Closely related to the gimlet is the larger tool called the auger. It has the same cross-head handle and straight shank, and a twisted spiral cuttting portion ending in two sharp lips or chisels, and a gimlet-point. The auger is one of the finest of all the boring-tools used in wood-work. At the hardware store we shall find them in every size, from the great tools used by the car-builder, ship-builder and house-builder, down to the slender spirals used by the piano-maker and cabinet-maker, and the long augers used by the electric-wiring man. The augers have a real beauty of their own, for their graceful spirals are formed on true scientific principles, and are the result of a correct application of means to end. The spiral cutting-shank of our wood-boring augers was invented in this country and, like the gimlet-pointed screw, is an American idea. As each auger bores a hole of a fixed diameter, it is usual to purchase them in sets of a dozen sizes or more. They come in neat boxes, and are used with some form of bit-stock or brace, an appliance for holding the tool and turning it as the hole is bored. When an auger has its own handle, it is a simple auger, when several augers are used with one brace or bit-stock, they are called auger-bits or simply bits. Auger-bits are made in a very great variety of forms, and are used in doing a great variety of work, there being over fifty different bits or allied tools used in wood and metal work. The auger idea has also been applied in making holes in the earth and in setting iron piles into sand in making foundations for docks and light-houses. A faucet for drawing liquids from a cask may have an auger-point so that it can be bored into the head of the cask, making the hole and setting the faucet in one operation, the faucet plugging the hole as soon as it is cut through. All styles of augers are now used in groups or gangs, particularly in car-building, and we shall no doubt soon see automatic augers driven by compressed air.



Brace and Bits

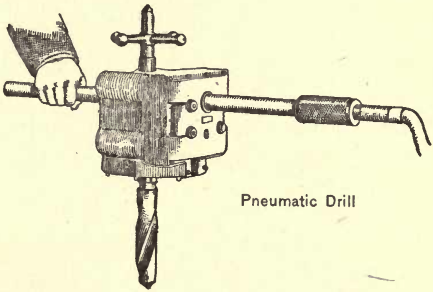
Closely related to the augers is another large class of boring-tools called drills, and used in boring holes in metals, bone, stone, ivory and other hard materials. They range from the little drills used by the watch-maker and jeweler in making holes for his tiny screws, to the great machine-tools used to bore out the hub of a locomotive driving-wheel. Drills bore out holes by the slow-cutting action of sharp lips or cutting-edges of the tool, and all must be used in some form of carrier, like a brace or similar appliance, for the drill must cut under great pressure and very slowly. The oldest form of drill-carrier was a simple bow of wood, the bowstring being carried twice round the drill, the simple backward and forward motion of the bow causing the drill to rotate rapidly in opposite directions alternately. We have now far better tools for operating drills, the most common being the ratchet-drill. It is a form of brace having a ratchet and pawl to operate the drill. All metal-drills employ some form of carrier that can be used under great pressure to force the drill continually up to its work. As all modern steel structures are put together with bolts or rivets, there must be vast numbers of holes drilled in every imaginable direction and in a great many sizes. All holes in moving parts of engines and machines have to be carefully and accurately drilled, but in making the million holes required in a ship or railway bridge, it is found to be cheaper to punch the holes for the rivets. This punching is not boring at all, but the forcing of a bit of metal out of the plate by direct pressure, precisely as we see the conductor on the railroad train punch holes



Ratchet-Drill

in our tickets. The conductor uses a hand-punch weighing less than a pound, the shipbuilder uses a monster hydraulic punch weighing many tons. Drills, like augers, are often arranged in gangs, and many new and powerful drills are now operated by compressed air, and are called pneumatic drills.

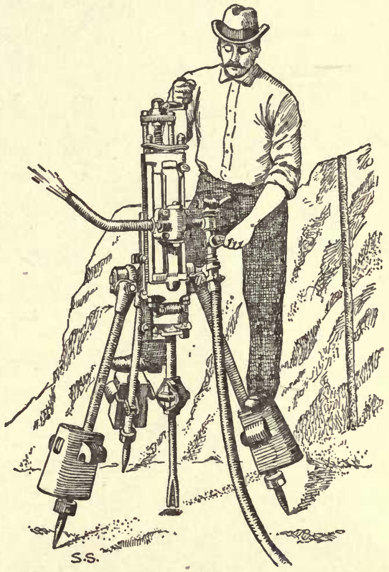
It sometimes happens that a hole, when drilled, or even when punched, may require enlarging, or it may be necessary to give it a tapering form or to shave down the edges of the hole. This is called reaming, and is done with a reamer, a tool having either a straight or taper shank and sharp corners or edges. It is used simply to shave off the sides of a drilled or punched hole without making it any deeper. In punched holes the edges are sometimes left ragged or broken, and a reamer is used to shave the edge of the hole down smooth. Rivets and screws for metals are often sunk in the metal so as to be "countersunk," or made flush with the surface, and it becomes necessary to pare off the lip of a drilled or punched hole. The work is done with a counter-sink bit, a form of reamer.


Pneumatic Drill

The dentist uses small drills upon our defective teeth, and employs fine tools driven at a high speed, for it is far less painful to have a tooth bored out in a few seconds, by an electric drill, than to suffer half an hour while the dentist chisels out a hole with his unhappy old hand-tools.

With the introduction of railroads came a demand for some kind of machine for boring holes in stone. For centuries men had cut blocks of marble and granite out of quarries by the use of a hand-tool called a drill. It was a simple bar of iron, having a rounded, double-faced chisel at the lower end, and it required three men to use it at even very slow speed. One man held the drill upright on the rock and the other men, or "hammer men," struck the top of the drill with heavy sledges. Between each blow the holder gave the drill a quarter turn in the hole to present the cutting-edge in a new place. This work was slow, laborious and costly, but it was the only method that could be used in quarrying stone. Before the invention of gunpowder, quarrying was all done by making drill-holes in rows close together and then driving wedges in the holes till the stone split off along the line of holes. With gunpowder less holes were required, because the explosion of powder in a drill-hole is far more effective than any form of wedge. When in our times the railroads spread over the country, there sprang up a great demand for some form of drill that would do more work than the old hand-drill. The railroad must be level, and this meant that rocky hills must be cut through and mountains tunneled, and all this demanded an enormous amount of drill-work for rock-blasting.

Naturally, inventors endeavored to use steam-power in rock-drilling, and to-day in the steam or compressed air rock-drill we have one of the most important and valuable of all modern tools. It consists of a steam cylinder and piston and its rod, and to the rod is firmly secured a steel rock-drill. The cylinder is supported upon a strong and heavy tripod that may stand in any position and present the point of the drill in any direction. The steam or compressed air is conveyed to the cylinder through a hose, and when ready for work, it delivers its tremendous, thundering blows upon the rock in rapid succession. The man controlling the machine regulates the speed and pressure of the blows, the machine automatically turning the drill as it sinks into the rock and continuing its terrific labor as long as the supply of steam or compressed air is maintained. This grand tool has done more to develop the mineral wealth of our country than any other tool or machine. It has enabled us to sink deep mines and to dig for



Pneumatic Rock-drill

miles through the mountains. It has discovered and brought to the surface oil, gas, and water, has given us a wonderful wealth of beautiful marbles and building stones, and has led the railroads over or through the highest mountains. If we were to select any one tool that should stand as distinctly the modern tool, more universally useful than any other, it would be the power rock-drill.

The drills used in sinking deep holes for oil, gas or water are operated by steam-power in tall machines resembling in appearance a pile-driver, and called a derrick. For very deep wells, and wherever it is necessary to ascertain the character of the rock hundreds of feet below the surface, another and most interesting form of drill is employed. This is the diamond rock-drill, a power-tool that is a true boring-tool, for it cuts a circle in the stone, leaving the center, or core, untouched. The drilling-tool is a steel tube, open at the lower end, the circular edge being armed with cheap, yet very hard, diamonds. The drill is placed upright upon the rock to be bored, and is operated by turning it round precisely as if it were a diamond-shod auger. The intensely hard diamonds cut a ring in the rock, and as the tool cuts its way downward, the blank center remains standing in the middle of the hole or well. By removing the drill and using the right tools, this stone core can be broken off and hauled up to the surface. The core then shows exactly the kind and character of the rock cut by the drill, even if the drill has been at work a hundred feet under ground. The removal of the core enlarges the well to its full size. No tool ever used in working underground has given us such useful information concerning the rocky interior of the earth as this diamond drill, and the curious stone records of its work have been preserved as stone books, telling us the secrets of the crust of the world. Some of these stone cores have led to the discovery of valuable minerals hidden deep in the earth, and that might never have been found without the aid of the diamond drill.

Eskimo Bow-drill

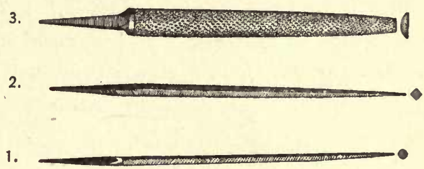
Within the past few years a remarkable improvement has been made in the drills used to bore metals. This is the pneumatic drill, a small and powerful drill operated by compressed air. It works at a high speed, and as it can be used in any position within the limits of its air hose, it is a most useful and valuable tool in shops and shipyards and wherever metal-boring tools are employed. Like the pneumatic hammer, it is destined to be one of the most universal of all small power-tools.

CHAPTER X

THE ABRADERS AND GRINDERS

Any tool that has been well used, and has a wooden handle, will show that it has been used, by the polish that appears upon the handle. A new hammer has a smooth, but dull handle; an old hammer may show a fine polish. This was, no doubt, observed centuries ago, for we find in museums ancient arms and tools that are highly polished. At first this might have been the result of handling and long use. Then, perhaps, some more thoughtful huntsman decided that if the mere rubbing of his hands upon the bow or spear would polish the wood, he could rub it all over and give the whole surface this attractive polish. Then he discovered that such polishing could be hastened by using rough material in place of his bare hand. The rough skin of a fish, when dried, would be a good polisher, and besides doing better work, would save his own hands from wear. The next step would be to wrap the fish-skin round a stick and use the stick as a handle for the polisher. It was from some such experiment as this with dried fish-skins that we obtained one of the most common of all tools—the file.

A file is an abrading tool or surface-finishing tool. It is a steel tool, made in many forms, the surface of the steel being cut or raised into small ridges or burrs of uniform size, and arranged in rows or groups side by side. It is the universal finishing-tool, and "to file to shape" means to use a file to bring a piece of wood or metal to a true plane, or to the exact form of the pattern. In technical schools the first lessons given to the students are in the use of the file, as it is an extremely delicate tool, and to use a file with precision and skill is an excellent training for the hand and eye.



1. Half-round Rasp File 2. Four-square File
3. Round Double Cut File

There are in use in the arts, at least two thousand different kinds of files, varying in their shape and size, and the manner in which the teeth are arranged. Three points will be found in all files, these points being their length, measuring from the end of the file to the tang (that portion inserted in the handle), their shape, and the manner in which the file is cut, or the arrangement of the cutting teeth. For instance, a file may be four, five, ten or more inches long; it may be of square section, triangular, round or half round, or may resemble a knife-edge or be square with one side convex, or may resemble a low pyramid; and it may have single detached teeth, like a rasp, or it may have fine teeth arranged in parallel lines or arranged in double lines crossing each other. A file may be also cut on three sides with the fourth side blank or "safe."

If we take up any file we shall find that it includes these three points—length, shape, and style of cut. The large files, with single, detached teeth, are said to be of "rasp cut." Smaller and finer files are single-cut or double-cut, and each of these rasp, single, and double-cuts has various degrees of fineness. The length and shape depend entirely upon the work to be done with any particular file, and so universal is the use of files and rasps in every trade, that we are simply lost in wonder at their infinite variety. A mere list of all the kinds would fill many pages, and it would certainly be quite as dull reading as a trade-catalogue.

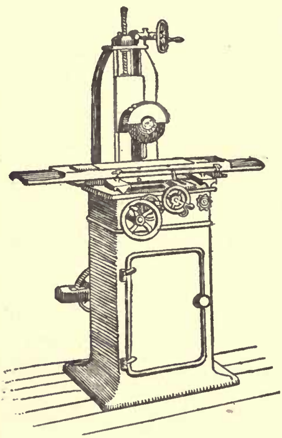
It is clear that in the use of files we have only to consider the character of the work to be done and the nature of the material to be filed, to be able, with a little practice, to select just the right kind of a file for our purpose. A jeweler requires small, fine-cut files, the dentist, very fine-cut files of a variety of shapes. A locksmith fitting a key wants a rather coarse single or double-cut file of the exact shape to fit the work, whether it be to trim off a tiny shaving of brass or to cut a blank key to fit a lock. A horseshoer wants a big, coarse rasp for his work, and the cabinet-maker wants his special files to fit his work. In the kitchen we see the nutmeg-grater and the horseradish-grater, and recognize that they, too, are abraders and raspers.

A sheet of stiff paper, painted with hot glue and then lightly sprinkled with fine, hard, beach sand, gives us an admirable material for smoothing and polishing.

When the hot glue cools it hardens, and holds the tiny grains of sand, and each bit of hard stone acts as a file tooth. We call such prepared paper sandpaper, and by using sand of different degrees of fineness, we can make sandpaper with fine teeth or coarse teeth. We can also use other materials upon paper as abradants, such as powdered glass, corundrum, emery and other hard, fine-grained powders. Wooden rods and sticks are also covered with glue and sprinkled with sand or emery to make polishing-sticks. Loose emery, rouge and other materials are also used with a piece of cloth in polishing glass and metals.

The most useful of all these abrading and polishing appliances is the emery-wheel. A wheel covered with emery-paper and placed in a lathe makes at once a circular abrading-tool of great value in polishing metals. A still better plan is to make a wheel of some material that will hold emery, corundrum or other abradants all through its substance. Then, as fast as it is worn out, new, fresh grinding-surfaces will be exposed. Such emery-wheels are now in universal use in every shop where metals are to be filed, smoothed or polished. They are used also to give shape to pieces of metal, it being found as easy to grind a block of metal to the right form as to plane it or to mill it in a milling machine. Such machines are called grinding-machines, because they grind down metals to shape by means of swiftly moving abrading-wheels.

A great variety of rubbers, grinders, and polishers are used to polish plate glass, buttons, and the countless small things made of brass, copper and glass, and that we use in every trade and in all our homes. Very hard grinding-wheels are used to cut glass into the beautiful forms we call "cut glass." Very soft wheels coated with rouge are used to polish glassware and silver. Very delicate and beautiful decorations are also applied to glassware by lightly touching the glass to swiftly moving grinding-wheels. Window glass is often depolished by grinding and rubbing with sand. Such partially opaque glass is called ground glass.



Surface-grinding Machine

The most interesting machine used in grinding and decorating glass is the sand-blast. This machine employs a blast of air to drive a stream of fine sand against a sheet of glass. Every tiny speck of sand thus violently driven acts as a file to crack and roughen the surface, and as many thousand grains of sand strike every minute the glass is quickly depolished or made dull like common ground glass. The sand-blast is also used to decorate silverware. A thin sheet of cloth or paper spread over the glass under the sand-blast, checks the operation, and the sand makes no mark. Thus the shape of the paper may be used as a pattern in decorating glass or silver. The parts under the paper will remain polished and the parts not covered by the paper will be dulled or matted, and the contrast between the two may be a very beautiful form of decoration.

The abradants have still another use. A grindstone is a grinding-wheel, and we use it to grind away a part of the blade of a knife and give it a fine, sharp cutting-edge. There are also many forms of fine sandstones or sharpening-stones that, with the aid of a little oil or water, enable us to keep our tools sharp. Even the scissors-grinder at the door may remind us that abrading-wheels and sharpening-stones, and even razor strops, all sprang from the old dried fish-skin that some hunter once used to polish his spear handle.

One of the largest and most useful of the abrading-machines is the stone or marble-saw. In the marblo yard we shall see huge blocks of marble being sawn up into thin slabs. We see a wooden frame holding a number of long saws, swinging slowly backward and forward over the marble. At first we might imagine that this was a real sawing-machine. Then we observe that the man in charge of the machine keeps putting sand on the marble, while tiny streams of water flow over the white block. The sand-saw is not a saw having cutting-teeth like a wood-saw. The cutting of the marble is done by the sand that is continually "fed" to the thin strips of iron called the saws. The water sweeps the sand into the cut and keeps the saws cool, otherwise the strips of iron would soon grow hot under the friction. The machine we see is a giant sand-file, the iron bands merely serving to keep the sand in motion and causing it to file away the hard marble. From the stone-saw the thin slabs of marble go to great tables, where swiftly moving arms provided with brushes or other appliances for holding abradants glide over the marble to give it the beautiful polish we see in every marble washstand, counter, table, and mural tablet.

CHAPTER XI

WOMAN'S ANCIENT TOOLS

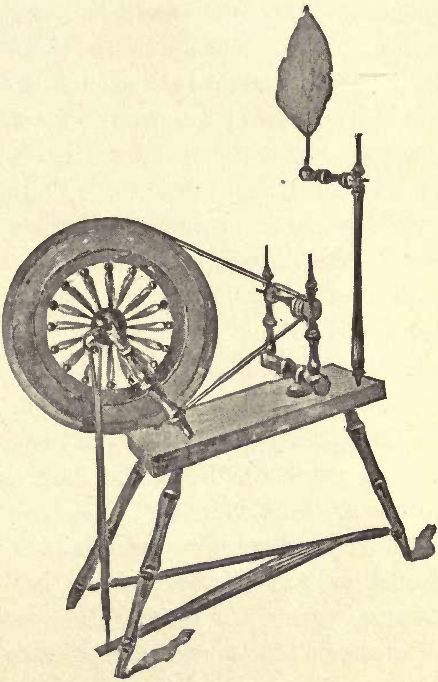
THREE things mankind must have: food to eat, a roof for shelter, and clothing for protection against the weather. It was the demand for food and shelter that led to the invention of many tools. The demand for clothing led to still other tools. The first clothing was stolen from the backs of animals. The sheep wore a thick, warm coat, and men did not hesitate to kill the sheep and strip off the skin and use it as a garment. Of course, a sheepskin on a man would be a pretty poor fit, and some woman picked up a thorn or a sharp stick and used it to pin pieces of sheepskin together to make some rude kind of a garment that would be comfortable and look more or less pretty. Then came the awl, and with the awl came the invention of stitching or sewing.

Men and women for centuries thus used the skins of animals as materials for garments. Invention and improvement move slowly, and centuries may have passed before they recognized that it was a very poor plan to kill a sheep for his skin, when the wool or fleece could be cut off each spring and still keep the sheep alive. A dead sheep would give one small skin, a live sheep would give wool once a year for several years, besides a new lamb or another sheep. Such a simple idea as this must have completely changed the whole business of making clothes, and we know that in time it led to

Indian Woman Weaving

the invention of one of the oldest of old tools—the distaff.

A flock of wool from a sheep's back, or a boll of cotton gathered from a cotton plant, seem very unpromising materials for a coat. Pull the soft wool or fluffy cotton out in the fingers, giving it a twist as you pull, and you make a discovery. It "threads" or spins. With a little practice any material, like wool, cotton, or flax, can be twisted and drawn out into a thread called yarn. Women discovered this centuries ago, and some one invented a tool with which it was possible to spin long, continuous yarns or threads. It was a short, thick stick, split at one end and held under the arm, and was called a distaff. The bunch of loose wool was caught in the cleft stick and firmly held, and the spinner pulled it out, twisting it between the fingers with a twirling motion, and wound it on a spindle or spool, the weight of the spool helping to stretch out the twisted wool. This, the oldest form of yarn spinner, has been used for uncounted centuries, and was in general use up to our own colonial times.



Spinning-wheel

The only improvement made on the distaff was the spinning-wheel, and to-day in many an old New England home you can still see the spinning-wheel once used by our great-great-grandmothers, for the colonial women were all famous spinners of yarn. The Continental soldiers often wore "home-spun," meaning garments made from cloth that was first spun into yarn at home by wife and mother.

Fortunately, the spinning-wheel has been replaced by spinning-machines, and now wool, flax and cotton are all spun into yarns, ready for the loom, by the most complex and wonderful machinery, and women are forever free from all the toil of spinning.

We cannot even imagine how long ago women began to use the distaff, because we can readily understand that even before it was invented, women and men had learned to weave grass, straw and slender rods of willow into baskets, and the demand for clothing must have suggested the weaving of yarn into cloth, or the braiding and knitting of yarn into stockings and other coverings for the head, the hands or the feet. These things are all lost in the dim, far-away past, of which we have no records or even faint memory or tradition. Somehow, somewhere, plaiting, braiding, knitting, and weaving grew up among the people, and the first fabrics or cloths were made. The thorn suggested the pin, and the awl suggested sewing, and so from these and the fabrics came clothing. Then, at last, came the greatest invention of all—the needle. The awl made holes in the fabrics, but the thread had to be put through the hole afterwards. The needle was an improved awl, with an eye. A thread could be passed through the eye, and then the sewer had a portable thread-carrying awl or needle, and the real art of sewing began.

Knitting, plaiting and braiding, combined with sewing, made it possible to make real cloth, but basket-weaving, a hand labor, no doubt suggested the last and best of all fabric-making machines—the loom. In museums where colonial relics are preserved we can sometimes see a strange wooden machine with a great frame, a roller and a curious spool, sharp at each end, and called a shuttle. We see in the machine many threads of yarn stretched side by side from the back to the front of the machine. These threads may be, let us say, all white. At the front of the machine is a curious device looking like a huge double comb, the threads all passing through it. The shuttle may be lying loose in the loom and wound with a single black thread. The operation of the machine is very simple. By a movement of a foot-treadle, one-half of all the parallel white threads extending from the back of the loom, and called the warp, are raised or separated from the others, every alternate thread being thus lifted above the others. Then through this space between the two sets of threads the weaver throws the shuttle with its black thread, called the weft or woof. The woof unwinds and lies between the two sets, or crosswise of the warp-threads. The woof is pressed back close to the last thread delivered by the shuttle. The weaver then raises the other group of alternate threads and the shuttle is thrown back again on its return journey. In this manner the fabric is slowly woven, and as the warp is white and the weft black, the result will be a mixed black and white, or gray fabric. The fabric, as fast as woven, is wound upon the cloth roll in front of the loom.

To show how old the loom is we have only to recall how many words in our language are but names of the parts of a loom or terms used in weaving.

With the application of power to the loom, in the eighteenth century, there sprang up in our country and Europe the great and prosperous business of weaving, giving employment to hundreds of thousands of people, and making it possible for all the people to have beautiful cloths for garments at very low cost. A very great number of improvements have been made in the loom, so that now it bears very little resemblance to the original hand-loom. One of the greatest of these improvements was made by Jacquard in France in 1801. Jacquard's improvement consists of a most ingenious system of perforated cards, so arranged that one card at a time was placed in the loom just as the shuttle was thrown. The perforations of the cards, through suitable machinery, controlled the number of yarns to be raised or lowered as the shuttle passed. As each card had a different set of perforations, the arrangement of the warp-threads was changed at every flight of the shuttle, and, as a result, a figured pattern was woven in the fabric. Thus, by this remarkable invention, the loom itself automatically produced any pattern marked by the perforations in the cards. It is not possible here to examine all the countless additions and improvements that have been made to the loom in this and other countries within the past one hundred years. We can only recognize that they have made the power-loom one of the most important of all modern machines. Knitting has been for centuries a handicraft for women, and yet now very few women and girls can knit, for we have another fabric-making machine—the knitter.

The old tool, the needle, is still used, and will, no doubt, always be used. It is the one household hand-tool that every girl and woman should be able to use with skill, and yet this tool also has been changed to a power-tool. For centuries the eye of the needle has been at the top or blank end, which is the proper place for it in hand-sewing. The simple idea of placing the eye near the point made the sewing-machine practicable, and to-day the larger part of all sewing is done at home or in factories on sewing-machines.

These machines—the spinning-machine, the power-loom, the knitter, and the sewing-machine—have taken a grievous burden from the shoulders of women. To-day beautiful cloths and garments are cheaper than ever before, and millions of women have been released from dull and monotonous labor, and left at liberty to do better and finer work in other directions. No girl can afford to say that she cannot use a needle or a darning-needle. It is a good and womanly thing to be able to sew and to make a garment. Even darning and patching are little arts of which every girl should be mistress. A girl may well say she would rather darn her old stockings than run in debt for a new pair.

CHAPTER XII.

SOME CLOSING SUGGESTIONS

We have now examined some of the great tools used in the work of the world. We have seen that they are like milestones, marking the progress of the human race. Up to our own times all tools were heavy, clumsy, and inefficient. Now all tools made in our own country are wonderfully light, strong, convenient and effective. Many are even beautiful as well as useful. They do the work for which they are designed in the quickest, cheapest and best way, and any young man or woman may be glad and proud to use them, for they are the best tools in the world. They are constructed upon scientific principles, and are effective because scientifically adapted to their work. Moreover, they are marked by a wonderful ingenuity, a more wonderful originality. The Englishman, the German and the Frenchman also make fine tools and splendid machines, yet all three are ever ready to see the last new American tool, and, if it be good, to adapt it at once to their own trades and manufactures.

We have also seen that all the hand-tools have been slowly merged into machines and that all machines are in reality greater tools. The needle has been transformed into the sewing-machine, the sickle has become a harvesting-machine, and the plane has grown into the planer. As for the knife, it is in a hundred machines, and the file, the saw, and the gimlet all live in great power-saws, files and borers. Then, too, some hand-tools have disappeared and have been replaced by machines. Not a woman in all the land holds a distaff or whirls a spinning-wheel, because all the work of spinning yarn for weaving is now done in the spinning-mills. Not a farmer in the land uses a sickle to gather his wheat. Not a single laborer drags up and down the heavy pit-saw used a hundred years ago. Millions of men and women have been released from hard and ill-paid labor, and to-day their labor is performed by machines. Now, this might lead us to think that, because so much of the work of the world is performed by machines, therefore, you and I need not use hand-tools at all.

That would be a strange mistake. The great and wonderful multiplication of machines does not mean that hand tools are not or need not be used. There are more and better hand-tools in the stores to-day than ever before, and no young man or woman can afford to say that he or she has no tools and does not know how to use them. We all use tools of some kind every day in our lives, and the greater our skill in their use the greater our ability to do good work.

There is that old tool the pen. Up to quite recent times every pen was cut out of a quill plucked from a dead goose. Every man had to have a pocket-knife or "pen-knife" to keep his quill pens properly cut. Now the pen is a wonderfully fine piece of steel or gold, and even the steel pen has been improved, and we have the self-inking fountain pen. On the desk is a rubber stamp to save pen labor. It is a printer or printing-tool, and it stands for a grand machine—the printing-press. Within the past few years still another printing-machine has been invented—the typewriter.

We go to walk and take a wonderful new tool with us, and record the scenes we see with a camera. In the store we see a cash-register counting and recording money. In the bank we see strange machines that will do endless sums in arithmetic and never make a mistake. In the telegraph office we hear the chatter of that marvelous tool—the sounder—or we listen to the mystic voices that come to our ears through that strange new machine, the telephone. Even as we walk the streets we see the electric car and the automobile, machines full of wonderful possibilities in the future. Everywhere are tools and machines to save labor, to do work and contribute to the comfort and pleasure of all the people. What, then, is our duty? It is to see, to study, to understand and to use these grand things to the end that the world shall be better for our knowledge and our skill with tools.

We may not, just now, stop to examine every tool and machine, yet with the knowledge already gained we can go on and see and admire still other machines not already mentioned. There are the great motors, the self movers, the turbine, the steam-boiler and steam-engine, the traveling engines, the locomotive and the marine engine. Then there are the transformers and conveyers of power, the dynamo and the electric motors. There is the great and notable company of the printing-presses and their relatives, the composing-machines. There are the new strange machines for handling materials, the car-loaders and unloaders, the steam-shovels and the wire transport machines and the elevators and conveyers of coal and grain. Then, in shops and factories, we shall see box-making machines, chain-making machines, laundry-machines, stamping and pressing-machines, traveling-cranes and hoisting-machines. Everywhere machines in endless variety, of tremendous power and wonderful ingenuity. Our studies of tools enable us to comprehend, and certainly lead us to admire this vast array of strange, new and wonderful things, that so marvelously contribute to our comfort and safety, that make life to-day so well worth living.

Within the past few years there has grown up among the people of our country a desire to own and preserve fine examples of the hand-made silverware, furniture, rugs, embroidery, and pottery made by the skillful craftsmen of colonial times. Every old house in New England and Virginia has been searched, and still the demand far exceeds the supply. This has inspired hundreds of young men and women to endeavor to supply this demand for hand-made things by making new rugs, tables, chairs, embroidered table-linen, baskets, jewelry, silverware, and pottery made from original designs and with hand-tools. Scores of little shops are springing up all over our country, where these young men and women make and sell the products of their own skill in the handicrafts.

Here we see still another reason why every young man and woman should know how to use hand-tools. Skill in the use of such tools, combined with an artistic education, opens the way to new and profitable employments. This revival of the handicrafts teaches even more; for, while we may not use tools, the knowledge of what tools are and how they are used will add greatly to our appreciation and understanding of the beauty and value of these new things made with old tools.

Lastly, we should, every one of us, be able to own and use a few good hand-tools. In every home there should be some place for tools. A drawer or box will answer, but the best plan is to have some kind of closet or cabinet with doors and a lock. Inside there should be hooks or nails on which the tools may be hung up in a safe place and yet within easy reach. There should also be a shelf or two for the heavy tools like the plane. A few boxes for small things, like loose nails or screws, should also be provided. Now, whether such a tool-closet be large or small, whether it hold few or many tools, it should always contain certain convenient things that are used with all tools.

The first of these is the level. At the hardware store we may see many levels of different sizes and styles.

The common carpenter's level, which is a very useful form, consists of a bar of wood containing a glass tube imbedded in the wood, the tube being filled with a liquid. In this liquid we see a shining bubble of air imprisoned in the tube. Placing the level on a table, we observe that the most minute and delicate vertical movement of one end of the level causes the bubble to glide from side to side along the tube. We soon discover that only when the level is resting on a true plane, with no part higher than any other, that the bubble rests quietly at the exact middle of the tube. The level appears to have been known to the ancients, and we see that by its aid all buildings and structures ever built were made true and level. We plane a board on edge and rest the level upon it to prove if our work be true and level. If the place on which the board rests be level (and we can prove that) and the bubble in the level remains in the center when the level rests upon it, then our work is right. So with the making of everything, so even with the hanging of a picture, let us be true, exact and "on the level," and prove all our work with our level.

Next we should have in our cabinet a small steel square. This is a simple right angle of steel, usually marked as a footrule, and we should never do any work of construction, even if it be only a wooden box, without testing our work that it be square, right angled and true. There are many styles of squares, from the simple steel "try" square to a combined straight-edge, level, bevel and square. For making drawings and plans for work we shall also find a T-square very convenient. We should have also an adjustable try-square for forming angles and bevels.

Next to the level and square is the plumb. This we should make of wood for our use, buying only the iron plumb-bob at the hardware store. Borrow a plumb of some mason, and use it as a pattern. The level gives us a true horizontal plane. The square proves our work to be true and right angled, and the plumb proves that any structure we may build stands erect, and that its sides are vertical or "on line." The plumb proves whether our work be "out of line" or not, and anything "out of line" is false and disagreeable.

The next essential is a rule of some kind, the most convenient being the common wooden folding rule, marked in inches and fractions. A small rule that fits into the vest pocket will soon prove to be of daily use in all that we may do with tools. With these four—the rule, square, level and plumb—we can use any tool, and, testing our work as we proceed, know with certainty that it is correct in dimensions, is true, square and level.

A large part of all modern work is now put together with screws, or is bolted together with nut and bolt. All pipes, steam, gas, and water-fittings are now put together with joints that screw together with couplings or other applications of screws. So we shall find a common screwdriver indispensable, both in putting woodwork together or taking it apart. For nuts and screws in all pipe and metal work, we shall require a good wrench, and the best style for our purposes is the wrench having adjustable jaws and called a "monkey-wrench." For tightening up a leaky gaspipe we need a pipe-wrench, and for all ordinary purposes small burner-pliers with roughened jaws will be sufficient.

So many things are sold by weight or are measured by weight, that we shall find that some kind of weighing-machine or spring balance will be useful. We can find them at the hardware store in every style and at all prices. A cheap and convenient style is a spring balance, as it is easily carried in the hand and can be hung upon a hook in our cabinet. If we use our saws and wish to do good work, we shall find that a miter-box will be very useful in sawing wood at an angle. It is a simple, narrow box of wood open at the top, and having sawcuts at different angles in the sides of the box. The best plan is to borrow one from the nearest carpenter as a pattern, and with your own tools, to make your own miter-box.

There should also be a quantity of cut nails, wire nails, barbed nails, tacks and brads. An assortment of screws of different sizes, a few double-pointed tacks, staples, and screw eyes and screw hooks will always be useful. The best plan is to get at first a few tools, say a hammer, two saws, an awl, a gimlet, a chisel and a knife, and then add to the stock as we learn to do more and better work. Lastly, paint a neat sign on the inside of the cabinet:—"*A Place for Everything and Everything in Its Place.*"

INDEX