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THIRTY VOLUMES

VOLUME TWENTY

PRACTICAL AND AVAILABLE MEANS OF DEVELOPING EXACTNESS AND SKILL BOTH MENTALLY AND PHYSICALLY. THE CULTIVATION OF QUICK AND ACCURATE DECISION AND THE GROWTH OF CONSCIOUS POWER AS ESSENTIAL ELEMENTS OF SUCCESS

"*Men, my brothers, men the workers, ever reaping something new.*" TENNYSON.

"*Patient training is a necessary ingredient of genius.*"

"*The secret of success is constancy to purpose.*" DISRAELI.

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takes to do with his own hands. This is the right culmination of all that he has been gathering. His ideas of angles, lines, and points, help him to see; his sense of companionship and achievement helps him to do — and from seeing, feeling, dreaming, and thinking, it is the end and aim of Manual Training to lead the child to a *doing* that shall be to him a sign and representation of his own power.

Sewing is given to children in schools because it belongs to man's growth along the higher degrees of existence and has proved to be an element of refinement in education. The needle is a little cylindrical tool; the thread is the means by which a design may be carried out to completion. Through practice with the very first card sewing, the child discovers that his lines run up and down, from side to side, round about through the circle and across by every possible slanting line. He works in this, in common with all humanity, finding the line possessed only of length or direction — its single dimension. He sews through and through his material, it is true, but the result of his work is on the outside — a result of outline inclosing a plane. But as a child or a class works on in the higher department of sewing, this flat linear work gives place to the production of the round — that is, to the making of clothes that are in themselves cylindrical in shape, having bodies, legs, and sleeves — the encasement of living human figures. This is the natural progress of sewing, and this is the far-off goal of every child's ambition when first she enters upon a course of sewing proper. So the industry follows human life, and in its technical development becomes an illustration of the law of growth that in all things "rests, works, and rules."

The charm of sewing as a process lies in its element of repetition. The movement along the seam is continuous for the eye, for the hands, for the needle. The line that is left behind is similar at all its points. The distance may be long, requiring many sittings, or it may be accomplished, as is best for beginners, at one lesson or sewing hour. But the motion of the stitch once taken, the muscles follow upon the model given and the pleasure of rhythmic movement becomes consciously pleasant. This comes with practice, the first pleasure to a child being the appearance of the stitch itself as a result of painstaking, and the looking forward to an end — to the knowing how and the power to do. But the rhythmic quality of sewing is peculiar, and to consider it and its effect upon a child will be a help to any one who has an observant eye for changes of mood consequent upon changes of occupation. The sewing should never be a task severely imposed. It should be so presented as to be attractive — the vital point to remember here being that the force in the child is really seeking for some form by means of which to express itself, and the sewing, if given pleasantly, may be of service to calm a restless moment by its own character — its quality of repetition. Here, too, many times with youngest sewers, it is of use to fall into some gentle song leading to the work — a song for clean hands, a song for work, for change of work, or for work after play. Many a child's idle habits of refusal, of questioning, or of over-eagerness, can be prevented from expression, or made to be forgotten, by the quick singing of some favorite melody. The child who in a class is about to distinguish herself by tears, or by some misuse of her hands, with things or other people, can be made the leader of a song — as the kindergartner and many a mother and teacher knows. And with the sewing, many little songs, or the quoting of couplets or verses at apt moments, will touch a child's intelligence and sympathy, holding the volatile energy steady until the spirit of the occupation asserts itself and leads the power of mind and hand together along the way of industry.

In a small advanced class of sewers, or especially at home, when some proficiency has been attained, the teacher should have this question of the mental attitude of the pupils always in mind and should keep prepared for its instruction. For sewing is in itself a silent occupation. There is no sound to distract or to forbid thought or speech; there are no tools, as with woodwork, to lay down and to take up, no constant change of position, measurement, and adjustment of heavy or noisy materials. It offers periods of silence between periods of instruction and oversight, and thus, by its own character, to a degree sewing is a conversational employment. It allows and invites more or less of talk, not steadily continued, but broken by attention to the work, flowing along, a happy, open chatter, a commentary, a whisper, or even the telling of some little incident.

Here, then, natural inclination and habit offer opportunity for educational influence, and for training children in the fine art of conversation. This talking together is a mutual art, wherein all who enter are equals as to right of expression; and it is wise to set forth this principle of companionship and to establish it in all its native delightfulness at the beginning.

In a conversation, each has something to say, or will have as the time passes. Each should have opportunity to speak, and if one in a group is not by nature a talkative child, he should have all the time he needs and all the help that he can agreeably accept, by means of gentle questioning, or in brief suggestion, and in silence free from all impatience.

Conversation is an art, because it can always pass from the prosaic statement of facts to the flight of fancy and to the true imagination that lies above any subject whatever. Language is for all uses and for all estates of life. It arises as a sign of the power of life within us, and if we observe its process, we see that it comes forth as a result of the life within in connection with the life that the child meets in nature and in society. "Language, like mathematics, has two sides; it belongs both to the inner and the outer world. Viewed in the light of the study of nature, language is an expression of energy lifted into life; viewed in the light of the study of man, it is the expression of the human mind lifted into consciousness. Language, therefore, must be born as the spirit of man enters consciousness, and is inseparably one with this spirit."

The idea of language, as it may be used in our companionship with children, and in their association together, is, then, to help the energy of thought and of feeling that stirs within them to come forth, or, to be "lifted," into a clear vocal sound that shall be a revelation of the spirit within. Neither the child nor we who seek to train him have any real vantage until, at its right season, this power of speech comes to our aid. When developed, it is a threefold process. Life within is the starting point; the world without is its arousing influence. The child perceives, desires, purposes, and speaks. That he should learn at once to speak well is important, and the first principle in this practice is the same with the child as it is with the man, —that he shall first have something real to say, and that he then shall have time for the utterance of his words.

It is easy to show to a class the real meaning of the word conversation. It is alternate speaking. It implies the presence of two, or of more than two, persons. It is a giving and taking—a circling round of thought and speech in a company of people. It is a social art, and as such it reveals many and diverse points of human character; selfishness and its restraint, perception quick and true, or disregard of outward objects; a natural fluency in language, or the slower grasp upon words and phrasing.

In all of this there is room for interesting study, both for the children and for whoever is leading them; and if the conversational habit is rightly allied to that of handiwork, the two can grow together toward excellence. That is, if the children are to talk while they are engaged in any of the lighter crafts, such as sewing, for instance, a conversational standard can be established at first that will gradually become a habit of mind and will be of effective service as a mental training. This can be done by setting before them, in phrase and verse and brightly-spoken sentences, the allurement of pleasant words; by leading always toward things that are positively fine, by leading away from personal remarks, by teaching that all are to help and none are to hinder, and that conversation is one of the lovely ways of using the time, of promoting companionship, of creating joy. In this the teacher should not be dictatorial. Politeness requires listening and reply. The speakers are to be heard singly, not in chorus, except now and then when some natural exclamation calls out their voices together.

When we wish to give voice to sound in unison, we put our language into music. In that musical expression we speak the same words at the same time, fitting part to part in a regular order which all observe. This creates musical harmony. It is one means of human utterance. It is a way by which we show our love for all things — the life and beauty of nature — the love and joy, or sorrow, of our human life — our love of God.

But we talk more than we sing, and when we talk we take no measured time or form of words, but following our thoughts, phrase them as seems to us best, so that others shall know what we are thinking about. The first idea underlying conversation, then, is freedom, with consideration for the rights of each in the circle, and room for the power of each.

That there are natural rules to govern the talk of children at work is in itself an attractive idea; and since that rule is "the unchangeable third principle to which pupil and teacher are equally subject," there is nothing arbitrary in its control. It is in reality an esthetic principle, lying at the basis of common usage and having influence to redeem an hour from dullness for the teacher, while to the child it discloses a rule and a reason for conduct that can but be a stimulus, not merely in what he says, at the moment, but in his general social bearing.

It is by means of this unity of principle within, and unity of social right, that harmony is attained. If that sense of right remains, the outward expressions can be as varied as impulse may prompt, and all will go cheerfully and well.

As to subjects, they are often admirably proposed by the children. What is then required is a clear response. Also, no training in language is better for a child than simple, sincere reading of things that are well said. For instance — "You do not know what leaf-form means unless you have seen the buds burst, and the young leaves breathing low in the sunshine, and wondering at the first shower of rain." These words refer to drawing, but let a child hear them quietly read or repeated and he is at once inclined to go out and look for himself at this work of nature.

Whatever a parent or teacher can read to give impulse to real observation of nature will prove most suggestive as to language and its use for children — real observation being of course not purely for the sake of fact, but also for the sake of beauty. For instance, in

Ruskin's « Two Paths,» in a few pages upon « Iron in Nature,» hints are given that suggest at once the ever-present action of iron, and the charm that in common things results from its presence; and a hint so gathered may, at a happy moment, be given to a child and become a means of interest that will lead away from meaningless words to the use of good language as an expression of the growth of thought. So too, in Ruskin's « Queen of the Air,» in his « Modern Painters,» in his « Deucalion,» and books upon flowers, may be found clear-sighted, accurate description, relating the forms of nature to human life, and offering lines of conversation, because they deal with things that children love and notice for themselves, and because they unite bare fact with beauty of every degree in nature, and are set forth in language that is in itself an educating influence.

In any social talk with children the ideal should be to draw out the native power of each in relation to a given subject, in the way of refinement of thought, perception of grace and beauty, and the happy choice of words. The talk should be a harmony free from emotion, with a good balance of heart and head, and with nothing that is either a task or a moral too pointedly put, or in any sense personal except in general ways. When this ideal is held by the mother, she will store up pleasant things to use at need, and in the drifting talk that runs along with any of the children's industries, but especially with sewing, she will elevate the tone by wise words dropped here and there on the basis of what is, with herself, a long thought and a clear one, as to all that conversation means.

It is evident that the study of any industry in its connection with children leads us as in a circle through all the steps of its development back to our starting point, which is the child himself. By any work that the child may do, in the light of modern educational thought, the idea that underlies the occupation is that the process makes manifest the law of the work, and that by its practice both the child's mind and his body get a training that helps his general development of power. To keep this clearly in mind is to relieve the teacher from the sense of restriction and drudgery, for refreshment lies in the comprehension that in education we deal primarily not with facts and things, but with life itself. And life comes eager to seize everything that offers as a means for representing itself « externally » along the lines of its threefold relationship,— the natural, visible things of the earth, the invisible power of the divine, which is purely spiritual, and the things of human life,— the plane of human being where all activities culminate.

« Man is developed and cultured not only by what he receives and absorbs from without, but much more by what he puts out, and unfolds from himself." In order that the force of life may put itself forth in those directions that in the return and reaction of energy will enable them to bring the best back as their harvest, we should surround the child, while he is at work, with everything that is fine and elevating. The sewing hour should be made charming with tidy dressing, with flowers, potted or cut, with a book or two at hand out of which some one may read a verse or a little story, and, above all things, the atmosphere should be kept equable and clear, without strain, and without direct teaching. Incidental remark goes a long way to touch a child's sensibility, and the sewing hour may be to a teacher, or to the mother at home, an opportunity for wise dropping of seeds of thought that will have influence upon character, and lead in time to that high and clear representation of mind and heart that is our constant ideal.

To this end we must ever remember that what we are doing is a part of the universal life. As Froebel says: "This is the first general presentation of the great laws and tendencies of nature — to represent each thing in unity, individuality, and diversity, to generalize the most particular, and to represent the most general in the most particular; and lastly, to make the internal external, the external internal, and to represent both in harmony and union.

"If, at the same time, we keep in mind that man, too, is almost wholly subject to these great laws, that almost all the phenomena and events of his life are based on them, these considerations will reveal to us also the nature of man, and teach us how to develop and educate him in accordance with the laws of nature and of his being."

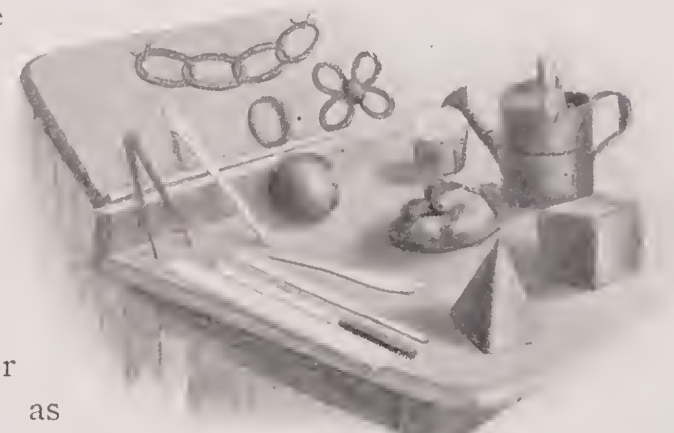
MODELING IN CLAY

Clay is one of the best mediums we have for imparting a knowledge of form, because in modeling it we deal with solids and not with planes, and in using it as a mode of expression the sense of touch is highly developed. The most beautiful curves which the sculptor molds are produced by the fingers, and their delicate variations are sometimes perceptible to the touch more quickly than to the eye. Clay modeling employs both hands — an important thing from an educational and physical point of view. It may be so linked with nature study, in the reproduction of forms of fruit, fish, butterflies, and other objects, that the pupil will have greater interest in both lines of work. It also increases the sense of power in the modeler, as he finds himself able to reproduce his finest ideals in so plastic a medium. It quickens the faculty of observation and as an aid to memory it is invaluable.

For example, suppose a dog is to be modeled from memory. In his first attempt the pupil may produce a gross caricature of the animal, but he will know that it is incorrect, and when he next sees the living animal, he will note with care its proportions, its lines, and its natural poise. On repeating his attempt to reproduce the dog in clay, he will draw on his memory for a faithful picture of the dog, and come nearer to success.

THE PLANT

The plant needed for clay modeling is simple and inexpensive. A table with a smooth top, twenty inches wide, and at least thirty inches long, will be needed, and should have a strip at the back, so that the clay will not be pushed off and litter the floor. A hinged back, which may be fixed at any desired angle, for holding drawings or models, is a useful accessory. The tools include a palette-knife, with which to cut and smooth the clay, and one or two wooden modeling-knives such as are sold by kindergarten supply stores.



Ruler, triangle, and compasses, will be needed in measuring some kinds of work. A small watering-pot, for moistening the clay, completes the outfit. Drawings and models may be supplied as needed.

There are several kinds of clay,— red, yellow, blue, and gray. The gray clay is preferable. It may be obtained from a pottery, where ten or fifteen pounds will cost only twenty-five or thirty cents. If no pottery is accessible, clay of fine grade may be purchased at an art store, where the price will be higher — four or five cents a pound.

A wooden box in which to keep the clay must be provided. Clay cleaves from wood but adheres closely to metal or porcelain, and boxes lined with either of these substances should not be used. When not in use, the clay should be covered with a piece of thick, woolen cloth, which will serve to keep it moist. If the clay is not to be used for some time, it should be exposed to the air and allowed to dry, which will keep it "sweet" and do away with any musty odor. When it is again needed, water may be added and the whole mass moistened and kneaded to the proper consistency.

There is no reason why clay-modeling should "make a mess," either on the floor or on the clothing. The lump of clay should be kept on one corner of the board, and portions cut off only as they are needed for immediate use. Scraps and shavings should be kneaded into the original lump. The work may be done even in the library or the sitting-room, and should not "make dirt" to trouble the housekeeper. A care for neatness in the beginning will prevent litter, and will contribute to the educational value of the work.

The first models will be crude and not worth keeping. They may be thrown into the clay-box and worked into the general mass of clay with a small wooden spade. This may be quickly fashioned from a shingle. The working over of dry clay will call for the vigorous use of an iron shovel. In this way the original purchase of clay may be made to serve as material during many lessons, for it can be used over and over.

MANIPULATING THE CLAY

Before beginning to model forms, it is desirable for the learner to understand, in a general way, the properties of clay. Unless the clay is of the right consistency, it cannot be easily modeled. If it is too stiff, it will crumble and break and cannot be readily made to take the desired shape; in this case it must be moistened by applying a very little water at a time and kneading the clay until the water has been distributed throughout the lump, making it of even consistency. On the other hand, if the clay is too wet, it will not retain its shape and will be too sticky. It must be dried a little before it is used.

Take a piece of clay as large as a hen's egg and roll it between the palms of the hand, as you would roll molasses candy, until it is about as thick as your finger throughout its length. Hold it up and you will see that it is as limp as putty. But if you pinch it so as to make it hold together more firmly, it becomes quite stiff and will stand alone. This pinching is what the potter calls "wedging." In modeling it is necessary to constantly pinch or "wedge" the clay so that it will retain the shape you give it.

Take the same piece of clay and roll it briskly on the board. Squeeze it in the hand and then roll it out again. The clay does not hold together, but breaks and crumbles. The potter would say that it is "rotten"; that is, it has lost its elasticity and in this condition it cannot be used for modeling. But if you moisten it and knead it thoroughly, it will resume its former pliable state and be ready for use. This is called "tempering" the clay.

ELEMENTARY FORMS

The first forms modeled should be simple ones, chosen with a view to giving the pupil familiarity with the manipulation of clay, rather than with reference to the modeling of form, a sense of which is, nevertheless, quickly developed, even by preliminary exercises. A ring is a good form for practice. Take a small piece of clay and roll it in the palms of the hands until it is three or four inches long, and half an inch in diameter. Join the ends and manipulate the clay so that the joint will not show. Take pains to make the ring of even thickness, and smooth throughout. Another ring may be made and linked to the first, and then a third, thus forming a chain.

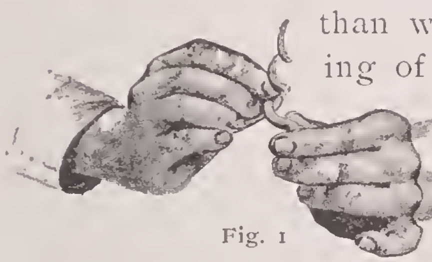


Fig. 1

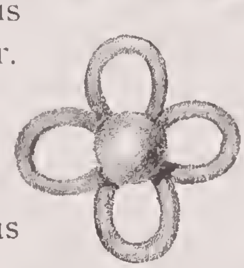


Fig. 2

The sphere will naturally suggest itself as a good form. It will be difficult to make a perfect sphere unless the clay is of the right consistency, and it should be brought to this consistency before the form is laid aside, in order that another may be taken up. Small balls, about the size of marbles, may be rolled out and piled in pyramids, like the mounds of cannon-balls at a fort.

A leaf may be easily made. Shape a small piece of clay between the palms until it resembles an arrowhead. Then, holding it between

Fig. 3

the thumbs and forefingers, press it thin and at the same time give it the form of a leaf. A tiny ridge down the center will be the mid-rib, and the veins may be indicated on either side. The edge should be notched and the stem fashioned as nearly as possible like the natural leaf. All this may be done by pressure of the thumbs and fingers, and without implements. A walnut, with its sharp-pointed end; a chestnut, with sloping sides; an egg, a turnip, a carrot, are some of the forms that may be easily made in this way. Five of the leaves thus made may be joined by the stems, and a half sphere added at the center so as to form a rosette.

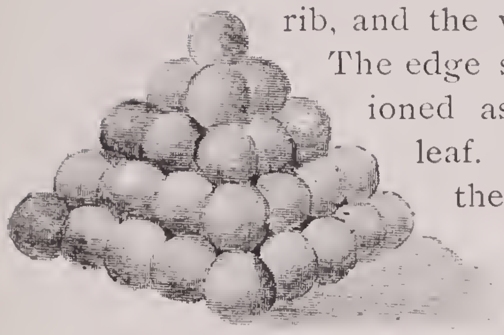


Fig. 4

Fig. 5

It is suggested that the forms of fruit, vegetables, etc., first attempted, should be those which can readily be reproduced in the natural size. For example, the first egg modeled in clay from memory will probably be larger or smaller than the average real egg. After a clay egg has been made, it may be compared with the real one and the difference in size noted. This helps to train both observation and memory, two faculties which clay modeling stimulates in a large degree. Miniature forms should not be made when it is practicable to reproduce the model in its natural size.

Fig. 6

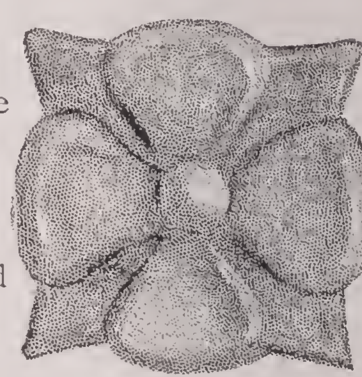


Fig. 7

Children always manifest great interest in the modeling of animal forms, and the pupil should be encouraged to make them from memory. For example, a dog may be modeled. A piece of clay as large as the fist may be rolled out, then flattened at the sides, for the body. A small ball will serve for the head, and the snout should be given shape, while the neck is made thinner than the head. Small pieces of clay may be modeled to represent the tail and the legs. The figure produced at the first attempt may not resemble a dog very strongly, but that does not matter. The pupil can make another, and the second will surely show an improvement over the first. A chicken, a cat, a lamb, a pig, may be modeled in like manner.

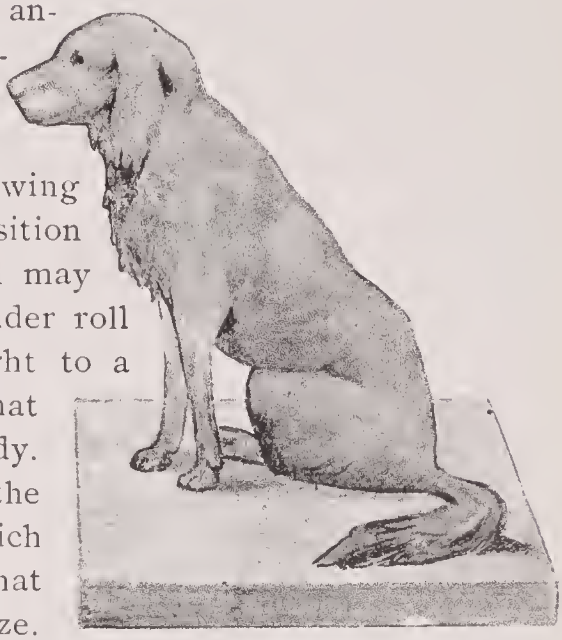


Fig. 8

A frog is not an easy form for a beginner, owing to the difficulty of representing properly the position of the legs; a snake is simpler, and may be made without difficulty. A slender roll of clay is made, the tail is brought to a point, and the head is flattened so that it is a little wider than the body. With the tool make the eyes, the mouth, and the tongue, which will necessarily be somewhat exaggerated in size. The snake may be curved in a wavy line, as if moving through the grass, or coiled, with the tail projecting and the head raised in the attitude of defense.

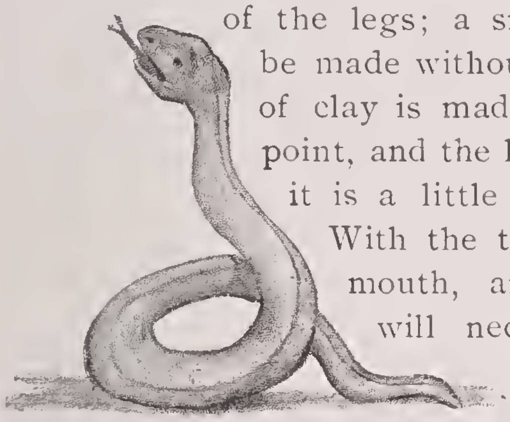


Fig. 9

A mouse is another form that may be easily made. The body is made from one piece of clay. The legs and feet are pinched to the proper shape and a long slender tail is made, and these are stuck on. Two bits of clay are added in the proper position for the ears, and the ears, eyes, and mouth are then shaped with the tool.

A squirrel sitting on its haunches is a good subject. The hind legs should be rolled out and pressed into shape, and incorporated with the body; then the fore legs, with the paws raised, and holding a nut. Making the long bushy tail curve gracefully up and away from the body will test the sense of form already possessed by the modeler.

Fig. 10

All these forms from life are instructive and pleasing to the modeler, and, although the first figures produced are often so crude that they are not worth preserving, the practice afforded is excellent.

HOLLOW FORMS

The making of hollow forms is an interesting phase of modeling. A cup will naturally suggest itself as one of the first of these forms to be made. Take a solid piece of clay, an inch and a half in diameter, and press the thumbs down into it. Spread it out little by little, turning it round from time to time, and try to secure an even thickness by manipulation with the thumbs and fingers. Do not try to make it too thin. The clay will have a tendency to spread out from the top and must be "wedged" and restored to the proper position. The sides should curve gently toward the bottom. Flatten the base on the board, and then pinch the edge of the base into the form of a rim. For the handle roll out a slender piece of clay and mold the ends into the side of the cup, giving the loop a graceful bend. A small pitcher, flattened at the sides, is another good form. The rim may be drawn out to form a lip. The pitcher should not have too narrow a top, which would prevent easy manipulation with the fingers on the inner side. In making such forms as have been suggested, the worker will need to remember that, wherever it is necessary to attach legs to an animal's body, or the handle to a tea-cup, the joint must be made by manipulating the clay at that point so that the two pieces will be thoroughly incorporated with each other; if the small and slender pieces are merely pressed into place, they will drop off when the clay dries.



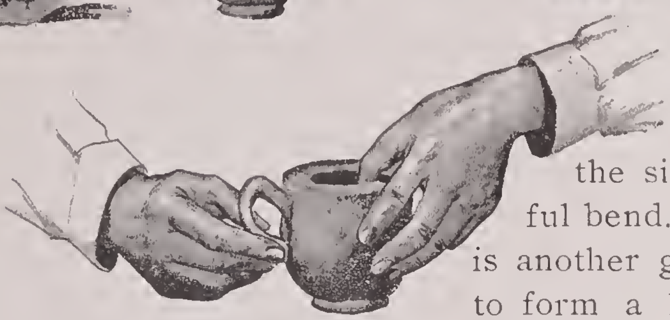


Fig. 11

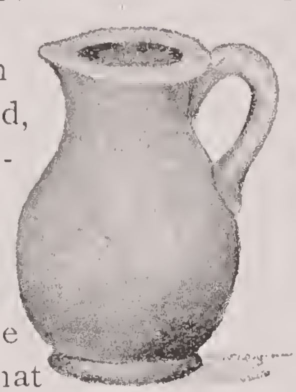


Fig. 12

Fig. 13

TILES

The modeling of tiles in design is not so interesting to a young child as the making of forms from nature, in the round, but it affords excellent practice, and the making of simple tiles and borders should form a part of an elementary course.

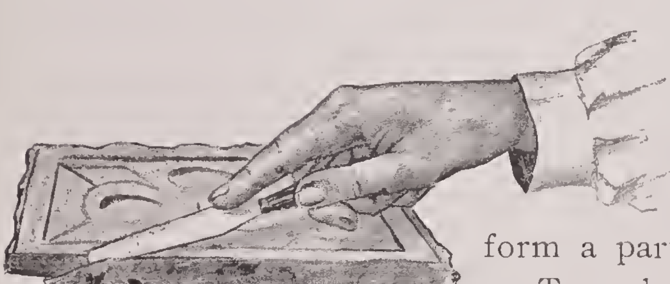


Fig. 14

To make a tile, take a piece of clay and press it flat on the board. Then add another piece and join the two thoroughly. Keep on adding pieces in this way, until you have a flat piece large enough for the proposed tile. Make it flat on both sides by pressing first one side and then the other against the board, and have it of even thickness throughout. Then transfer it to the slate. With the end of the knife cut the clay to a rectangular form. A pattern may now be drawn on the tile and then pricked with a wooden point, as in Figure 15. A more elaborate design is shown in Figure 16. Here the outline is pricked and the rosettes are embellished wtih bosses, which are separate bits of clay added to the tile and then pricked. Animal and fruit forms may be mounted on simple tiles and preserved in this way.

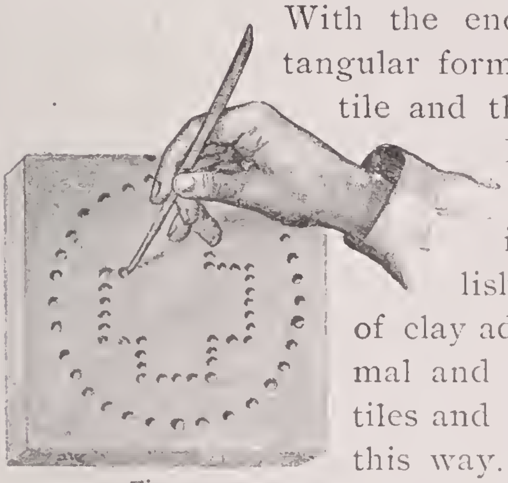


Fig. 15

The exercises suggested up to this time are merely introductory, and are intended chiefly to familiarize the pupil with the possibilities of modeling and the actual manipulation of clay, and to make the work so interesting that he will be enthusiastic in his desire to take up advanced work. These simple forms are not only suitable for modeling by young children, but should be selected as the first to be attempted by older hands. Manual Training, of which clay modeling is a feature, seeks not only to impart information but to create interest in the work done, as a sure means of generating ideas. The modeling of geometric forms, which has its place in advanced work, is essential in teaching accuracy, but, in creating interest, is not to be compared with the modeling of natural forms; hence the preference given to the latter in a course for beginners.

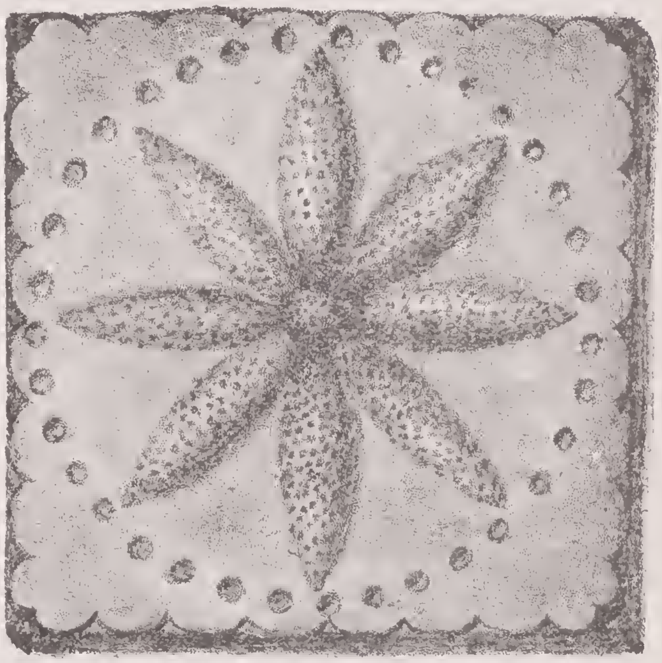


Fig. 16

CLAY MODELING AS AN AID TO NATURE STUDY

One of the advantages derived from clay modeling is the opportunity it affords for combining the actual work in clay with nature study. Instructors in modeling often lay too great stress upon the imitation of approved objects of art, and set children to modeling from casts of famous sculptures. Undoubtedly these forms are both beautiful and worthy of reproduction, but to the young mind, the armless Venus of Milo is less interesting than a living animal or a fruit; it is farther away from the sphere in which the child's mind is accustomed to dwell. Besides, it is the work of a great sculptor, who understands those principles of art of which the child has, as yet, no conception. The apple, on the contrary, appeals at once to his understanding. If he undertakes to reproduce the Venus of Milo in clay, he will fail, and recognize the failure, which dampens enthusiasm and may lead to positive disgust; but to model the familiar apple seems much easier, and on that account, the work will be easier, since it is undertaken with confidence in the result. The clay model of the Venus of Milo can never be more than a feeble imitation of the wonderful marble made by another modeler; but this especial apple is now to be modeled for the first time; the work is, therefore, original. No one ever saw a child who did not look doubtfully at the Venus of Milo, wondering why the statue should be called beautiful, since it has no arms. The child mind demands completeness. An "art atmosphere" is often considered to be essential, but we are not now trying to produce artists, but rather to develop ideas and impart general education.

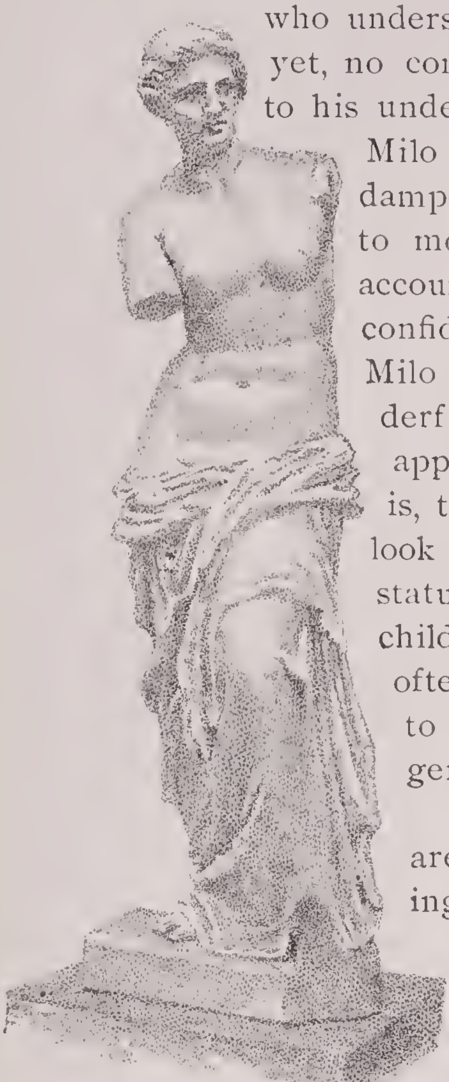


Fig. 17

Fig. 18

Fruit, vegetable, and animal forms are therefore recommended for modeling, and real apples, turnips, and potatoes, should be first provided. While their colors cannot be reproduced in the clay, the model is more interesting because they appear in it, and from closely observing the real fruit, much more is learned concerning it than when use is made of a clay or marble model of the same subject.

Any model from nature will suggest a line of supplementary study. For example, if a peach is being modeled, the structure and growth of the fruit should be understood — how the stone is planted to produce the tree, in what climates peaches are most successfully grown, the extent of the market, etc. So with any natural model, some knowledge of its part in the scheme of nature should be gained. Take for a model a beet. What about its seeds? Do they come from within the beet, as in the case of the apple, or from the plant? Of what size, form, and color are they? How planted and cultivated? In what forms does the beet furnish us with food? What great industry has been affected

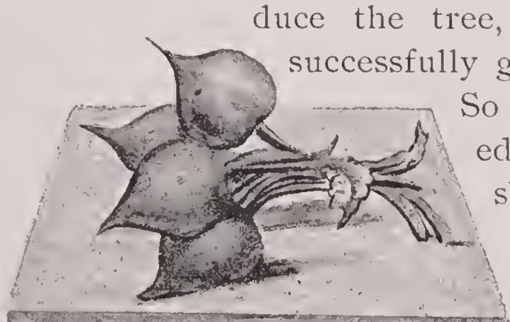


Fig. 19

by the extensive cultivation of the beet? People who decry Manual Training as dealing with non-essentials are answered in the broad general knowledge acquired by the pupil who deals with models as real things, to be intimately known and understood, and modeled in clay or carved in wood as a means of expressing the knowledge acquired.

An apple may be had for a model at any time in the year. Model an apple. Take a piece of clay and give it, roughly, the desired shape. Now take the tool and form the sides, following the lines of the model and not attempting to idealize it. If the apple is slightly flatter on one side than on the other, model it so; but no very eccentric form should be selected as a model; it is better to have an average fruit. The correct form is imparted to the clay by shaping with the tool, which should all the time press the clay into greater compactness, but without scraping it. If there is a little wen on the apple, dab on a bit of clay at the proper spot and model it with the tool. The hollowing out of the stem and blossom ends may be done with the tool. A bit of clay is then modeled like the stem and inserted in the proper position. It should be as nearly as possible like the original, in form, but it is a mistake to insert the stem of the real apple in the clay. This makes the work grotesque and unnatural. The work in clay may be so well done as to be worth keeping, but the natural stem will wither and drop out. To omit the modeling of the stem in clay and use a real one instead, is to suggest the slighting of the work, since the stem is a part of the form to be modeled, and should not be borrowed. The model should not only be looked at, but should be taken in the hands, turned over and over and felt. Clay modeling seeks to develop the sense of touch and the outlines of the real fruit should be felt as well as seen.

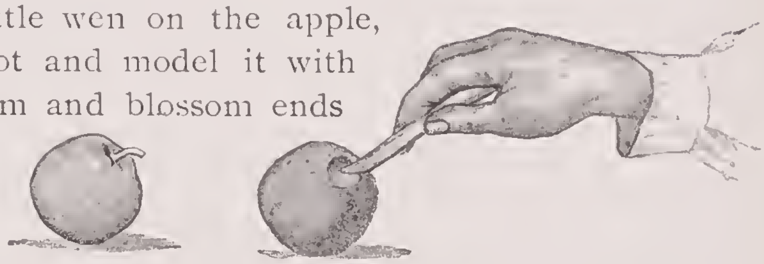


Fig. 20

An orange may be modeled, and the little indentations on the surface indicated by pricking, care being taken not to prick too deep. A lemon is another good form, and the banana, which is more difficult, affords excellent practice. The clay should be rolled to nearly the proper size, and then the flat or slightly rounding sides of the banana, four, or sometimes five, in number, should be formed by drawing the tool from one end to the other. One end must be curved. The other tapers to a blunt point. The angles formed by the sides of the banana should not be too sharp. The thick, rough stem should be carefully modeled with the tool. Attention must be given to the consistency of the clay, which must be rather stiff, so that the banana will keep its slight, but characteristic, curve.

Among the vegetables, also, there are most interesting models. The common potato, the sweet potato, the carrot, the beet, the cucumber, the tomato, and the radish are good forms. In modeling the potato, the eyes may be made with the tool and the reproduction of the uneven surface should be carefully molded with the fingers. Make a carrot, and take pains to give the clay the form of a carrot, not that of a parsnip. The distinction should be clearly made. It will be a good plan to first study the carrot, the parsnip, and the radish, side by side, noting carefully their differences. Model one form, and then follow with the others. It should be easy for a critic to distinguish the several forms in the clay without hesitation. A bunch of asparagus offers an excellent model. Each stalk is made by itself. The clay is rolled to the proper thickness and the head is then carefully formed with the tool. The second stalk may be placed beside the first, as soon as completed, and incorporated with it at the lower end. When all the stalks have been assembled in this way, clay should be added around the bunch and the string modeled with the tool.

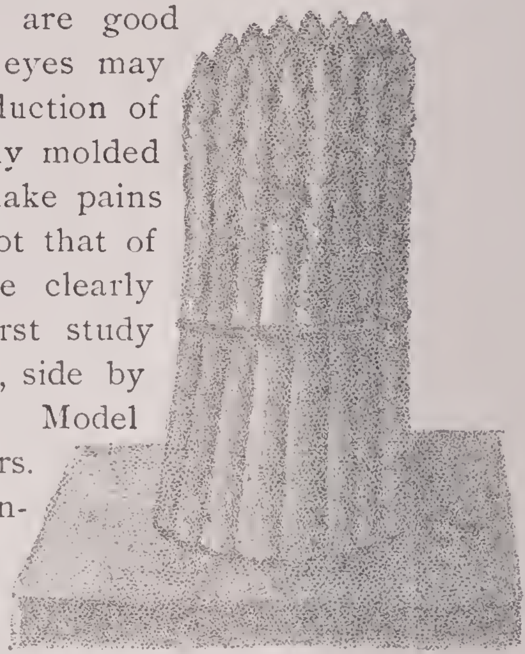


Fig. 21

Fig. 22

Fruit and vegetable tiles are interesting forms, and afford excellent practice. Shape a tile about five inches wide and ten inches long. Give it the proper thickness, but do not trim it until the fruit has been added, as the edge will probably be marred and must then be trimmed again. If possible, have for a model a branch of a tree, from which the fruit has not been removed. A piece of grape-vine, with two or three of the broad leaves, and a bunch of grapes hanging from the vine, is a good model. Model the bunch of grapes, building up from the side that rests on the tile. Then roll out a piece of clay and with the tool give it the rough texture of the grape-vine. Place it in position and attach the stem of the bunch of grapes to the branch. Three or four of the broad leaves may then be modeled and attached to the main stem, and to the auxiliary branches which may be added to the tile. Figure 19 will give an idea of the composition. Of course, the clay leaves cannot be made as thin as the real ones, but if the edges are made thin and the under part of the leaf is made thick, the effect is natural. It is surprising to see how the appearance of thinness can be imparted in this way. One or two trials will make it plain. The leaves should be modeled with the fingers, as was done in the elementary course, and the veins may be plainly indicated by the same means. Curve the end of the leaf outward. If necessary, sufficient clay may be placed beneath the leaf to support it. It is useless to attempt to make clay leaves or stems as thin as the natural model.

Have the grapes as smooth and rounded as possible, but do not attempt to give the leaves more smoothness than comes from the modeling with the hands. Let the face of the tile show the marks of the tool. They give it a more picturesque appearance than if it were carefully smoothed. When the fruit has been successfully modeled, trim the edges of the tile with the knife.

In making a tile of this kind, do not try to raise the fruit and leaves too far above the surface of the tile. The bunch of grapes need not rest upon a single row of grapes, but may rest upon two or three rows. The loss of symmetry is inconsiderable, so long as the tapering end of the bunch is well formed. The stems and branches will require careful modeling with the tool, when they are incorporated with the clay on the tile.

Fig. 23

A vegetable tile showing the beet and its broad leaves, is a good study. The beet-top may be very accurately represented, as the leaf-stalks are thick. The leaves of the carrot and the potato are more difficult to make and need not be attempted in the early stages of the work. Indian corn, however, is an excellent subject for modeling, and the long, narrow leaves and the thick stalk are easily formed. The corn silk may be represented with some degree of success by careful work with the tool on clay raised a little above the surface of the tile. The modeling of the kernel of corn on the ear will call for equally careful work with the tool.

These suggestions are but a few of hundreds that might be made. The modeler should not be confined, in practice work, to reduplication of the same form, nor even to one class of subjects.

When the bunch of asparagus has been well made, it is much better to take up the carrot, than to make another bunch of asparagus; and the vegetable model may give place to fruit forms for a time.

GEOMETRIC FORMS

Modeling geometric forms is apt to become quickly tiresome to children. As they sec neither prisms nor cubes outside of the schoolroom, they cannot fail to wonder "what they are for," and as the production of mere abstract forms seems useless, they cannot reach the same degree of interest in modeling them that they find in modeling forms from nature. It must not be supposed, however, that clay modeling is intended to furnish amusement first and education afterward.

While it is a safe principle in education that the more entertaining the work can be made, without departing from correct lines of instruction, the surer will it be to bear fruit, the merely pleasing features should not be exaggerated at the expense of the less pleasing, but should be equally instructive.

It is desirable, therefore, to undertake some work in modeling geometric forms. This work involves in a high degree, accuracy and attention to proportion. Little children should not be compelled to model cubes, prisms, and cylinders, too often nor too long at a time. Older learners may profitably devote to such work a reasonable part of the time for modeling, but even they will do well to change frequently to the natural forms.

The spherc, the cube, the cylinder, the cone, and the prism, are suggested for the study of the geometric forms. They should not be attempted on too large a scale. A size suited to the grasp of small hands should be chosen. Wooden models may be obtained from dealers in school supplies, and are inexpensive. Do not invest in a large variety of these models. Beyond the amount necessary to purchase the five forms mentioned, the money may be better spent on natural models and a few good casts.

In modeling these forms, the aim should be to reproduce them in exact counterpart in clay. The hcight should be the same, the angles the same,— all measurements on the original should be duplicated in the clay. The purpose now is to teach accuracy. A plane should be quickly distinguished from an uneven surface, a right angle from one of eighty-eight degrees.

Make a Sphere.— Roll a piece of clay in the hands, turning it constantly; rub away the hills and fill up the hollows, using no tools except the hands, and when it has been made as nearly spherical as possible, place it beside the model. See if the diameter is the same in the clay as in the wood. Test it with the dividers. If the clay does not form a true sphere of the proper size, add more clay and roll it again. Of course it is not to be thought that a perfect sphere can be made in this way, but perfection can be nearly approached.

Fig. 24

To model a cube, take a piece of clay of nearly the proper size, and tap one side on the board until it is plane. Turn it over and tap the opposite side until that is also plane. See if the planes are parallel to each other. Set the clay beside the model and observe the height. If it is too high, rub away some of the clay with the fingers, and repeat the tapping. If it is too low, add more clay. Having made two sides plane, turn the clay on end and tap another face to a plane, which is perpendicular to the two previously made. Again test the height. In the same way tap the remaining three sides of the clay to planes perpendicular to the adjacent plane and parallel to the opposite sides. At every step the clay should be compared with the wooden model. The tapping should be carefully done, and the corners made clean and sharp. The completed

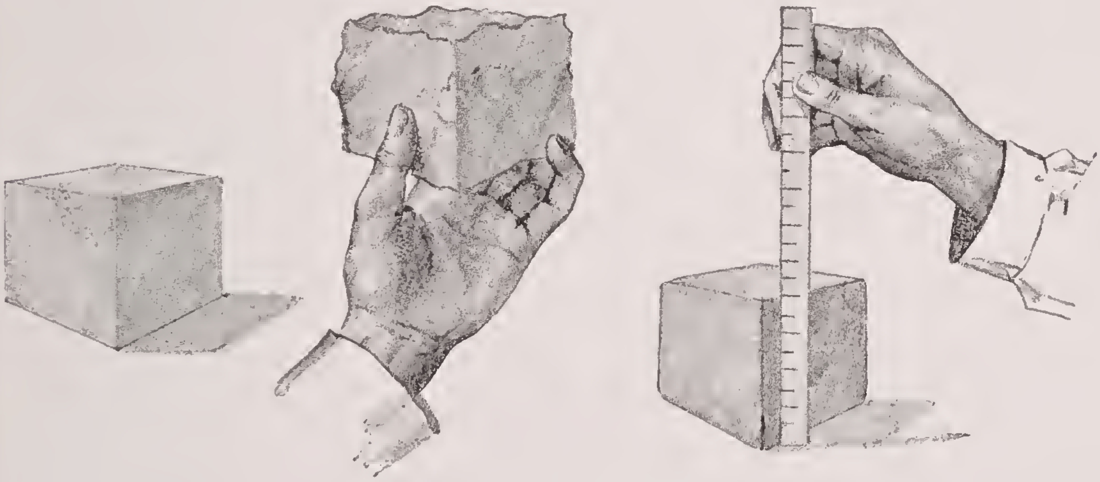


Fig. 25

cube should be measured and the measurements compared with the wooden model. Do not measure with the rule during the progress of the work, but try to produce six planes equal to each other and to those of the model, by judging with the eye. This compels attention and gives the eye power to measure distances accurately.

In making the cylinder, the methods of making the sphere and the cube are combined. Roll a piece of clay between the palms,—

not on the board,—and tap the ends to produce planes. The ends should present equal circles.

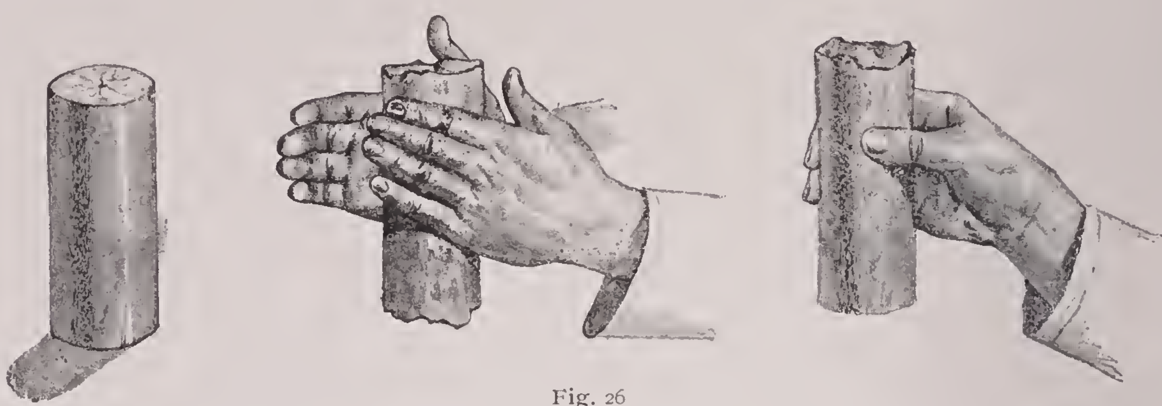


Fig. 26

The cone is made by rolling it first in the hands and then on the board. Notice the angle at which the sides slope from the base, and roll the clay about a central point. The base must frequently be tapped.

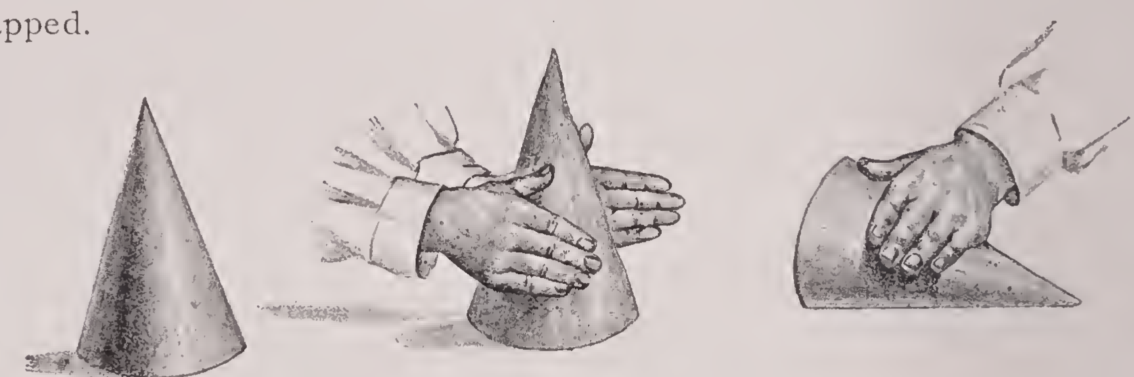


Fig. 27

The prism may be made by tapping the cone until the four plane sides have been formed.

Fig. 28

Each of these forms should be repeated three or four times and the several results compared, each with the others and with the wooden model. But do not work on them until they become tiresome.

CONVENTIONAL FORMS—TILES AND BORDERS

The modeling of conventional leaf forms, scrolls, and the like, on tiles, affords good practice in forming curves, which must constantly be used in modeling natural objects. The preliminary work is not particularly interesting, but it should not be slighted, and when sufficient practice has been had, the opportunity to develop original ideas in modeling tiles and borders is large.

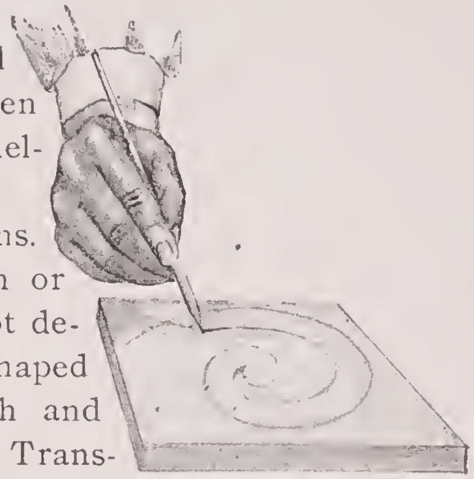


Fig. 29

The work begins with the making of scroll forms. A tile should first be made, three-quarters of an inch or an inch in thickness, and ten inches square. It is not desirable to make smaller ones. This tile may be shaped with the hands and built up to the desired breadth and thickness by the addition of successive pieces of clay. Transfer the tile from the board to the slate, where there will be no danger of its sticking. On the surface of the clay, draw the design with the point of the tool. This should be done free-hand. As often as the drawing is unsatisfactory, it may be obliterated by working the face of the clay with the fingers. Draw the scroll so that it will fill the space on the tile, and make it as graceful as you can. When the drawing has been satisfactorily made, roll out pieces of clay and incorporate them with the tile, on the lines of the scroll. Build up the scroll piece by piece, in this way, until it has been roughly formed throughout.

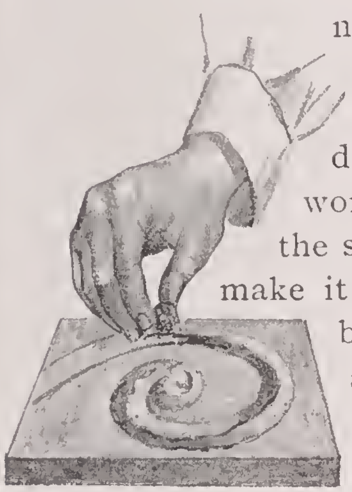


Fig. 30

Now comes the shaping of the curve, which is more difficult than it looks. The tool should be swung freely around the curve, with a long, steady sweep. Do not try to make the curve with short, jerky strokes. The tool should be held in both hands, as shown in Figure 31. You should try to make the curve with a single sweep. This will not be easy, but as you persist in the effort, you will acquire greater manual dexterity, and you will see that the longer the swing of the tool, the more perfect will the curve be. The forming of the curve will bring the scroll to a sharp angle at the top, and the line so formed should be even and not wavy. When the curve is satisfactory, trim the edge of the scroll down to the face of the tile

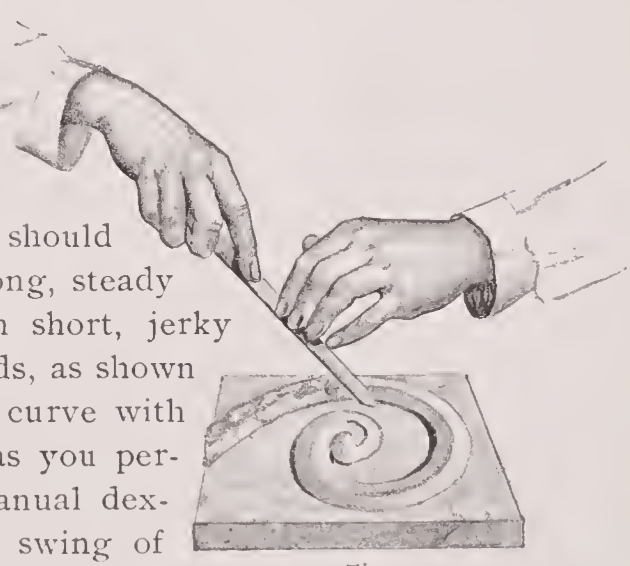


Fig. 31

with vertical cuts. There is no absorbing interest to be developed in making the scroll, but it affords such excellent practice in swinging curves and developing a greater dexterity of the hand that it is worth while to spend hours of patient effort upon it, if nced be, until the work becomes easy.


Fig. 32

The scroll with crockets, Figure 32, may be made as an advanced excrcise. The drawing should be made in the same way as before. Take time to draw it well. Then build up the scroll with clay, and shape the curves and tips first with the fingers, then with the tool. At the inner angle between the crocket and the scroll take pains to form a clean junction. The inner curve of the scroll is to be concave and the outer curve convex; hence the concave curve of the crockets will meet the convex curve of the scroll, and the convex curve of one crocket must be made to diminish into the concave curve of the scroll, without showing a line of junction.



Fig. 33

A tile may be made, ornamented with a three-pointed-leaf form. The latter should be modeled with the hands and incorporated with the tile. The tool is then employed for modeling the surface of the leaf, first the midrib, then the side-ribs and veins. The edge of the leaf should curve upward from the tilc and be made thin.

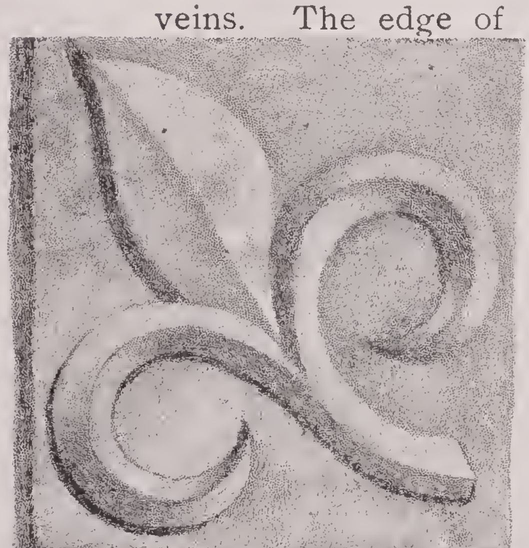
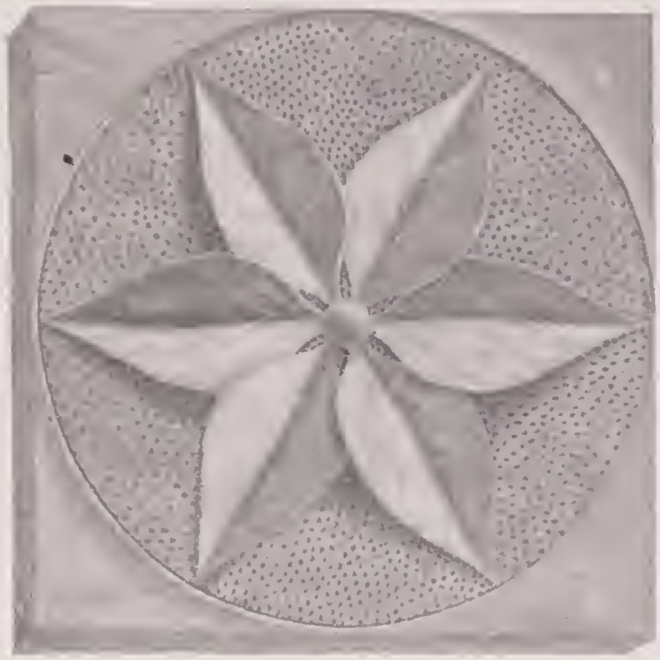


Fig. 34

The leaf and scroll forms may now be combined in a variety of exercises. Add one lobe of the leaf to a double scroll, as in Figure 34, or shape the leaf itself into a scroll form, as in Figure 35.

To make a rosette which shall cover the face of a tile, draw the design on the clay, varying it, if you choose, from Figure 36, which is suggested as one good form to make. Begin to build up the form at the center, by making the boss roughly. Then shape the five large leaf forms in the hands and add them to the tile, centering the stems at the boss. Let the leaves overlap each other. Finally, model with the tool. Make the pieces look like leaves, not like slices of bark. Model carefully, and do not be satisfied if the work comes merely to the point of suggesting leaves. During the progress of the work, the position of the tile with reference to the modeler should not be changed. It will not be altogether easy to model the leaves farthest away and that is the very reason why they should be made without turning the tile. In other words, the hands must learn dexterity by doing things that are not easy when first attempted.

Fig. 35



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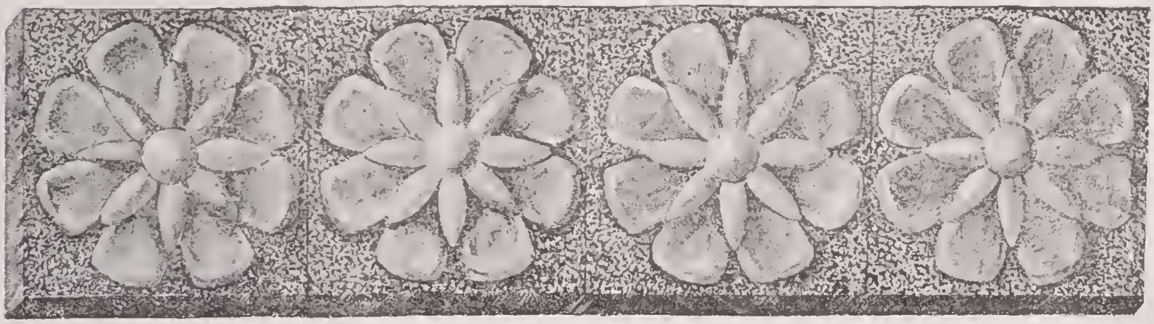


Fig. 37

When sufficient practice has been had in making tiles embellished with these suggested forms and others similar in character, it is a good plan to undertake the making of several borders, or friezes, on which a conventional design may be repeated several times.

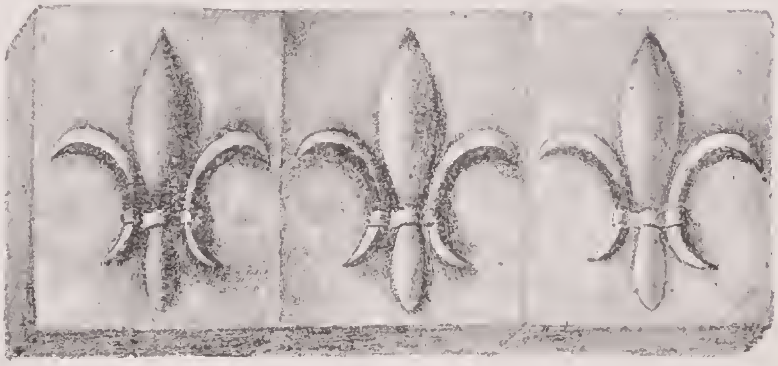


Fig. 38

Figure 37 shows a border consisting of a series of single rosettes. Figure 38 introduces the fleur-de-lis. In making these borders, the work should not be crowded. Make a piece not less than six by eighteen, or eight by twenty-four inches. This would divide into three squares. The repetition of the design will test in a very high degree the modeler's skill in accuracy and the sense of form.

In all these exercises, avoid making the tiles and borders too small. The educational benefit comes very slightly from delicate picking with the tool, but to a large degree from bold, rugged modeling with the hands or the forming of large designs with sweeping curves of the tool. It is not so easy, at first, to make large forms well as it is to make smaller ones, but greater manual dexterity comes from accurate bold movements than from restrained ones.

NATURAL FORMS—ADVANCED WORK

The beginner's work was done on natural forms—the egg, the apple, the dog, etc.—all of which were, of course, modeled but roughly. It is not to be expected that either drawing or modeling will be other than crude in the first stages of the work. The development of skill in making the geometric and conventional forms, and successful practice with the fruit and vegetable models, will gradually lead up to advanced work in natural forms. They may unhesitatingly be given preference over any other class of models for the serious work of more or less skilful modelers.

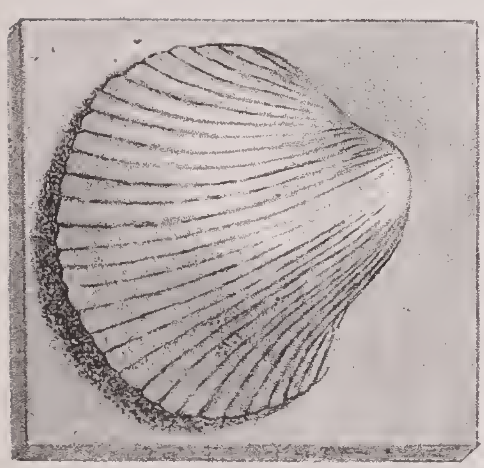


Fig. 39

A shell is an excellent model. Its delicate fluting, whorls, spirals or scallops, its charm of form and color and the mystery that attaches to it as the deserted home of a once living thing that dwelt in the green, silent depths of ocean, make it at once a beautiful model and the teller of a story. A wooden cylinder tells us no story, nor is it beautiful.

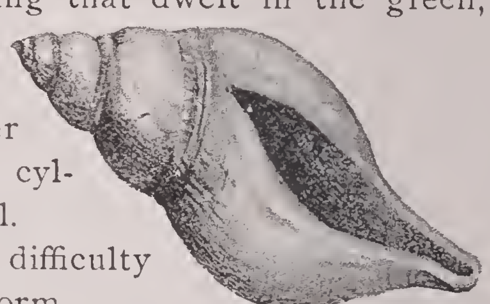


Fig. 39*a*

Flowers usually present more or less difficulty in modeling, owing to their delicacy of form.

The animal forms prove to be the most satisfactory of all. The pupil takes great interest in reproducing them accurately in clay and, if the purpose of making clay-modeling and nature study interdependent is adhered to, there is always something new to be learned concerning the subject in hand.

For models, it is possible to obtain fish, preserved and mounted on wooden panels, stuffed birds, butterflies, etc. The Barye casts of animals are the best models to be had of the quadrupeds, but the animals of the household or the farm, which are near at hand, should also be made to « pose.» They will not remain in one position for long at a time, but if the modeler has patience, and will persevere, the clay can be shaped into a suitable likeness of the living animal.

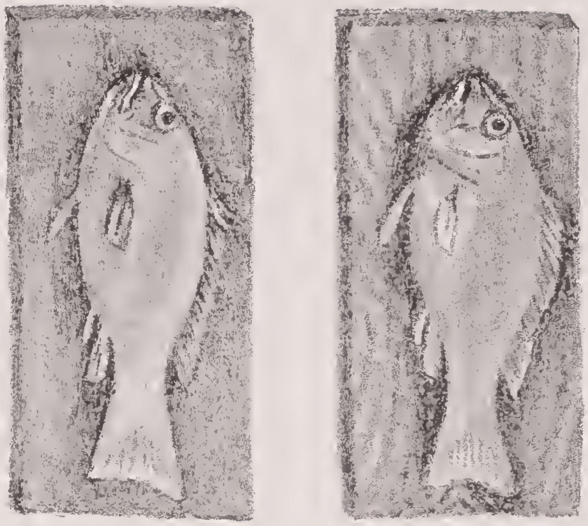


Fig. 40

These animal forms may be modeled in relief on panels, as in the case of the tiles already described, and also modeled in the round, with a substantial base to serve as a support. In modeling in the round, it is a good plan to begin with an animal's head — the one of which you can obtain the best model. For a complete animal form, the base or pedestal on which the animal is to rest is first made and then a mass of clay larger than the body of the proposed animal figure is held in place by a second mass of clay used as a support from beneath. The form is given rough shape and left until the second day, when it will be found to have dried and shrunk somewhat. In another day it will be quite hard. Clay can now be added to this substantial core and the actual modeling of the form may begin.

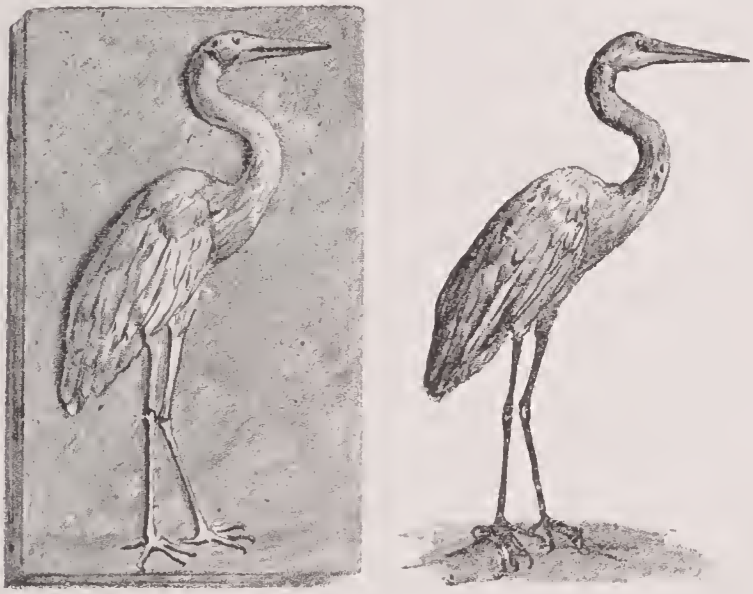


Fig. 41

The shape should first be blocked out roughly, without attempting to indicate features. As piece after piece is added, to build up the block, take care that each is thoroughly incorporated with the mass. If any air spaces are left, the clay may crack or drop apart after it dries, or when it is fired.

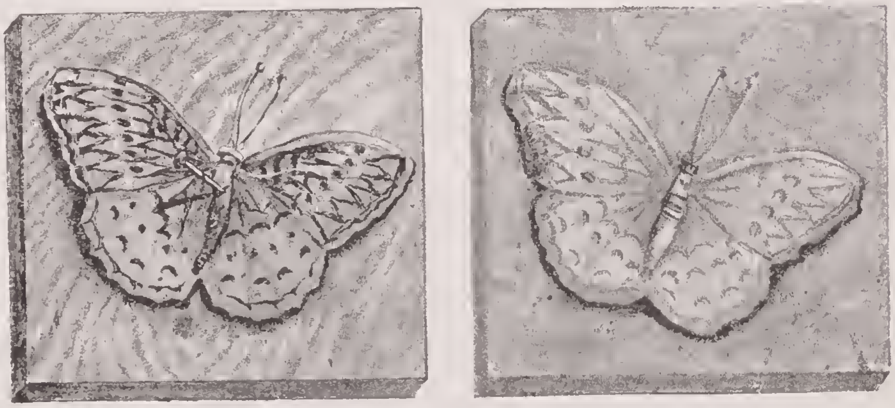


Fig. 42

The tool may be used to reduce the block to a semblance of the model, but the hands should be used as much as possible. Sculptors often model the most delicate features of their work with the thumbs and fingers alone. Their sense of form enables them to produce perfect likenesses of individual human faces in this way; and it is obvious that similar practice is excellent for young modelers in cultivating the sense of form.

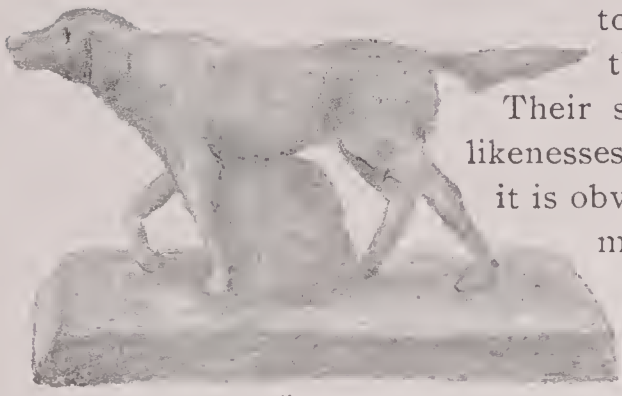


Fig. 43

While this work is in progress, care must be taken to keep the clay of the right consistency. The core must not be too dry, or the added clay will shrink the more of the two, and there will be serious cracks. When the modeling has been completed and the clay has shrunken so that it is comparatively hard, the support may be cut away, leaving the weight of the body to rest on the legs. Pieces of wood, pipe, or wire are sometimes used as supports, inside the animal's legs, but it is much better to make the form wholly of clay. When a good one is made, it can be fired and will then be permanent. If a plaster cast is to be made and the modeled form thrown away, the wood or metal supports may be used, but the modeler will derive the greater satisfaction from having his original work in permanent form.

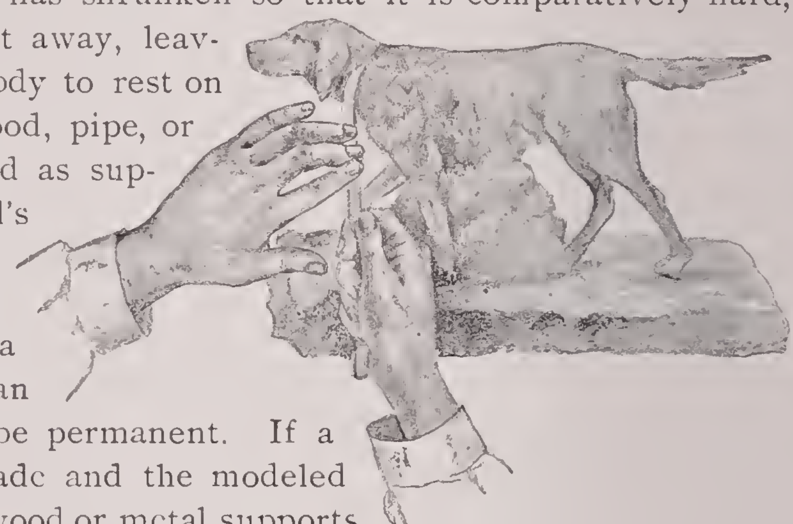


Fig. 44

In all clay-modeling, an effort should be made to become expert in representing texture. The skin of a potato is quite different from that of an apple; a lion's mane should not look like the feathers of a bird. In general, learn to measure with the eye. The dividers and the rule should be used only for comparing measurements or for laying out work that it is desired to enlarge on an exact scale.

Fig. 45

It is almost out of the question to lay down a printed set of rules for the guidance of modelers. This chapter is intended only to make pertinent suggestions as to following an orderly course of study, with some hints as to the character and manipulation of clay to enable the beginner to enter upon the work with confidence. The real secrets of the art he must learn by actual experiment. That is, indeed, the actuating principle of Manual Training — "to learn by doing."

It is especially desired to call to the attention of parents and guardians the advantages of clay-modeling as a help in educating children not so fortunate as the average, in that they are "backward," feeble-minded, or of such frail constitution that wearisome book-tasks must not be set them. These unhappy little people especially need such employment as clay-modeling affords. They may not be able to do serious work, but the advantage to them, mentally and physically, of some such healthful and diverting occupation, has already been exemplified in many cases.

Clay-modeling suggests a higher step in Manual Training. However beautiful the forms made in clay may be, they are fragile. The desire to produce similar beautiful forms in a more enduring substance leads the successful clay-modeler to look forward to wood-carving.

SLOYD

Manual Training, as a system, is not new. It dates back to ancient Greece and Rome. Greece imparted to her youth physical as well as moral and mental training. In Rome the physical at one time predominated over the mental. With the revival of learning, due to the advent of the printing-press in the fifteenth century, an extensive knowledge of classical writings was demanded of scholars and the training of the physical man in harmony with his mental development was slighted until it came to be wholly disregarded. This gave rise to a system of education which was dominant for four centuries, and it still exists in those of our schools which are schools of learning, not of training.

Locke, in the seventeenth century, advocated Manual Training, as did Jean Jacques Rousseau, in the eighteenth. "If, instead of chaining a child to his books," he said, "I occupy him in a workshop, his hands labor to the profit of his spirit, he becomes a philosopher, though he thinks he is a workman. Now, of all occupations which serve to furnish subsistence to man, that which brings him back to nature again most closely is the work of the hands. 'A trade for my son! my son an artisan! Monsieur, what are you thinking of?' 'Madam, I think better of him than do you, who would render him incapable of ever being anything but a mere lord, a marquis, a prince, and perhaps one day less than nothing. While I, for my part, wish to raise him to a rank which cannot be forfeited, a rank which makes him honorable for all time. I wish to raise him to the rank of manhood, and, say what you will, he will have fewer equals in that title than in those you will give him.' 'The letter killeth, the spirit giveth life.' It is not so much a question of teaching a trade for the sake of the knowledge of the trade, as of overcoming those prejudices which despise it. . . . I desire without reserve that Emile should learn a trade." . . .

"Everything taken into consideration, the trade which I should above all wish to be chosen by any pupil is that of the carpenter. It is neat, it is useful, it can be followed at home; it provides abundant exercise to the body; it demands in the worker some skill and industry; and though the form of the work is determined by its utility, yet elegance and taste are not lost sight of. . . . We are not apprentices to a trade — we are apprentices to *manhood*: and this latter apprenticeship is more troublesome and longer than the former. . . . »

« He must work like a peasant and think like a philosopher, unless he is to be worthless as a savage. The great secret of education is to make the exercises of the body and of the spirit serve each to relieve the other.»

Froebel gave the first strong impetus to the demand for Manual Training, in our own time, through his kindergarten system.

In far-off Finland, however, definite Manual Training was first made a part of the national system of education, through the advocacy of a native clergyman named Uno Cygnæus. Its teaching was begun in 1866. The movement spread to Sweden and Norway, where it developed rapidly, and later to France, Germany, and Great Britain. In these countries Manual Training is generally considered under the term Sloyd. Sloyd is the English equivalent of the Swedish « Slöjd,» which means skill, or dexterity, especially mechanical skill; and « Sloyd-work » means, definitely, work which employs mechanical training as a part of general education and not as preparation for a trade. It is « educational handwork.»

In the beginning, however, Sloyd was based on an economic, rather than an educational, purpose. It was intended to preserve and advance home industries, by producing skilled workmen at an earlier age and in greater numbers than had previously been the rule; and basket-making, saddlery, turning, and other woodwork were taught to boys, while weaving, knitting, sewing, spinning, and cookery were taught to girls. The purpose was utilitarian, not educational.

All this was changed by Otto Salomon, whose name has come to stand for the genius of Sloyd. Otto Salomon was born of Jewish parents at Gothenburg, in 1849. He was trained in preparatory schools and the gymnasium, and entered the academy for the training of engineers. He left to assist his uncle in the management of the latter's large estate, and to qualify himself for his duties, attended an agricultural institute, in 1870. At the same time he assisted the parish schoolmaster and started an evening school for farm servants. About this time Sloyd schools were opened in the neighborhood and both Salomon and his uncle became intensely interested in the work. They opened Sloyd schools and later a training department for teachers. Since that time Salomon has devoted himself heart and soul to the advancement of Sloyd.

He soon saw that the economic purpose of the Sloyd schools was bad for schools and pupils, and with great energy he set himself to the work of recasting them on educational lines. This he successfully accomplished.

The first Sloyd teachers were artisans who knew nothing of teaching as a science; and Salomon saw that to get educational advantages from Sloyd he must have ordinary teachers trained in Sloyd-work. The artisans were displaced and such teachers took up the work. Simultaneously, the utilitarian purpose of the schools was destroyed and in its place was developed the splendid educational force of Sloyd. This experience has been repeated in this country, where Manual Training schools have found it profitable to dispense with the artisan and employ regular teachers. As a rule, the artisan has enjoyed few educational advantages; he has learned carpentry as students learn Latin, by rote; and in any event the finer sympathetic and esthetic side of teaching is a sealed book to him. Regularly-trained teachers, who have passed from the theoretical schools into schools of Manual Training, have reached the highest degree of success in this work.

The unthinking mind will be likely to decide offhand that a carpenter can teach woodwork better than a teacher who never was a carpenter. But it is educational woodwork that Manual Training contemplates, and experience proves the wisdom of employing the generally-trained teachers. In one of the large cities, the teaching of music in the public schools is intrusted to a young woman who, for ten years, had taught the ordinary branches in the graded schools. She is not a musician, can sing or play but indifferently, yet her music classes make wonderful progress, and she has attained a proficiency in her work that has amazed the school authorities, who at first regarded her appointment as a doubtful experiment.

One of the first principles of Sloyd is that children shall be taught as individuals and not as a class. In class teaching, the teacher is likely to regard the class as a unit and to proceed upon the same plan for all; indeed, it is difficult with a large class to adopt any other method. But this does not produce individual development, and the normal development of one child, as a rule, calls for methods of treatment which are not suited to another. All children cannot keep the same pace in learning; some are slow and others swift, yet in accord with the capacity of the brightest pupils, not the dullest, who most need to be developed, the work of the class as a whole proceeds inexorably.

The promoters of Sloyd recognized the defect in class teaching as a means to education, and undertook to educate the individual. There is a difference between instruction and education. Instruction in manual work, which is designed to implant knowledge, may be given in class; but education, which seeks to develop the faculties, must necessarily be individual. Sloyd-work gives this individual training from which comes education. As the work of the class-room often fails because the pupils cannot keep the same pace, so Sloyd-work might fail if the attempt were made to teach it in class,— that is, to give out a set of models and expect all the pupils to attain the same degree of excellence in the same time. The theory of class-teaching has been that the dull pupil learns from the bright one, and that the desire to maintain a creditable standing induces ambition in the dull pupil. The fact is, however, that the dull pupil leans upon the brighter one, and so makes less progress than he would by himself.

Sloyd teachers are required to address only one pupil at a time, instead of stopping the work of the entire class, so that the latter may listen to what is said. To interrupt the work of all in order to state something required for the instruction of an individual, and which may not be required by all, takes the minds of pupils from their work, involves moments of idleness, and prevents progress.

Considerations of economy affect all general educational systems. Appropriations from the public funds for the maintenance of schools are seldom based on accomplishing the greatest possible amount of good, but on providing the least number of educational facilities that will be tolerated by the public. Class-teaching is made necessary by the fact that funds are not available for the employment of a sufficient number of teachers to do individual work. This form of economy suits the childless taxpayer for the time being, but it dwarfs education and denies to the ripening years of youth the preparation for after life that should be afforded. Recognizing this fact, the Sloyd schools of Sweden employ at least one teacher for every twenty pupils, and experience has shown that better results are attained where the number of pupils under a single teacher's supervision does not exceed twelve or sixteen. In Sloyd-work there are so many tools and manipulations that the individual pupil needs frequent attention, and when as many as forty pupils are placed under a single teacher, it is found that the objects produced are wholly useless, and the work is a failure, because sufficient instruction had not been imparted to make effective education possible.

Under the class system, the directors of Sloyd found the same difficulty in keeping their classes together, that is, the pupils equally advanced, that troubles all teachers. Some Sloyd pupils finished their work more quickly than others. Such pupils, in some cases, were told to repeat the same work, in order that the remainder of the class might catch up, but this was found injurious, for the pupil, having done one thing well, naturally desired to take up more advanced work; and his need of repeating the work already done, as a matter of increasing his skill in certain manipulations, was far less than that of the tardier workers. To provide no work for those who have finished would be equally bad, or even worse, as it would promote idleness, and the spectacle of one pupil idling after having quickly completed his work, would have a depressing effect on the pupils still striving to reach the goal. Therefore, they have abandoned the class system in favor of individual instruction,— that is, a class may be at work at the same time, but upon different objects.

In Sweden, where Sloyd has reached a high stage of development, the term embraces not merely such woodwork as carpentry, carving, fretwork, and turning, but also work in brass, iron, wire, leather, and cardboard; besides brush-making, basket-making, bookbinding, straw-plaiting, and coarse painting. In England, the term Sloyd is generally applied only to woodwork. In America, the term Manual Training is employed almost exclusively to designate the same system.

Education is generally considered from one of three points of view, first, the utilitarian, second, the disciplinarian, and third, a compromise between the two. The utilitarian method looks to making the knowledge acquired of practical use. The disciplinarian methods regards education as, properly, formative, and seeks to develop the powers and faculties of the child not for special, but for general application.

The promoters of Sloyd consider it as purely formative education. It is not regarded in any sense as a part of technical education, and is intended to be a part of the general education in elementary schools. For those who wish to learn a trade, there must be a subsequent course in a technical school. The formative aims of Sloyd are set forth in the following order by its advocates:—

1. To instil a taste for, and a love of, labor in general.
2. To inspire respect for rough, honest, bodily labor.
3. To develop independence and self-reliance.
4. To train in habits of order, exactness, cleanliness, and neatness.
5. To train the eye and sense of form. To give a general dexterity of hand, and to develop touch.
6. To accustom to attention, industry, perseverance, and patience.
7. To promote the development of the physical powers.

It has also the utilitarian aims:—

1. To give dexterity in the use of tools.
2. To execute exact work.

It will be seen that these aims are in general the same as those previously outlined in this volume as the essential purposes of Manual Training for American pupils.

Mr. Salomon, speaking of the various materials which may be used in educational Sloyd, such as wax, clay, pasteboard, paper, metal, and wood, recommends wood as the most suitable. Sloyd carpentry, he says, is adapted to the mental and physical powers of children, and awakens and sustains genuine interest by enabling them to make useful articles. It admits of cleanliness and tidiness in the work and, he adds, it cultivates the sense of form more completely than instruction in drawing does. It also promotes physical development. The exercises are easily adapted for methodical arrangement, and may comprise those of varying degrees of difficulty, for the theory of instruction in Sloyd is that it shall proceed from the easy to the difficult, from the simple to the complex, from the known to the unknown. It is essentially constructive, and not analytical.

The carpentry of Sloyd differs from the carpentry of the artisan in all save the material used. The articles made in Sloyd carpentry are smaller than those made in workshops; they introduce curved outlines, while the artisan's work is usually on rectangular or cylindrical lines; and a difference exists in the use of tools. In Sloyd, the knife is considered to be the most characteristic tool, while the carpenter rejects the knife in favor of the chisel. Moreover, in practical carpentry there is a division of labor which is antagonistic to the principles of Sloyd.

Turning and wood carving were formerly largely employed in Sloyd-work, but Mr. Salomon looks upon them with disfavor, and his views have been so far accepted that in Sweden, at least, these branches of woodwork are now oftener absent than present in Sloyd schools. Turning involves preliminary exercises not on the objects to be made, which is contrary to the practice of Sloyd; and the difficulty of procuring suitable turning-lathes has been another obstacle. Wood carving is objected to as too "fine" a class of work, which does not call for sufficient bodily exertion and is pronouncedly ornamental, so that it does not produce that respect for rough bodily labor that Sloyd carpentry aims to inculcate. Wood carving, applied to articles on which the rough work has previously been done by the pupil, is regarded as sometimes desirable, but applied to objects made by others is considered undesirable.

In the Manual Training schools of the United States, wood carving has been made a prominent factor of educational work, and the advantages derived from it are regarded as infinitely superior to the objections of the original promoters of Sloyd. It inspires a love for the beautiful, for one thing, and develops accuracy and a feeling for form; and in subsequent sections of this volume its utility will be made apparent.

The method of Sloyd includes the arrangement of a series of exercises and a series of models in such a way that the knowledge gained in the preliminary exercises may be applied upon the models without delay, the work thus going forward systematically and re taining the interest of the pupil by enabling him to produce completed articles. A provisional list of exercises prepared by Mr Salomon numbers eighty-eight. The first four of the exercises dea with simple knife-cuts; they then proceed with sawing, planing, squar ing, gauging, boring, filing, beveling, scraping, chiseling, chopping pegging, nailing, dovetailing, panel-grooving, mitering, lock-fitting hinge-sinking, staving, hooping, etc. A list of fifty models, also pre pared by Mr. Salomon, begins with a small pointer, flower-stick pencil-holder, etc., and goes forward to bowl, scoop, clothes-rack, foot stool, box, ax-handle, bracket, picture frame, bookshelves, hooped bucket, cabinet, small table, etc. In producing work, he says, the question should be not how much or how many objects can be made but how well the work may be performed.

Sloyd seeks to give an intelligent knowledge of the material used as well as the tools, and as wood is chiefly employed, its structure and composition, the changes it undergoes, and a comparison of the qual ities of different kinds of wood, enter into the instructions given. This imparts accurate information as to why woods shrink and crack and suggests the means of preventing warping and cracking, where a large plane surface is desired, by seasoning the wood, before use, and in use, by jointing.

A comparison of the qualities of different woods is valuable The chief qualities of wood are its strength, the ease or difficulty with which it may be split, hardness, toughness, elasticity, texture, color, smell, weight, durability, and its capacity for shrinking or swelling.

The directors of Sloyd-work lay great stress upon a proper choice of tools. The tools must be adapted to the capacity of the pupil, neither too large nor too heavy. The use of miniature tools, that is, sizes such as are usually made for children's tool-boxes, is con demned, partly because such tools are usually of very inferior quality, and again because it is found that greater skill and dexterity come from the manipulation of tools which in size and weight have been found, from long experience best adapted to their several uses. There is another consideration, and that is the preference of the pupil for standard tools—he does not want "boys' sizes" when he is trying to do the same work that men could do, and takes greater pride in his work if his tools are such as would be used by men. At the same time, it is necessary to bear in mind that the child's hands are not so large and powerful as a man's and the handles of tools, such as the knife and the chisel, should be of a size that enables him to grasp them easily and wield them efficiently without undue strain, which will produce unnecessary muscular fatigue.

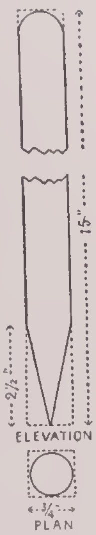
Tools of good quality are considered indispensable, and, once procured, they must be kept in good order. Motives of economy might suggest that children should not be allowed to undertake the sharpening of expensive tools, but in Sloyd the method followed is to teach pupils to sharpen their tools, and to require them to keep them in good order. Poor work almost always results from the use of tools in bad condition. The teacher must thoroughly understand how to sharpen tools, including the use of the grindstone, the oilstone, the saw-set, and the file, and by easy stages to impart this knowledge to the pupil. The child may spoil a tool, now and then, but if properly directed, this will be a rare occurrence, and the educational value derived from learning to care for his tools will more than compensate for the financial loss.

ARTICLES FOR YOUNGER CHILDREN TO MAKE

Young children may derive great benefit from simple work in wood. They should not be allowed to use chisels, drawknives, and hatchets, until they have established a reputation for carefulness, but the knife, the saw, the plane, the file, and the gauge may be intrusted, without misgivings, to children ten or eleven years old. It is expected, of course, that in the use of these tools they will have the direction of a parent or guardian, who will give them some instruction and teach them at least to handle the tools without danger to themselves.

The work attempted by young children should be simple and of a character to appeal to their love of useful things. Much can be done with the knife alone, and the first exercise should employ that tool only. Work of this kind will not miss its object if the child learns to appreciate accuracy and is stimulated with a desire to "do" greater things.

No. 1. A FLOWER-STICK



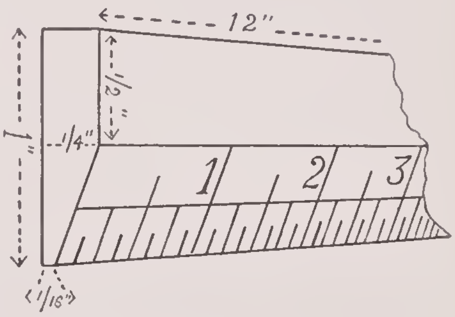
Making a flower-stick is a good exercise to start with. This is not merely an ornamental, but, more strictly, a useful, object, and may be handed to the gardener, when completed, for use among his plants. If the child sees his own handiwork thus made serviceable, he will be pleased with the sense of accomplishment that comes to him.

Take a piece of pine, ¾ inch square and 15 inches long. With the knife cut four new faces on the stick, making eight in all, so that it will be octagonal. Then make the stick as nearly round as you can, taking off very thin shavings in succession and drawing the knife the whole length of the stick at each stroke. When you have made the stick round, set off a point 2½ inches from one end. From this mark, taper the stick to the near end, so as to form a point which may easily be pressed into the ground. Now carefully cut away the sharp edge at the other end and round it as neatly as you can. Do all this work with the knife and see how smooth a surface you can make.

You can make another flower-stick, but instead of rounding it with the knife, put it on the bench and with the plane reduce it to six sides, instead of four. Then make a point ½ inch from one end and draw a line around the stick at this point. This line will be the base from which you can taper the sides of the stick to a sharp point. Finish the end of the stick that is to enter the ground, as you did the stick just made. With the knife, cut two very shallow notches around the stick, one $2\frac{1}{2}$ inches from the top, the other 6 inches below the first. These will serve to catch the strings and hold them in place, when the plant is tied to the stick.

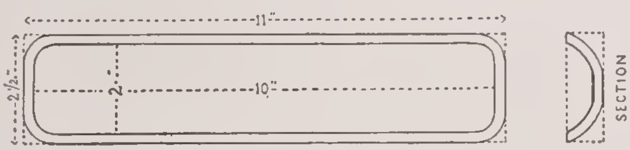
No. 2. A BEVELED RULER

From a piece of birch wood, saw a stick 12 inches long and 1 inch wide. Reduce it with the plane to a thickness of $\frac{1}{4}$ inch. On one face, lay off with the gauge $\frac{1}{2}$ inch and draw a line parallel to the edge of the stick. With the gauge mark a line $\frac{3}{16}$ inch from the face, on the edge. Now chamfer the corner between these two lines, with the plane. Finish all surfaces of the stick with the smoothing-plane. With the dividers lay off spaces on the beveled edge, and with the point of the knife draw lines through these points, extending across the chamfer. These lines may be blackened with a needle heated red-hot in a gas-flame or in the coals. The slight cut made by the knife will guide the point of the needle. Take care not to make the lines too broad. Make clear numbers, 1, 2, 3, etc., against the inch lines. This makes a neat and serviceable ruler. You can make it still more useful as a measure by marking off half-inch, quarter-inch, and eighth-inch spaces and blackening the lines.



No. 3. PEN TRAY

Cut a piece of birch 11 inches long and $2\frac{1}{2}$ inches wide. Plane it smooth and reduce it to a thickness of $\frac{3}{4}$ inch. On the working face, mark out a rectangle, 10 inches long and 2 inches wide. With the compasses, round the corners of the rectangle to quarters of a circle. Use the gouge to cut out the wood within the marks, but be careful not to go more than $\frac{1}{2}$ inch deep. When you have removed the greater part of the wood with the the gouge, use the scraper to produce a smoother surface, and then finish carefully with fine sandpaper. The ends and sides should slope to



PLAN

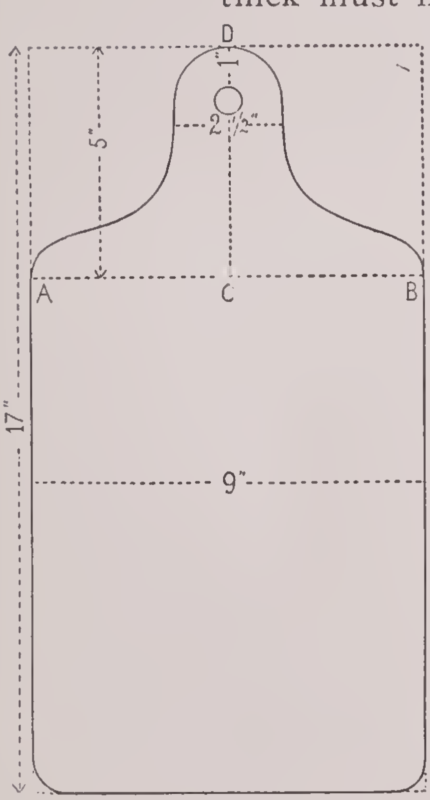
ELEVATION

the bottom of the tray in a long curve, and not at an abrupt angle. The outside of the tray is now to be finished. Round the corners with the compasses, and with the chisel pare them to the curved line. First with the plane and then with the knife, reduce the sharp corners of the underside to a curved surface and curve the upper edge in the same way. A smooth finish is obtained by using first the scraper and then the sandpaper. It will take some time to complete the pen tray if you do the work well, so do not hurry it but divide the work into two or three periods. This tray may be kept on the desk to receive penholders, pencils, etc.

No. 4. BREADBOARD

HERE is an opportunity to make something that will be useful to mother, in the kitchen — a clean, nicely-finished breadboard.

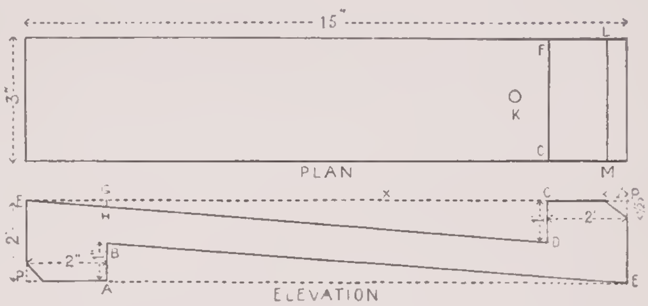
A piece of white wood 17 inches long, 9 inches wide, and 1 inch thick must first be gotten out. Plane one face and one edge smooth.



With the gauge, lay off 5 inches from one end of the board and, with the beam of the square pressed against the working edge, draw a line AB. Find C, the center of AB and draw CD. Draw the round end at D with the compasses and then draw the curves of the handle, making them graceful and flowing. Let the handle be 2½ inches wide at the point where it will be grasped. Now, with the compass-saw, cut along the curves of the handle and pare the edge with the chisel. Go over both faces, the wide ends and the parallel edges, with the smoothing-plane and, if necessary, use the scraper to produce a very smooth surface. With the smoothing-plane take off a hair-like shaving from the corners, around both faces of the board. With the center-bit bore a hole, ½ inch in diameter, one inch from D. By means of the hole, the board may be hung on a nail in the pantry. The board may be used as a chopping-board, as well as to cut bread upon. After a time, if it becomes badly hacked, you can dress it with the smoothing-plane and give it a clean, fresh surface.

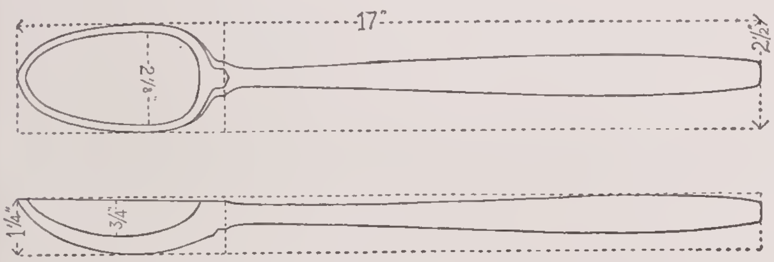
No. 5. BENCH-HOOK

MAKING a bench-hook affords good practice in the use of tools, and the article itself is very useful on the bench. Saw out a piece 15 inches long, 3 inches wide, and 2 inches thick. Plane one face and one edge and mark each with an "X." On the working edge, X, lay off 2 inches from each end, and draw AB, CD, each 1 inch long, with the square, perpendicular to the face. Connect the points B and D with the corners, E. Draw CF across the face, parallel to and 1 inch from the end, and repeat the first markings on the opposite elevation; then from A draw a line across the lower face parallel to the end and 1 inch from it. Saw out the triangular pieces, ABE, CDE. You may find it hard to start the saw at the proper angle at E. A remedy for this is had by fastening the stick in the vise against another block of wood. This has the effect of extending the face beyond E and the saw will take the line easily. Or you may make a saw-kerf, like GH, near the end, and cut out the small triangular bit of wood, EGH, with the chisel. The saw will then start easily at H. When you have sawed the oblique lines ED, EB, with the rip-saw, saw AB, CD, with the back-saw. The hook may now be finished with the smoothing-plane, and the corners, P, chamfered and rounded with the chisel from LM outward. With the bit, bore a hole $\frac{1}{2}$ inch in diameter at K, so that the bench-hook may be hung on a peg. You will find the hook very useful when you have occasion to saw through pieces of wood and wish to avoid cutting the bench.



No. 6. SPOON

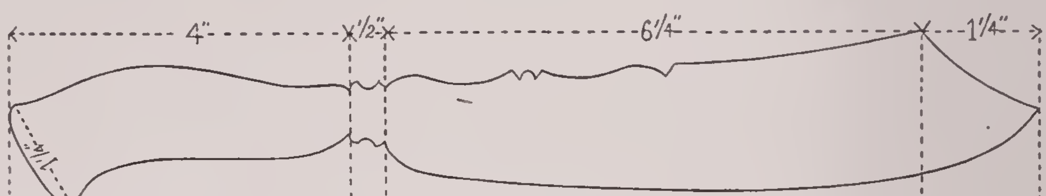
A good exercise is to make a spoon, which will be found very useful in the kitchen. Select a piece of birch, 17 inches long, $2\frac{1}{2}$ inches wide, and $1\frac{1}{4}$ inches thick. On the face of the wood, draw the plan of the handle and the ellipse of the bowl, and on the side mark out the elevation.



At the shoulders formed by the junction of the handle with the bowl, cut holes with the center-bit. With the saw cut nearly to the lines of the handle and the shoulders of the bowl. The bowl must now be hollowed out with the gouge and made smooth with sandpaper. Now saw the under curve of the bowl with the saw, and also saw the lower line of the handle. The greater part of the superfluous wood has now been removed. The remainder of the work consists in modeling the bowl and handle. In this work, the knife should be the tool chiefly used. It may also be necessary to use the file and spokeshave, and the finishing may be done with sandpaper. In modeling the convex surface of the bowl, be careful not to cut too deep and so make the bowl of the spoon too thin. Try to have the bowl symmetrical, so that the rim will be a perfect ellipse, and let the convex side present a graceful curve. The bowl should be thicker at the bottom than at the ends and at the rim.

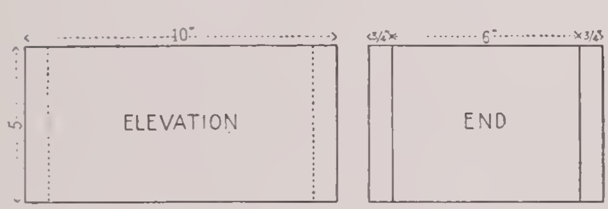
No. 7. PAPER-KNIFE

A piece of birch or cherry can be made into a pretty paper-knife. Take a piece 12 inches long and 2 inches wide, and with a plane reduce it to a thickness of $\frac{3}{16}$ inch. Draw the outline of the knife, and with the saw, cut as near to the outline as you can. Model the handle

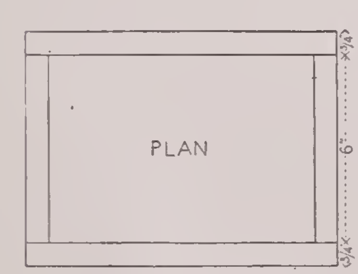


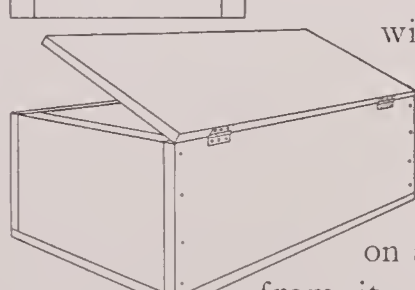
and the blade with the knife. To reduce the blade to a thin edge, on one side, mark the center of the edge with the marking gauge and cut to this line on both sides of the blade, with the knife. Use the knife to model the notch between the blade and the handle, and to round the handle. The work may be finished with the scraper and sandpaper.

No. 8. BOX



To make a small box, get out four pieces from a board $\frac{3}{4}$ inch thick. Two pieces must be 10 inches long, for the sides, and two 6 inches long, for the ends. All will be 5 inches wide. Dress the boards with the jack-plane and finish with the smoothing-plane. Fix one of the end-pieces in the vise, side edge upward. Start three nails in one of the side-pieces, on a line parallel to the end and $\frac{3}{8}$ inch from it. Hold the side-piece flush with the end in the vise, and drive the nails home. Use a brad-awl to make holes in which to start the nails, so that you will not split the wood.



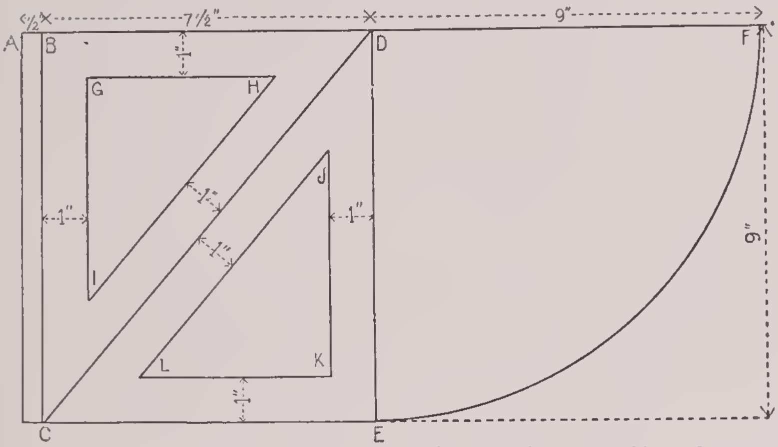


Use five-penny or six-penny nails and drive them carefully, so that they will not bend. Now fix the other end-piece in the vise and nail the same side to it in the same way. Start nails at the ends of the other side-piece and then place it flush with the end-pieces, the whole resting on the bench. Nail the side to the ends. This gives you the skeleton of a box. You will now need to get out a piece foı the bottom. Measure the length and width of the skeleton and saw a board a little larger than these dimensions. Reduce it to a thickness of $\frac{3}{4}$ inch and smooth it with the smoothing-plane. Place it on the skeleton and with the brad-awl make holes around the four sides. Be careful not to locate any nails so near the corners that they will encounter the nails which have already been driven into the end-pieces through the sides. Nail the bottom along one side, first, and then with the try-square test the skeleton to see if the corners meet at right angles. If they do not, press the skeleton into shape before nailing the bottom all the way around.

When all the nails have been driven, sink them with the nail-set, being careful that the latter does not slip and mar the wood. With the back-saw, trim the ends of the bottom piece close to the frame, and plane the long edges to make them flush with the side. Go over the outside with the smoothing-plane, and be careful not to split the ends when planing across the grain. Sandpaper the inside of the box, stretching the sandpaper over a block of wood while doing so. You can now make a lid for the box and supply it with hinges, like those shown in the illustration. They are fastened in place with screws. Select screws not more than $\frac{5}{8}$ inch in length, so that they will not pierce the side and lid of the box. Make holes for the screws with the brad-awl. Be sure that your hinges are not too near the center of the box, and are at equal distances from the ends.

No. 9. CORNER BRACKET

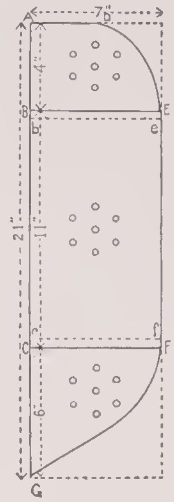
There are many corners about the house where a corner bracket may be placed, and where it will serve very acceptably for holding a vase, a clock, or something that is purely ornamental. If well made, the bracket itself will be ornamental. From a piece of white-wood $\frac{1}{2}$ inch thick, cut a piece 17 inches long. Reduce the board to a width of 9 inches, with the plane. Make one end true and square. On the working edge, lay off $\frac{1}{2}$ inch, AB, and with the gauge set to that measure draw a line, BC, parallel to the end of the board. Lay off BD, and with the ruler draw DC. From C lay off E, $7\frac{1}{2}$ inches, and draw DE, at right angles to the edge of the board. Set your dividers to a measure of 9 inches, and with the point on D, describe the arc FE. Now draw the inside triangles GHI, JKL, whose lines are one inch from the sides to which they are parallel, in each case. Hold your board on the bench-hook and with the back-saw, saw very carefully DC. Now saw DE. Bore holes with the bit at the corners of the inside triangles and with the compass-saw saw out the pieces GHI, JKL. With the knife, or with the chisel, make the angles clean and true. With the compass-saw cut to the arc FE, keeping just up to the line but never cutting it, and then with



the knife make the arc a perfect quarter of a circle. True the edges of your triangles, so that they will be perpendicular to the face, in every case. Now place DCE in the vise with the edge DE upward, and against this edge place ABC, so that A will coincide with E. With the awl, bore through ABC into the edge DE, and then with long, slender wire nails fasten the two pieces together. Remove the work from the vise and see if the angle made by the junction of the two pieces is a right angle. Test the top with the beam of the square pressed against the face of the bracket, to see if the tops of the supports are in the same plane. Now fix one of the supports in the vise and lay the shelf in place. It will project one inch beyond the supports. With the brad-awl, make holes through the shelf into the supports and drive the nails. Countersink the nails with the nail-set and the bracket is finished. It may be held in place by means of screws, or supported on brass hooks, driven into the wall, which project beyond the edges GH, LK. The bracket will be more ornamental if stained with cherry or mahogany color.

No. 10. BOOK-SHELVES

A NEAT book-shelf may be made without difficulty. From white-wood stock $\frac{3}{4}$ inch thick, get out two pieces, each 21 inches long and 7 inches wide. Saw and plane the ends square with the working edge. On the working edge lay off AB, 4 inches, and BC, 11 inches, and draw BE, CF at right angles across the board. Lay off AD, 3 inches, and draw the arc DE. Draw FG in the same way. With the compass-saw, cut out the corners DE, FG. In the center of each of the three spaces on the board, make a series of holes with the center-bit. These break up the plainness of the board and give it a touch of ornament. Finish both boards in the same way. These are to be the sides of the book-shelf.



You now need two boards, $\frac{3}{4}$ inch thick, 7 inches wide, and 16 inches long, for shelves. Make these two boards perfectly square and smooth, taking pains to finish the ends neatly. On the inside face of the side-pieces draw the lines *b–e*, *c–f*, $\frac{3}{4}$ inch from BE and CF, respectively. With the back-saw make saw-kerfs $\frac{1}{4}$ inch deep on each of these four lines. Be careful to keep your saw level while making these kerfs. With a chisel, cut out the wood between the saw-kerfs, to the depth of $\frac{1}{4}$ inch. Smooth the mortise with sandpaper stretched over a block $\frac{1}{2}$ inch thick. Do not sandpaper very much, just enough to remove the roughness. Now give the side-pieces a final smoothing with the plane.

Have hot glue ready, together with some slender brass screws, $1\frac{1}{2}$ inches long, with half-round heads. Across the outer faces of the two side-pieces, draw very faint pencil lines exactly opposite the center of the mortises on the inner side. There will be four of these lines. With the dividers, mark points for five screws on each of these lines. Now fix one of the shelves in the vise, end upward, and drill holes with the awl through the side-piece into the end of the shelf. Do this on each of the four lines. Set the screws upright in the holes just made, and start each into the wood with gentle taps of the hammer.

With the end of the shelf held upright in the vise, apply a thin coat of glue to the end only. Brush a little glue on the mortise of the side-piece, fit the mortise to the end of the board, and with the screw-driver drive the screws home. The gluing should be done as quickly as possible. If any glue oozes out on the shelf or on the side-piece, wipe it away with a cloth from which hot water has been wrung. Now fix the other shelf in the vise and fasten the side-piece to it in the same way. The side completed may now be placed on the bench, and the other side-piece fastened to the shelves. In doing this work, remember that the glue should be hot, and neither too thick nor too thin. When the glue has dried, you can give the shelf a coat of cherry or mahogany stain. A good way to support it against the wall is by means of two stout hooks, screwed into the wall which enter holes bored with the bit at the back of the shelf.

WOODWORK FOR BOYS

In suggesting the following course of lessons in woodwork for young boys, the aim is not to teach them to be carpenters, nor merely to give them instruction in the use of tools, letting manual training stop at that point, but rather, to give them an appreciation of tools as a means to an end, to teach them the dignity of labor, and to stimulate the faculty of invention. In other words, the purpose is to make the work educational, not utilitarian. This does not prohibit the making of useful articles, of intrinsic value; but the mere making of objects, from the sale of which a profit might be derived, is no part of the plan.

To acquire dexterity of hand, it is necessary to use that member rationally, in work which compels it, in order to produce satisfactory results, to respond readily and accurately to the prompting of the brain. The hand itself is a tool, but so little employment is found for it, in theoretical education, that its possible usefulness too often remains wholly undeveloped. To encourage this needed development, manual training gives the hand definite and orderly work to do.

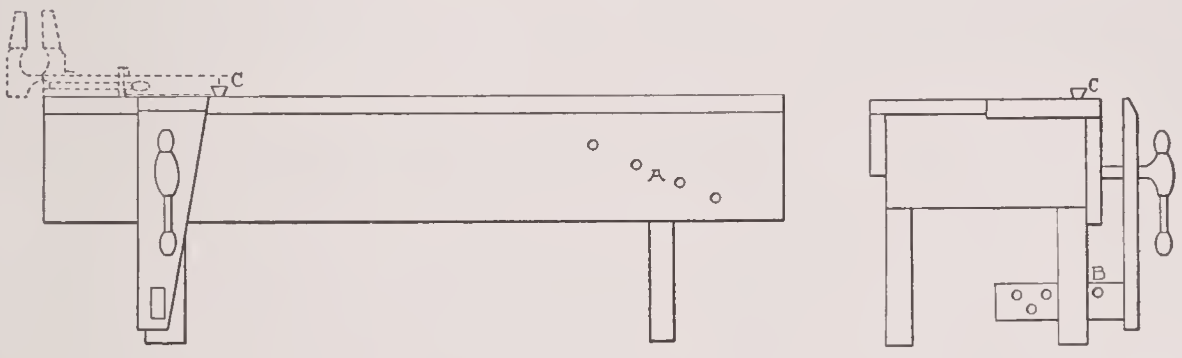
Before the boy undertakes to make articles of recognized utility, he should get some idea of the power of the hand under control. This will fix in his mind the fact that it is the hand that is to do the work, not the wooden or metal tool; and at the same time it will open up to him a new field of activity whose novelty cannot fail to appeal to him. The knife is selected as the first tool to be used, in manual training. A carpenter seldom uses a knife; the chisel is his favorite cutting-tool; but the knife is a better tool than the chisel for imparting dexterity, and while it does not take the place of the chisel in practical work, educationally it is of great importance. The knife is the primary form of cutting-tool; the chisel, the plane, and the saw are modifications of it.

TOOLS AND MATERIALS

In providing a set of tools for the beginner in woodwork, expense will naturally be taken into consideration. There need be no extravagance in making the necessary purchases, but it is well to remember in regard to tools, as in the case of nearly all other merchandise, that the best is always the cheapest, in the end. The tools selected should be of the best quality; it is better to get along with a smaller number of excellent ones, than to invest the money available in the purchase of a greater assortment of tools of cheaper grade. The tools sold with the ordinary "boy's tool-chest" are mere toys, and are worthless for educational work. Saws that will keep their "set," plane-irons that will not "nick" when they encounter slight obstruction in the wood, and chisels that will retain a keen edge for a reasonable length of time, give the young workman a chance to do his best. Inferior work must be expected when inferior tools are used

It is possible to make the assortment of tools larger than good judgment would dictate. Two or three chisels of different sizes are sufficient for the work that may properly be assigned to the beginner; to provide a dozen is to tempt him to change from one to the other without mastering any. As he becomes skilful enough to take up advanced work, he will desire additional tools; and these should be provided when actual need for them arises. If the worker has comparatively few tools, he learns to use them more skilfully and intelligently, in producing a given piece of work, than when he tries to find uses for a great variety of tools merely because he has them, and wants to see what he can do with them.

The wood-worker needs, first of all, a suitable bench, equipped with a vise and a rack at the back. Figure 1 shows the front and end ele-



Fig, 1

vations of a bench. The holes at A are for the insertion of a plug at different heights, in order that it may support one end of a long board when it is required to hold one on edge, in the vise. The holes at B show the method of changing the position of the lower end of the jaw of the vise in order to keep it parallel to the face of the bench, as pieces of different thicknesses are held in it, a device which is necessary to insure a proper grip on the piece of work to be held. At C is a bench-peg. This is to prevent a board from slipping along the bench while it is being planed. The bench-peg may be a stick of wood which fits tightly in a mortise, and can be driven up or down, as desired; but a much better form is an iron "bench-stop," shown in Figure 2. This is sunk in a mortise so that the face D is flush with the surface of the bench. The stop E may be held at the desired height by the screw F.

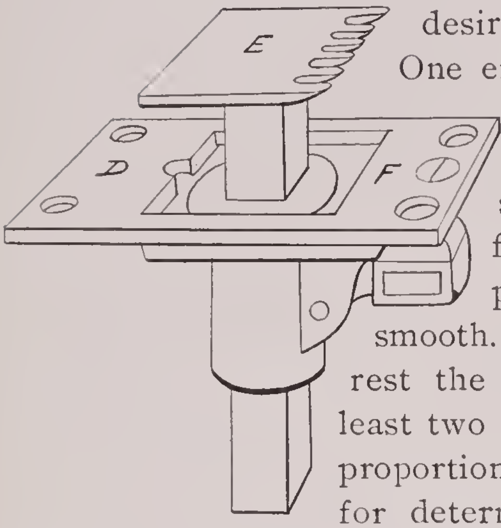


Fig. 2

One end of the bench should be open, as it will be found very convenient to have a projecting surface against which a piece of work may be held with a hand-screw, as in Figure 3, where a piece of work is held for chamfering. The outer edge is formed by a thick plank, selected with care, and made perfectly true and smooth. This affords a reliable plane surface on which to rest the work, and gives solidity. The bench should be at least two feet wide and six feet long. Its height should be proportioned to the stature of the worker. One rule for determining the height is that the top shall be just above the wrist, when the arm hangs naturally at the side. The bench should be oiled or shellacked, and care should be taken not to deface it.

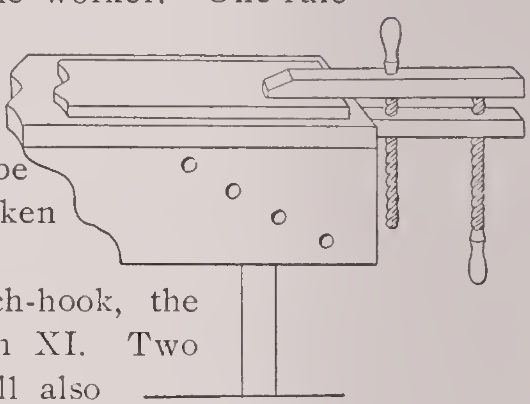


Fig. 3

One of the furnishings is the bench-hook, the making of which is described in Lesson XI. Two horses, or trestles, will also be needed, but after learning to use the saw and the plane, the wood-worker can make these for himself. The construction, which is simple, is illustrated in Figure 4. Two boxes of equal height may be made to serve, temporarily, in place of the horses.

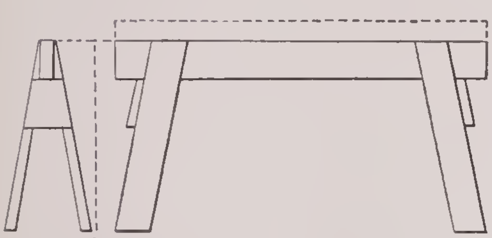


Fig. 4

In making up a kit of bench tools, the following list will be found a practical one. It is possible to get along without some of the tools listed below, but it is not considered desirable to do so: —

Strong pocket-knife, two blades, of the best steel.
Hatchet.
Marking-gauge, 8-inch.
Bevel, 8-inch.
Cross-cut saw, 20 inches long, 8 teeth to the inch.
Rip-saw, 24 inches long, 6 teeth to the inch.
Back-saw, 10 inches long.
Claw-hammer.
Mallet.
Try-square, 6-inch steel blade.
Compasses, adjustable for pencil.

Two-foot folding rule.
Straight-edge, wood, $\frac{3}{16}$ inch x 2 inches x 30 inches.
Jack-plane, stock of iron and wood.
Smoothing-plane, 8-inch, iron preferred.
Block-plane, 6-inch, iron.
Plow.
Brad-awl.
Four chisels, $\frac{1}{8}$-inch, $\frac{1}{4}$-inch, $\frac{1}{2}$-inch, 1-inch.
Two gouges, $\frac{1}{2}$-inch, 1-inch.
Draw-knife, 8-inch.
Brace.
Set of bits, including counter-sinker and screw-driver.
Screw-driver, wooden handle.
Nail-set.
Scraper.
Spokeshave.
Handscrews, two or more.
Grindstone.
Oilstone.
Oil-can.
Glue-pot.
Bench, brush, and dust-pan.

Glue, nails, screws, sandpaper, and oil will also be needed. The bench should be placed in a favorable position with reference to the light and trued up so that it will stand firmly in its place. It should be so placed that the operator can stand not only at the side, but also at either end of the bench, as desired. This will facilitate the training of both hands and help in the physical development of both sides of the body. The beginner should practise economy in the use of his materials, from the start. It is not well to have on hand too great a supply of lumber. A piece of wood spoiled is a piece wasted, and waste should not be encouraged by making it too easy to throw away a first piece of wood and replace it with a second from the stock. For the same reason, nails and screws should not be carelessly dropped and lost among the shavings. It takes but a few seconds to straighten a bent nail, and when straightened it will serve its original purpose as well as a new one.

A proper care for his tools and surroundings bespeaks a neat workman. The tools should have their individual places and be restored to them when not in use. The bench should have a back, against which may be fastened a rack for chisels, bits, etc. The saws should be kept in a dry box. When putting them away, after use, they should be freed from sawdust and rubbed with a drop of oil, which will prevent the rusting of the blade. Edged tools should be handled carefully and not allowed to become nicked or dulled by striking against hard substances.

A few preliminary exercises in the use of the knife and the hatchet will make clear the importance of understanding the nature of wood, in order that the work to be done upon it may be done intelligently. The necessity of laying out the work, in order to avoid waste of time, labor, and material, is suggested in Lesson VI., on "Working Drawings."

LESSON I.—KNIFE AND HATCHET CROSS-CUTTING

You may have seen a log split by means of wedges, which are inserted in a narrow crack and driven farther and farther into the log until they force it apart. A knife or a hatchet is a wedge and is forced into the wood to divide it. Take a stick of pine wood, three-quarters of an inch square and a foot long, and with your knife try to cut off a piece two inches long. Press the knife down on the wood, holding the blade across the stick. Although you press hard on the knife, you find that it enters the wood but a very little way, and you can make only a shallow notch in the stick, as at A in Figure 5. Yet the knife is sharp and the wood is soft. The reason the knife makes no greater progress through the stick is that the wood at the sides of the notch presses against the blade and prevents the knife from cutting deeper. The only way to make it possible for the knife to cut all the way through the stick is to cut away the wood at the sides of the notch, so that the knife can enter the wood a little farther, and continue this work until the stick is cut in two. But there is a speedier way to accomplish the same result. Instead of holding the knife-blade perpendicular to the surface of the stick, hold it at an acute angle, so that the back of the blade is slanted toward the near end of the stick, and push the knife into the wood. See Figure 6. It enters the wood more easily and penetrates farther than it did before, and the wood above the blade curls upward, as at A.

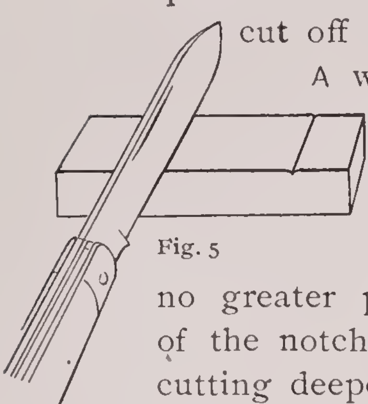


Fig. 5

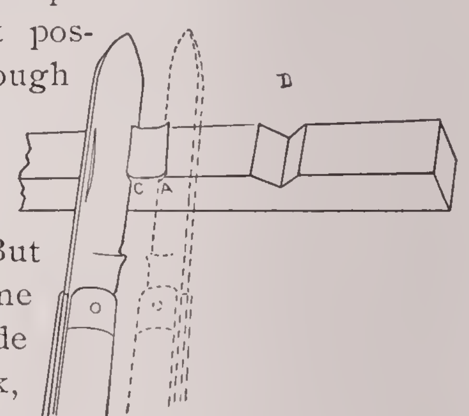


Fig. 6

Now hold your knife at the same angle, but with the back slanted toward the other end of the stick, and cut in obliquely, as you did before. The knife pushes through the wood to C, and again the wood curls upward. A little chip is formed, which drops out and leaves a wide notch in the stick, as at D. Now place the knife a little back of the first cut and push it into the wood again. The wood curls upward much more readily than it did at first and the knife penetrates farther into the stick. Repeat the cut from the other side and another chip drops out. In this way you may continue to cut into the stick until you have reached its center. If you now turn the other side of the stick upward and repeat these cuts, the knife will again penetrate to the center and the stick will be divided.

This experience in cross-cutting teaches us that the knife or any other tool for cutting will not enter wood to any great depth if it is pushed straight downward. But you have seen that when the knife is pushed into the wood in an oblique direction and drawn along, it divides the wood quite easily. The reason for this lies in the formation of the wood. The fibers of the wood run the long way of the stick but they are not very tightly packed together. When you press directly down on them they can offer considerable resistance, but if you separate them from each other they yield more readily. When the knife enters the wood in a slanting direction, it is really separating the fibers from each other. If you try to cut into an old broom, by pressing straight downward, you may sever a few of the upper stalks of the broom-corn, but you cannot cut in very far. If you cut in a slanting direction, the stalks yield readily, and you can cut through the broom, if you wish, without difficulty. The fibers of the wood are laid one over the other, as the stalks of the broom-corn are laid, but are pressed more closely together. So it is plain that when you draw or slide the knife along, at the same time that you press down upon it, you can cut more easily than when you try to break the fibers by straight downward pressure, without separating them from each other.

Notice that when the cook cuts the bread, she slides the knife back and forth at the same time that she presses down on it, and so divides the loaf with ease. But if she presses straight downward, the bread does not divide readily and, at best, crumbles and breaks, leaving ragged, uneven edges which show that it was torn apart roughly. In due course we shall see how the sliding motion of the knife is applied in cutting wood with the saw, which is another form of knife.

When you have cut two or three pieces from the stick, holding the knife in the right hand, shift the knife to the left hand and make the same cuts as before. You should learn to use the knife as readily with one hand as with the other. Remember, whenever you use it, to keep the edge of the blade turned away from the hand that is holding the piece of wood you are cutting. If you pull the knife toward you, the wood may suddenly splinter, or the knife may slip, and gash your hand. This rule applies to the other edged tools you will use in woodwork, as well as to the knife. Keep the edge turned away from you, and then it will not be likely to cut you, in case the tool slips, or if you fall while you have it in hand.

The stick you have been cutting is only three-quarters of an inch square, but suppose you take a stick three or four times as large — a piece of two by three inch pine, for example. You could cut a section from this with your knife, if you took time enough, but it would be a long and tedious job. Instead of using the knife, therefore, you will use the hatchet, which is really another form of knife. In using the hatchet, however, we do not press it against the wood, as with the knife, but strike blows with it. If you try to cut with the hatchet directly across the fibers of the stick, you will have the same experience as with the knife. It will enter the wood only a little way. But if you hold the stick so that the hatchet will enter the wood in a slanting direction, when you strike, you will find that it throws up a chip, as the knife did. By striking first from one side and then from the other, so that the cuts meet in the form of a V, you will be able to divide the stick with ease. In cutting with the hatchet, be careful to rest the end of the stick at or beyond the center of the chopping-block, so that if the tool glances or slips from the stick, it will strike the chopping-block and not swing around and cut you.

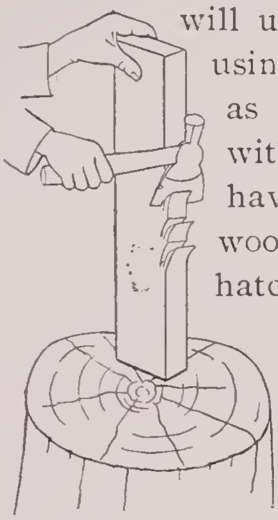


Fig. 7

From the use already made of the knife and the hatchet, we see that they are not well adapted for cutting straight across a stick of wood, for even if we adopt the plan of notching the wood, with cuts delivered first from one side and then from the other, we are obliged to waste some of the wood. Moreover, the pointed ends of the stick must then be finished square for ordinary uses. The proper tool with which to make a straight cross-cut is the saw, about which we will talk later on. But the knife and hatchet are very useful tools for making cuts of another sort. Let us see what these cuts are.

LESSON II.—SPLITTING AND HEWING WITH KNIFE AND HATCHET

Take a piece of pine half an inch thick, three inches wide and eight or ten inches long, and with your knife try to cut from one edge a piece three-quarters of an inch in width, as AB, Figure 8. You press the knife-blade against the end of the stick, as at A. Press downward with considerable force and the wood is parted by the knife, which acts as a wedge and a piece is separated from the stick. At the top, where your knife first entered the wood, the piece to be split off is three-quarters of an inch wide. You wished it to be of the same width throughout. But in splitting the wood, the knife did not follow a course parallel to the side of the stick. Instead, it went too far to the right and the piece you split off tapers to a point. Turn the other face of the stick toward you; place the knife against the edge, three-quarters of an inch from the side, as at C, and press downward as before. The wood divides again, but this time the knife goes too far to the left and the piece split off is wider at the bottom than at the top, as in Figure 9.

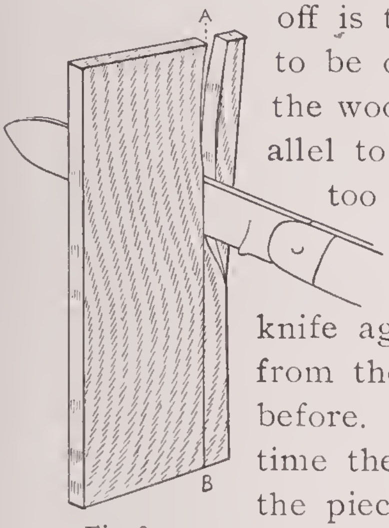


Fig. 8

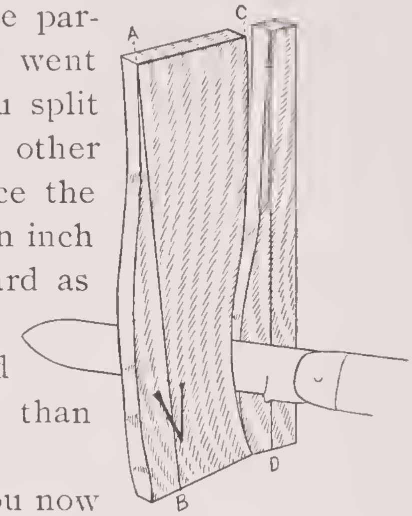


Fig. 9

By looking at the sides of the three pieces of wood you now have, you will see that the knife followed the grain of the wood. Examine the face of the wood and you will see the lines which indicate the grain, running obliquely through the wood. When you select another piece from which to split off a section of equal width throughout, look at the grain of the wood, and if it runs parallel to the sides of the stick, you will have no difficulty in splitting off a piece approximately of the same width at the bottom as at the top.

It may be that a straight-grained piece of wood is not available, yet it is necessary to have a stick with parallel sides. This can be obtained from the piece V. Take the straight edge and lay it on the face of the stick and with the pencil draw a line FK, as in Figure 10. You wish to trim the irregular side down to this mark. Notice how the grain runs, and begin to cut above F, and toward K, so that your knife will tend to turn outward. Pare away the wood carefully until you are down to the line. When you reach the point S, you will see that the grain turns inward and if you keep on cutting in the same direction you may split off too much at K. Turn the stick, therefore, and cut from K toward S. In this way you can make a straight edge. Draw a line LM, parallel to FK, and repeat the paring operation on that side. Your stick will then have straight sides and be of equal width throughout.

The experience you have had with the thin stick may be repeated in the case of the heavy stick, two by three inches square, on which you made cuts with the hatchet. In reducing the irregular edge to a straight one, you will find it necessary to cut off chip after chip until the line has been nearly reached. Then with light, even strokes, smooth the edge. This is called hewing. Railroad ties are hewn in this way. In olden times, the heavy beams of houses and other buildings were squared and smoothed in the same manner, with the ax and the adz, which are similar to the hatchet in form and in the method of using them.

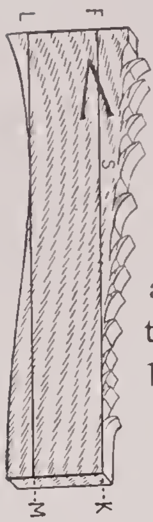


Fig. 10

If the grain of the wood is very irregular, it may be necessary, in using either the knife to pare, or the hatchet to hew, to a line, to "score" the stick several times with cuts made at an angle, as in Figure 10. The stick is then turned and the same kind of cuts applied in the opposite direction. This breaks up the fibers and prevents splitting.

Sharp tools are necessary in order to do this work well, and, in fact, all tools used in wood-working must be kept well sharpened, if good results are to be had from their use.

LESSON III.—THE STRUCTURE AND STRENGTH OF WOOD

The experimental cutting of the pine stick with knife and hatchet has shown you that it is necessary to know something of the structure and strength of wood before you can work upon it with tools in an intelligent manner. In another volume of this work will be found extended accounts of the cellular growth of plants and trees. In this lesson we shall look at the structure of wood from the practical point of view, in order to understand it as lumber, rather than as a plant-growth.

Plants are made up of a succession of long or short cells and tubes. When the plant is young, these cells have soft walls and contain a substance which is almost fluid. As the plant grows older, the fluid contents of the cell become hard and fill the cell. When the plant is cut down and dried, these cells become harder, but at the same time they grow smaller. This is why timber shrinks in drying. When the cells, which are placed side by side, become hardened in this way, they form a woody tissue, and the hardness and weight of timber depend on the closeness with which the fibers, or hardened cells, are packed together. Trees are made up of these tissues or fibers.

A new layer of tissue is formed each year, between the bark and the pith or center of the wood, so we may know how old a tree is by counting the rings which appear on a cross-section of the trunk. As the tree grows older, the woody tissue near the center becomes harder. This is called heart-wood. The outer layers, which are not so old and are therefore softer, are called sap-wood. (See Figure 11.)

When timber is cut from a tree immediately after it is felled, the wood is "wet," or full of sap. But by exposure to the air the moisture of the tree, or the sap, is evaporated and the tissues are packed more closely together. This is called seasoning the timber. Trees are generally felled in winter, when the sap runs least freely through them, and they are, therefore, in a condition to dry, or season, more quickly than if cut in the summer, when they are full of sap. If the unsawed log is allowed to lie on the ground, it takes moisture from the soil and decays.

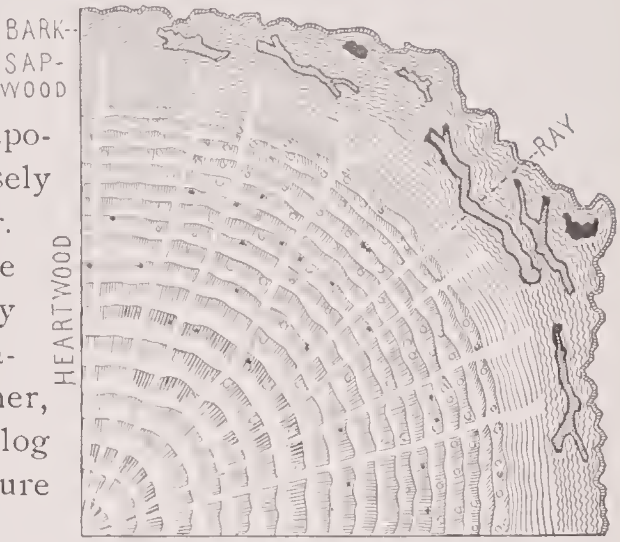


Fig. 11

After a log has been sawed into planks, or boards, the boards must be seasoned. They are usually piled up in a place where they are sheltered from the sun and the rain, with sticks between them to allow the air to reach freely all parts of the board. We often see, in houses, door-panels that have shrunk and doors or windows that will not open and shut easily, because the stock from which they were made had not been sufficiently seasoned before it was used. The seasoning or drying process has continued after the doors and windows were put in place.

As it takes a long time for the natural seasoning process to do its work thoroughly, artificial means are sometimes employed. The boards are steamed, or dried in a blast of hot air. The term "kiln-dried lumber" is applied to wood which has been dried in this way. Such wood, carefully seasoned, is used in making fine cabinet work, where shrinking or warping would spoil the work. These artificial methods of seasoning, however, sometimes cause a change in the color of the wood or reduce its strength.

Shrinking and warping are drawbacks with which every wood-worker has to contend. It is well to understand why and how they take place. The sap of the tree is composed chiefly of water. While the tree lives and continues to draw moisture from the soil through its roots, and from the air through its leaves, the wood cells are filled with water. Then the tree is felled, and these sources of moisture are cut off. The water or sap already in the cells evaporates, little by little, and none comes to take its place. Then the walls of the cells fall in and all the fibers are packed more closely together. The wood really shrinks in all directions, but the shrinkage from top to bottom is very slight — so slight that it is hardly noticeable. The shrinkage from without toward the center is more marked. In shrinking, the fibers sometimes separate from each other and cause cracks, which you will notice at the end of a log or of a board. As there is more moisture in the sap-wood than in the heart-wood, there is more shrinkage nearer the bark. The medullary rays, however, which radiate from the center of the tree outward, and are formed of hard plates, shrink very little. The shrinkage of the wood between these rays tends to draw the ends of the rays together, as in Figure 12, and this causes cracks. As wood shows a tendency to split along these rays, logs are often halved, or quartered soon after they are felled, to prevent cracking, as far as possible. Figure 13, *a* shows how a log may be split along the medullary rays, *b* the effect of shrinkage when it is quartered, and *c* the effect when it is sawed into boards.

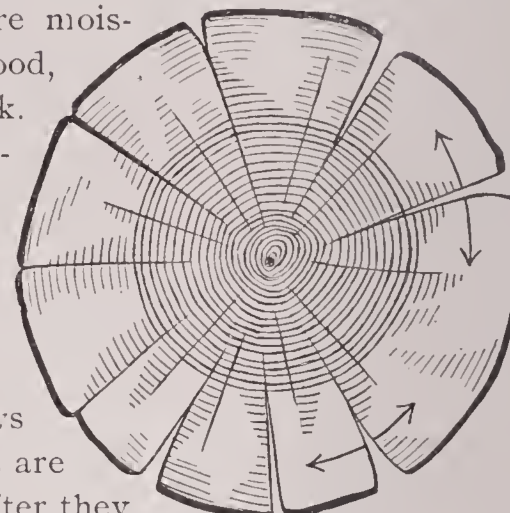


Fig. 12

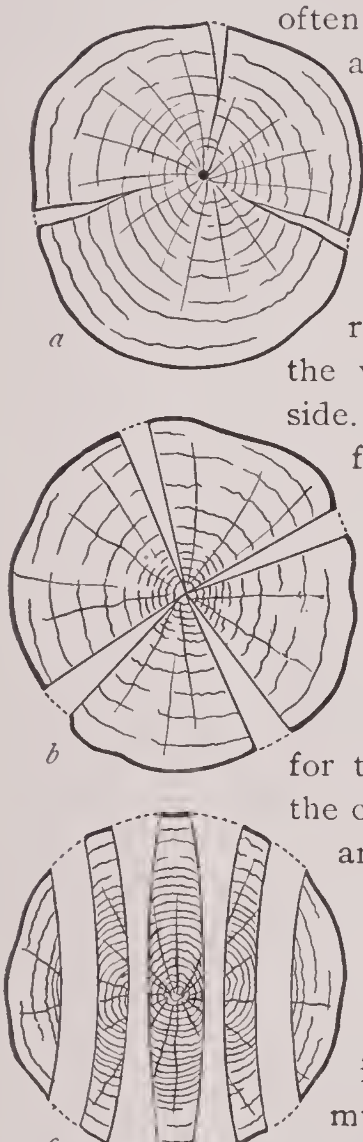


Fig. 13

When a log has been cut into boards, and for any reason one side of the board dries faster than the other, the wood becomes more closely packed together on the drier side. This hollows the board on the dry side and the wet surface becomes convex. We call this "warping." Seasoned timber which has been thoroughly dried will warp in the same way if one side becomes wet. This is one of the reasons why we take pains to keep our houses well painted on the outside. The paint fills up the pores of the wood and prevents the moisture from getting in.

Different kinds of timber have different characteristics, for the woody tissues are not alike in all trees. Pine is one of the commonest of the "soft" woods, or those in which the fibers are more loosely packed together than in the "hard" woods. There are many kinds of pine, and they differ from one another in formation, strength, and color. Generally, pine has a straight, even grain, is light and easily worked, and is inexpensive, in comparison with other woods, because it is more plentiful. It is not strong enough for work which must withstand great strains.

"Whitewood" is not quite as soft as pine, but is easily worked and is in general favor. This wood comes from the tulip-tree, the basswood, the linden, etc. It is largely used for doors, window-sashes and parts of wagons and sleighs.

Elm has a closely-twisted grain, which makes it very strong. It lasts a long time even when buried in the earth or sunk in the water, and for this reason it is used in making coffins, the keels of ships, etc. It does not split easily, because of its twisted fibers, and keeps a firm hold on nails which are driven into it.

The chief characteristic of ash is its flexibility. It bends easily, and for this reason is not employed in building construction, but the same quality makes it valuable to the carriage-maker, who uses many pieces of curved wood. Ash may be steamed, and bent while hot, and if held in the bent position until it dries again, will retain its curved shape. The shafts of carriages are curved in this way.

Oak is the most durable of all timbers. It is one of the most useful woods employed by man, and for centuries has been chosen for work where great strength and durability were essential. It is very handsome when finished in oil or varnish, and in recent years has been used in enormous quantities for making furniture. Oak is tough, strong, hard, and flexible. Some kinds of oak are much more easily worked than others, which have a grain more or less twisted. Oak contains an acid that will corrode iron; hence it is preferably fastened together with brass nails and screws, or those made of galvanized iron. In ancient buildings, wooden pins were used for fastening parts of oak together. Oak trees grow to great size and live for hundreds of years, and the timber obtained from them is correspondingly durable. It is used in building ships, in making doors, posts, staircases, furniture, staves of barrels for liquors, and for many other purposes. When finished in oil or varnish it shows a beautiful grain. Oak varies in color from yellow and red to brown. It darkens with age and exposure. In very old houses may be seen doors, panels, and ceilings of oak, which have become almost black.

There are many other kinds of wood in common use, ranging from mahogany and ebony, whose beautiful color and fineness of grain make them especially suitable for elegant cabinetwork, down to the spruce, which is used for coarser work.

The proportionate strength of various woods may be accurately measured by testing-machines. These are used by builders, who need to determine accurately how much strain may be placed on timber without danger of breaking it. All timber is much stronger lengthwise than crosswise, because the fibers, singly or in bundles, resist powerfully any attempt to divide them by pulling at their ends, but separate readily from each other. To get a clear idea of this, split from a round pine-stick, five inches in diameter and ten inches long, which represents the tree, a section like LM, in Figure 14. You now have a short piece of board, and you can see that the grain of the wood runs up and down the board, as in Figure 15. From the end of the board saw a section half an inch wide, like NO. Take this piece by the ends and pull as hard as you can. The wood will break. The grain runs the narrow way of the stick, and the short fibers may be pulled away from each other without difficulty. Now, split off a half-inch width of the board, the long way, so that you have the piece PQ. It is of nearly the same size and shape as the first piece. Take it by the ends and pull as before. The stick shows no signs of breaking, and try as hard as you will, you cannot divide it in this way. You could break it by bending it, but that would be the same as cutting across the fibers, and destroys the comparison.

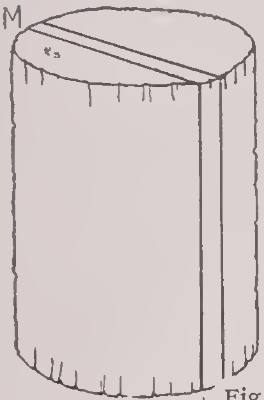


Fig. 14

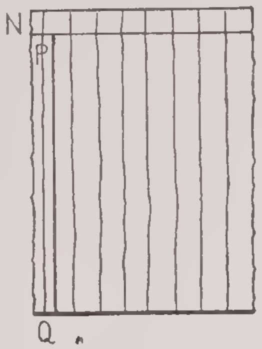


Fig. 15

So we see that while wood may be wedged or pulled apart without much difficulty, when the force is exerted in the direction of the shortest way of the tree, the same, or very much greater, force, exerted in the direction of the long way of the tree will have no effect whatever. In the first experiment, we pulled the fibers away from each other, just as we did with the knife and hatchet in the lesson on splitting. In the second experiment, however, we tried to break the fibers crosswise, with an up-and-down pull, and this we could not accomplish. The greatest strength of timber is found, therefore, in the long way of the wood — the way the grain runs; this is a fact which should always be remembered by the wood-worker.

As you advance in practical woodwork, you will find that a knowledge of these properties of timber is essential to success in constructing articles which will be substantial, as well as attractive to the eye.

LESSON IV.—SAWS AND SAWING

When you tried to cut squarely across the stick with a knife, you found that you could not divide it in that way and were forced to make a series of slanting cuts which formed successive notches. This wasted some of the wood and left the ends of the two pieces pointed. Again, when you tried to split the wood lengthwise, you found that it was difficult to split to a line, and a considerable amount of time was consumed in scoring, and paring, or hewing, the wood. It is necessary, therefore, to have a tool which requires less time for cutting straight across the stick or through its length in such a way as to leave a clean edge close to the line. The saw is the tool we use for these purposes.

The saw is a thin blade of steel, much longer than it is wide, notched or toothed along one edge, and fixed firmly in a handle which may be grasped easily. There are many shapes and sizes, and the teeth are very differently arranged for different kinds of work. But, however the teeth may be shaped, the saw is really another form of knife. If you look at the edge of a knife-blade under the microscope, you see at once that instead of being straight it is made up of a succession of very fine notches. You will remember, also, that you found it easier to cut into the wood when you drew the knife along with a sliding motion than when you pressed it straight downward. These two facts are taken into consideration in determining the form of the saw. It has large, regular notches, and the teeth are filed to a sharp edge. By pushing or drawing the saw against the wood, the teeth are enabled to cut the wood so as to form a succession of little notches. This breaks the fibers and divides the piece of wood into two parts, leaving a clean, true edge, without appreciable waste of material.

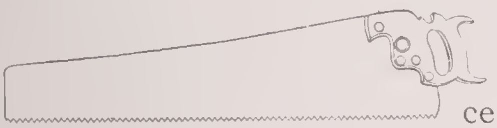


Fig. 16

The teeth of the saw are arranged according to the direction in which the wood is to be cut. The cutting-off saw, or crosscut-saw, is designed for sawing across the grain of the wood. In Figure 17, is shown the triangular shape of the teeth. Looking along the line of the teeth it will be noticed that one tooth is sharpened or beveled on the right side only; the next tooth is sharpened on the left side only. The teeth are thus sharpened, alternately, throughout the length of the saw. But the teeth are not in the same plane with each other nor with the blade of the saw. One is bent a little to the right, the next a little to the left, and so on, alternately. A little channel is thus formed between them, and if you place a needle between the teeth, near the handle, and raise the handle, the needle will slide between the teeth and drop out at the other end of the saw. This spreading of the teeth is called the « set » of the saw.

Fig 17

Let us see why the saw, made in this way, can cut neatly through the wood when the knife fails to do so. When one of the teeth is pressed against the wood, it makes a little cut, as a knife might. The next tooth follows and makes another cut, but not in line with the first because the second tooth is bent away from the first. It makes, therefore, a similar but separate cut. The fibers have now been cut across at two points close together, which releases a little chip. This falls away, leaving an opening in the wood Now comes the third tooth in the line of the first and as some of the wood has been cut away, tooth number three cuts farther into the wood. The fourth tooth follows in the line of the second, and a second chip is released. As the teeth have been bent, alternately, to the right and to the left, the path they make is wider than the blade of the saw. The advantage derived from this is apparent. As the saw penetrates deeper into the wood, the sides of the cut do not press against the blade of the saw and hold it back, as was the case with the knife; and as fast as the tiny chips, which we call "sawdust," fall away, the saw is enabled to penetrate farther into the wood. This is shown, in a purposely exaggerated form, in Figure 17.

The "set" of saws differs according to the character of the wood on which they are to be used. For soft wood, the teeth are set farther apart, and the path they make through the wood is comparatively a wide one; for hard wood, the teeth are not so much bent, nor so large, and they make a narrower cut. This cut that the saw makes is called the kerf.

The saw is one of the tools most frequently used in woodwork, and it is necessary at the beginning to understand how to use it correctly. Take a pine board, of any length, about six inches wide and three-quarters of an inch thick. Rest it on two horses or two boxes of equal height. If you are using undressed lumber, the end of the board will be irregular, as in Figure 18, showing that the log was felled with the ax. The end is also cracked or "checked," which shows that it has undergone shrinkage, as explained in the preceding lesson. The cracks extend in for two or three inches, and you desire a straight end free from cracks. Place the wooden side, or "beam" of the try-square A against the long edge of the board and let the steel blade B lie across the face of the board. Holding the beam firmly against the edge, mark with a lead-pencil, or with your knife, a line across the board, using the steel blade of the square as a ruler. This line should be far enough from the end to avoid the cracks.

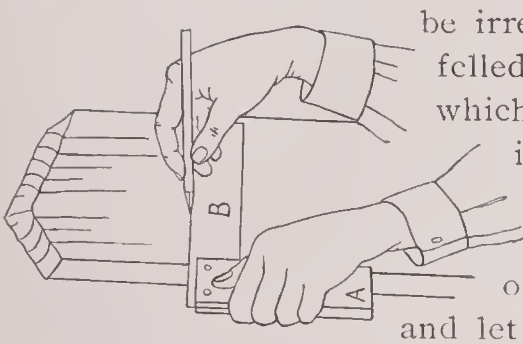


Fig. 18

Now take the cutting-off saw in your right hand, with the forefinger extended along the blade. Grasp the board with your left hand at the edge farthest from you and rest the toothed edge of the saw on the edge of the board so that the teeth come close to, but do not go beyond, the line you have marked. Use the left thumb-nail to steady the saw in this position. The proper position for the hands and the saw is shown in Figure 19. Draw the saw backward, without bearing down on it, but taking care to hold it perpendicular to the face of the board, and the teeth will sink into the wood. This must be done slowly and carefully and the saw must not slip, else the edge of the board may be splintered. Your forefinger, pressing on the right side of the blade, will serve to hold the saw against the thumb-nail. When you have drawn the saw back nearly to the end, the teeth will have made a little kerf in the wood. Now push the saw forward and draw it back again, and repeat this action, taking care to keep the saw upright and close to the line. Do not bear down heavily on the saw. The teeth will cut through the wood of their own accord, when the saw is pushed forward, and if you bear down too heavily you may cause the blade to "buckle," or bend, and the saw will leave the perpendicular.

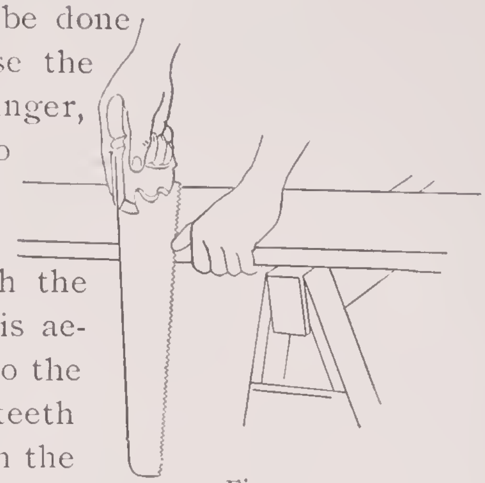


Fig. 19

Do not saw with short, jerky strokes, but at each stroke push the saw forward until the arm is extended in a straight line and draw it back until the hand comes near the shoulder. Do not draw it back so far that the forward teeth will be raised above the lower surface of the board. When the board has been cut nearly in two, support the outer end with the left hand and saw with very gentle strokes, so that the lower near edge may not be splintered by the sudden falling of the board by its own weight, before the wood has been cut all the way through by the saw.

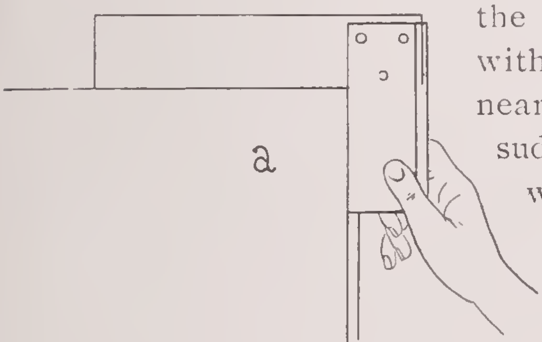


Fig. 20*a*

You now have a straight edge at the end of the board Place the try-square against the board, the beam resting on the near edge, as in Figure 20*a*, and see if you have sawed the board at right angles to the edge. Try it again by placing the beam against the edge of the board *b*, and see if the edge is perpendicular to the face. For practice, mark and saw off several strips, each an inch or two in width, and try the edge with the square each time.

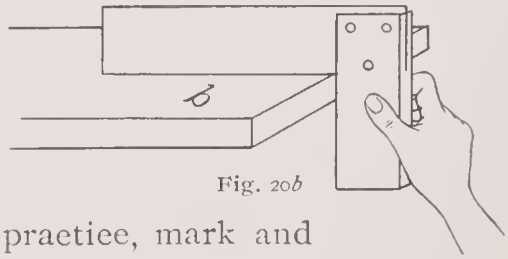


Fig. 20*b*

Remember that the teeth of your saw are sharpened and bent with great care, and the tool must be handled carefully if it is to remain in good condition. Do not throw it down anywhere, when you are done with it, nor let the teeth come in contact with iron or other hard objects

You have been using the crosscut-saw to cut across the grain of the wood; but you will often need to divide a board on a line running the long way; that is to say, with and not against the grain. For this work a different saw is needed. It is called a rip-saw or splitting-saw, because it rips or tears the fibers apart, or splits them. In this saw, also, the teeth are triangular, but the triangles are not like those formed by the teeth of the crosscut-saw. In Figure 21, you will see the shape of rip-saw teeth. They are not beveled on the side, like the teeth of the crosscut-saw, but are sharpened so as to form a series of tiny chisels, and they have only a very slight "set," that is, they are not bent to the right and to the left as much as the teeth of the cross-cut-saw. When this saw is pushed against the wood it separates the fibers from each other, and cuts out some of them altogether.

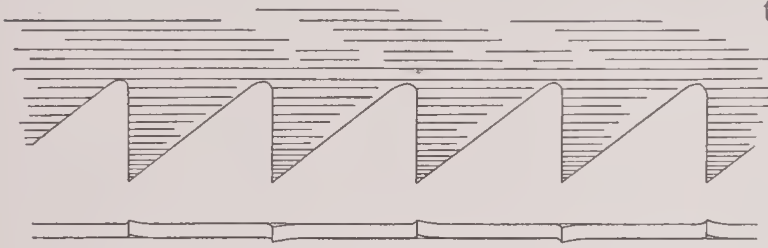


Fig. 21

You will need some practice in using the rip-saw. Take a board — the dimensions do not matter — and with your marking-gauge mark along one side a line two inches from the edge. The marking-gauge, Figure 22, consists of two parts: the stick, which is marked in fractions of an inch, and the block, which is mortised to receive the stick. A thumb-screw in the block makes it possible to hold the edge of the block firmly at any measure on the stick. The measure begins at the steel point which is inserted in the end of the stick. The steel point is not conical, but flattened, so that it will cut like a knife. Having set the gauge to the proper measure, you press the face of the block against the wood to be marked, and draw it toward you with the block tilted, as in Figure 23. If the pin is held in a perpendicular position, it will sink in too deep and tend to follow the grain of the wood, making an irregular line. If it is tilted, it will make a lighter line and cut across the grain, if necessary, thus making a straight line. When the first shallow groove has been made in this way, the pin may be pressed farther into the wood and the line strengthened by a second drawing. Having marked your board in this way, rest it on your horses or boxes and start the saw into the wood as you did with the crosscut-saw.

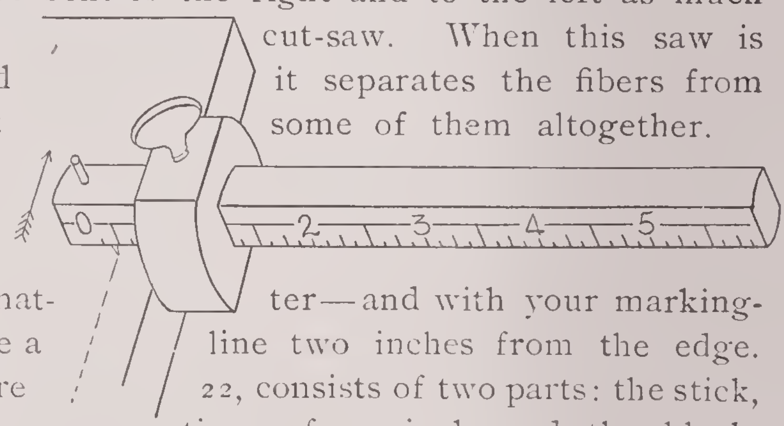


Fig. 22

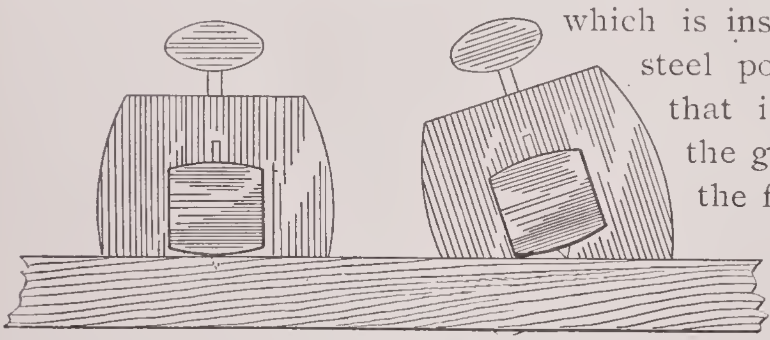


Fig. 23

Keep the saw close to the line. Do not bear down on it when you pull it toward you but exert some pressure upon it when you force it forward. The kerf made by the rip-saw is narrower than that made by the crosscut-saw, because the teeth are not bent so far outward, and the saw may show a disposition to bind or stick in the kerf. If you are sawing from the butt of the tree toward the top, the two parts of the board will be inclined to spread apart and will not bind the saw, but, when the saw progresses from the top of the tree toward the butt, the parts of the board will tend to come together, and thus pinch the saw. In this case, you can insert a screw-driver or a thin piece of wood in the kerf, not too near the saw, and so keep the two pieces of the wood wedged apart, as in Figure 25. As you saw farther into the board, the saw will approach the horse.

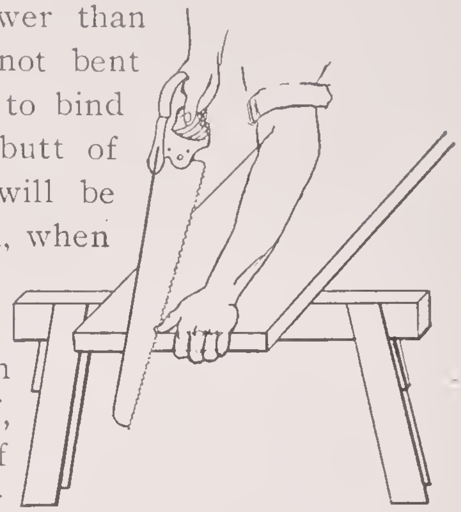


Fig. 24

In order not to cut into the horse, lift up your board and move it back, so that the part already sawed through will rest on the horse but the saw will be behind it, as in Figure 25. Follow the same plan when you approach the second horse. Move the wedge in the kerf nearer the saw as the work progresses, so as to keep the board spread apart. Do not take your saw out of the kerf until you have sawed the board to the end. If the saw shows a disposition to leave the line, bend it back toward the line, while sawing, and remember to keep it perpendicular, so that you will not make a beveled edge.

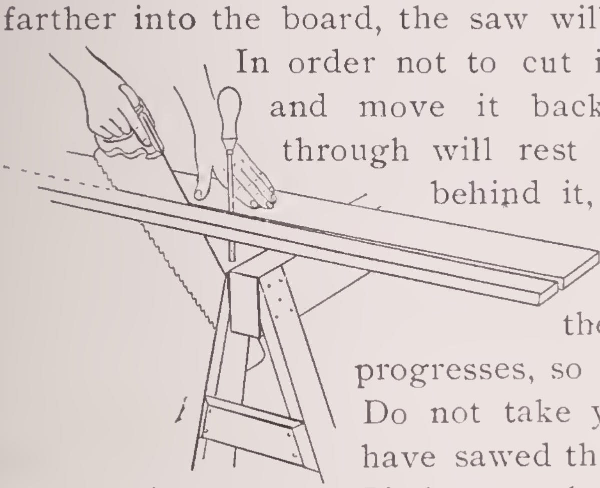


Fig. 25

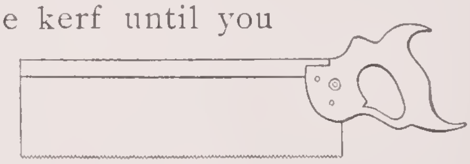
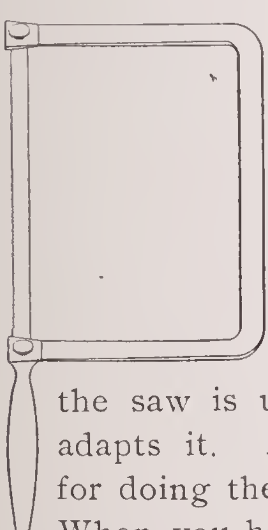
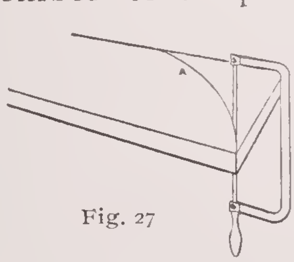


Fig. 26





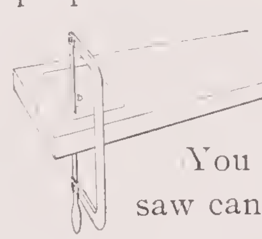


Fig. 27

You may ask if the rip-saw cannot be used to cut across the grain, and the crosscut-saw to split the wood. They may be so used, but the edges they make will not be so clean, and the work will be very much harder than when the saw is used only for the work to which its form especially adapts it. Always select a saw the teeth of which are formed for doing the work in the best manner, and most easily.

When you have made further progress in woodwork, you will need to use the tenon-saw and the dovetail-saw, which are back-saws with very fine teeth. There is also the frame-saw, which has a very narrow blade, with fine teeth, set in a frame as shown in Figure 27. This can be used for sawing on a curve, *a*, or within the board. In the latter case, a hole is made with the bit, and the saw, which is held taut in the frame by means of thumb-screws, is inserted in the hole, *b*. The compass saw is a saw with narrow blade (Fig. 28) used for sawing on curves and for cutting within the edges of the board, where a frame-saw could not be used. This saw is also called the keyhole-saw, as it is used for cutting out keyholes and similar openings. For the present, you will need only the cutting-off saw and the rip-saw, and when you are able to use these two dexterously, you will have no trouble in using the others.

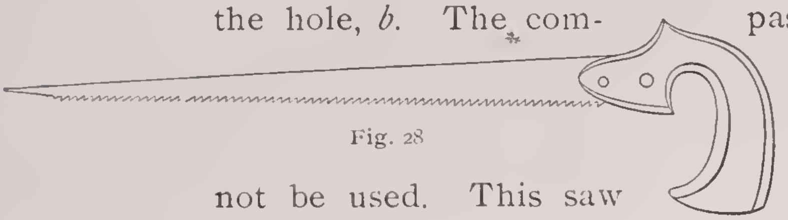


Fig. 28

In giving instructions for the use of the saw, you have been told to grasp it in your right hand, and to grasp the board with the left. The terms "right" and "left" are used merely to simplify the explanation. In practice, you should learn to use the saw with either hand. It is often very convenient to be able to do this, but there is a better reason for it in the fact that the use of tools in both hands, alternately, tends to an equal development of both sides of the body. A good sawer should be able to shift the saw from the right hand to the left, and *vice versá*, while making a single cut, and to work equally well with either hand.

LESSON V.—PLANES AND PLANING

The board on which you used the saw was a piece of ordinary "mill-dressed" lumber. When a log is sawed into boards by the circular saw, the surface of the board is left rough and shows the saw-marks. To remove these and reduce the roughness, the board is run through a machine called a planer, which "dresses" the surface, making it comparatively smooth, and of even thickness throughout. If the board is to be used for making work in which little value is placed on appearances, as in packing-boxes or in house construction, where the board will be hidden by other woodwork, it requires no further dressing. But if it is to be used in making something as conspicuous as a tool-box or a chest of drawers, for example, it will require to be smoothed still further. This smoothing is done by hand, with the plane.

There are many kinds of planes, as there are many kinds of saws, and each kind is adapted to a special use. All have, however, two principal parts, the stock and the iron. The stock is made of iron or of wood. In the latter case, it is made from a block of very hard wood, like boxwood or beech, which has been thoroughly seasoned and is carefully finished so that the bottom, or sole, is a perfectly plane surface. In the stock a mortise extends from top to bottom, to admit of the insertion of the plane-iron. The plane-iron is sharpened at the end like a chisel. It is placed in the mortise, or socket, in the stock, in an oblique direction, the cutting edge pointing forward, and is secured in place by a wedge driven in above it. The socket ends at the bottom of the plane in a narrow slit, called the mouth, through which the plane-iron projects for a small fraction of an inch.

When the plane-iron is forced against the wood, it makes the same kind of cut that was made by your knife, when held in a slanting position, as in the first lesson. But the iron must be prevented from going too deep, and splitting off too much of the wood. You now see why it is held in a stock. The stock is pressed down upon the board and prevents the iron from going in too far. Now, when the plane is pushed against the wood, it tears up a thin shaving, which enters the mouth of the plane and passes up into the socket. But, although the stock of the plane prevents the plane-iron from entering the wood too far, the shaving or splinter, once started, might extend into the wood deeper than is desired and choke the mouth of the plane, or break, leaving a rough place and a considerable hollow in the board. To prevent this, the plane-iron is provided with a back-iron, or cap, which is a blade of about the same width and thickness as the plane-iron itself. This cap-iron is fastened to the plane-iron by means of a nut and screw. The lower end is bent upward, and the lower edge rests on the plane-iron a sixteenth of an inch, or less, or more, from the cutting edge. When the shaving passes through the mouth of the plane, it encounters this cap-iron, which causes the shaving to bend forward and crack. This crack is repeated as fast as the shaving is pushed upward, and the shaving is thus made very weak. If you examine a shaving carefully, you will see the little cracks across it which have been made in this way. The result is that the shaving has no lifting power and cannot tear up the wood beyond the desired depth.

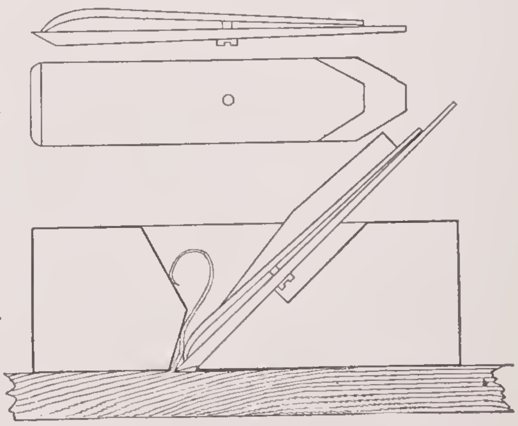


Fig 29

Your first attempt at planing may be made with the jack-plane, since this is the tool used for planing rough surfaces. The iron of the jack-plane has an edge which is slightly curved, as in Figure 29. If the edge were perfectly straight, and at right angles to the side of the iron, each stroke of the plane would produce a hollow with perpendicular walls. But as the edge is curved, the shaving taken off is thinner toward the sides than it is in the center, and thus tears off easily, while in the first case it would be much harder to remove it.

Before you begin to use the plane, take it apart, so that you may see exactly how it is adjusted. If the plane-iron is held in place by a wooden wedge, tap the plane on the heel with a hammer, which will loosen the wedge. You can then remove both wedge and plane-iron. If the wedge is of iron and held in place by a spring, you will readily see how to take it out. You can now examine the plane-iron and notice the curved edge, and the back-iron. Replace the iron in the socket, with the beveled side downward, and insert the wedge. Now turn the plane over so you can glance straight along the sole. Do not allow the plane-iron to project too far beyond the block. Even if you have to readjust it and push it farther out, after trying it in use, it is better not to have it project far at first. Be sure that the edge of the plane-iron is at right angles to the side of the stock, that is, it must not be higher at one end than at the other, or it will make a beveled cut. Having secured it firmly in position, by means of the wedge, you are ready to use it.

Place your board flat on the bench, with the end resting against the bench-peg, which must be lower than the surface of the board. Brush off any dirt there may be on the board, so that it cannot dull the edge of the plane-iron. Stand near the rear end of the board, with the right side of the body near the bench, and the left foot forward. Grasp the handle of the plane firmly with the right hand, extending the forefinger as you did in grasping the saw. Place the left hand on the toe, or forward part of the plane, as shown in Figure 30. Resting the sole of the plane on the board, at the edge nearest you, push the plane forward with the right hand and at the same time bear down, but not too heavily, on the toe of the plane with the left hand, so that the sole will lie flat on the board. If you do not hold the toe down with the left hand, it will have a tendency to jump upward, the plane-iron will enter the wood too far below the surface, and this will make the shaving thick at first and then thinner, leaving a rounding surface on the board.

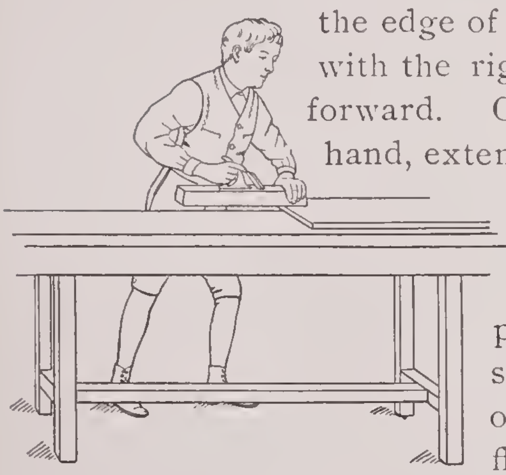


Fig. 30

When the plane nears the farther end of the board, lighten the pressure of the left hand, though still grasping the toe with it, and bear down more with the right hand, so that the heel of the plane may not be tilted upward. In the latter case, the iron would cut in too deep and you would again have a rounding surface. Generally speaking, you must plane *with* the grain of the wood, not against it, and, where the grain alters its direction frequently, it may be necessary to turn the board end for end in going over certain portions of the surface. Take as long a stroke as you can, and do not shift the position of the feet unless the board is a very long one, so that you cannot push the plane to the end without changing your position. When you have planed to the end of the board, on the near edge, move the plane to the right and repeat the action. Do this until the entire surface of the board has been planed. You will now find that you have reduced the roughness and given the board a fairly smooth surface, but it is not a plane surface. Move the blade of the try-square along the surface of the board, and you will see that the surface is made up of a succession of hills and valleys. To get a smooth and plane surface the board must be planed again. For this work you will use the smoothing-plane.

The jack-plane itself is sometimes used for smoothing. The plane-iron is readjusted so that it projects very slightly from the stock, and can, therefore, take up but a very thin shaving. The cap-iron is also readjusted, by means of the screw, so that it comes very near the cutting edge. The curved edge of the plane-iron will still make hollows, but they will be shallower than those made by jack-planing, and will tend to produce a more even surface.

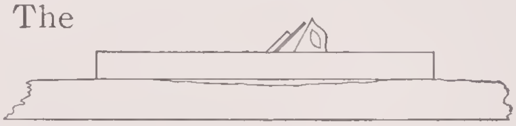


Fig. 31

But the jack-plane is not the tool generally used for this work. On large surfaces a fore-plane is employed. This is a plane with a long, heavy stock, and an iron shaped differently from that of the jack-plane. Instead of being curved, the edge of the iron is straight, except that at the sides it is slightly rounded, as in Figure 32. The fore-plane is used in the same way as the jack-plane, but it takes off thinner shavings and leaves a square, not a hollowed surface. The fore-plane thus acts as a smoothing-plane, but for finishing small surfaces you will use the smoothing-plane proper.

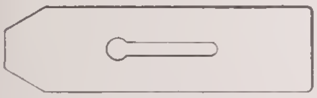


Fig. 32

The smoothing-plane has a short stock and is without a handle. It is grasped with the hand, from the top, the thumb being on the left side and the fingers on the right. As it is short and light, this plane may be used for taking short, quick strokes. It takes off but a thin shaving, and as it may be easily pushed in any direction, it is very useful in removing the ridges left by the jack-plane, and the roughness where the jack-plane was pushed against the grain of the wood. When you have carefully dressed the surface of your board with the smoothing-plane, it will be as nearly smooth as you can make it without the use of the scraper or sandpaper. Of the use of these you will learn something in another lesson.

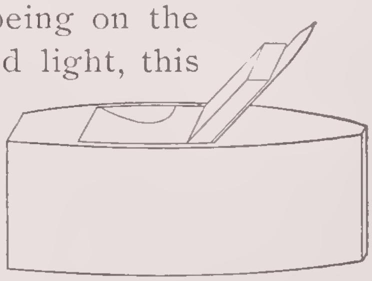


Fig. 33

It will sometimes happen that you have a board one inch thick which you wish to reduce to a thickness of three-quarters of an inch, or it may be that you have a "winding" board, which is so warped that when placed on a plane surface, only three corners touch the support; the fourth corner, A, is raised a little from the bench. (See Figure 34). A board in this condition is not suitable for good work, such as making a neat box. You must be able to reduce it so that it will lie flat on the bench and touch at all four corners.

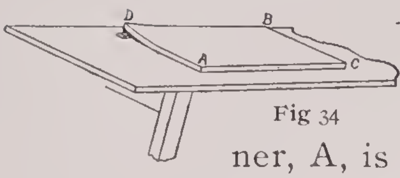


Fig 34

Put a chip under A, so that the corner will not be depressed when you bear down on the board with the plane. Now take the jack-plane and, beginning at D, make first a short stroke, then a longer one, and so on, toward B. Begin at D each time and let the last and longest stroke reach nearly to B. If you now apply your straight edge to the surface, you will see that it is nearer to being plane. Continue with the jack-plane, moving a little farther toward AC each time, and testing with the straight edge after every few strokes, until you find that the "winding" has been removed from that side of the board. Dress it with the smoothing-plane, and you will now have a surface that will touch the bench at all four corners. In other words, it is plane. But the board is now thicker along AC than it is on the side BD. You wish it to be three-quarters of an inch thick throughout its length. Set your marking-gauge to a measure of three-quarters of an inch. Now, hold the board on edge. Hold the marking-gauge in your right hand, and press the block against the surface you have smoothed. Draw the gauge toward you, being careful to keep the block pressed closely against the face of the board, and in this way mark a line all the way around the board. Press the pin into the wood very lightly. It will make a tiny groove in the wood. When you have marked once around the board, go back to the starting point and repeat the operation. The groove already made will guide the point and you can now press harder, so as to make a deeper line, which will be readily seen.

Now, place the board, smooth surface down, on the bench, and with the jack-plane go over the surface to reduce it to the mark made by the gauge. Be careful not to take off too much on the side where the board is thinnest, or to plane below the line marked. Finish with the smoothing-plane. Now test your board with the straight-edge, and if you have planed to the mark, all parts of the board will be of equal thickness, and it will be free from "winding." The edges, however, will not be at right angles to the surfaces, and it is necessary to true them. Put the board in the vise and plane one edge smooth and true. Be careful to have it at right angles to the surfaces of the board throughout the length. Having secured one true, square edge, set your marking-gauge to the measure you wish, and then, pressing the block of the gauge against the trued edge, draw it toward you, and make a very light mark, as before. It will be hard to make a straight mark when the pin is so far from the block, and with the left hand you may steady the end of the stick that contains the pin. Move the gauge, and press the block against the board, with the right hand only. You now have a mark to which you can plane. Do this very carefully. Your plane must not be tipped forward nor backward nor over either side of the edge.

The board is now finished as to face and side edges, but the end edges are yet to be made neat and smooth. With the beam of the try-square pressed against the side of the board, see if the end is at right angles to the side. If it is not, mark a line and saw close to it, so as to obtain a square end. This end is, however, more or less rough. To make it smooth, fix the board in the vise, with the end upward, as in Figure 35, and plane it with the block-plane, which differs from other planes in having the iron inserted with the beveled side uppermost, so that, when it is driven against the wood, it acts precisely as a chisel would. The iron is also held at a much greater angle from the sole than in the case of the jack-plane, for the wood to be cut with it is made up of the ends, not the long surface of the fibers, as is the case when the jack-plane is used. Heretofore you have pushed the plane straight forward along the wood; now you start it at an angle, as in Figure 36. Push it against the wood very carefully, with short, quick strokes. If you allow the plane to go too far it will splinter the edge, by separating the fibers from one another as it did when you used your knife in splitting. By planing first from one side and then from the other, you avoid such accidents. Have a care to hold your plane squarely on the end of the board, or you will make a curved end, instead of a square one. This concludes the dressing of the board, and it is now ready for use.

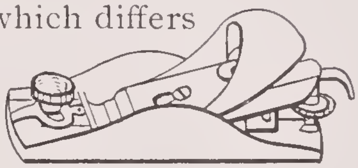


Fig. 35

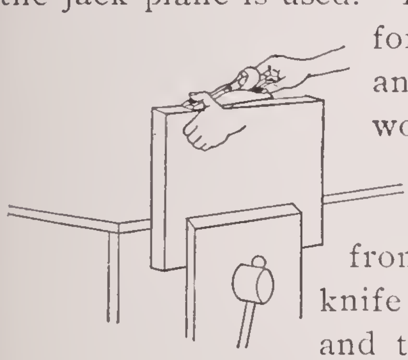


Fig. 36

Among the things you should remember in using the plane is that, after pushing it forward, you should tilt it on one edge, or lift the heel, before drawing it back to the starting point, as in Figure 37. This is to prevent the plane-iron from resting on the wood and so dulling the edge when it is drawn back. Another thing to be remembered is that the plane-iron must be examined from time to time, to

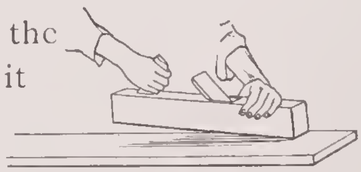


Fig. 37

make sure that it has not been pushed out of place, so that one side is higher than the other. This is likely to occur when the iron strikes a hard knot in the wood, if the wedge is not driven in tight enough.

Remove the shavings from the socket of the plane, frequently, and do not let them clog the mouth. If you find that shavings slip between the plane-iron and the back-iron, the screw that holds the two blades together should be tightened so that no shaving can pass between them. If you start the plane and too thick a shaving is torn up, so that the wood is splintering, do not try to mend matters by forcing the plane forward still farther, but withdraw it carefully. Then set the plane-iron so that it will not project so far from the stock, and plane from the opposite direction until the partially raised splinter has been planed away. Do not force your jack-plane against hard knots. The knot presents a surface where the ends of the fibers are upward; that is, you must cut against the grain. A block-plane or a smoothing-plane or the scraper must be used to reduce the surface of the knot. Generally speaking, you will avoid using lumber that is knotty, and lay out your work so as to cut out those sections of the board in which they appear.

LESSON VI—WORKING SKETCHES AND DRAWINGS

You have now learned the use of the saw and the plane in reducing the lumber to the desired length, breadth, and thickness, and giving it a smooth surface. Before you proceed to construction work, however, you should know how to plan your work, and, having planned it, you should execute it according to the plan. In woodwork we cannot expect good results from guessing; we must know how to do a thing so that the result will be an exact counterpart of the article we can see, in imagination, as the finished product.

You decide to make a box. You can see a mental picture of such a box as you desire to make, but this mental picture is not an accurate guide for the tools which must be used in the actual work of construction. You therefore need a diagram, or a working sketch, as it is called, on which you can mark the several dimensions of the box in figures. With this to aid you, you will be able to cut out pieces of wood whose dimensions will correspond to those marked on your diagram, and if you make them with accuracy, they will fit together neatly and the desired result will be accomplished.

The box is to be fifteen inches long, eight inches wide, and seven and one-half inches deep, outside measurement, and it is decided to make it of boards three-quarters of an inch thick. First draw a rectangle, like Figure 38, to represent the front elevation of the box. This will be a freehand drawing with a pencil, made on a piece of paper. In drawings of this kind, the mark (′) is used to represent feet, and the mark (″) to represent inches. On the upper line, therefore, you mark 15″. The sides will be less in width than the outside depth of the box; by the sum of the top and bottom thicknesses, which equals 1½″. On the side lines, therefore, mark 6″. This shows that there will be needed two boards, each 6″ x 15″, for the sides of the box.

You now draw the plan, or a figure, to represent the bottom of the box. As the bottom will be nailed to the sides, and the outside measurement of the end must be 8″, you will see that the bottom must be 8″ wide and 15″ long. Draw another rectangle, as in Figure 39, and mark these dimensions on it. Mark it, also, « Plan. »

Now we come to the end of the box. If this were to be nailed to the ends of the sides and bottom, it would need to be 8″ wide and 7½″ deep. But the box will be much stronger if you place

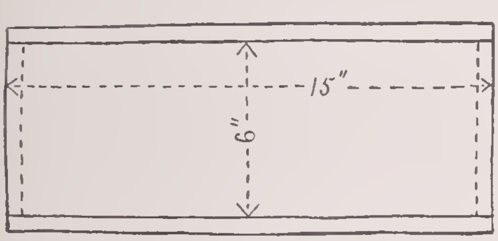


Fig. 38

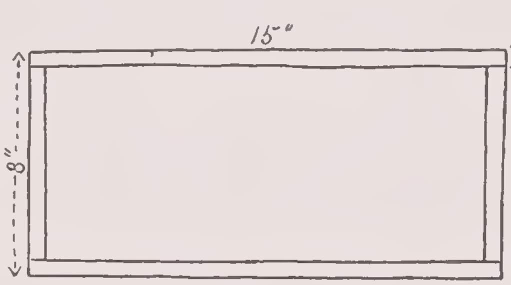


Fig. 39

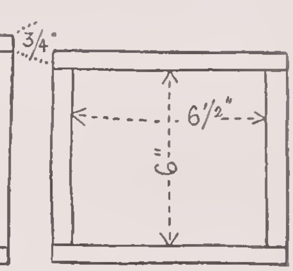


Fig. 40

the end board between the sides and nail into it from the sides and the bottom. This makes it necessary to have end-pieces of the same width as the sides, *viz.*, 6″ and 1½″ less in length than the width of the bottom. Draw a third rectangle, Figure 40. Mark the sides 6″ and 6½″, respectively. Mark this rectangle, « End. »

The top of the box must be large enough to extend to the outer edges of the sides and ends when they are in place, because the nails are to be driven down through the top into the sides. You will not need to draw another figure to represent the top, because that is to be a duplicate of the bottom, represented on the plan.

All these drawings should be made without a ruler, and quickly, their lines being in approximate, not necessarily in accurate, proportion to the proposed dimensions of the box. You now have three drawings which represent the boards to be used in making the box, and these drawings have been marked with figures to indicate the dimensions of the boards. From this working sketch, as it is called, you will be able to work your boards to the dimensions indicated, using measure, try-square, gauge, saw, and plane. When completed, the pieces should fit together in the manner indicated so as to make an oblong rectangular box, 15 inches long, 8 inches wide, and 7¼ inches deep, outside measurement.

As there might be a doubt whether the figures on a sketch referred to inside or outside measurement, it is customary to draw a dotted line with arrowheads at the ends, to indicate the points to which the line extends, and to mark the number of feet or inches on this line.

A working drawing differs from a working sketch in that it is drawn accurately to a scale; that is, if the scale is 1 to 4, a line in the drawing which is one inch long will represent a measurement of four inches on the object to be made. The lines of a working drawing are made with a ruler as a guide, are carefully measured, and must be so accurate that, if we simply make the drawing and mark on the margin of the paper "Scale ¼," a workman, by measuring each line in the drawing and making the corresponding line on his work four times as long, could produce the article in exact dimensions, as required.

Instead of marking the drawing, "Scale ¼," we may say "Scale ¼″ = 1″," to show that a quarter of an inch on the drawing represents an inch on the object to be made. Another method is to

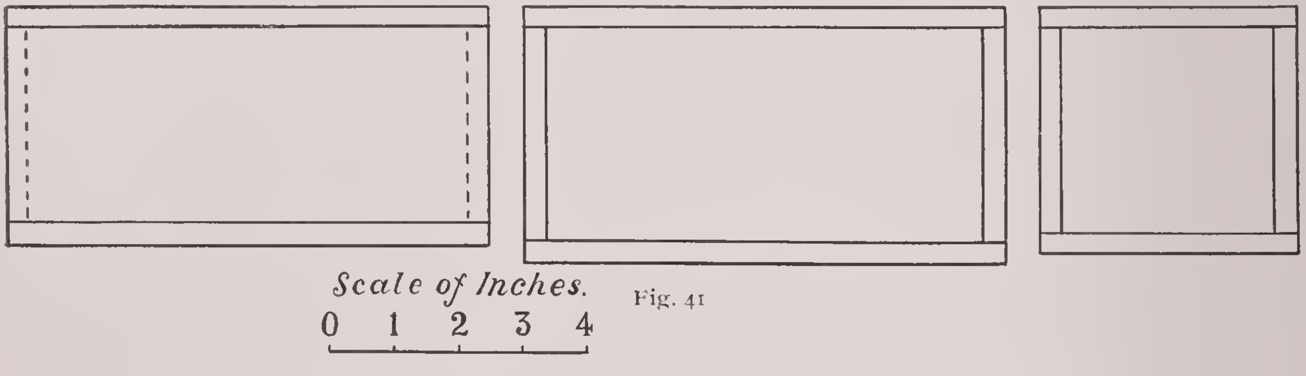


Fig. 41

draw a line and divide it with the compasses into quarter-inch sections, as in Figure 41. In this case, the distance from 0 to 4 represents a length of 4 inches. Of course, a smaller division may be adopted, as one-eighth, so that one-eighth of an inch on the drawing will represent an inch on the object to be made, but the scale must be large enough so that the workman can measure the lines of the drawing without difficulty. Figure 42 shows a working drawing of the box you wish to make, and you will see that the lines are accurately drawn to the scale indicated and require no numbers.

In making working drawings, it is often necessary to supply separate drawings of certain details and sections, which cannot be clearly indicated on such drawings as you will make for your box. In the chapters on mechanical drawing, in another part of this volume, you will find a full description of sectional drawings. With the drawings now in hand you can proceed to the making of a box.

LESSON VII.—MAKING A BOX—LAYING OUT THE WORK

You are now ready to put to practical use the knowledge you have acquired as to the sawing and planing of wood and the making of drawings. You decide to make a box like that called for by the working sketch in the preceding lesson. Examine your working sketch. You find that you will need two pieces of wood, each 15 inches long and 6 inches wide, for the sides of your box, two pieces each 6½ inches x 6 inches for the ends, and two pieces each 15 inches x 8 inches for the top and bottom.

First prepare the four pieces to be used for the sides and ends of the box, all of which are 6 inches wide. Their combined length is 43 inches. Take a board ¾ inch thick and not less than 44 inches in length and select the better edge of the board. Mark this "X" with your pencil and use it as a base for your measurements. Apply your try-square to the end of the board and draw a line across it at right angles to the selected edge. With your cross-cut saw, cut to this line, so that you will have a square end. Now take your rule and mark a point 15 inches from the squared end, along the selected edge. With the try-square as a ruler, draw a line across the board 15 inches from the end. If you were to saw through the board on this line, you would have a piece for one side of your box, but it is better to lay out the work farther before cutting off any of the pieces. As you will need a second piece 15 inches long, you could make a second mark 15 inches from the first and draw another line. But you have learned that the kerf of the saw will occupy a little space, and if you do not allow for it, one of the two pieces will be shorter than it ought to be. Therefore you must take your square and draw a line just beyond the first one and parallel to it. Let the space between these two lines be equal to the width of the kerf. To make sure of doing this accurately, after you have drawn the first line, you can saw into the board for about an inch, close to, but not encroaching on, the line.

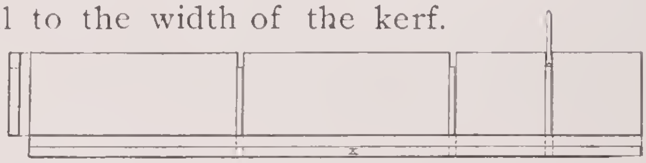


Fig. 43

Then draw your second line touching the other side of the saw-kerf. Now mark another point 15 inches from the second line and draw another line. Repeat the sawing; then mark off a space of 6½ inches; make another saw-mark; draw another line and then mark off the fourth piece. You now have your board divided as in Figure 42.

Saw off the pieces, one after the other, taking care to make perpendicular cuts and to keep between the lines drawn as a guide for the saw. Try the edges, one after the other, with the try-square, to see if they are at right angles with the selected edge "X" of the board. If they are merely a trifle out of square, it may be possible to correct them by planing with the block-plane, as has been described; but you should aim to secure accuracy at first.

You may now dress your boards with the plane. In planing, smooth first the surface, and then the selected edge, of the several pieces. If your boards are much more than 6 inches wide, you may need to use the rip-saw to remove a piece from the side opposite the selected edge. If they are only a little wider than 6 inches you can plane them to the mark which you make with your gauge, set to 6 inches, in the manner already described.

When your boards have been sawed and planed, measure them carefully and see if they are all of exactly the same width, and if the two end-pieces and the two side-pieces are of the same length, in each case.

It may be that, in laying off the spaces on your board, you will find that the end of one of your pieces comes close to a knot. You will have to nail through the ends of your pieces, and you cannot drive a nail through a knot, nor very near to it, without splitting the board. It may be that you can so lay off your several pieces, by first marking off a side and then an end, instead of two sides, one after the other, so as to discard the section of the board in which the knot is, without wasting very much of the board. Whenever you can do so, discard knotty pieces. If it is not practicable to discard the knot altogether, let it come well within one of your pieces, and at least twice its own width from the end.

Fig. 43

Having made the side and end pieces, you may prepare in the same way the top and bottom pieces, each of which is to be 15 inches long and 8 inches wide. Refer frequently to your working sketch and use your rule and square after each sawing or planing. Remember that you are not making a box by guesswork, nor from the mental picture which you have before you, but according to the dimensions marked on the sketch.

Now comes the work of putting the box together. This introduces the use of a new tool, the hammer, and new materials, nails.

LESSON VIII.—HAMMER AND NAILS

The saw and the plane are tools for cutting. The hammer is a tool for striking. It consists of a head, made of steel, or steel-faced iron, and a handle of wood. The head has a face, or ball, which delivers the blow; the eye is a hole in the center of the head in which the end of the handle is inserted. The end of the head, which is opposite the face, is shaped to a claw, for pulling nails, or to a peen, which is used for riveting. The eye widens toward the top and, when the end of the handle has been inserted, the latter is split, and a wedge is driven into the split, which prevents the handle from slipping out of the eye. Sometimes the wedge becomes loosened, and the head ceases to pinch the handle firmly. When this occurs, the end of the hammer farthest from the head should be struck sharply on some solid object, which will cause the head to settle firmly down upon the handle, and the wedge in the head end may then be driven in farther. This will prevent the head from slipping.

Probably you think that "everyone knows how to use a hammer"; but there is an incorrect, as well as a correct, way of using it, and you wish to avoid the former. Three movements are employed in using hammers of different weight. The light tack-hammer is for tapping, that is, delivering light blows, and is operated by a wrist movement. Thin nails and brads, which are driven with a heavier hammer, but are liable to bend if struck too hard, are struck with a movement which comes from the elbow, only the forearm furnishing the power. Large nails are driven with a blow from the shoulder.

For the present you will use only the claw-hammer, which is heavy enough for striking blows from the shoulder when desired. Take a block of soft wood about six by eight inches, and with ruler and compasses mark on its surface twelve points equally distant from one another. Place the block on the bench, and stand behind it, with the right hand grasping the handle of the hammer so that about an inch projects beyond the hand. This position is shown in Figure 44. When you grasp the hammer in this way, you are enabled to deliver much heavier blows than when the handle is grasped at a point nearer the head.

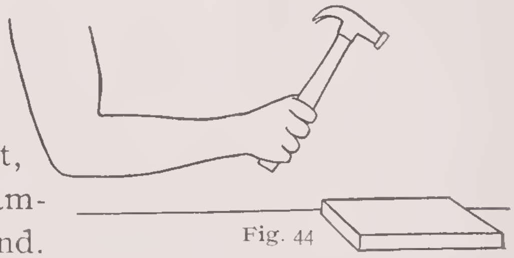
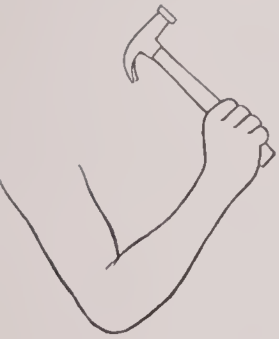
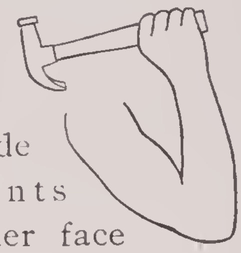


Fig. 44

Rest the face of the hammer on one of the points you have marked on the block of wood, then raise it with a motion from the elbow, and try to strike the point on the block so that the face of the hammer will make a round dent of which the point will be the center. Strike squarely. Your hammer should sink as deeply in the wood at the side farthest from you as it does on the near side. Repeat the blow and try to have the hammer strike within the circle made by the first blow.



When you have practised the elbow-stroke on half the points marked on the block, raise the arm from the shoulder and strike a heavier blow. This position is shown in Figure 46.



When you have made dents at all the points marked, turn the other face of the block upward and without marking it, try to make on it the same number of dents as before, at equal distances apart. This exercise will teach you how to strike square blows with precision, that is, how to deliver successive blows in the same place. You will realize the importance of learning to do this if you have seen people, who seldom use a hammer, trying to drive a nail. Some strokes miss the nail altogether and at other times glancing blows are struck which bend but do not drive the nail.

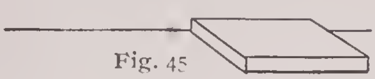


Fig. 45

Fig. 46

Nails are made in a great variety of forms, some of iron and some of steel. Iron nails have rectangular heads, which project beyond the shank so as to form a cap. The shank tapers from the head toward the bottom, which is cut off squarely, and does not end in a sharp point. Two of the sides are parallel and the other two sides are inclined so as to form a wedge. You should remember this when you drive iron nails, because the inclined sides make the nail a wedge and if it is driven in so that the wedge pushes the fibers of the wood apart, it may split the board, as in *a*, Figure 47. But if you drive the nail so that the wedge acts in the direction in which the fibers run, that is, with the grain of the wood, there is less danger of splitting.

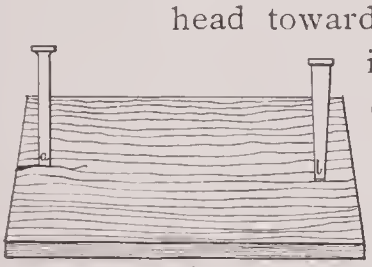


Fig. 47

Iron nails are used chiefly in coarse work; for fine work, steel wire nails are generally employed.

Take a block of wood and mark off a series of points as you did before. Six points, in line with each other, will be sufficient. Take a nail between the thumb and forefinger of the left hand and place the entering-end at one of the points on your block. Hold the nail upright and with an elbow-movement give it a few preliminary taps to start it into the wood. Increase the weight of the blows, and when the nail is settled well in place, release the hold of the left hand and with strong

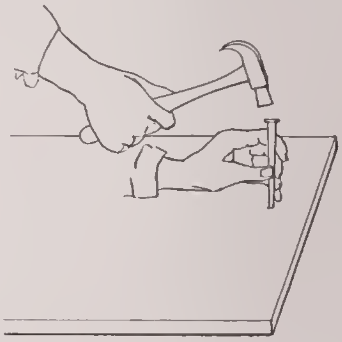


Fig. 48

shoulder-blows drive the nail home. It should sink into the wood until the head is flush with the surface of the board, but do not try to drive it farther with the head of the hammer or the latter will mar the wood around the nail. Good work should show no hammer-marks. But it is desirable to sink the head of the nail a little below the surface of the wood. To accomplish this, use your nail-set, which is a piece

Fig. 49

of hardened steel, with one end tapering to a circle. Place the tapering end squarely on the nail-head and strike the head of the nail-set one or two blows with the hammer. This will drive the nail farther into the wood and yet the wood surrounding the nail will not be marred.

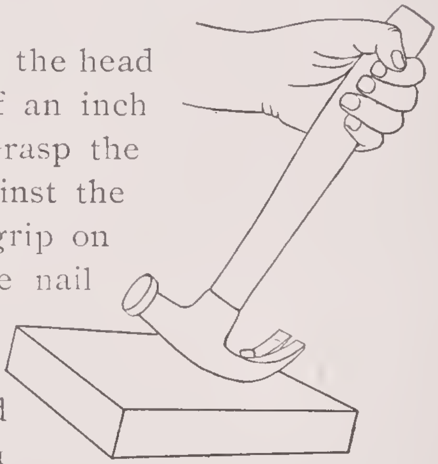


Fig. 50

Drive another nail into the block, but not so far that the head will enter the wood. Let the head remain a quarter of an inch above the surface. Now you can withdraw the nail. Grasp the hammer as shown in Figure 50, and slide the claw against the nail, so that the edges of the claw will obtain a good grip on the head. If you now pull the handle toward you, the nail will be pulled upward, but after it has been drawn up half an inch, it will bend, if the head of the hammer rests on the wood, and the force exerted in pulling the nail will cause the head to sink into the wood, which will leave an unsightly mark. To avoid both bending the nail and marring the wood you must place a piece of wood under the head of the hammer. We will suppose this piece is an inch thick and two inches wide. The length is not a matter of importance. Any scrap of waste wood will serve. Rest the head of the hammer on the wide side of the block and then pull on the nail. It will be withdrawn for perhaps three-quarters of an inch, but, if pulled farther, will bend. Now turn the block on which your hammer rests so that the narrow side is uppermost. This will give the head of the hammer a higher point on which to rest. Again draw the nail and it will come farther upward. If it does not wholly leave the wood before it again reaches the point where continued pulling will bend it, you must find a wider piece of wood on which to rest your hammer. In this way the nail may be withdrawn without bending it, without widening the nail-hole, and without marring the surface of the wood.

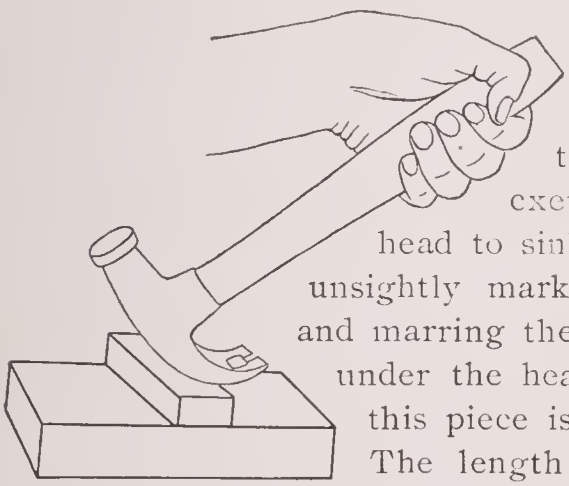


Fig. 51

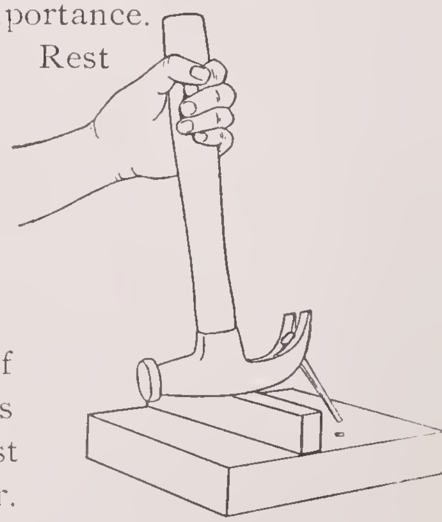


Fig. 52

Repeat this exercise in driving and withdrawing nails, several times. In driving, it is probable that in one or more cases you will release the nail from the left thumb and finger before it has fairly entered the wood and the next blow of the hammer, unless it strikes the head squarely, will cause the nail to bend a little to one side. Do not continue to drive it while it is in this position, but move the nail to an upright position, with the fingers, if you can do so without bending it, and then drive as before. Sometimes, when a nail has been driven part way into the wood, it encounters a place where the fibers of the wood are harder, or, it may be, a knot, and when the hammer strikes again, the nail will bend. If it has gone too far to be straightened with the fingers, it may be tapped with the hammer on the side that leans toward the wood, and so bent back to an upright position. If it bends again, when driven forward with lighter and more careful blows, it is best to withdraw the nail and, after straightening it, enter it at another point.

A bent nail should not be carelessly thrown away. It is a simple matter to straighten it, and it is important that you should learn not to waste your materials, whether wood, nails, screws, or glue. Rest the head and point of the nail on a piece of waste wood, and hold it firmly with the fingers of the left hand while you tap it with the hammer at the point where it is bent. When it is nearly straight, move the head beyond the edge of the block, and continue tapping it, while rolling the nail, until the shank of the nail touches the wood throughout its length. This will make it again available for use.

LESSON IX.—NAILING THE BOX TOGETHER

You are now ready to nail the pieces of your box together. Remember that the sides are to be nailed to the ends, not the ends to the sides. When the edge of a side-piece is flush with the surface of the end-piece, as in the completed box, the end-piece will cover a space three-quarters of an inch wide at the end of the side-piece. As you wish to drive nails through the side-piece into the center of the edge of the end-piece, you should draw a light pencil mark across each end of the side-pieces, three-eighths of an inch from the edge and parallel to it. On each of these lines mark four points, two at a distance of one inch from each end and the other two at equal distances between. Lay one of the side-pieces on the bench and drive eight nails nearly through the wood at the points you have marked.

Now fix one of the end-pieces upright in the vise, and place the end of the side-piece against it. With your finger try the edges, to make sure that the end of the side-piece is flush with the surface of the end-piece. If you are using iron nails, be sure that you hold them so that the parallel sides of the nail will be parallel to the grain of the wood. Drive one of the nails nearest the center of the side-piece into the end, but do not drive the head quite down to the wood. The concussion produced by driving this nail may cause the board to move from its proper position. Readjust it if necessary, so that it be flush with the surface of the end-piece again, and drive one of the corner nails nearly home, holding the side-piece in position with the left hand. Now try the end with your square and, if the side-piece is not exactly flush with the end, place a block against the edge and drive it forward or back a little, as may be needed. Drive the other two nails almost down to the wood, and if the edge is now square with the end, drive all the nails flush with the surface, taking care not to mar the wood with your hammer.

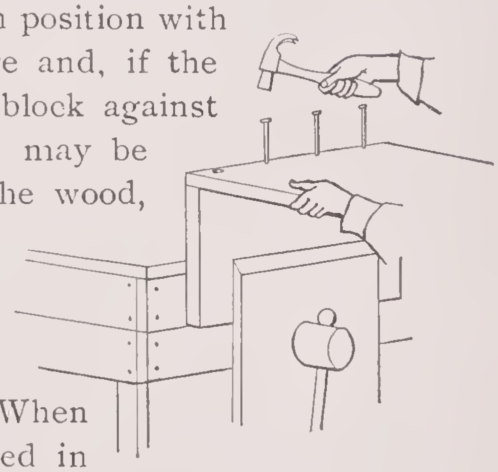


Fig. 53

Fix the other end-piece in the vise and nail the other end of the side-piece to it in the same way. When nailing to an end, be careful to have the board fixed in the vise so that it will not be driven down, and thus leave a narrow space between itself and the side-piece.

When you have nailed one side-piece to both end-pieces, lay that side flat on the bench, and, after starting four nails in each end of the other side-piece, place it on the end-pieces and nail it to them in the same way as before. In doing this you will need to be very careful to get the second side-piece square with both end-pieces. If it is not, your box will be in "winding" when you have finished nailing. When you set the box on its edge, on the bench, it should touch the bench at all four corners, if the surface of the bench is plane.

"Winding-sticks" are used in testing for winding. These are two strips of wood, for example, $\frac{3}{4}'' \times 2'' \times 30''$, which have straight and parallel edges. They must be finished with exactness. If these strips are laid across the box at opposite ends, and you sight across them, you will be able to detect any winding which exists in the box, even though it is so slight as not to be noticeable when you look directly at the box. The reason for this is that the long sticks carry the sides of the angle of divergence far enough from the apex to enable you to detect the divergence, which may be very slight in the box. This will show whether the box is in winding.

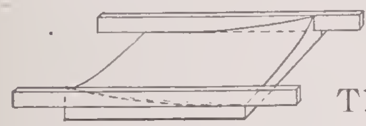


Fig. 54

The same test may be used to determine whether a board is free from winding. If the box proves to be in winding, it should be possible to correct the trouble with the plane, by taking thin shavings from the edges, at the proper places, until the box will touch a plane surface, at all four corners.

With your box resting on edge, on the bench, you may now nail the bottom in place. When you have done this, your box is ready for the cover. Ordinarily, you would not nail the cover on unless the box were to be first filled with articles which were to be stored or sent away, but as you are now learning how to use your tools rather than to make a box, you may turn the box over and nail the cover on. Before nailing the bottom and the top to the sides, you will draw a line three-eighths of an inch from the edge, all the way around the board, and mark on it the points where the nails are to be driven, as you have done in nailing the side-pieces to the ends.

Now try your box on all sides with the square. See if the ends are at right angles to the top and bottom, and to the sides. See if the top and bottom are at right angles to the sides and ends. With your rule, measure the box carefully and see if you have made it of the dimensions indicated on your working sketch. Remember that you are striving to do accurate, not passable, work, and that, even if your box is neat in appearance, it is not up to the standard you have set unless it conforms to the given dimensions.

LESSON X.—TAKING THE BOX APART

You have many times seen the wooden cover removed from a box with so little care that the wood is split and disfigured, and if the box is to be used again, a new top must be provided for it. This causes a waste of wood and of labor. Before you can apply your box to any ordinary use you must remove the cover, and in order to learn how to take apart nailed work, you may not only remove the cover but separate all the pieces from one another. This should be done carefully, so as to leave no marks on the wood.

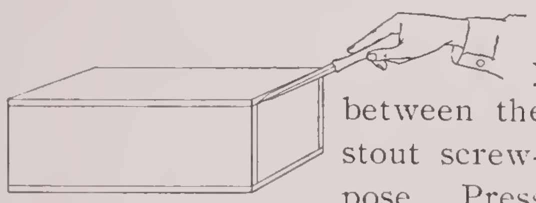


Fig. 55

The top should first be removed. To do this, you will have to insert a thin steel or iron wedge between the cover and the end at the corner of the box. A stout screw-driver with a flat blade may be used for this purpose. Press it inward, across the end-piece, until the end of the screw-driver has reached the inner edge of the end-piece. A cold chisel may be used for this work, but it will mar the wood more than the flat-bladed screw-driver. Now raise the handle of the screw-driver, not with a jerk, but slowly. When you have raised the top so that the corner nail has been drawn upward a little, move your screw-driver along a little farther and lift again, near the next nail. Do this until all the nails at the end have been raised a little. Now place the screw-driver near the nails that were driven into the side-pieces, one after the other. In this way you may raise the top a little, on all sides of the box.

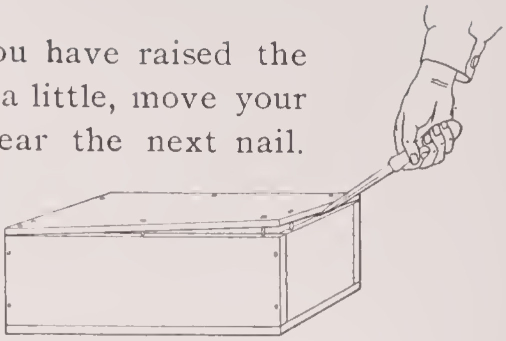


Fig. 56

Do not try to pull the top off by drawing the nails at one end entirely out before the nails in the other end have been loosened, or you will bend the nails and possibly split the wood at the farther end. When the top has been raised half an inch, you can turn the box on one side and, applying a block to the edge of the top, drive the latter farther from the sides with blows of the hammer, delivered on the block. Repeat this, moving the block along and pushing the top off a little at a time, until the nails are released from the sides and ends and the top comes clear of the wood. The nails still remain in the top. Place the board, face down, on the bench, with the end projecting an inch beyond it, and drive the nails out by striking them on the points. When the points are flush with the inner side of the board, turn it over and pull them out with the fingers, if you can. If they will not yield to a pull from the fingers, use the claw of your hammer to remove them, resting the head of the hammer on a block. Straighten the nails and lay them aside.

To remove the bottom, rest the box on its side, and, with a block to receive the blows of the hammer, drive the bottom away from the sides and ends. This can be much more easily and quickly done with the hammer than by using the screw-driver, as you did to start the top. Having removed the bottom, you can take apart the skeleton of the box in the same way, separating each side first from one end and then from the other. For convenience, you can fix the ends in the vise while you are doing this. The block on which you strike should be placed close to the inner surface of the end of the box, so that the blows will be delivered as near the nails as possible, and, if there is not room to strike with the face of the hammer, strike with the broad side of the head. As you separate the pieces, mark them so that they can be quickly fitted together again in the same position, and lay them aside. Straighten all the nails you have withdrawn and reserve them for future use.

Fig. 57

LESSON XI.—THE BACK-SAW

Before we put the pieces of the box together again, we will take up the use of certain tools which you have not yet handled. One of these is the back-saw. See figure 58. It is a crosscut-saw whose blade is of the same width and thickness throughout. In the ordinary crosscut-saw, which you have already used, the blade tapers from the handle toward the opposite end, both in outline and in thickness. See figure 16. The blade is also thicker at the toothed edge than at the back of the saw. The back-saw has a thin blade, of even width and thickness, and, to prevent it from bending when it is thrust through the wood, a stiff back is added. This gives the blade the necessary strength to prevent "buckling," but it also limits the depth of the cut, which can be made to a distance equal to the width of the blade. The teeth of the back-saw are much finer than those of the ordinary crosscut-saw and have less "set," so that they make a much narrower kerf. This saw is used to saw either with or against the grain, where fine work is essential. A small back-saw, with still finer teeth, which have no "set," is called a "dove-tail saw," and in another lesson we shall see what use is made of it.

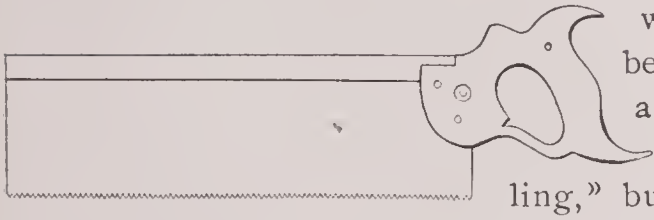


Fig. 58

As the back-saw makes a fine cut, it is used in making mitered corners. For this purpose it is used in connection with a miter-box. A miter-box may be made of three pieces of seasoned board, two pieces being nailed to the third, as in figure 59. It is a box without top or ends. At the center a saw cut is made through both sides, at right angles to the sides, as at A. The sides are just high enough to stop the back of the back-saw when the toothed edge has reached the bottom of the miter-box. Saw-kerfs B, are then made diagonally across the box, to the right and the left of the center, at an angle of 45° to the sides of the box. When a piece of wood is to be cut off at right angles to its edge, it is inserted in the miter-box and the line marked for cutting is placed opposite the kerf A. The piece to be sawed is grasped by the left hand, while the back-saw, sliding back and forth through the kerf, descends upon the stick and cuts it off squarely. If the wood is to be mitered, as, for example, in making a picture-frame, the molding is first sawed at an angle through one diagonal; the saw is then shifted to the other diagonal and the other end is sawed at an equal opposite angle. When four pieces of

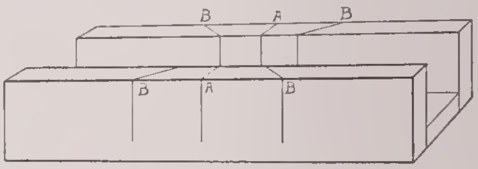


Fig. 59

equal length are sawed in this way, if the ends are joined, each corner will form a right angle and the edges will form a square. You will have no difficulty in making such a miter-box for yourself, and you will find it very useful.

Our present use for the back-saw involves the use at the same time of a much simpler tool than the miter-box, that is, the bench-hook, which you see represented in figure 61. This is made of well-seasoned stock so that it will not be likely to warp. To a board eight inches wide and twelve inches long, are fastened two strips of wood, one inch thick, three inches wide, and eight inches long. One of these strips is fastened to the upper side of the board at one end, and the other strip to the under side of the board, at the other end. A bench-hook cut from a single piece of wood is illustrated in Figure 60. It is made with care, so that the edges of the cross-strips shall be perpendicular to the sides of the board

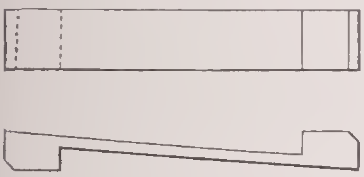


Fig. 60

In use, the bench-hook is placed on the bench, the cross-strip on the under side being pressed against the side of the bench. The board to be crosscut is then placed on the hook, and pressed against the edge of the cross-strip on the upper side. By pushing the board against the cross-strip, with the line where it is to be cut off opposite the end of the strip, you can keep it firmly in place while using the back-saw, and the board can be cut through without allowing the saw to strike the bench and mar it. The end of the crosspiece serves as a guide for the saw in making the cut. In starting the saw, raise the handle and make the first few strokes carefully, with the saw pointing downward, as shown in the illustration. As soon as the kerf is well started, hold the saw with the edge nearly parallel to the surface of your board and saw slowly, letting the teeth touch the board all the way across. Keep the saw upright and in touch with the crosspiece, but not pressing hard against it, and you will be able to make a clean crosscut.

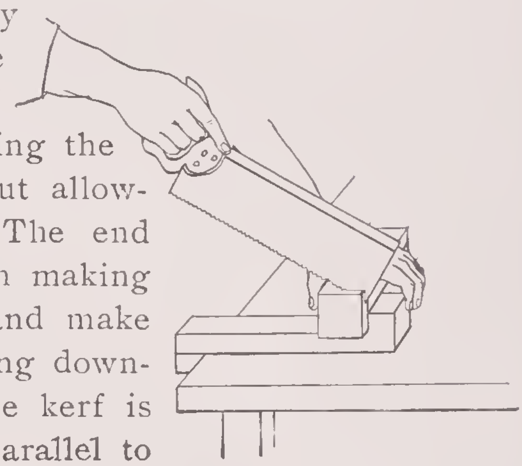


Fig. 61

To apply this use of the back-saw practically, you may take the pieces of your box which you laid aside. If the box were to be nailed together again, with the nails replaced in the holes from which they were withdrawn, the box would not be nearly so strong as at first. You could drive the nails in new places, and this would make the box as strong as before, but would leave a row of unsightly nail-holes around the edge. As we wish the box to look neat, when completed, we will shorten it a little by cutting off enough wood at each end of the sides, top, and bottom to do away with the nail-holes.

Before driving the nails in your box, you made a light line, with the lead pencil, across the ends of the sides, top and bottom, three-quarters of an inch from the end, in each case. You may now try these lines with the square, and after making sure that they are at right angles to the "working edge," which you must keep in mind, darken the lines with the lead pencil. On these lines, saw off the ends of the boards, using the back-saw and the bench-hook as already described. If you now assemble the parts of your box in proper position, you will have no nail-holes at the ends, but the top and bottom pieces will show the nail-holes along the sides. To reduce these two pieces to the proper width will afford you an excellent opportunity for practice in the careful use of the rip-saw and planing to a line. When the top and bottom have been reduced on the long edges to the three-quarter-inch line, as in the case of the ends, it appears that the end-pieces are too long by an inch and a half. No lines were drawn on the surface of the end-pieces, but you may now draw the three-quarter-inch line at each end, and saw as before.

Again reassemble the pieces of your box, and you will see that they are prepared for nailing together again. But, instead of nailing them, we will again lay the pieces aside and learn something of the use of the chisel. Before we are done with the chisel, we shall learn of a better way of putting the box together than by simple nailing.

LESSON XII.—THE CHISEL: PARING

The chisel is a tool which does the work of a knife, or a plane, especially in places where neither of those tools can be used, by reason of its size or shape. The blades of chisels are from five to ten inches long, and in width they vary from one-eighth of an inch to two inches. The blade is made of steel, with a narrow shank which is fixed in a wooden handle. The blade is thin near the cutting end, but it increases in thickness toward the handle; and very narrow chisels are made especially thick, in order to give them strength. Figure 62 represents a chisel with the outlines of the cutting end exaggerated in order to give a clear idea of the form produced by grinding. The back of the chisel is flat. On the face, the cutting end is beveled from E to F: this bevel is produced on the grindstone; from F to G is a second and shorter bevel, which is produced

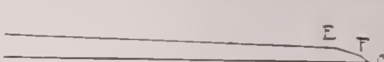


Fig. 62

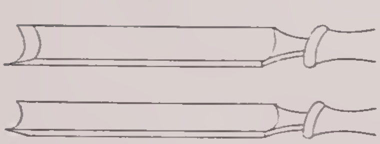


Fig. 63

on the oilstone. This second bevel is so narrow that it is not perceptible unless you examine the chisel closely. The first bevel is formed at an angle of 25 degrees; the shorter bevel, or cutting angle, measures about 35 degrees. You will see that the cutting edge of the chisel resembles that of the plane-iron. Chisels which have curved blades are called gouges. The cutting edge is usually on the convex side; in some gouges, however, it is on the concave side.

The draw-knife is another form of chisel. This has a long blade with the ends bent at right angles to its length. These ends are inserted in wooden handles and the cutting edge is ground on the inner side of the blade, or that nearest the handles. See Figure 64. Other chisels are pushed against the wood and away from the operator; with the draw-knife the action is reversed, and the operator draws the blade toward him.


Fig. 64

The spokeshave is a smaller tool, with a short blade, held in a frame as a plane-iron is held. It is drawn toward the operator, who uses both hands in working it. It is used for finishing surfaces where a very thin and narrow shaving is to be taken off at each stroke, as in finishing the spokes of wheels; hence the name spokeshave.

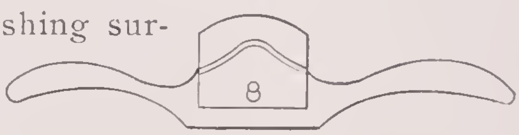


Fig. 65

The draw-knife and the spokeshave are used for much the same purposes as the jack-plane and the smoothing-plane, respectively.

For the present, we will use only the straight, or "firmer" chisel, as it is called. In using a chisel, always remember that it must be handled with great care, for it is, or should be, one of the sharpest tools used by the wood-worker, and its edge is unprotected. You are not likely to be cut by the plane-iron, which is guarded by the stock of the plane, nor by the saw, since it is not easily turned against yourself; but the chisel is pushed with great force against wood on which it may be necessary to rest your fingers and, in any event, it has so keen an edge that, to turn it carelessly against the hand, may produce a serious, even a dangerous, cut. When you are obliged to carry a chisel from one place to another, always hold it with the cutting edge farthest from you, and keep constantly in mind the fact that you are carrying an edged tool. Do not carry it with the edge downward, for if it should drop from your hand it might easily pierce your shoe and maim your foot. When not in use, a chisel should always be placed in a rack at the back of your bench, or in the tool-box, with the edge pointing downward. The tool should be supported at the shoulder of the handle, so that the edge does not rest on any hard substance.

For the first exercise with the chisel, we will undertake to reduce a rough edge to a smooth one, by paring. Take a piece of $1\frac{1}{2}$-inch plank, 8 inches or 9 inches long, which has a "wavy" grain. Split the piece in two, with the hatchet. The edges produced by splitting will be irregular in outline, as in Figure 66. Take the wider of the two pieces and mark a line around it parallel to the straight edge and just within the irregular edge. Fix the piece of wood in the vise, with the irregular edge upward. Grasp the chisel in the right hand, with the end of the handle resting in the hollow of the palm. Lay the chisel flat on the wood, with the cutting bevel upward, and hold the blade down by pressing on it with the fingers of the left hand. Push the chisel forward, keeping it flat on the wood, and it will act very much like the plane. When the grain of the wood is comparatively straight, the chisel may be pushed along in this way and it will, without much difficulty, reduce the edge to a straight line.

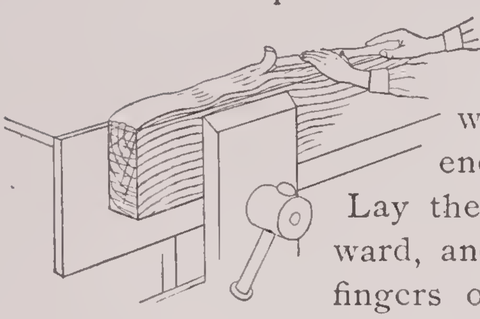


Fig. 66

But where the grain is irregular, so that in pushing the tool forward you work now with the grain and now against it, it is better to push the chisel across the wood in an oblique direction and with a sliding motion. There is a good reason for using the sliding motion. As you have already learned, every cutting edge, however keen, reveals a succession of fine nicks, or teeth, when seen under the microscope. If the edge is pushed straight forward, the effect is the same as in pressing the knife straight down on the wood, as in Lesson I, but if the tool is given a sliding motion, the microscopic teeth cut into the fibers of the wood just as the saw does. The proper way to use the chisel, therefore, is to slide it to the right or to the left at the same time that you push it forward. In Figure 67 you will see this method illustrated. Holding the chisel at an angle to the side of the piece of wood, push it toward A, but at the same time slide it to the right, toward B. The combination of the two motions brings the chisel to the point C. This is perhaps the most important thing to be remembered in connection with the use of the chisel, and you should practise this motion until you can control the tool as you wish. If the edge of your piece of wood presents a very irregular surface, you will find it well to "score" the edge before paring it. To do this, you should hold the chisel at an angle of 60 degrees or more, so that the edge is not pushed along, but down into the wood. This turns up thick chips. Then, scoring from the opposite direction, the higher points

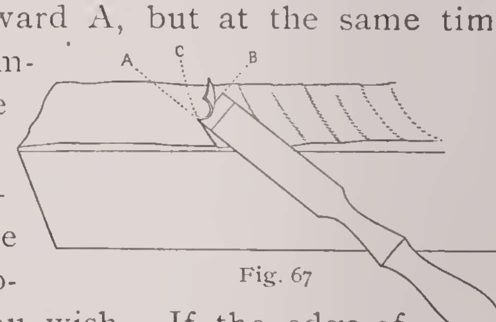


Fig. 67

of the edge are cut away and you have the edge prepared for paring.

You will sometimes have occasion to pare the edge of a piece of wood that has a curved outline. Take a piece of pine, one inch thick, and with the dividers draw a semicircle at the end. Place the stick on a waste board which lies flat on the bench, and hold the chisel in the left hand, with a firm grip. The blade should be perpendicular to the surface of the wood. To drive the chisel downward through the wood, you will hold the stick with the left hand and press hard on the end of the handle with the right hand. If the wood is very tough, it may be necessary to hold the chisel in the left hand and strike the end of the handle with the right hand, and it may be advisable to hold the stick to the bench by means of a handscrew. Make the first cut nearest the side of the stick, with the edge of the chisel cutting across the grain. This will cut off the wood at the point where you begin and split it to the top of the stick. Take off successive chips in this way, until you reach the center of the stick. Then begin and repeat the work on that side of the stick. Still holding the chisel upright, you can now pare off the irregularities and leave a perfectly rounded end. If the chisel is not held perpendicular to the surface of the stick, the edge will be beveled. It is necessary to have a keen edge on the chisel in order to do this work neatly. Do not cut down on to the bench, as that would mar it, but keep your stick on the piece of waste wood, where the chisel marks will do no harm. (See Fig. 68.)

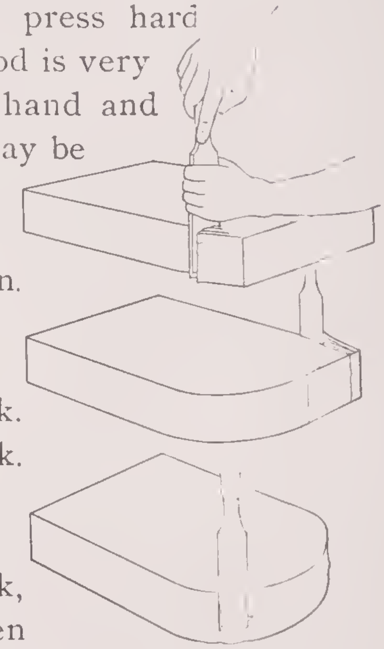


Fig. 68

LESSON XIII.—THE CHISEL: CHAMFERING

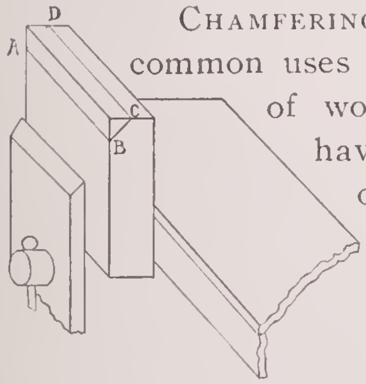


Fig. 69

Chamfering is another name for beveling. One of the common uses of the chisel is to chamfer the edges of pieces of wood. Suppose you take the stick on which you have just made a rounded end and chamfer the other end. Draw a line across the surface of the stick, half an inch from the end. This line appears as AB in Figure 69. From B draw the line BC to a point in the center of the side. Draw CD to the other side of the stick and the line AD on the farther side. In the illustration, the farther side of the stick is hidden from view and AD is therefore represented by a dotted line. These lines, AB, CD, should be drawn with the marking-gauge, and BC, AD connected by lines drawn with lead pencil and ruler. As the stick is an inch thick, CD will be midway between and parallel to the top and bottom surfaces

Fix the chisel firmly in the vise so that the line CD will be above the jaws of the vise. This will leave both hands free to guide the chisel and, as the work must be carefully done, you will need them.

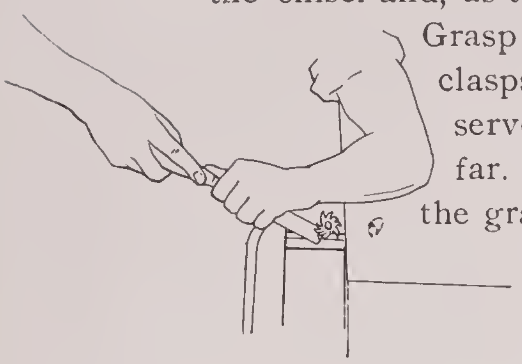


Fig. 70

Grasp the chisel as shown in Figure 70. The left hand clasps the blade, while the wrist rests on the wood, to serve as a check and prevent the chisel from going too far. Now push and slide your chisel obliquely against the grain of the wood, taking off a thin shaving from X to Y. Start the next cut a little farther toward B, and take off another thin shaving. See that your shaving is of the same thickness throughout, so that you will not take off more from one side than from the other. Continue chamfering until the chisel, lying flat on the beveled wood, will touch all the lines AB, BC, CD, DA (Fig. 69) at the same time.

Remove the stick from the vise and mark on the side not beveled lines to correspond with AB, BC, and DA. The line CD is, of course, at the edge of the stick where the bevel meets the orignal square surface. You may now chamfer the stick as marked, but instead of putting it in the vise, hold it in the left hand, with the side to be chamfered turned from you, and the narrow side upward. Rest the end on the waste block and, leaning over, push your chisel downward, not forgetting to slide it. You are now guiding the chisel with the right hand only, and must be careful to keep it upright. To obtain greater pressure, you may hold the chisel with the flat side close to your body and press down from the shoulder, as shown in Figure 71. In this way you can push the chisel with greater force than with the arm extended full length. When you have chamfered to the lines drawn, the bevel thus produced should be an exact counterpart of the one previously made, and the line CD should be represented by a thin, straight edge.

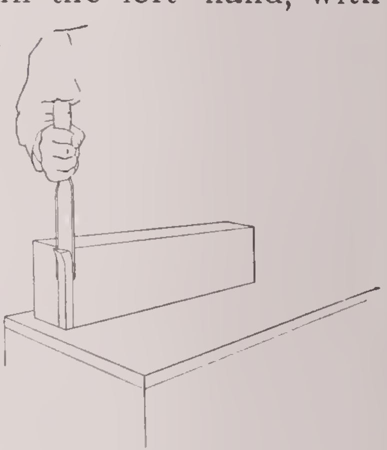


Fig. 71

For another exercise in chamfering, we will chamfer the face of a block so as to make twelve square pyramids. Take a board one inch thick and saw out a piece 3 inches x 4 inches. It must be strictly rectangular. With the dividers point off 1-inch spaces on all four sides. Apply the ruler and draw straight lines across the block. Draw a line XY around the edge of the block, ½ inch from the surface edge, and continue the lines on the surface to meet this line at right angles, as in Figure 72. With the back-saw, make clean, narrow kerfs through the lines AB, CD, EF. Be careful not to cut below the line XY, on either side. Repeat the saw-cuts across the block from the side which will now appear as in Figure 73. Now draw the lines MNO, OPQ, and QRS. Hold the block in the vise and begin to chamfer on the edge VA. Chamfer to the line MN, and then to the line NO, cutting across the grain of the wood. Repeat this, going all the way across the block, until it presents the appearance shown in Figure 74. With the dividers, mark the center of the

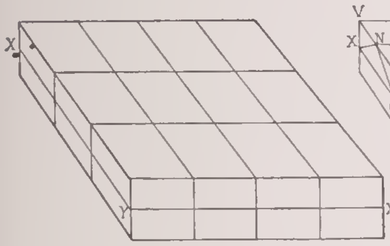


Fig. 72

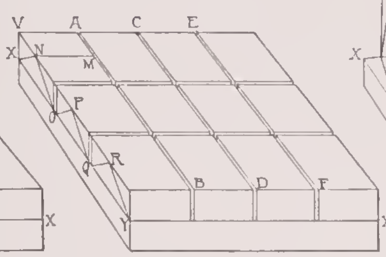


Fig. 73

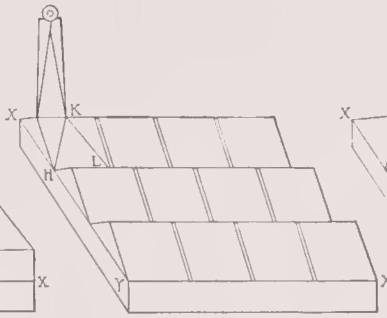


Fig. 74

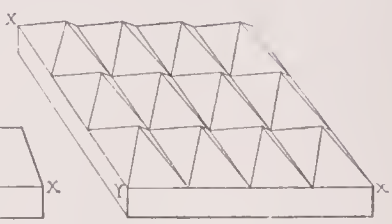


Fig. 75

apex of each pyramid, and from these centers draw diagonals to all four corners in each case. Two of these diagonals are shown in the figure. The corresponding diagonals on the other side are hidden from view. With the chisel, now cut V-shaped grooves to the diagonals. Remember that you are now cutting with the grain of the wood, and be careful to take off very thin shavings, so that the chisel may not plunge in too deep and tear off large splinters. When you have completed this part of the exercise, the block will look as in Figure 75, presenting twelve square pyramids. As you cut near the apex of the pyramid, in each case, cut slowly and carefully, or you will chip off the top of the pyramid, which should come to a point, and the apex so formed should be on a level with the apexes of all the other pyramids in the block.

LESSON XIV.—THE CHISEL: MORTISING

In practical woodwork the chisel serves many important uses, one of which is in the cutting of mortises. You should learn how to do this work well. A mortise is a hollow cut intended to receive a projection, called a tenon, which fits snugly into the mortise so that the two pieces of wood are joined more or less firmly together.

To make an open mortise-and-tenon joint, take a piece of 2-inch x 3-inch lumber, 12 inches long, and plane it smooth. Cut it in two, so that you will have two pieces, each 6 inches long, and of the same breadth and thickness. Mark one piece A and the other B, and mark one of the narrow sides of each with an X, to show that those surfaces will be adjacent when the joint is completed. The mortise is to be ¾ inch wide and 3 inches deep, since that is the width of B, the piece to be fitted into A. On the narrow side of A mark out with gauge and square the space to be mortised. Continue the parallel lines at right angles, across the end of the stick, as in Figure 76, and repeat, on the farther side of the stick, the marks first made. Take the piece B, and on the narrow side mark the lines which show that the tenon, or projection, must be ¾ inch wide and 3 inches deep, when completed. Carry these lines across the end and repeat the first marks on the farther side. C in the illustration shows the parts of the wood that are to be cut away, in each case.

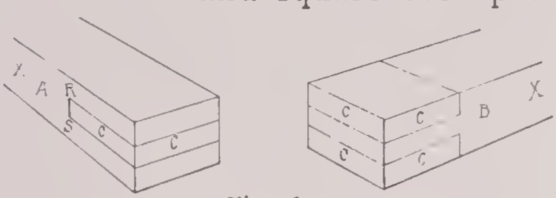


Fig. 76

Fix the stick A upright in the vise, with the narrow side toward you. With your back-saw cut downward to the mark RS, parallel to the end of the stick. Take care that the saw-kerfs do not extend outside the parallel lines. If you are not yet sufficiently expert in the use of the saw, you may saw a little inside the parallel lines, on each side, and afterward widen the mortise with a chisel; but you should aim to have such a complete mastery of the saw that after making these cuts no further work need be done on the sides of the mortise. Now take A from the vise and place it on a block of waste, with the narrow side, X, upward. Begin near the end of the stick, and with a sharp chisel, cut downward, chipping out the wood that remains between the saw-kerfs. As you near the bottom of the mortise, be careful not to cut below the line RS. Take pains to make the corners of the mortise square. If the sides of the mortise are not quite three inches apart, true them to the lines with the chisel, pushing and sliding the tool as you have learned to do. When finished, the mortise should be of the same width throughout, and its bottom should be at right angles to its sides and to the outer surfaces of the stick.

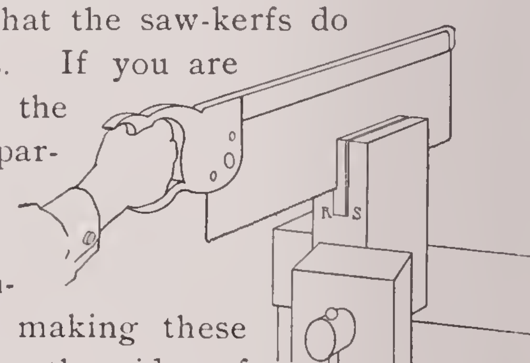


Fig 77

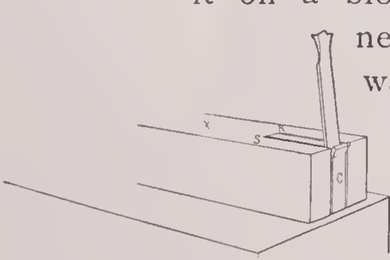


Fig. 78

To form the tenon, hold the stick B against the bench-hook and make a saw-kerf that will touch the line LM, in Figure 79. Turn the stick over and make another saw-kerf, NO. Now place the stick in the vise, the X side toward you, and with the back-saw cut to the lines PQ and RS. The pieces C will then fall away from the stick. If the sawing has been correctly done, the tenon is ready for the mortise. Enter it in the mortise and see if it fits snugly and squarely at all points. If it does not, you may find it necessary to do some paring on the tenon with the chisel, but take off the wood very sparingly, for if you make the tenon even a trifle too small, it will slip loosely into the mortise and the joint will be weak, instead of strong. When the pieces A and B are fitted together, the mortise should receive the tenon so reluctantly that it may be necessary to drive the tenon into place with light blows of the mallet.

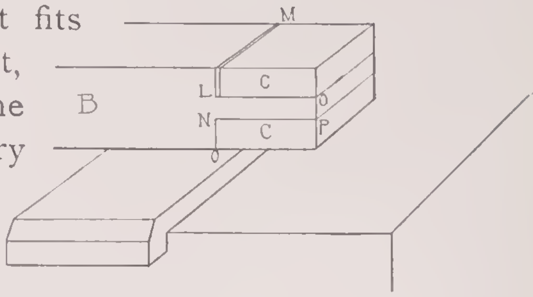


Fig. 79

Such a joint as you have just made is called an open mortise-and-tenon joint. This form of joint, or some modification of it, is used in putting together frames or other work where much strength at the corners is desired. You will readily see that two pieces of wood thus fitted together will retain their places, at right angles to each other, much better than if they were simply mitered and fastened together with nails. If glue is used to give additional strength to the joint, the two pieces cannot be taken apart without splitting or breaking them, unless they are first soaked in water.

The making of an open mortise-and-tenon joint is not very difficult, but we sometimes need to make mortises which are closed at both ends; that is, they cannot be entered from the end, but only from the face of the stick. In making a mortise of this kind, we cannot use the back-saw, and before the chisel can be used to cut out the superfluous wood, we must employ another tool. This is the bit.

LESSON XV.—MORTISING: THE BRACE AND BIT

We will now make another mortise, using the brace and bit to do a part of the work. This is the first boring-tool for which you have found a use, thus far.

The common boring tools are the brad-awl, the gimlet, and the bit, which is a smaller size of the auger. A bit may be described as a spiral or screw chisel, adapted for boring holes through wood. It has a tapering, four-sided shank, which is slipped into the socket of the brace, where an adjustable clamp holds it firmly in place. The brace is a crank, with a flattened knob at the upper end to receive the pressure of the workman's hand or chest, while he rotates the crank with the free hand. Figure 80 shows the form of the brace and of an ordinary bit. Bits whose cutting ends are of varying sizes and forms are made with shanks of the same size, so that they can be interchangeably used in one brace. See Figure 81. At the end of the bit is a short screw-point, or spur, which is pressed into the wood at the center of the circle to be described by the cutting edge. Immediately above the spur is the cutter, which is like a knife-point. As the bit is pressed downward, this knife-point, which is very sharp, revolves and scores the wood, and thus divides the fibers before the revolving chisel begins to cut deeply into them. The mission of the knife-point is to prevent the surface of the wood from being splintered, as it would be if the chisel plunged directly into it, and began tearing up chips before the fibers had been cut on the line of the circle.

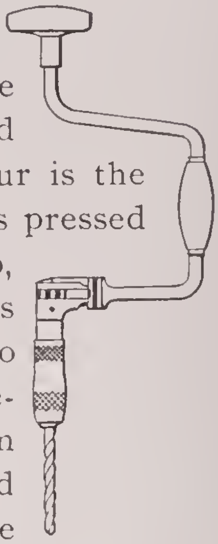


Fig. 80

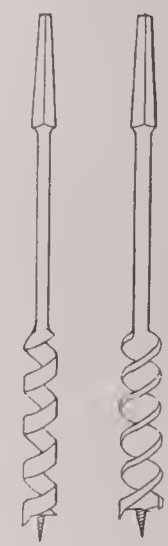


Fig. 81

Take a piece of waste wood and learn to use the brace and bit. Place the wood through which you intend to bore over another piece of waste. Push the spur of the bit into the wood and hold the tool upright, leaning over it and resting your chest against the left hand, which holds the handle of the bit. With the right hand rotate the crank of the brace from left to right. Do not bear down too heavily on the brace. The bit should cut its way through the wood without much pressure from above, if the bit is sharp and the wood is not too hard. In this case we are using a scrap of soft pine and little pressure will be required. Be careful not to suddenly bend the bit to one side or the other. Step back a pace, now and then, and, while you steady the brace with the left hand, look to see if the angle formed by the meeting of the bit and the surface of the block is a right angle. If it is not, the bit is not boring straight through the wood. When the spur pricks its way through the under surface of the wood, it will strike the block beneath and you will feel the impact. You can now press the wood you are boring firmly against the waste, and continue to rotate the crank until the chisel has cut clear through, but the last few turns should be made slowly, so as not to splinter the under surface when the bit cuts through it. Rotate the brace-crank from right to left, at the same time drawing it upward, and the bit will leave the hole it has made, bringing up the chips which have accumulated therein.

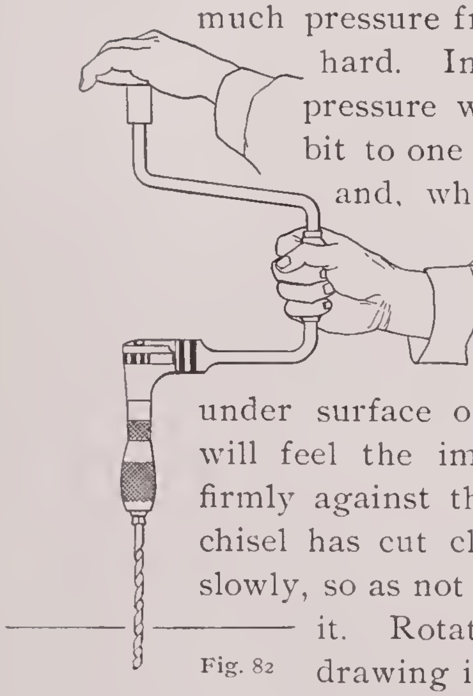


Fig. 82

Bore another hole in the same way, until the screw-point reaches the under surface. Then withdraw the bit, by rotating the crank. Turn the block over and enter the screw-point at the point where it pricked through the wood from the other side. Carefully rotate the crank a few times and the bit will cut away the remaining wood and leave the hole open at both ends. This method does away with all danger of splintering the wood at either surface.

Having become familiar with the use of the bit and brace, you may proceed to the making of another mortise. Take a short piece of the 2-inch-x-3-inch stuff from which you cut the pieces for the mortise-and-tenon joint, and on the surface of the wood, mark out a rectangle one inch wide and two inches long, as in Figure 83. Repeat this rectangle on the opposite side of the stick, making it correspond in position to the rectangle previously drawn. To do this, you will need to use measure, gauge, and square, very carefully. Fasten the block in the vise, with the side toward you and the other surface resting against a piece of waste. The two pieces should be so firmly held together in the vise that neither can slip, and one end of the mortise should project beyond the jaws of the vise. Select a bit whose diameter is a little less than the width of the mortise and fix it firmly in the brace. Enter the spur of the bit midway between the side-lines of the mortise, and at least a quarter of an inch from the end. Hold the bit in a position horizontal with the floor, and rest the handle of the brace against your breast. Now rotate the crank, at the same time pressing forward, but not too heavily. When the bit has cut through the block and entered the waste piece, withdraw the bit, rotating it from right to left. Change the position of the block in the vise so that the other end of the mortise will project beyond the jaws, and bore a second hole, like the first. In boring these holes, be careful to keep the bit perpendicular to the surface of the block, otherwise it may bore in an oblique direction and cut away some of the wood outside the lines of the mortise. (Fig. 84.)

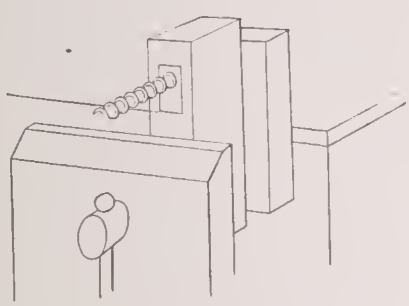


Fig. 83

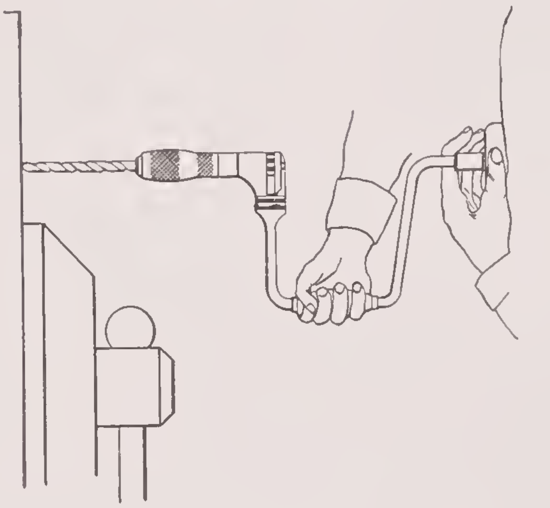


Fig. 84

Remove the block from the vise. You are now ready to use the chisel again. Place the block on the bench, and select a chisel not quite so wide as the mortise. Set the chisel across the grain, about one-eighth of an inch from the near end of the mortise. The flat side of the chisel should incline slightly toward you. Drive it into the wood with a stroke of the mallet. Whenever you have occasion to drive a chisel with a heavier blow than can be given by the hand, remember to use the mallet, and not the hammer. The blow from your striking tool is transmitted through the chisel to the cutting edge, but a portion of the force employed is spent in the wooden handle. The iron or steel head of the hammer is more elastic than the softer wooden head of the mallet and the blow from it is sharper and more quickly spent. For this reason, hammer blows will soon cause the handle of a chisel to split, while the blows from the mallet do not injure it, except to bruise the end which receives the blow. (Fig. 85.)

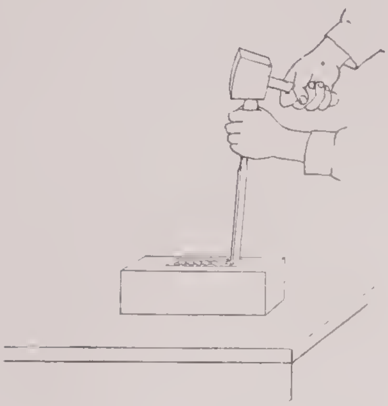


Fig. 85

After making the first cut, move the chisel forward, and make another cut. Then return to the first position and drive the chisel in again, when the chip between the two cuts will fly out and leave a gap. Cut away the wood from the sides of the mortise with a beveling stroke, so that the mortise will not be made too large by accident. The holes bored with the bit will made it easier for the chisel to get the greater part of the superfluous wood out of the mortise. When you have gone about half-way through the mortise in this way, turn the block over and work from the lines on the opposite side, in the same manner, until you again reach the center. The sides of the mortise will now be irregular and must be made smooth, perpendicular to the surface of the wood and parallel to each other, in pairs. To accomplish this, you will use the chisel for paring, taking off very thin shavings. (Fig. 86.)

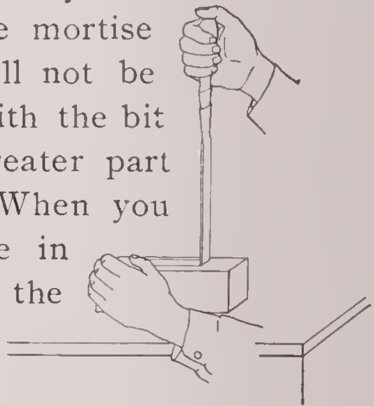


Fig. 86

Mark out and cut the tenon from another block, as described in the preceding lesson, and enter it in the mortise. The tenon must not fit too tightly in the mortise. If you have to use great force in driving it in, you may split the mortised block. Withdraw the tenon, if it fits too snugly, and you will see on its faces bruises where it has crowded against the sides of the mortise. Try the faces of the tenon with the square, and if they are plane, look for the corresponding bruises on the sides of the mortise and use the chisel very sparingly on these places.

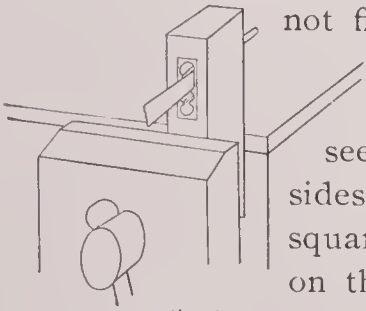


Fig. 87

There is another method of removing the superfluous wood from the mortise, after the holes have been bored with the bit. This is to insert a keyhole-saw in one of the holes (Fig. 87) and saw nearly to the lines of the mortise. The sides are then pared with the chisel. This method is speedier than the one previously described, but does not afford as much practice with the chisel.

A blind mortise-and-tenon joint is one in which the mortise is sunk only part way through the wood. In this case, the end of the tenon does not appear at the outer surface of the mortised block but is hidden or "blinded" within the block. A common example of the blind mortise is that which is sunk in the stile of a door, to admit the lock. In making a mortise of this kind, holes are bored into the wood with the bit, care being taken not to bore too deep. The depth of the mortise should be marked on the wide surface of the block, and the bit removed from time to time, during the progress of boring, so that the depth to which it has penetrated may be determined. This is most quickly done by placing the finger against the bit, close to the wood, and laying off on the side of the block the depth to which the bit has penetrated, which may thus be compared with the depth proposed for the mortise. (Fig. 88.)

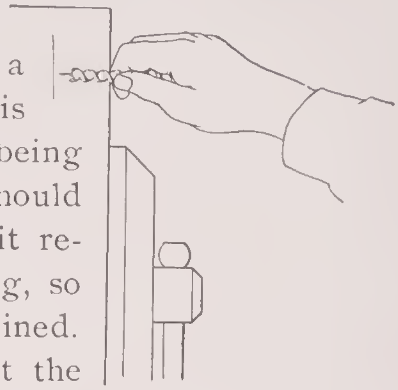


Fig. 88

When holes have been bored to the proper depth, the superfluous wood is removed with the chisel, as in making the mortise previously described, but care must be taken not to drive the chisel too deep. The depth to which it has penetrated must be frequently measured on the blade of the chisel and compared with the depth marked on the side of the mortise, as was done with the bit. The sides of the mortise must be pared smooth and perpendicular to the surface of the board. The bottom of the mortise will present a rough surface. By careful chiseling it may be made fairly even, but as it will not be visible when the tenon is inserted, it need not be perfectly smooth. In making the tenon, remember that the tenon will be shorter than the width of the side of the mortised block, and with the measure determine where the shoulder should come, in order that it may fit snugly against the block.

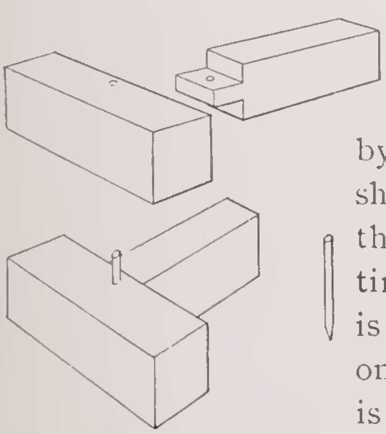


Fig. 89

The tenon is sometimes secured in the mortise by driving a wooden peg through both blocks, as shown in Figure 89. A hole is bored through the mortise with a small bit. This hole continues to the farther side of the block. The tenon is then inserted in the mortise and a mark made on it opposite the center of the hole. The tenon is then withdrawn and a hole bored in it a hair-breadth nearer the shoulder than it would be if it coincided with the hole in the mortise. A tightly-fitting peg is then driven through the hole and pared flush with the surface on either side. As it passes through the hole in the tenon, it serves to draw the tenon more snugly into place, on account of the variation in the position of the holes in the mortise and the tenon. It will now be impossible to withdraw the tenon unless the peg is first removed from its place.

You should make several mortise and tenon joints, in the manner described, until you have obtained full control of the chisel, and of the brace and bit as well. Then you may take up another form of mortising.

LESSON XVI.—END DOVETAIL

In the mortises and tenons you have made up to this time, all the lines have been at right angles to the adjacent lines. Unless the joints have been fastened with pins or glue, it is possible to pull the tenon from the mortise by exerting force in the direction shown by the arrow in Figure 90. Suppose, however, that we do not wish to pin or glue the joint, and yet the tenon-piece B is to exert a strain in the direction of the arrow. To make a joint that will withstand the strain and hold the piece B firmly to A, we form a dovetail. The dovetail is so called because its outline resembles that of a

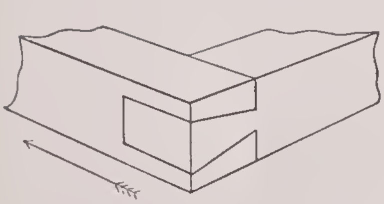


Fig. 90

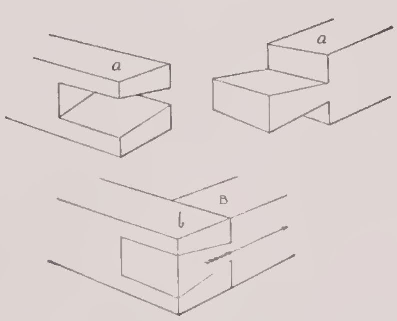


Fig. 91

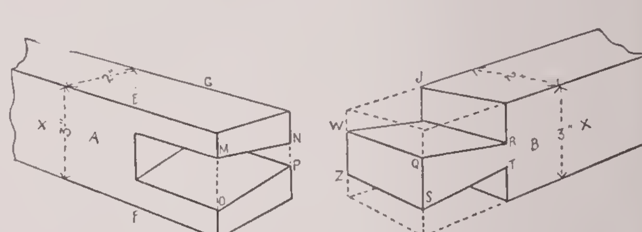


Fig. 92

dove's tail, when spread. You can see plainly that if we fit the tongue at the end of B into a hole of similar outline in A, as in Figure 91, the piece B cannot be withdrawn by pulling it in the direction of the arrow.

Let us make an end dovetail. Select two pieces of wood, A and B, of 2-inch-x-3-inch stuff, and plane them perfectly smooth and square. On the wide side of A, marked X lay off the thickness of the piece B, 2 inches, as shown by the line EF in Figure 92. Carry this line around the stick, at right angles to each adjacent surface, as EG. GH and FH are hidden in the illustration. In the same way mark the thickness of the piece A, 2 inches, on the piece B, and carry the lines around the stick, as in JK, KL. Now draw the oblique lines MN, OP, and QR, ST, on the end of A and on the X side of B. These lines should start from a point at least half an inch from the corner of the stick and slant inward toward its center. They should not meet within the surface of the stick, however. There is no rule for fixing the angle. In some cases it is greater and in other cases less. In this case we will begin the line ½ inch from the edge and carry it to a point one inch from the edge, on the line KL. The lines MV and OY should be drawn to EF, parallel to each other and to the edges of the stick, and QW, SZ in the same way.

On the piece A the wood within the lines VMN and YOP is to be cut away, and on the piece B the wood outside the lines WOR, ZST will be discarded. Mark a few X's on the parts that are to be cut away.

We will first form the tenon on the piece B. Fix the stick firmly in the vise, with the line QR perpendicular to the floor, and with the back-saw cut very carefully on WQ, along QR, as far as R. Now change the position of the stick in the vise, so that the line ST will be perpendicular to the floor, and saw as far as T. Remove the stick from the vise, place it against the bench-dog, and saw to the lines JKR, LT. The pieces outside the tenon will drop away. If the corners at R and T are not clean and sharp, make them so by paring carefully with the chisel. Place the tenon against the marks on the piece A, and see that its outline coincides with TMN, YOP.

Now place the piece A in the vise and saw on the lines VMN, YOP as before. Take the stick from the vise and place it on a waste-block, X side upward. With a chisel, you can now split out the superfluous wood (xxxx) between the saw-kerfs and pare carefully to the cross-line VY. Remember that the end of the mortise, the upper edge of which is represented by VY, must be perpendicular to the surface X.

The pieces A and B will now appear as in Figure 93, *a* before they are joined, and *b* after they have been joined. It is plain that they cannot be separated except by drawing the piece B toward you; a pull in the direction of the arrow will not separate them. In this way, by altering the position of the dovetail, the two pieces may be joined so as to resist a strain from any direction. Make several dovetail joints like that already made, changing the position of the dovetail each time.

LESSON XVII.—DOVETAILED BOX

We are now ready to do some further work on the box, the pieces of which we laid aside after cutting off the strips in which the nail-holes appeared. As some time has elapsed since the pieces were laid aside, examine them carefully to see whether they have shrunk or warped. If such is the case, remove any "winding" that exists, as you learned to do in a previous lesson. This will reduce the size of the box somewhat. We will suppose, however, that the pieces are smooth and plane on all sides, and are ready to be put together.

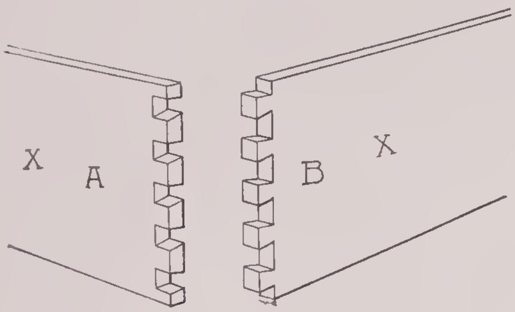


Fig. 93

Instead of nailing the sides together, as we did before, we will put them together with dovetail joints. In Figure 93, A represents one of the end-pieces of the box and B one of the side-pieces. On the end of A we will cut five dovetails, or mortises, to receive five tenons or pins which we will form on the end of B. Select the working face of A and B and mark an X on each. Before beginning work on the box, you should make a working drawing. Figure 96 shows a working drawing of the end-piece A, and the side-piece B; also the plan of the box. You should make a drawing like this. First determine the angle at which the oblique lines of the tenons shall be drawn. As already stated, there is no rule for determining this angle, but in fixing it you should aim to secure the greatest strength possible for the joint to be made. If the base of the tenon is too small, the tenon will be weak. Set your bevel at various angles and mark out dovetails of different shapes on a piece of wood. Select the form that seems to promise the greatest strength, bearing in mind the liability of the wood to split when subjected to a strain, if the pins or tenons are too weak. The form shown in the illustration is a good one.

Mark off on the X surface of the end-piece A, the thickness of the side-piece B, as shown by the line EF. On this line mark off eleven spaces. That from E to *d* will be half the distance from *d* to *e*, or *e* to *F*; *ef*, *gh*, *hi*, *ij*, *jk*, and *kl* will be equal to each other, and *l*F will be equal to E*d*. Having marked the eleven spaces, draw, from the end of the board, lines to meet *d*, *e*, *f*, *g*, etc., which will be at right angles to the end of the board and parallel to each other and to the sides. (Figure 94.) Make little X's on the wood which is to be cut away. Now, for convenience, put the board in the vise, end upward, and fix your bevel at the angle which you have determined upon for the oblique lines of the dovetails. Holding the bevel so that the apex of the angle is at *m*, draw *mn*, *op*, etc., on the end of the board. Then, with the bevel reversed, and the apex of the angle at *q*, draw *qr*, etc. Mark X's on the wood to be cut away. The end of the board will now appear as in the illustration. Take the board from the vise, and on the face opposite the X side, draw lines to correspond with those first drawn, *dm*, *eq*, etc. This completes the marking of A, but before cutting it we will mark the side-piece B.

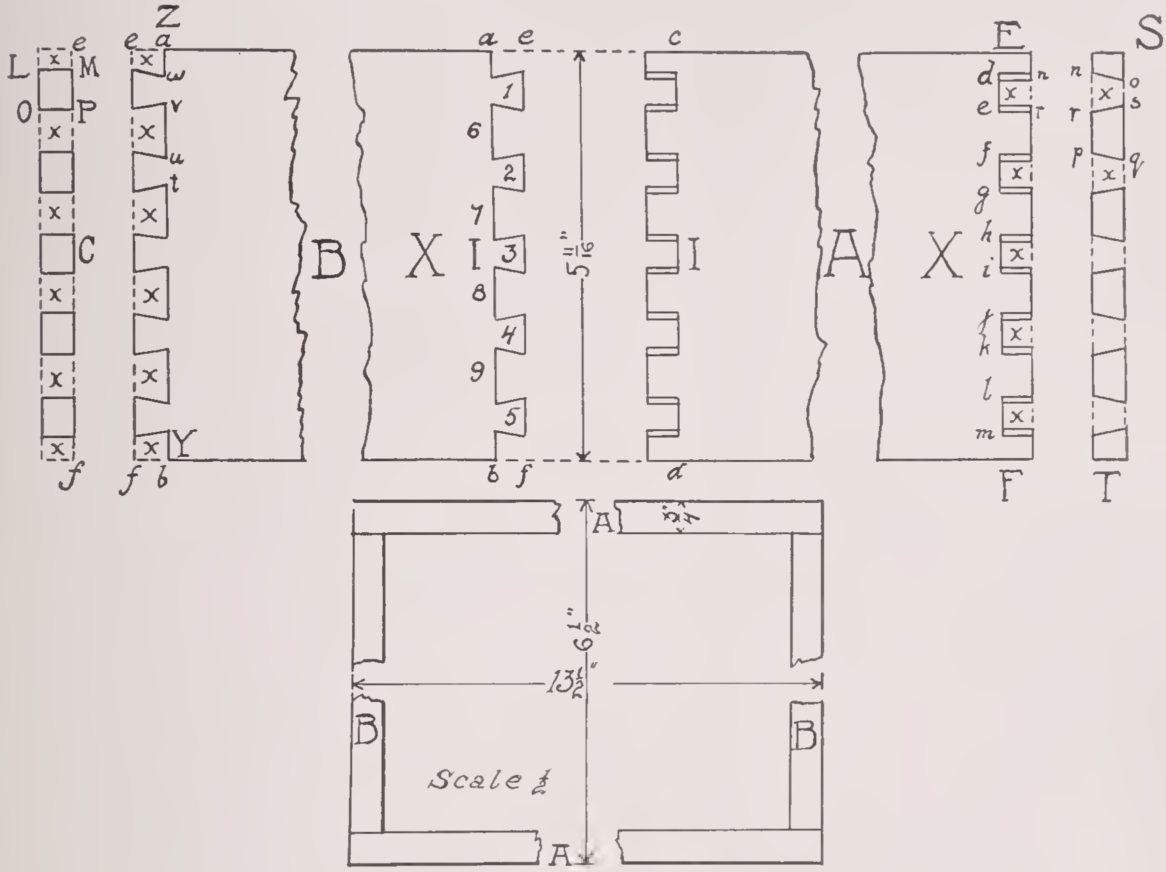


Fig. 94

On the X side of B lay off the thickness of A, as shown by the line ZY. It is against this line that the inner edge of the end-piece, represented by ST, is to come when the joint is made. The space Z*w* will therefore correspond to S*n*, the space *wv* to *nr*, the space *vu* to *rp*, etc. With your dividers, measuring from Z, lay off these spaces on ZY.

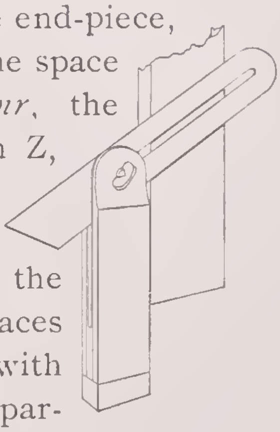


Fig. 95

Without altering the angle of your bevel, place it against the end of the board and draw lines from *w*, *v*, *u*, *t*, etc., to the end of the board, as you did before. Mark the waste spaces with X's. Now fix the board upright in the vise, and with the square draw the lines LM, OP, etc., which should be parallel to each other and perpendicular to both faces of the board. Mark the waste spaces with X's and then repeat on the other face of the board the lines previously drawn on the X face.

Place the piece B against A, and see if the lines of the dovetails to be cut in the one coincide with the pins of the other. When you are satisfied that they are correctly marked, repeat the work on the ends joining the three other corners of the box. It is well to mark out all the work before beginning to cut.

You already know how to do the cutting. The back-saw is used to make saw-kerfs on the oblique lines extending from the edge of the board inward, and the chisel for chipping out the waste between the saw-kerfs. This work must be done with great accuracy or the pins and dovetails will not mate. When properly done, the end of each board will be flush with the adjacent surface, and no spaces will show between the pins and the dovetails. As now fitted together, the box is securely fastened at the corners. The end pieces cannot be pulled away from the sides. The sides cannot be separated from the ends except by exerting equal force at both ends of the box at the same time, and even this will be very difficult, if the pins and dovetails fit closely together.

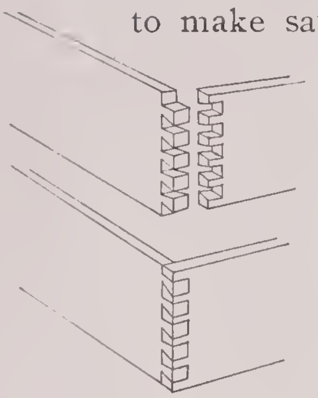


Fig. 96

We will, however, make the box doubly strong by gluing the joints, and as gluing is an important feature in woodwork, we will take up the subject in another lesson.

LESSON XVIII.—GLUING

The glue used in woodwork is chiefly of two kinds, animal glue, and fish glue. Animal glue is made from bones, horns, and hoofs, which, when boiled, yield a sticky substance. Fish glue is made from the entrails and spawn of fish. Glue may be had in liquid form, ready to apply cold; but we will use that which is bought in cakes or chips, to be dissolved in water and heated before it is ready for use.

Break the glue into small pieces and let it soak for several hours in cold water. The water should barely cover the glue. If the glue is soaked over night, it will be soft in the morning, and ready for boiling.

The glue-pot consists of two parts, an inner pot, in which the glue is placed, and an outer pot which is partly filled with water. A rim on the edge of the inner pot prevents it from dropping to the bottom of the water-pot, and it is thus suspended in the water. You must take care that the water in the outer pot does not boil away; if it does, the glue will burn. So long as the inner

Fig. 97

pot is immersed in water, the heat of the glue will never rise above the boiling temperature of water, and this keeps the glue from burning.

Whittle out a small wooden paddle and use it to stir the glue from time to time, while it is boiling. The glue should cook slowly for an hour or two, in order that the chips may be thoroughly dissolved, so as to make the glue of even consistency. It is important to have the glue of the proper consistency when it is applied to the wood. If it is too thin, it will be absorbed by the wood and will not hold the pieces together. If it is too thick, or too cold, it will form a layer over the wood and prevent the two pieces from touching each other. When the glue hangs persistently to the paddle and forms slowly in large globules, it is too thick. More water should be added and the glue should be boiled again. If it is too thin, further boiling will cause some of the water to evaporate and reduce the glue to the right consistency. When it reaches this point, it will run from the paddle — not in drops, like water, but in a smooth, even thread.

The glue should be hot when applied, and in order that it may not be chilled when it comes in contact with the wood, warm the wood, by holding it near the fire. Have your brush ready and saturate it thoroughly with the glue.

While your glue is making ready, put your dovetailed box together and adjust two handscrews so that they will grip the sides of the box, as in Figure 98. Be careful to have the pressure from both

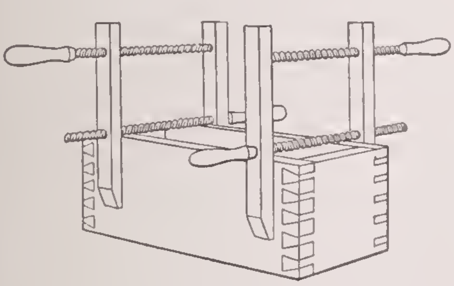


Fig. 98

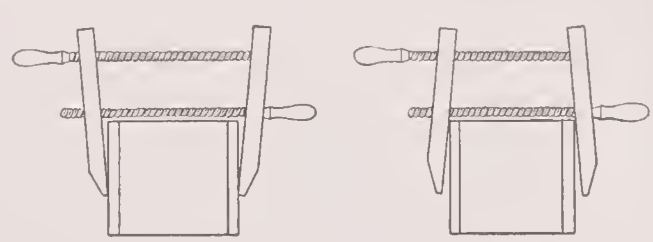


Fig. 99

jaws of the screw come squarely against the side of the box. If the upper screw is tightened more than the lower one, the jaws will spread apart at the bottom and the pressure will come on the upper edge of the box, as in Figure 99. If the lower screw is tightened too much, the pressure will be exerted nearer the bottom of the box and the sides will not be held squarely against the ends *b*. By loosening and tightening first one screw and then the other you can secure an even pressure at top and bottom. When the handscrews have been properly adjusted, loosen them a little, remove them from the box, and lay them near by, where they can be quickly reached after the glue has been applied.

Number the corners of the box so that they can be quickly readjusted in their proper positions, and take the pieces apart. Warm the pieces by placing them in front of the fire, or on top of the stove, turning them frequently so that one side may be heated as much as another. If you place them on top of the stove, you will, of course, rest them on thin strips of waste, so that they may not be burned by direct contact with the hot iron. When they have been thoroughly warmed, lay them on the bench, one above the other, in the order in which they are numbered.

The glue must be applied quickly, but not carelessly. Brush the glue over the pins and dovetails, taking care that none gets on the parts that are to face outward when the box is put together. Join the end-pieces to one of the side-pieces and then add the remaining side-piece. If you join both side-pieces to one of the ends at first, you will have to spread them apart at the other end to admit the remaining end-piece, and in doing this some of the pins may be cracked or broken. In putting the pins and dovetails together, it may be necessary to drive them into place with the mallet, and if so, the blows should be delivered on a block of wood held against the side of the box.

As soon as the four pieces have been glued and joined, apply the handscrews at a distance of an inch from the corners, and tighten them. Some of the glue may be forced out of the joints. Do not allow it to remain on the surface, but wipe it away with a cloth wet with hot water. If you allow the glue to dry on the surface, it will be hard to remove it without defacing the box.

It is a good plan to go through the form of doing this work with a dry brush, before you apply the glue, so that you may not be confused when you come to do the actual gluing and must work quickly.

When the box has been glued and tightened with the handscrews, place it on the bench and see if it is square and without winding. If it is a little out of shape, loosen the screws, press it into correct position and again apply the screws. You must do this before the glue "sets."

Put the work away and allow it to remain undisturbed for several hours. The glue will then be thoroughly dry and the corners so firmly joined that they cannot be separated except by soaking them in water.

LESSON XIX.—FINISHING THE BOX

When the glue applied to the dovetailed joints has thoroughly dried, the handscrews may be removed and the box will be ready for finishing. The edges of the bottom should be planed square and smooth. Be careful not to splinter the edges of the end-pieces when you plane across the grain of the wood at the corner of the box.

The bottom of the box may now be glued to the sides, for further practice in gluing; but it will be well to secure it with a few nails, along the sides and in the center of the ends. Do not drive nails too near the dovetails, lest they be split.

The upper edges of the sides may now be dressed, and the box should be of the same height at all points along the sides and ends. Make it so, if necessary, by planing. Now finish the sides of the box with a smoothing-plane, being careful about planing across the dovetails at the corners. If there are any very rough spots, reduce them with the scraper. If any glue appears on the inside of the box, at the corners, remove it with a sharp chisel. You cannot use the smoothing-plane on the inside of your box, so the inside may be dressed with sandpaper.

Sandpaper is often a valuable help to the wood-worker, but it should not be used when the smoothing-plane will do as well. Never hold the sandpaper against the wood by direct pressure of the hand, when you are using it on a plane surface. If you do so, it will be pressed unevenly against the wood and will make the surface more or less uneven. It also tends to destroy the sharp corners, and should be used sparingly.

To use it properly on the inside of your box, fold a piece of the sandpaper about a block of wood and, grasping the block at the sides with the thumb and fingers, rub it back and forth over the wood. Be careful to keep the block flat on the surface of the wood, as you would a plane, so that the sandpaper will cut with its entire surface and not simply with the edge where it is folded about the block. It may be difficult to finish neatly in the corners of the box, but if the sides of the block have a beveled edge and the sandpaper is drawn tightly against it, you will be able to sandpaper close to the joint.

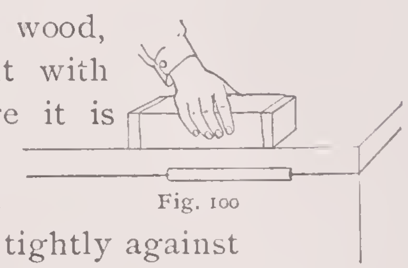


Fig. 100

If the sandpaper is so coarse that it leaves scratches on the wood, it is manifestly unfit for the work you are doing and should be replaced with sandpaper of a finer grade. Do not let the sandpaper incline against the edges of the box or it will round them, more in one place and less in another. Should you find that you have done this, restore the sharp edge with the smoothing-plane.

The box is now ready for the cover, but instead of nailing it in place, we will fit it with hinges, so that it may be easily opened and closed.

LESSON XX.—THE BOX COVER—HINGES

A METAL hinge has two leaves, or straps, each of which has rounded projections, or knuckles, along one edge, and these knuckles alternate with similar knuckles on the other strap. The knuckles are perforated, and through them is passed a pin which holds them together and upon which they revolve. In a door-hinge this pin is removable, but in the small hinges which we are about to use on the box, the pin is permanently fixed in place. The straps of the hinge are pierced to admit of passing screws through them for holding the hinge to the wood. Figure 101 shows a hinge of this character. The upper half of the hinge is to be sunk in the top, and the lower half in one of the edges of the box, so that when the lid is closed, it will meet the sides properly.

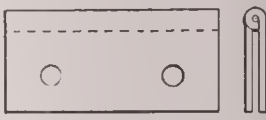


Fig. 101

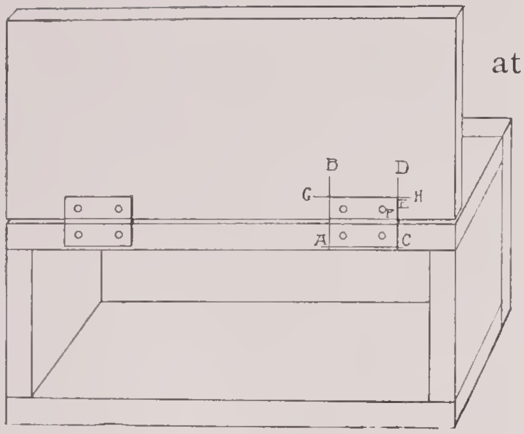


Fig. 102

Place the two hinges on the back edge of the box, at equal distances from the ends, but not too near the center. With your measure, determine accurately where the edge of the hinge is to be. Mark the length of the hinges on the edge, and with pencil and square draw lines across the edge at these points, AB, CD, in Figure 102. Now find the width of the hinges on the edge, which will be equal to the distance from the center of the pin to the edge of the hinge, because, when the hinges are in place and the cover is closed, the center of the pin will be in line with the outer surface of the back side and the edge of the cover. Draw lines to show the width of the hinges, EF.

Now hold the top against the back, flush at both ends, and set off the length of the hinges on the inner surface of the top. With the gauge find half the thickness of the folded hinge, by measuring from the center of the pin to the surface of the end that is to meet the wood, and mark this on the edge and the top, as shown by the lines GH. Each strap of the hinge is to be sunk in the wood so that when the hinge is closed, the cover will touch the edges of the box at all points. It must not be sunk too deep, or the cover will be tilted up from the back; and if it is not sunk deep enough, the cover will not meet the back edge of the box, and will be tilted slightly forward.

Having marked the positions of the hinges, as described, cut to the lines with the chisel. This is done exactly as in paring the mortises, in the preceding lessons. Use a sharp chisel. First score the wood across the grain. Then drive the chisel straight downward along the lines AB, CD, with light blows of the mallet. Pare the sides of the mortise, being careful to keep within the lines and not to cut too deep.

Now put the folded hinges in place on the edge of the box and lay the cover in place. See if the hinges fit perfectly in the mortises and if the cover touches all sides of the box. If it does not, the mortises should be sunk a trifle deeper. Lay back the top, and holding the hinges in place against it and against the back side of the box, see if the edge of the top just meets the edge of the back. If it is separated from the back at one end, the hinge-strap does not go far enough toward the inner edge of the back or the outer edge of the cover. Pare away the wood so as to make the mortise a trifle wider.

When you find that the mortises have been correctly made and the hinges fit properly in their places, lay the hinges in place on the cover of the box, and make a small hole with an awl in the center of the wood defined by the holes in the hinges. The awl-hole will serve to « center » the screw when it is driven in.

You will notice that the holes in the hinge are countersunk on the inner side; that is, the edge about the hole has been beveled. This is to admit of driving the screw in until its head is flush with the surface of the hinge-strap. The screw-head should fit neatly into the holes, and the screws should not be so long that they will project through the upper surface of the box-cover, when they have been driven home. Place the point of the screw in the awl-hole and give the head a tap with the hammer to settle it in place. Fix the screw-driver point in the brace and drive the screw home. If your brace is not supplied with a screw-driver point, use your small screw-driver with wooden handle. A screw can be driven straight more easily with the brace than with the common hand screw-driver.

When the hinges have been screwed to the back edge of the box, lay the cover on the bench and place the box on its side so that the upper straps of the hinges will fit into their places. Set the screws and drive them home.

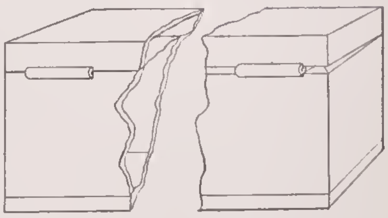


Fig. 103

Now let us see how the box looks. If the hinges have been properly set, the cover will be flush with the sides of the box all the way around, and will meet the upper edges at all points.

If the hinges were not sunk deep enough in the wood, the cover will not come close to the box at the back. If they were sunk too deep, the cover will not meet the front edge of the box, and if you force it down, the strain will pull the screws from their places and perhaps splinter the wood. If the hinges have not been set far enough toward the inner side of the box, they will project from the back so far as to look ungainly, and when the cover is thrown back, there will be a wide gap between it and the back of the box. If the hinges were set too far in, toward the front of the box, the cover will crowd against the back as soon as it is lifted, and if forced back the hinges will be torn off. If one hinge has been set correctly, and the other too far out, the cover will not be flush with the sides of the box.

If you find that any of these faults exist, examine the hinges carefully and see whether they have been set correctly on one piece,—the edge of the box, we will say,—while they have been incorrectly set on the top. In this case it will be necessary to reset only the straps which are fastened to the cover. Take out the screws. First plug the screw-holes, by driving in wooden pegs which fit tightly. They should be dipped in glue before they are driven in and should then be cut off close to the surface. When the glue has set, you can replace the hinges, after adjusting them properly. If the hinge was sunk too deep, when first set, place one or two thicknesses of cardboard, or a shaving, under it, in order to raise it. If it was not sunk deep enough, pare the bottom of the mortise with the chisel. Use the chisel to widen the mortise, if that is necessary. Having adjusted the hinges, screw them in place as before, using the awl to make the centering hole. You will see now why it was necessary to plug the original screw-holes, so that the screw could be driven home in a new position, without danger of its being diverted into the hole first made.

You may now fit a hook to the front of the box. Find the center of the front edge of the cover and drive in a brass nail, with rounded head, letting it project an eighth of an inch from the wood. A small screw-eye may be used instead of the nail. Screw the hook to the side of the box so that the tongue will fit snugly over the nail or in the screw-eye. The hook should have a small shoulder on the inner side, or a washer, to allow of its turning freely without rubbing the side of the box.

Your box is now completed, so far as the woodwork is concerned. But the wood will soon become soiled, if handled often, unless it is stained or varnished. You will do well, therefore, to give it a coat of shellac varnish, which is made of white shellac dissolved in alcohol.

First sandpaper the box with fine sandpaper and wipe it free from dust with a clean cloth. The varnishing should be done in a warm room. Apply one coat of varnish with a flat brush, drawing the brush over the wood with smooth, straight strokes. Do not take up too much varnish on the brush at one time, and do not let the varnish run down the sides and form streaks. Shellac varnish sets quickly, and you should avoid going over the parts where the varnish has begun to set, as the brush will break up the smooth surface. When the first coat is thoroughly dry, which will be within forty or fifty minutes if the room is warm, rub it down with the finest sandpaper, stretched over a block. Do not sandpaper too deep, but only enough to leave a perfectly smooth surface. Now give the box another coat of shellac, and let it dry.

The varnish will keep out the moisture and prevent the wood from warping or shrinking. Finger-marks or other soiled spots may be wiped off with a damp cloth and the box will have a neat, glossy appearance.

LESSON XXI.—MAKING A PANELED DOOR

For what reason is a door made of several pieces of wood, sometimes ten or twelve in number, rather than of one solid piece? A door is intended to fit neatly into a frame. We have already seen that wood has a tendency to shrink and warp, and although it may have been once thoroughly seasoned, it will warp and shrink if subjected to alternate moisture and heat. Even within the house, the amount of moisture in the atmosphere varies according to the state of the weather outside, and all woodwork, therefore, is subject, more or less, to shrinking and warping. To reduce to a minimum the effect of this shrinking and warping, doors are made of several pieces of wood, fastened together in such a way that the door will retain its shape and continue to fit snugly in its frame, notwithstanding the changes from dry to damp weather.

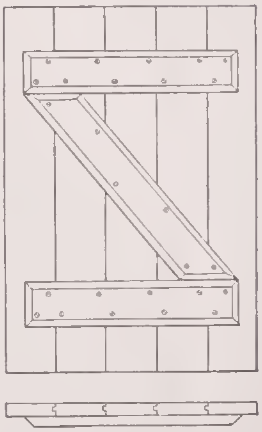


Fig. 104

Doors are made chiefly in two forms — the battened and the paneled door. The battened door is made of boards running up and down, and held together by crosspieces called battens, which are fastened to the several boards in succession. Figure 104 shows a battened door in which a diagonal cleat has been added to the cross-strips. This is to prevent the boards farthest from the hinges from dropping down by their own weight and pulling the door out of square. If the door were made in one solid piece, it would warp, as in Figure 105, which would throw it so much out of shape as to make it useless. But it is made of narrow boards, and as each board warps by itself, the result appears the same. This, as you see, causes but little change in the shape of the door. Wood

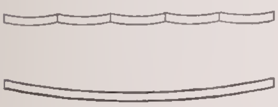


Fig. 105

shrinks in width considerably, but practically none at all in length. If boards that have been thoroughly seasoned, and have therefore shrunk to their least width, are placed close together and battened, they will swell, after being exposed to moisture, and increase in width. Expanding wood exerts great force, and this would cause the door to be thrown out of shape. It is necessary, therefore, to leave narrow spaces between the boards, in order to give the boards room to expand.

But this does not make a door tight enough to keep out wind and rain. To overcome this difficulty, the door is made of boards whose edges are "tongued and grooved." On one edge, a narrow slit, or mortise, is cut, running the entire length of the board, and on the other edge is a tongue, or tenon, which fits into the mortise on the adjacent board. Figure 106 shows the plan of the end of a door made of such boards. Now, when the door shrinks, the tongue will draw out a little from the groove, but without leaving an open crack. When the wood expands again, the tongue will be pushed farther back into the mortise, and, as the pressure is unresisted, the door will not be thrown out of shape. A battened door of this kind may be quickly and easily made, but it is not especially ornamental, and is therefore used only on barns, outbuildings, and like structures where ornament is not essential.

Fig. 106

We desire to have our home surroundings as attractive as possible; therefore, in dwelling-houses, as well as in office-buildings and the like, where regard is had for beauty of construction, doors are paneled instead of being battened. A paneled door consists of a framework of boards mortised together at the corners and grooved on their inner edge to receive a thinner board, called a panel. Figure 107 shows a paneled door. The two upright pieces are called stiles; the three cross-pieces, rails; and the panels are the boards inserted in the spaces between the rails and the stiles.

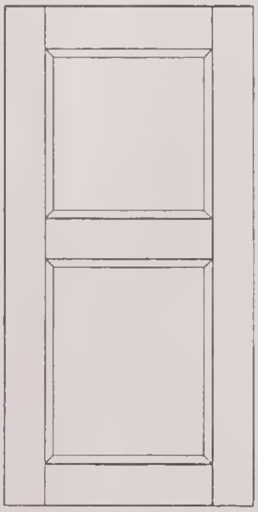


Fig. 107

The rails do not shrink perceptibly in length. The panels, when shrinking and expanding, slip back and forth in the grooves of the stiles. You will see, therefore, that the only measurable shrinkage in the width of the door will be that of the stiles. This gives little trouble, as compared with the shrinkage that would ensue if the door were made in a solid piece. The expansion of the rails and stiles is sometimes sufficient to cause the door to stick, after a season of wet weather, but the removal of a thin shaving generally causes the trouble to disappear.

You are to make a paneled door. First make a working drawing, like that shown in Figure 108. A represents the elevation, B the plan, and C a cross section of the door on the line *cf*, showing the panel slotted in the stiles.

The next step is to get out the stock. You will need two upright pieces for stiles, each 30 inches long, and three pieces for the rails, each 15 inches long. Doors are generally made with the middle and bottom rails wider than the top rail, but it will serve our purpose as well to make the door with stiles and rails all of the same width, 2½ inches. By reference to the drawing, you will see that the stiles project beyond the top and bottom rails, and the tenons of the rails project beyond the stiles. The mortises are to be cut very near the ends of the stiles, and to avoid splintering the ends and spoiling the work, the stiles are made longer than they are required to be when finished and shortened afterward. The projecting parts, or "horns," are to be cut off when all the parts of the door have been joined and it is ready for finishing.

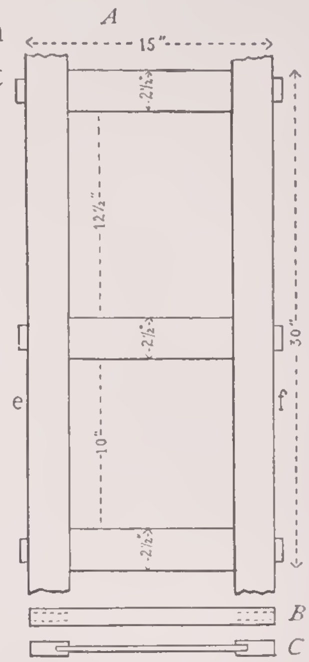


Fig. 108

In getting out the stock, therefore, it will be necessary to make the pieces for the stiles each 32 inches long, and the pieces for the rails each 16 inches long. As your pieces will have to be planed, you must allow for a slight reduction in width, when cutting the stiles and rails to width. If you use 1½-inch stock, the surface planing will reduce it to 1⅜ inches, which will serve your purpose.

For the panels, you will need two pieces of stock ⅝ inch thick. These pieces must be longer and wider than the space between the rails and stiles, as the edges are to be chamfered to fit into the grooves on the inner edges of the frame. Make one piece, therefore, 13½ inches long, the other 11 inches long. The width, 11 inches, is the same in both cases.

All your pieces are now sawed to length. Dress them with the jack-plane and smoothing-plane, as you have learned to do. Be careful to have all the parts of the frame of the same thickness when dressed. Do not forget to mark an X on the working edge and face of each piece, and to gauge from that edge in every case. Finish the ends true and square. When you lay the pieces on the bench, one against another, in the relative positions they will occupy when the door is joined together, they should fit snugly together, and all the angles, where they touch each other, should be right angles. Now you may undertake the jointing of the frame.

LESSON XXII.—MAKING A PANELED DOOR—JOINTING

You have already learned how to cut a mortise and a tenon, so you will not be daunted by the problem of jointing the door. Neverthe-less, you will need to work carefully, for a new feature enters into the making of the tenon. Before the panels can be fitted in their places, the inner edges of the stiles and rails must be grooved. You will not make these grooves just yet, but you know they are to be made, and you can see that if the tenon is made the full width of the rail, there will be left a hole between the shoulder of the tenon and the grooved edge of the door, as in Figure 109. To fill that hole, we must leave a projecting stud on the upper edge of the tenon, at the shoulder. The remainder of the tenon will not be so wide as the rail itself, because the mortise does not extend to the end of the stile, although the upper edge of the rail is to be flush with it.

Fig. 109

You should first make "projections" of the ends of the stile and the rail, as in Figure 110. A projection is a drawing in which the hidden

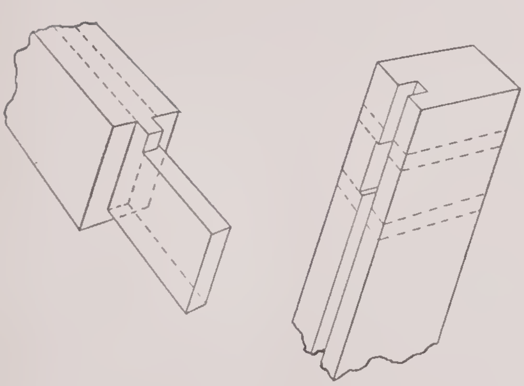
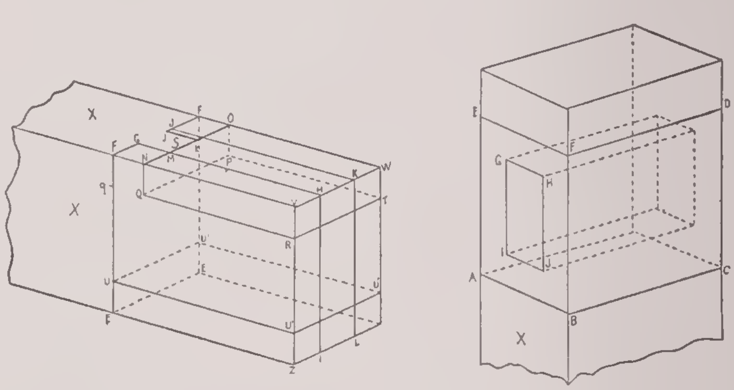


Fig. 110



A Fig. 111 B

lines of a solid object are represented by dotted lines corresponding in length and position to the invisible lines. In Figure 111, A rep-resents the end of the stile, showing the groove for the panel, and the mortise. B represents the end of the rail and the tenon S is the little stud that is to fit into the groove in the stile. As the groove is narrower than the mortise, the stud must be narrower than the rest of the tenon.

Figure 111A shows a drawing, to represent the end of the rail before the tenon has been cut, and then mark the rail. The tenon is to project $\frac{1}{2}$ inch beyond the stile, which is $2\frac{1}{2}$ inches wide, so you must set off 3 inches from the end of the rail and draw the line EF all the way around the board. The distance between this line and the inner edge of the opposite stile will be 10 inches; set off 10 inches, therefore, and draw a similar line, which will be, of course, 3 inches from the farther end of the rail. These lines represent the position of the shoulder of the tenon at each end. They should be broken in the center, on the edge, so that the stud S will not be sawed away by mistake. The tenon is to be 1½ inches wide and ⅝ inch thick. With the gauge, find the position of the tenon and draw the lines GHI, JKL, the space between which represents the thickness of the tenon. From G lay off ½ inch, GM, to indicate the length of the stud, and at right angles to this draw, with the square, NO. Using the square as a ruler, continue NO on the sides, making NQ and OP each ½ inch long. With the gauge find R and T, making VR and WT equal to NQ, and draw QRT, continuing it to P. This line shows the cut that must be made to reduce the width of the tenon to less than the width of the rail. With the gauge find U, and draw VU, which will be 1½ inches from QRT and parallel to it, showing the width of the tenon, and will also be 1½ inches from EZ. Mark X's on the spaces of the wood, which are to be cut away.

This work should be carefully done, the gauge and square being constantly used and the usual care being given to the making of right angles where lines meet. The bottom rail should be marked in the same way. The middle rail will also be marked in a similar way, but as it is to be grooved and to receive a panel on either edge, no provision need be made for a stud. The line NOPQ may, therefore, be omitted and the line RQ continued to *q*.

It will be easy to mark the position of the mortise. Figure 111B shows the end of the stile before it is grooved. Draw ABC very lightly, all around the stile, 3¼ inches from the end. The bottom of the rail is to touch this line. Lay off 2½ inches, the width of the rail, and draw the line EFD, which shows where the top of the rail will meet the stile. It will now be easy to find the position of the mortise. The lines GI and HJ will show the length of the mortise. IJ is ½ inch from AB, and GH is ½ inch from EF. The distance between them is 1½ inches. GI and HJ are found by the gauge, set to the same width as in drawing GH and JK, in Figure 111A. Having marked out the mortise on opposite sides of one end of the stile, repeat the marking on the other end. A mortise is now to be made for the middle rail. The upper edge of the middle rail will be 12½ inches distant from the lower edge of the top rail, or from AB in Figure 111B. From AB lay off 12½ inches and draw a line around the stile at this point, with the square. A second line, 2½ inches below the first, may be drawn, and the mortise centered on the edge of the stile, between them.

When the tenons and mortises have been marked for the ends of both stiles and the three rails, you may proceed to the cutting. Fix the rail upright in the vise and with the back-saw cut GHI, JKL, Figure 111. Next cut UU^1 and QRT. Be careful not to cut beyond Q, or you will shorten the stud S. Now cut QNOP and then EFJ, EFG. The waste pieces have now been removed, but the stud is of the same thickness as the tenon. A portion of it must be pared away, at JK, in order that it may fit into the groove in the stile, which is narrower than the tenon. This paring may be done with the chisel, but you will do well to delay the paring until you have cut the mortises and grooved the boards.

You have already learned how to cut the mortise. This may be done by making holes with the bit and then paring with the chisel, but as the mortise is narrow, the bit must be operated very carefully or it will cut into the sides, if it is not held perpendicular to the upper edge of the rail. It may be better to cut the mortise with the chisel alone. In this case you will need to hold the rail in the vise. Cut half-way through the stile as described in Lesson XIV., letting the sides slope toward the center; then turn the opposite edge of the stile upward and chisel from that side until you have cut through to the center. Pare the sides of the mortise smooth and perpendicular to the surface.

When all the mortises have been cut, fit the tenons in their places. The top and bottom rails cannot be driven home, for they will be stopped by the stud when it reaches the edge of the stile. This brings us to the cutting of the groove for the panels.

LESSON XXIII.—MAKING A PANELED DOOR—FITTING THE PANELS

You will remember that the planes whose uses we have discussed have in each case an iron narrower than the stock, so that the iron does not cut to the full width of the latter, and it cannot therefore be used to make a right-angled cut on the edge of a board. In order to make a groove between the edges of a board, we must use a plane called the plow. (Figure 112.) The sole and the cutting edge of the plow are of the same width. The plane-iron can be adjusted so that it will take off a shaving of greater or less thickness, as with other planes. On one side the plow is provided with a "fence," which may be set at varying distances from the plane-iron, and this determines the distance of the groove from the

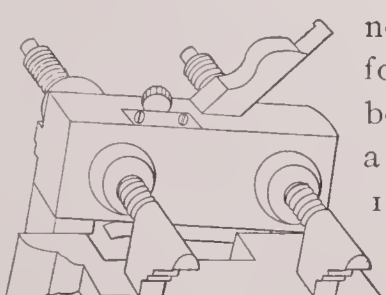


Fig. 112

face of the board. A stop, which may be adjusted, determines the depth of the groove. In use, the fence is pressed against the working face adjacent to that which is to be grooved, and must not be allowed to tip outward or to part from the face, else the groove will be irregular.

In preparing stock for doors, the stiles and rails are generally grooved by machinery, which works with great accuracy. For our purposes, it will be better to do the work by hand, with the plow. Several plane-irons of different widths are made to fit in a single plow. We will select the iron that has a cutting edge $\frac{3}{8}$ inch wide, and adjust the stop and the fence so that the plow will make a groove $\frac{1}{2}$ inch deep, midway of the board.

Try the plow first on a piece of waste board, until you fully understand its use, and then you may groove the stiles and rails. In every case, the fence is to be pressed against the X face of the wood. If you groove one piece with the fence against the X face, and the next piece with the fence against the unmarked face, your panels may not fit into place readily. The stiles and the top and bottom rails are to be grooved on the inner edge only. The middle rail is to be grooved on both edges. When grooving near the mortised ends of the stiles, push the plow carefully, so as not to splinter the edges of the mortise.

When the grooves have been cut to the required depth, the pieces may be jointed, and you will now see how and why the studs on the top and bottom rails must be pared to a width less than that of the tenon, so that they will fit into the groove. Pare the studs and drive the tenons home. See if the grooves meet each other accurately at the corners, and if there are any irregularities in them, take the frame apart and pare the grooves with the chisel, as needed.

Your next work is to fit the panels in their places. Plane to the desired thickness the two pieces which are to serve as panels, and finish them with the smoothing-plane. Plane one of the upright edges of each piece to a straight line, and then make the opposite edge parallel to it. The width of the panel is to be 11 inches. Saw and plane the ends of the panels so as to make them square with the sides. The upper panel will be $13\frac{1}{2}$ inches long and the lower panel will be 11 inches square

To fit the panels to the groove, you will need to chamfer the edges. With the gauge, mark a line lightly all around the panel, 1 inch from the edge. In the same way, mark on the edge of the panel a line to show the depth to which the chamfer is to extend, $\frac{1}{4}$ inch. Plane away the wood from the 1-inch mark on the face to the ¼-inch mark on the edge. In planing the upper and lower edges of the panel, remember to plane across the grain at an angle. Chamfer the other side of the panel in the same way. The panel should now fit into the groove as in Figure 113, the point being ½ inch from the bottom of the groove. It should not fit tightly, nor require to be driven in with the mallet. If it cannot be pushed into place with the hand, it is too tight, and the chamfer should be extended a trifle deeper. What is desired is to have the panel fit easily in place, but without being loose.

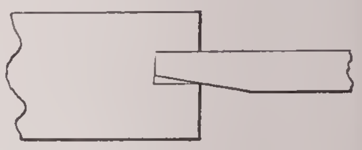


Fig. 113

We have made the frame thicker than it should be, to avoid splitting the stiles while cutting the mortises. Take the frame apart and plane the frame to a thickness of 1⅛ inch, as you learned to do in Lesson V., being careful to have the mortise exactly in the center of the stile when finished. This planing will remove the pencil marks drawn as a guide in making the mortises.

The edges of stiles and rails are now square, but a proper regard for the ornamental function of the door requires that the inner edges, surrounding the panels, shall have a finish of some sort. This may be obtained by chamfering the edges, or by inserting a narrow molding against the edges and resting on the panels. This is properly a part of finishing the door, which we will consider in another lesson.

LESSON XXIV.—MAKING A PANELED DOOR FINISHING

The panels of a door are generally finished alike, but as we are striving to learn all we can of methods in woodwork, we will finish the two panels of our door with different treatment. We will chamfer the edges of the frame adjacent to the upper panel, and fix a molding against the edges adjacent to the lower panel.

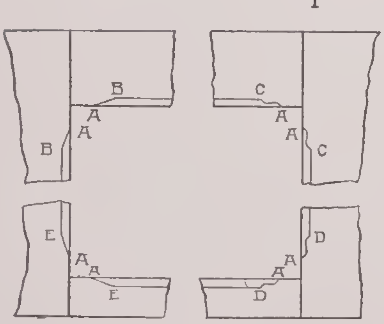


Fig. 114

The chamfering should be done before the frame is fastened together. Select a point, A, Figure 114, on the inner edge of the stile, 1 inch from the corner where the rail meets it. Lay off the same distance from each of the corners, on both rail and stile. Find the points B, C, D, and E, each ½ inch from the edge and 1 inch from A. Set the gauge to ½-inch measure and draw BC, CD. You will now draw AB, AC, etc. With a sharp chisel, score the edge, being careful not to go too far toward BC and CD. When the greater part of the superfluous wood has been chipped out, chamfer the edge to BC and CD. The bevel at AB may be given a gentle curve, represented by the curved line AC, Figure 114. The chamfer should be at the same angle to the surface of the panel and to the surface of the stiles and rails. To make this chamfer clean and smooth will test your skill with the chisel, and you will find it difficult to avoid leaving a very slight ridge, now and then, where successive strokes of the chisel were not quite in the same plane. A piece of very fine sandpaper, stretched over a block, may be used to finish the chamfer, in the manner described in Lesson XIX.

We have decided to finish the lower panel with a border of molding, but this cannot be applied until the door has been jointed. First, however, set the smoothing-plane so it will take off only a hair-like shaving, and pass it once only along the inner edges of the stiles and the rails, and over the surface of the panels.

The next step is to glue the tenons and mortises together, at the same time adjusting the panels in the grooves. First fix the three rails against one of the stiles; then slip the panels into place, and adjust the remaining stile. No glue should be put on the shoulders of the tenon, as it would be pressed out and daub the surface of the door when the frame is put in pressure. Do not glue the panels, but leave them free to move back and forth when they shrink and expand. If they are glued into the grooves, the glue may prove stronger than the wood and cause the panels to split, when they shrink. Before the glue sets, try the frame at the corners, with the square, and if necessary, true it with light strokes of the hammer, delivered on a block of wood held at the proper corner. In gluing the box together you used handscrews to hold the pieces tightly together until the glue had dried, but you have no handscrews large enough to receive the width of the door between their jaws. You must, therefore, improvise a handscrew. Take two stout boards, longer than the width of the door, and nail across them two strips as thick as the door. The first two pieces should be separated so that the distance between their inner edges will be less than the distance between the inner edges of the top and bottom rails, *viz.*, 25 inches. The crosspieces should be far enough apart to allow the door to lie between them, with two inches to spare on either side. Now shape four wedges, and place them in pairs between the door and the crosspieces, a little farther in than the edges of the rails, as in Figure 115. These preparations must be made before you glue the

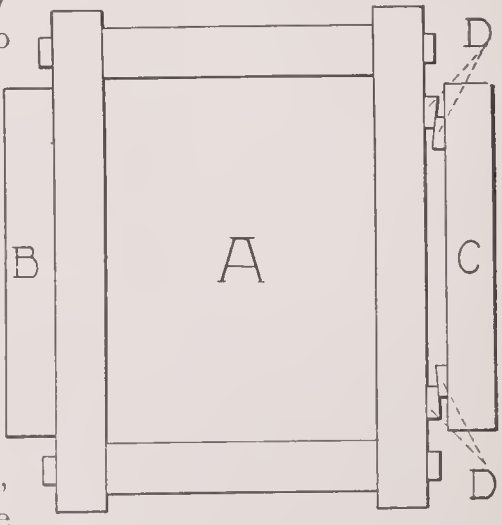


Fig. 115

frame together. When the gluing has been completed, lay the door between the crosspieces and drive the wedges against each other. This will press the stiles firmly against the shoulders formed by the tenons of the rails. The result is the same as in using the handscrew. When the glue has become thoroughly dry, the wedges may be knocked out of place and the door released.

You may now fit a small molding against the inner edge of the frame, around the lower panel. A very simple molding, or "bead," will serve. Measure carefully and get out four pieces, each 10 inches long. Miter the corners so that the highest surface of the molding is outward. Use your fine brad-awl to pierce three holes in each strip of molding. Unless you do this carefully, the molding will split. With small wire brads, nail the four pieces to the inner edges of the stiles and rails, not to the panels. The nails should be driven in an oblique direction, and set a little below the surface of the molding. Your nail-set will be too large for this work, and in its place you may use a small brad, striking on the edge of the head, which you will hold against the nail you have driven. The upper edge of the molding, when in place, should be a little lower than the surface of the frame.

You can now cut off the projecting ends of the stiles and the tenons with the back-saw, taking pains not to let the saw gash the frame. With the smoothing-plane, give a last light finish to the faces and the edges of the frame, and from the corners take off a hair-like shaving all the way around. This shaving should be so fine that the door will appear to have sharp edges, except on very close examination.

The door may now be lightly dressed with fine sandpaper and then given a coat of shellac varnish. These two processes have already been employed in finishing the box, in Lesson XIX.

LESSON XXV.—CARE OF TOOLS

In the foregoing lessons, frequent allusion has been made to the necessity of having sharp tools for certain work. It is assumed that all cutting-tools will be kept well sharpened, and these allusions have been made merely to emphasize the importance of keeping tools in a proper condition at all times. Good work cannot be produced with dull-cutting edges, and in general, no tool which is carelessly treated can be expected to be as efficient as one that is kept always in the best condition.

In the first place, every tool should have a place and be kept in that place, when it is not needed on the bench for the work in hand.

Nearly all the tools used by the woodworker have parts made of steel or iron, both of which are likely to rust. They should, therefore, be protected from moisture, by keeping them in a dry place, and should now and then be rubbed with a drop of oil, applied with a cloth. Do not put on too much oil — the merest film is amply sufficient to keep moisture from the surface of the metal.

Edged tools should not lie one above the other, nor should the cutting edges be allowed to come in contact with substances upon which they are not to be used. You cannot expect your chisels to remain in good order, if they are thrown carelessly upon the bench or dumped promiscuously in a box. They should be placed in a rack, where they can be supported at the shoulder between the blade and the handle, with the cutting edge pointing downward and the flat side outward.

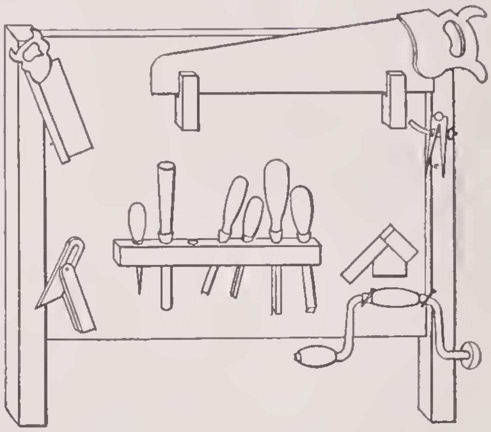


Fig. 116

Planes should not rest on the edge of the plane-iron, which projects a little beyond the sole. A small stick should be placed under the toe of the plane, so that the iron will be raised above the bench.

Saws should be kept in a rack consisting of two upright boards in which kerfs have been made, so that the blade may be placed in them, toothed edge upward.

A set of bits is often kept in a small box, but there is much less danger of injuring their cutting edges, if they are placed in a rack, made of a strip of wood in which holes have been bored, a little larger than the shank of the bits, but not large enough to permit the auger-end to slip through.

The drawknife should be supported on two pegs, separated nearly to the width between the handles.

Whenever you sharpen tools on the oilstone, remember to replace the cover of the box, after using it.

Materials, such as nails, screws, glue, etc., should be kept in covered boxes. After you have had as much experience as should be obtained from the foregoing lessons, you can make a small case of drawers, in which nails, screws, brads, etc., may be kept.

When you have finished work, for the time being, put away all tools in their places, brush the bench-top free from chips and dust, and cover it with a cloth. This takes but a moment and prevents dust from settling on the bench-top and the tools racked at the back of the bench.

It is desirable to have a substantial tool-box, large enough to hold planes, saws, chisels, and other tools, without crowding, and when you feel qualified to do so, you should make such a box for yourself. When the tools are not in use, keep the box locked and the key in your pocket. If other members of the family need to have small jobs done, they should apply to you, as the one who is supposed to know best how to use tools, instead of borrowing your tools for their own use, when you are absent.

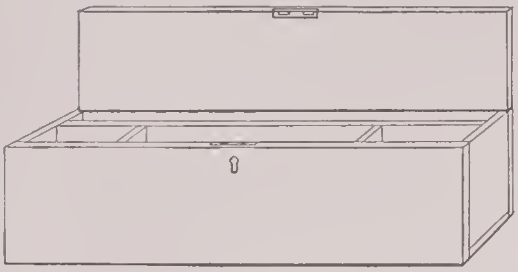


Fig. 117

Although they may have the best of care, tools become dull from legitimate use and must be sharpened. It is sometimes necessary to sharpen a chisel several times before you have finished using it on a single piece of work. One of the most important features of the woodworker's craft is, therefore, the sharpening of edged tools. For this work, a high degree of skill is required, as a good tool may be easily spoiled by unskilful sharpening. The pupil should, however, learn to sharpen his own tools, and as it is almost impossible to impart the knack of sharpening by means of printed instructions, it is urged that lessons in sharpening should be had under a competent instructor. The course of lessons outlined in this book is designed especially to aid those who are not within reach of regular Manual Training schools, but in every community there are carpenters and mechanics whose occupation obliges them to understand the sharpening of tools. They are not considered the most competent teachers of Manual Training, which, it must be remembered, is not carpentry, but they can at least give object-lessons in the sharpening of tools and the young woodworker should learn, by observation, how to use the saw-set, the grindstone, and the oilstone.

For the guidance of beginners when they undertake to sharpen their tools, certain rules are to be borne in mind. Take, first, the saw. You have already learned that the teeth of rip and crosscut-saws are "set" and filed differently, and that the amount of "set" determines the width of the saw-kerf. A saw which is to be sharpened is fixed, toothed edge upward, in a saw-clamp, which, in turn, is held in the vise. The saw-clamp consists of two pieces of hard wood which are joined by two screws, as in Figure 118. When the saw-blade is placed between the jaws of the clamp, the screws are tightened so that the saw cannot slip.

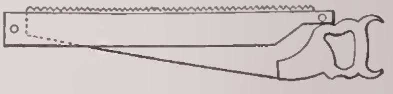


Fig. 118

The saw is first "jointed"; that is, a file is passed along the ends of the teeth, so as to make the teeth all of the same height. The saw-set, which is a notched steel blade set in a handle, is then applied to the first tooth, beginning at the handle, and the tooth is bent outward. The third, fifth, seventh, and remaining alternate teeth are then bent in the same direction. The second, fourth, sixth, and remaining alternate teeth are then bent to an equal angle, in the opposite direction. Another form of saw-set consists of a hammer, hinged at the back, which is made to strike the tooth while the blade of the saw is held against a plane surface at the correct angle. The setting of a saw must be done with great accuracy. The teeth must not be bent too sharply, lest they break. Nor should they be turned aside too far, the general rule being that the width of the kerf shall never be more than double the thickness of the teeth. The teeth are bent much or little according to the kind of work on which the saw is to be used. The teeth of a back-saw, which is used to make fine cuts, are not bent so much as those of a coarser saw, used for rough work. Saws intended to be used chiefly on pine and other soft woods have a wider «set» than those used on hard woods. The sharpening of the teeth is done with a triangular file, of such shape as to admit of its passage between the teeth to the bottom of the notch formed by their sides.

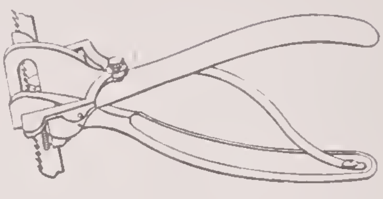


Fig. 119

In filing a rip-saw, the file is held perpendicular to the face of the blade. It is drawn at right angles to the blade, one side of the file resting lightly against the tooth A, Figure 120, while the real cutting is done at the tooth B. You will see by this that the sharpening is done toward the point of the teeth, and not away from it. As the filing leaves a slightly turned edge on the farther side of the tooth, the teeth are not filed one after the other, but the first, third, fifth, and so on, are filed toward C, until the end of the saw is reached, and the alternate teeth are then filed in the opposite direction, toward D.

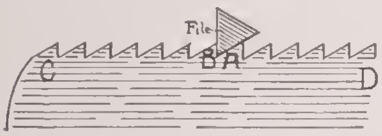


Fig. 120

In filing a crosscut-saw, the file is held at an angle to the edge, according to the character of the tooth desired, as in Figure 121, and the teeth are filed in alternation, as already described. An angle is formed on both inner edges of the tooth, in a crosscut-saw.

The jointing of the saw, which has been mentioned as the first step in sharpening, leaves a tiny face on the points of the teeth. The subsequent filing, or actual sharpening, must continue until this face has disappeared, which shows that the tooth has been brought to a keen edge.

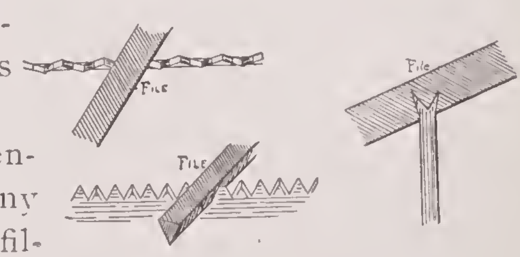


Fig. 121

To remove the edge formed on the outside of the teeth by the filing already described, the saw is «jointed» on both sides, by passing the file lightly along the teeth. An oilstone is sometimes used for this purpose. The file must always be drawn forward with long and steady, not jerky, strokes, and it must not be given a rocking motion.

The teeth should be only a little way above the clamp-jaws while the saw is being filed, in order that the teeth may not vibrate; and the screws should occasionally be examined to make sure that they have not slipped, so that the saw may not drop from the proper position.

While Manual Training does not look first to economy, but rather to giving the necessary educational training, there would be no educational value in spoiling a good saw because the unskilled beginner desired to set and sharpen it without having seen the work properly performed by a competent person.

The same argument applies to the use of the grindstone and oilstone, on which edged tools are sharpened. The use of these two implements is not so difficult to learn, however, and from the rules given in this article the beginner may learn to grind chisels and plane-irons properly. In actual experience, more rapid progress is made if this work is performed under the direction of a teacher or some competent workman.

The grindstone is a slab of sandstone, circular in form and made to revolve on an axle, which is turned by means of a handle or a treadle. For the beginner who expects to do most of his work by himself, the treadle will be a necessity.

To attempt to grind a tool on a dry stone will ruin the tool, as the heat generated by the friction will burn the steel and make it soft. To avoid this, a tank for holding water is elevated above the center of the grindstone at one end of the tank, and from a small tap the water is allowed to trickle upon the stone while the latter is in use.

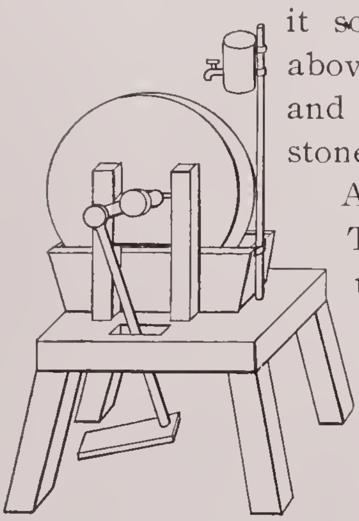


Fig. 122

A trough is fixed below the stone to catch the waste water. This water should be drawn off when the stone is not in use, as water softens the stone and makes the part that remains long immersed wear away faster than the remainder of the stone. The stone should therefore be kept dry when it is not in use. The water absorbs the heat caused by friction and at the same time carries away the fine grit loosened from the surface of the stone, leaving the cutting surface clean and effective. The grindstone should be provided with guards fixed to the frame, to keep the water from the clothing of the operator.

In grinding, keep the stone turning toward the tool, with a steady, continuous motion. Always apply the tool to the stone after the latter has been set in motion. Never revolve the stone away from the tool, as that will turn up the edge of the tool as in Figure 124, and spoil it.

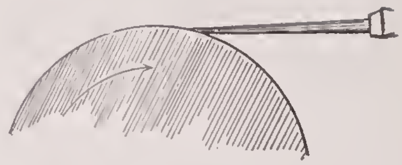


Fig. 123

To grind a chisel, the bevel should be applied to the stone at an angle of 25 degrees. As it is not easy for a beginner to hold the tool continuously at the proper angle, a support should be fixed to the frame, so that the blade of the chisel may be passed through a mortise, Figure 125. This support should be adjustable, so that different tools may be held at different angles, as required.


Fig. 124

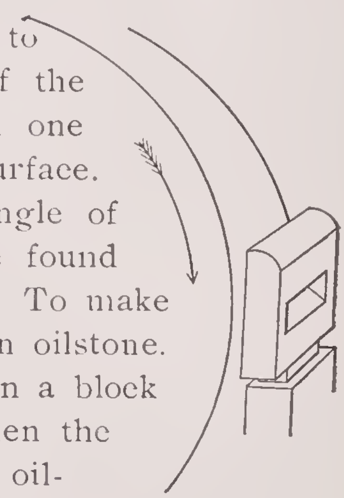


Fig. 125

While grinding, the tool should be moved from side to side, and not allowed to rest wholly on the middle part of the stone, nor on one side, as this wears away the stone in one place more than in another, and produces an uneven surface. When the bevel of the chisel has been reduced to an angle of 25 degrees, it is theoretically ready for use, but it will be found that the grindstone leaves a feather-like edge on the tool. To make this edge straight and keen, the chisel must be rubbed on an oilstone.

A piece of this stone, about two by five inches, is set in a block of wood, and a cover is provided to fit over the stone when the latter is not in use. Sperm-oil or olive-oil is used on the oilstone to absorb the heat generated by friction, just as water is used for the same purpose on the grindstone. So far as possible, the entire face of the oilstone should be brought into use, in order that it may not be hollowed by rubbing only in the center or beveled by rubbing only at one side.

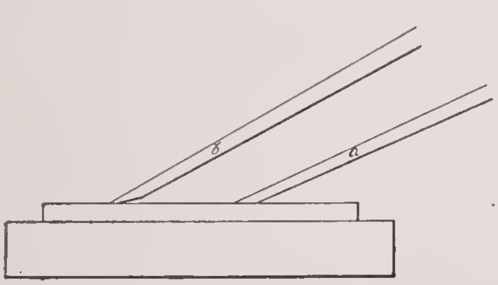


Fig. 126

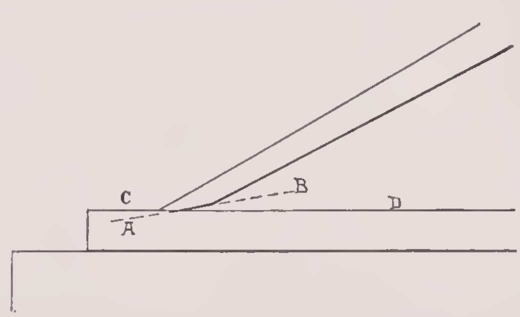


Fig. 127

The chisel, having been ground on the grindstone, is applied to the oilstone, as shown in Figure 126. The edge is pushed away from the operator, not drawn toward him. After the bevel produced by the grindstone has been rubbed a little, the handle of the tool is raised at an angle of 35 degrees, so that the edge is now given a different bevel. In Figure 127, AB shows in an exaggerated outline, the bevel produced by the grindstone, and CD shows that produced by the oilstone. In rubbing the tool, the hand must not move up and down as that would produce a rounded edge, as in Figure 128. The hand must move back and forth, parallel to the stone.

Fig. 128

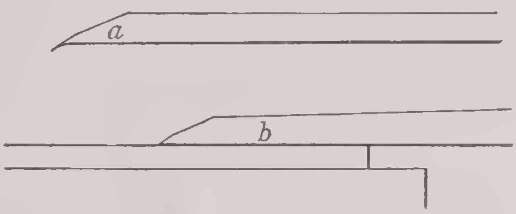


Fig. 129

When the bevel has been rubbed to a keen edge, the steel will tend to turn up a little, producing a wire edge, which is shown, in an exaggerated form, in Figure 129, *a*. This must be removed by rubbing the tool on the stone two or three times with the flat side close to the stone throughout, as in *b*. Be careful not to raise the handle while doing this lest you produce a rounded edge.

A chisel properly sharpened will have an invisible edge. As you sight along the edge of the tool it should be impossible to distinguish exactly where the edge is. If the edge is made plain by a shining line, it shows that the edge is rounded and it must be rubbed down.

When you use a chisel frequently, in the course of an exercise, as in cutting mortises for the door-frame, in Lesson XXII., this invisible edge, by constant use, will become dull, and you will need to improve its cutting quality by rubbing it often, a little at a time, on the oilstone. These frequent rubbings on the oilstone will in time widen the short bevel near the edge so much that the chisel will again require grinding on the grindstone.

"Slips" of oilstone are pieces of oilstone, rounded or wedge-shaped, which may be held in the hand and used for sharpening such tools as the drawknife or the gouge, which cannot easily be applied to the blocked oilstone. They are very convenient, but a steady hand and a true eye are needed to make them effective and prevent harm to the edge of a tool by a rocking or irregular motion, while sharpening.

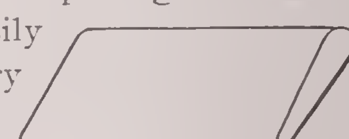


Fig. 130

A plane-iron is ground in the same way as a chisel, care being taken to hold it at a proper angle. It is given a final beveling on the oilstone. In effect, the chisel and the plane-iron are identical tools, although they are provided with different handles or supports and are used in different ways.

It is not so easy to grind a knife properly as it is to grind a chisel, for the reason that the knife-blade is narrow and cannot so readily be held in proper position on the stone. The blade is thin and the angle must be less than that at which the chisel or plane is ground. You will find it best to rest only a small portion of the blade on the stone at a time; but the blade should be kept moving back and forth across the stone. When the point is to be ground, the handle should be swung to and fro from the operator, in order that the entire edge may be ground. When the final sharpening is done on the oilstone, the knife is rubbed along the line of an O. As the blade is thicker near the handle than it is toward the point, it will be necessary to raise the handle slightly, now and then, in order to bring the point in contact with the stone. As the oil-stoning may leave a very thin, feather-like edge, the knife should be passed a few times over a strap of leather, as you would strap a razor. This removes the thin, brittle edge. Both sides of a knife, or of a hatchet, which is ground in like manner, should receive like treatment.

In spite of all the care that may be taken to bring the entire face of the grindstone into use, it will become more or less grooved and ridged. It will then be unfit to grind the broad edge of a plane-iron, for example, and must be trued. There are mechanical devices which may be applied to a grindstone to scrape the face, one of which consists of a cylinder having a screw-thread on its face. The cylinder revolves against the stone and shears away the ridges. Another method is to revolve the stone against the end of a flat piece of iron until the face is perfectly true.

Another treatment which the grindstone requires is the occasional removal from the face of the fine particles of steel, released from tools which have been ground, and the fine grit, which accumulates in the nicks of the stone until its face becomes smooth and fails to cut. The water dropped on the stone prevents this accumulation, to some extent, but not wholly. When the stone has become clogged so that it fails to cut, it must be scraped. For this purpose, it is revolved against a bar of soft iron, held across the face, which soon removes the accumulated grit and renews the cutting-face of the stone.

An oilstone, after long usage, may, like the grindstone, require to be "trued." To do this, the stone is placed face down on a sheet of sandpaper, and rubbed against the sandpaper with a circular motion until it is seen to be true, when tested with the blade of a square or other straight-edge. If the stone is badly grooved, it may be more quickly ground by rubbing it on a plane surface of iron, on which a little emery has been placed. A few drops of oil should be added to the emery.

The sharpening of bits is done with a file, which is applied only to the inner edge of the nib. If the outer edge were to be filed, the diameter of the hole made by the bit would be lessened. The cutting lip at the bottom is filed from the lower side and the spur may be kept in order by filing it with a triangular file. The sharpening of a bit is a delicate operation, and ought not to be undertaken by unskilled hands.

It is suggested that a cheap iron chisel may be ground and sharpened before the same work is attempted on more expensive tools. The use of cheap tools in woodwork practice is not recommended, however, as they soon become dull and fail to give satisfactory results.

LESSON XXVI.—ADDITIONAL TOOLS

The assortment of tools enumerated in the introduction to these lessons will be found amply sufficient for such practice work as should be undertaken by the young woodworker during the first nine months of his Manual Training course.

If, however, he desires to increase the scope of his work during the second year, additional tools may be supplied. They should not be purchased unless a definite need for them arises during the progress of work which cannot be satisfactorily turned out without adding to the original kit of tools. To have too many tools is as undesirable as to have too few. Parents and guardians must take into consideration, when urged to supply new tools, the progress made by the boy in using those which he already has. Granting that he has developed skill, accuracy, and inventiveness in using the simpler tools, his desire to possess and use new ones should not be hastily discouraged.

Additions may be made to the supply of chisels and gouges. In making mortises, particularly, the young woodworker often finds that if would be convenient to have a chisel a little narrower or a little wider than any in his kit. A compass-saw is extremely useful for sawing along curved lines, and for quickly getting out the superfluous wood from mortises, after holes have been bored with the bit. A crosscut-saw, set and filed especially for sawing hard, fine-grained woods, is a convenient addition to the tool-chest. A frame-saw, or jig-saw, with an assortment of narrow, thin blades, is useful for getting out such work as the inner scrolls of a bracket, where the compass-saw which is intended for coarser work, would not be effective. A small, light back-saw, called a dove-tail saw, makes it easy to cut dove-tails with more accuracy than when a larger and heavier back-saw is employed for that purpose.

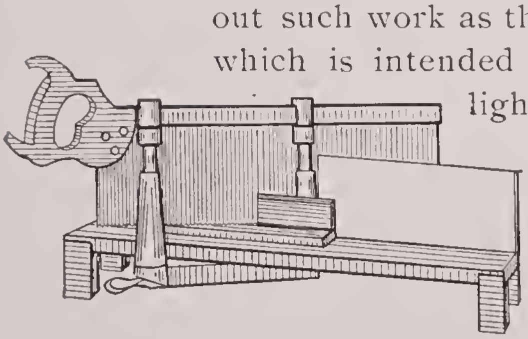


Fig. 131

An iron miter-box (Fig. 131) is a convenient accessory. It has a pair of adjustable guides through which the saw is pushed, and which may be quickly set at any desired angle. As the box is open in front, the wood to be cut away may be held in place more easily than in a wooden miter-box. Many styles of planes are made. A beading-plane is useful in forming a bead on the edge of a board, as, for example, the inner edge of door-stiles and rails, where it gives a neat finish to the panel. (Fig. 132.) A rabbeting-plane is for planing close to an adjacent surface, as in Figure 133. A circular-plane has an

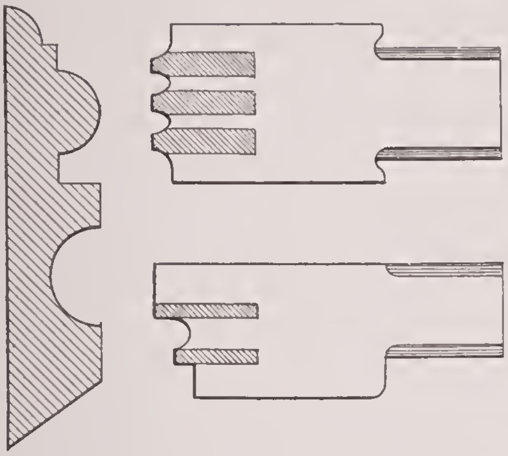


Fig. 132

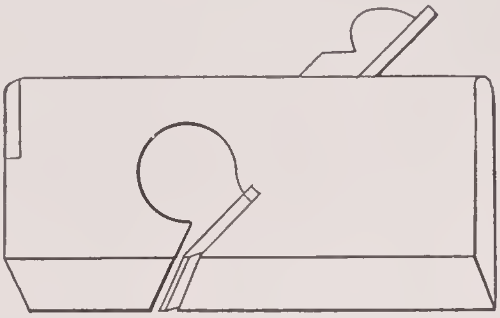


Fig. 133

adjustable sole, made of thin steel, which may be drawn to a curve, upward or downward, as in Figure 134. It will readily be seen that this is a most useful tool for planing concave or convex surfaces. In the foregoing lessons, it has been shown that the smoothing-plane may be used for planing end surfaces, but it is too large and cumbersome to be convenient for such use on small work. A small iron block-plane should, therefore, be provided.

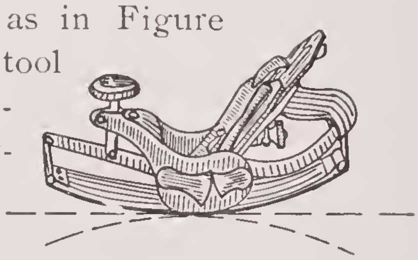


Fig. 134

The spokeshave, which was described in Lesson XII., is not an expensive tool, and is often used in smoothing rounded surfaces.

One of the most convenient of modern tools is the automatic boring tool, which takes the place of the brad-awl. Without entering into an extensive description of this tool, it may be said that it consists of a handle and a set of points, or drills, which are interchangeable, as in the case of the bits accompanying the brace. These points make holes from $\frac{1}{8}$ inch in diameter down to a hole suitable for the smallest brad. The point is placed in contact with the wood, and a straightforward pressure on the handle causes the drill-point to revolve at great speed. This not only bores the hole quickly but lessens the danger of splitting the wood, if it is very thin and narrow. When the pressure is removed from the handle, the drill, actuated by a spring, revolves in the opposite direction and may thus be quickly withdrawn from the hole. A similar tool is made for the quick driving of screws. (See Fig. 135.)

Fig. 135

Pincers, pliers, and a wire-cutter are not indispensable tools, but they are very convenient, and are not expensive. In each case, the tool consists of two steel or iron blades which move on a pivot near the jaws, the remainder of the blades being shaped as handles. Ordinary pincers have broad, curved jaws, and are used for withdrawing nails. In confined situations, where a claw-hammer cannot be used, they are exceedingly useful. The wire-cutter has nearly the same shape as the pincers, but the jaws are sharpened, so that it will cut off a nail or a wire, and this cutting may be done close to the wood in which the nail is driven. For quickly cutting a wire, especially one of soft metal, they offer so great an improvement over bending or filing as to be almost indispensable. Flat pliers have jaws whose inner surfaces are file-cut and meet in the same plane. Small pieces of metal may be firmly held in these jaws, for bending, etc. Round pliers have cone-shaped jaws, and are used in bending metal on a curve. (See Fig. 136.)

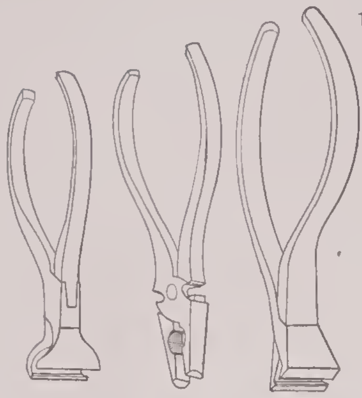


Fig. 136

The only form of file to which allusion has been made in the foregoing lessons is the triangular file, which is used for filing saws. There are, however, several forms of files which are useful in wood-work. A long, broad rasp will often be found useful in reducing rough edges, before the plane is applied. A flat file is a convenient tool for smoothing the sides and corners of mortises. The round file and the convex side of the half-round file are useful in smoothing concave surfaces, shaping the outline of keyholes, scrolls, etc. In use, the handle of the file should be grasped in one hand while the fingers of the other hand are pressed on the upper surface of the farther end. For straight work, it is necessary to avoid a rocking motion of the file, which should move forward in one plane. (See Fig. 137.)

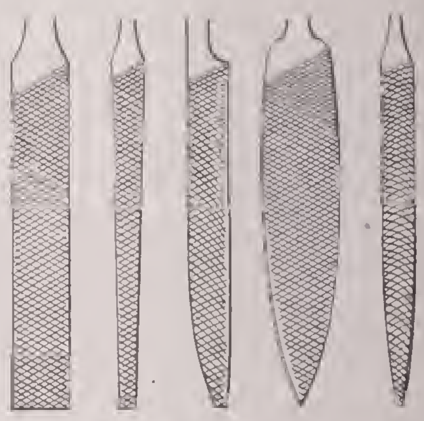


Fig. 137

The use of the dividers, the gauge, and the square and pencil have had frequent exemplification while the making of the box and the door were in progress.

Nothing has heretofore been said about the use of the chalk-line. This is useful on large work, where a long, straight line is desired as a guide for sawing or planing, and cannot be easily and accurately drawn with the ruler, as, for example, in marking a board to be divided with the rip-saw. (Fig. 138.) The chalk-line is a small, finely-woven cord, generally wound upon a wooden spool, whose end-discs are large enough to raise the cord above any surface on which the spool rests. The two points between which the line is to be drawn are marked on

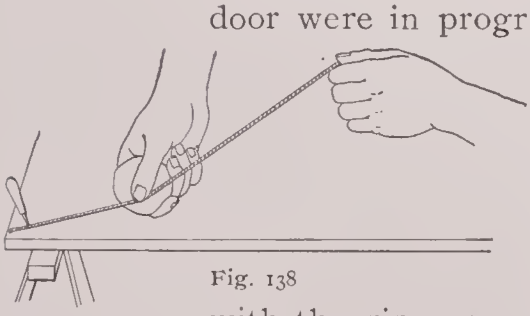


Fig. 138

the board. The point of an awl is then passed through a loop at the free end of the line and the awl is fixed upright in the wood at one of the points. Unwind a length of cord sufficient to extend beyond the other point. Holding the cord taut, and above the board, rub the chalk upon the cord, beginning close to the awl, and letting the cord bend about the curved surface of the chalk. When the cord has been well chalked, draw the line taut on the board and hold it, with

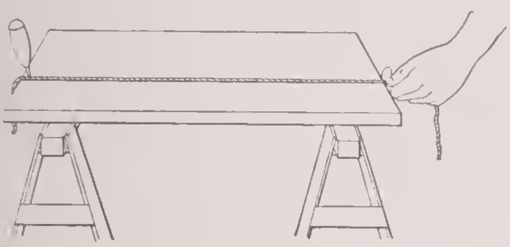


Fig. 139

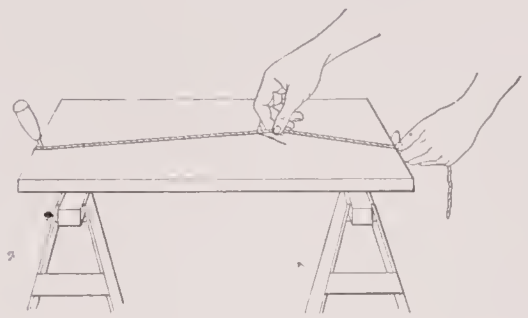


Fig. 140

the thumb, at the point on the end opposite from the awl. (Fig. 139.) Holding the line taut, with the thumb of one hand, draw it upward with the thumb and forefinger of the other hand, and sight along the cord to make sure that it is vertical throughout its length to the line between the two points. Let go the cord and it will snap sharply on the board, leaving a distinct chalk-line between the two points. (Fig. 140.) Wind the cord on the spool again, lifting it above the board so that it will not rub or widen the line just made, and put it away. On nearly all kinds of wood in common use, blue chalk makes a more distinct line than white, and is therefore recommended.

LESSON XXVII.—FASTENINGS

Nails, screws, brads, and glue have been used in putting together the box and the door, but only one kind of each has been employed, and it is well to be familiar with the different forms of these materials. Nails are divided into several classes, according to the material of which they are composed, the method of making them, and the purpose to which they are to be applied. Iron and steel are the materials commonly used in making nails. Cut nails are stamped from a sheet of metal. This is done by machinery and the nails are shaped very rapidly. Iron-wrought nails were originally made by hand, but are now produced by machinery. They are soft enough so that the ends can be bent for clinching, without breaking the nail.

Wire nails are made from drawn wire. Some are finished by merely giving them a head and a point; others have the shank roughened something like a broken screw-thread, so that it will be more difficult to withdraw the nail from the wood. Wire nails cling to the wood with great tenacity, and are not so easily loosened or withdrawn as iron cut or wrought nails, which are wedge-shaped.

Nails are said to be "four penny," "six penny," etc., according to their size, the term having originally come from the fact that a thousand nails of a certain size weighed six pounds, etc. "Pounds" was corrupted to "penny" and the term has survived in that form. An ordinary three-penny nail is 1 inch long; a twenty-penny nail is 3½ inches long. Brads are small nails, with small heads, used for finishing work, where the nail is generally driven in so that the head leaves but a small indentation, which may be filled with putty and painted over.

The heads and points of nails vary according to the uses to be made of them. Some have sharp and some have blunt points, some have broad heads and others have heads only a trifle larger than the

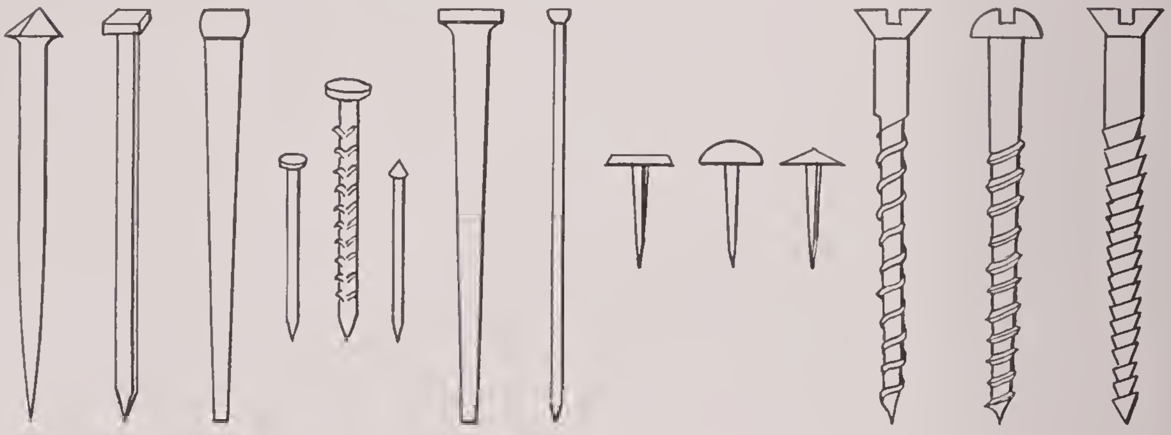


Fig. 141

shank. It will be apparent that those with large heads are intended to be used for coarse work, while those with sharp points and narrow heads are intended for more careful work in finishing. (Fig. 141.)

Tacks are very short nails with sharp points and large heads. They are not intended for joining pieces of wood, but are used for fastening cloth or leather to wood. They are described as one-ounce, four-ounce, etc., that is, 1,000 tacks $\frac{3}{16}$ inch long weigh one ounce, etc.

Screws are made in a great variety of forms and sizes. They are made of steel or brass, and are described as bright or blued. Bright steel screws are polished. Blued steel screws are given their blue finish by treatment in acid, which removes the luster of the bright screw. Blued screws do not rust as readily as do bright screws, and when made with half-round heads, they contribute to the ornamental finish of many kinds of work. Brass screws do not rust, and these are also used for ornamental purposes, those with half-round heads being preferred. Screws are graded in sizes from o to 30, the No. o screw being less than $\frac{1}{16}$ inch in diameter, while No. 30 has a diameter of almost $\frac{1}{2}$ inch. The length is also expressed in fractions of an inch.

One advantage derived from the use of screws in joining pieces of wood is that the screws may be easily removed and the pieces separated, if desired, without marring the wood. Small screws are especially useful in fastening metal to wood, as in the case of hinges. In general, their tenacity is greater than that of nails, and they may be driven with less danger of splitting the wood, because the thread of the screw cuts across the fibers instead of merely wedging them apart.

Wooden pegs are used for holding pieces of wood together, as already described in Lesson XIV.

The principle of the wedge is frequently used in forming tight joints. For example, when the mortise does not extend through the piece of wood, the sides of the mortise are sloped toward the blind end, as in a dovetail. One or two saw cuts are then made in the end of the tenon, parallel to the sides of the mortise. Wedges are entered in the saw-kerf and the tenon is then driven home. As it goes farther into the mortise, the wedges are pushed farther into the saw-kerf and cause the end of the tenon to spread and press closely against the sloping sides of the mortise. The open end of the mortise is narrower than the expanded tenon, hence the latter, when driven, cannot be withdrawn. (Fig. 142.)

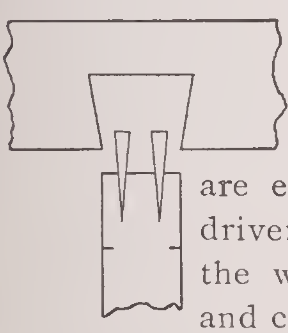
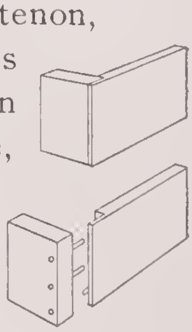


Fig. 142



Dowels are round pins, made of wood, which are used for making blind fastenings, as, for example, in joining the rail of a stair-case to the newel-post, or in strengthening mitered corners, which are comparatively weak joints except when reënforced by some such method as doweling. Holes are bored in the two pieces of wood to be joined, and pegs dipped in glue are then driven into the holes of one piece, or alternately in the holes of both pieces. The projecting ends are then given a coat of glue and driven into the holes in the other piece. If the pegs are made to fit tightly, this forms a strong point. Figure 143 shows the method of using dowels.

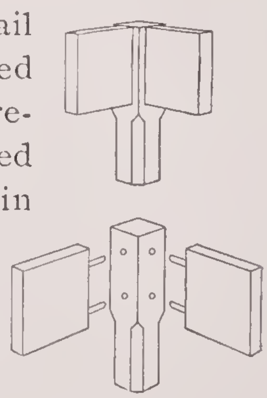


Fig. 143

In the foregoing lessons, the learner has been shown how to make a mortise-and-tenon joint, a mitered joint, and an end dovetail, the simplest form having been used in each case. There are several other kinds of joints which are used by the wood-worker to give strength in construction, and some of these are briefly explained at this time, with the suggestion that the learner devote a reasonable amount of time to actual practice in making examples of them.

A halved joint is shown in Figure 144. This may be made with the back-saw alone. Figure 145 shows a halved joint in which the chisel must be used for paring the mortise. A halved splice is illustrated in Figure 146. This is used in jointing two pieces of wood so

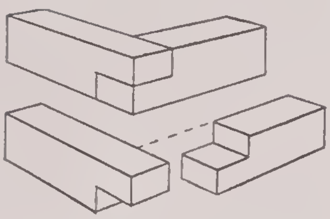


Fig. 144

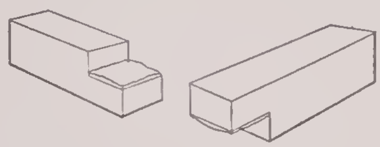


Fig. 145

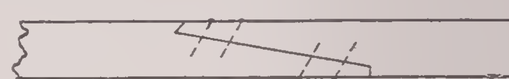


Fig. 146

that in their length way they will follow the same direction. When the two pieces have been cut and fitted together, they may be glued and further secured with nails driven obliquely from one piece into the other, as shown by the dotted lines. Another form of halved joint is shown in Figure 147. This is used when two pieces of wood are to be crossed, as in making the divisions of type-cases, etc.

A mitered corner may be greatly strengthened by a mortise-and-tenon joint; either open, as in Figure 148, or blinded, as in Figure 149.

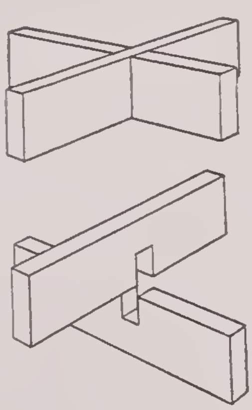


Fig. 147

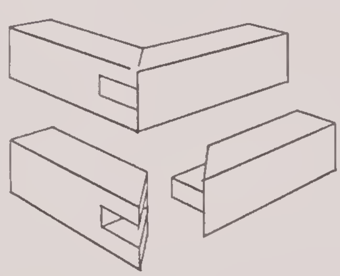


Fig. 148

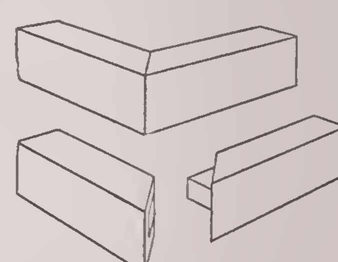


Fig. 149

The strength of a halved joint may be increased by dovetailing. Figure 150 shows a half-dovetail joint, halved together. An ordinary dovetail joint, with five tongues, was used in putting the box together in Lesson XVII. In making a second box, you may make a half-blind dovetail joint, as in Figure 151, a blind dovetail joint, as in Figure 152, or a mitered corner, dovetailed, as in Figure 153.

When the thickness of the wood permits of so doing, open mortise-and-tenon joints are sometimes made double, as in Figure 154, to which mitering may be added, as in Figure 155.

No rules for measuring, or for the use of the saw and chisel, in making these joints, are given here, because the principles involved have already been learned from the foregoing lessons.

The principal thing for the parent to keep in mind is that the boy should do real work. This work, of course, should be within his reach, but, when it is within his reach, insist that he do it. Let him make his own playthings. If he wants a sled, he should make it for

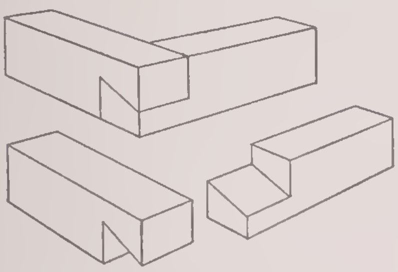


Fig. 150

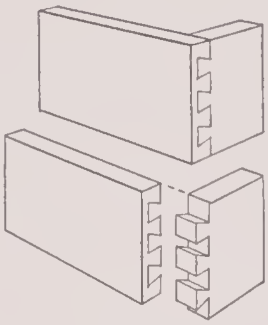


Fig. 151

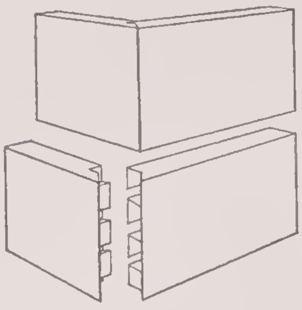


Fig. 152

himself. It is a wrong to the boy, an injury to his real growth and education, to buy for him a sled which he might have made for himself. The home-made sled has an individuality which a sled from the store cannot possibly have, and if it is well made it has a kind of value which the other cannot have. The same principle holds good in regard to other toys. The pair of stilts, the canoe, the frame for the butterfly net,—whatever plaything the boy wants, he should make for himself.

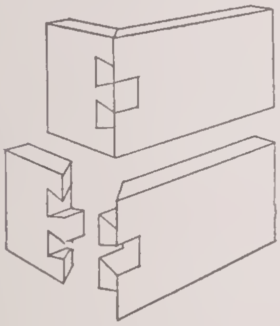


Fig. 153

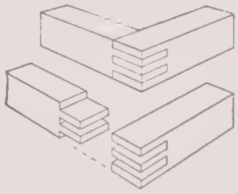


Fig. 154

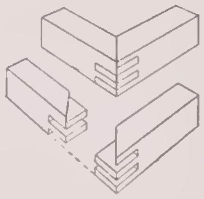


Fig. 155

Then, too, lead him to make things for the house. There are shelves to put up, boxes and chests to make, cupboards to build, and a thousand things to do, if one has an eye to see the need. Nothing should be purchased that can be made in the house. Then the repairs are almost infinite. Doors shrink and must be refitted, locks get out of true and must be readjusted, window cords wear out and must be replaced, and other unexpected calls for repair work are coming constantly. These are often—in fact usually—so slight that it hardly seems worth while to send for a carpenter. But as long as there is a boy-carpenter in the house, do not let these things go over for a day longer than necessary. Not only should his tool-chest and work-room be kept "ship-shape," but the house should be kept right. A door that sticks should be attended to at once and not be left to wear out the patience of every member of the family. That is what the boy-carpenter is for.

Whether the boy should be paid for this sort of work, is an important question. It is safe, and perhaps best, that he should be paid a small sum. But he should be made to feel that he has some responsibility for the condition of the house; that it is as much his business as his father's to look after the general welfare. He should not be paid so as to lead him to look upon the condition of the house, and the comforts of the family, as if he were an outsider. A small payment will help him to keep up his stock of tools and give him a little pocket money, which are good things. But he must never look upon these home jobs as good pickings. He must have the same care as if he were the head of the family and paid the bills. This will do more than almost anything else to make a man of him.

One caution is added. The boy must not be allowed to leave any work half done. When he starts in on any piece of work, whether it be a toy or an article of permanent value to the household, whether he is working for himself or for others, in every case insist that he shall finish. One of the vices with which many boys and men need to contend, is this disposition to shiftlessness. If the first beginnings are overlooked, it will grow like a weed. It chokes out the persistence which in manhood makes things go. It ruins the man and leaves him a laughing-stock. Certainly for nearly two thousand years, and probably from the beginning of civilization, the man who began to build and was not able to finish, has always been the object of derision. But the boy who thus does real work, useful work, and work that is always brought to completion, has a good preparation for the exacting needs which are sure to come in the period of his manhood.

WOOD-CARVING

Wood-carving has been made an important factor in Manual Training, in this country, and work done by pupils not more than twelve or fourteen years old is sometimes surprisingly beautiful. The educational advantages of a course in this work are large. It goes a step farther than modeling in clay, which produces fragile or perishable forms, while carved wood has a permanent beauty and value. Wood-carving gives the pupil a sense of form and stimulates a love of grace and beauty. When ornamental carving is added to a work of utility which the boy has made in his carpenter shop, it increases the value of the work as well as the pleasure of the worker, and shows that the useful may also be beautiful. The carving applied to a table, chair, picture-frame, bread-tray, ladle, or spoon, does not make those articles less serviceable, but it does make them more pleasing and gives them individuality.

Wood-carving is as really an art as is painting; and it makes large demands on the intelligence, originality, and skill of the carver. Its purely educational value, on general lines, is admitted to be less than that of carpentry, but on the other hand, it teaches much that is not to be learned in common woodwork, and it directly inspires a love of beauty. Like clay modeling, it requires the use of both hands, and a good carver learns to shift his tool from one hand to the other, using both hands with equal dexterity. It is clean and healthful work, and children almost always find great delight in it.

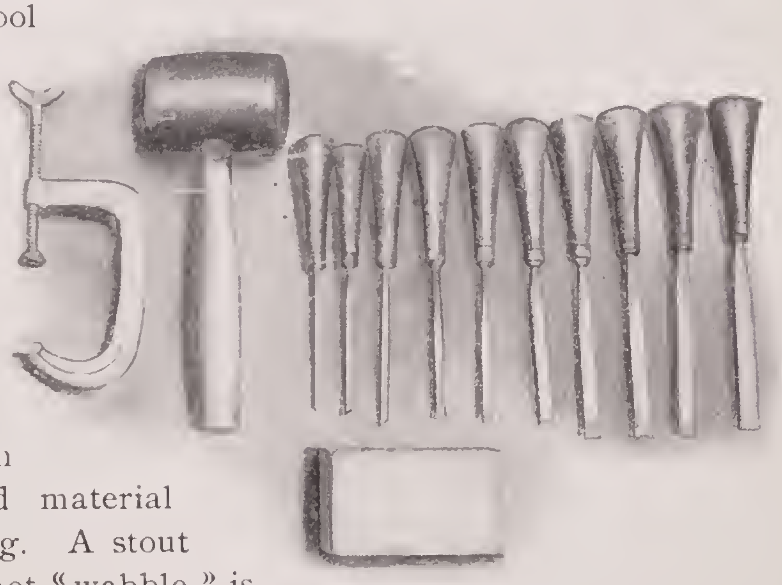


Fig. 1

TOOLS REQUIRED

No large expense is involved in providing the outfit of tools and material needed for a course in wood-carving. A stout table or heavy bench, which will not "wabble," is needed, and clamps to hold firmly in place the wood to be carved. The kit of tools comprises a mallet, and eight or ten chisels and gouges of different forms. It is a mistake to supply the child with too many tools. The best carvers rarely use more than six or eight; workmen who employ twenty, thirty, or forty tools generally do poorer work than those who use a less number. Moreover, with few tools at hand the ingenuity of the carver is likely to be developed, when an unusual condition arises in the work. In selecting a set of tools, it is desirable to buy those of high grade. They cost more than those of lower grade, but with cheap tools, good work is often out of the question. Further, it is always penny-wise and pound-foolish to buy an inferior quality of edge tools, for they will not hold their edge, and the time spent in sharpening them makes them dear in the end. An oilstone is needed for sharpening the chisels and gouges.

THE WOOD TO BE CARVED

Beginners often make the mistake of choosing soft wood for their first experiments. In practical wood-carving, oak, cherry, and mahogany, are most used. It is only now and then that carving is done on soft wood. The learner should, therefore, avoid pine or similar wood, which splinters easily. Oak is the cheapest of the hard woods suitable for carving and it is best to begin with this. It does not splinter too readily and is tough enough to offer the necessary resistance. The reason why it is desirable to use hard wood in learning to carve is the same as the reason why it is best to put regular, full-sized tools in the hands of the beginner in carpentry work: It does away with the idea that the work is play, and familiarizes the pupil with the actual conditions of advanced work. Moreover, beginners often do excellent work at the start, and there is an added pleasure in keeping the object, if it is presentable and, as practical work, worth saving. As wood cannot be used more than once for carving, it is a good plan at first to save all the articles made, and to examine them from time to time, noting the progress made. When the carver has grown so skilful as to produce uniformly good work, the earlier specimens may be sent to the kindling-box.

But the carver should never, even at the first, take up any work with the idea that it is to be thrown away. Children, as well as older people, like to make things which they believe to be of permanent value, and they should have that inspiration in beginning their first work. They should begin their work with the full determination to make it good. It is well to have work that amounts to something. The carver will learn the use of tools better by making articles of real value than by mere experimental exercises, for it will hold his interest to the end.

THE DESIGN

It is assumed that a course in free-hand drawing and one in clay modeling have preceded that of wood-carving. They should so precede it, in any event. If this has been done, the pupil may select, as a model for his first exercise in carving, one of the forms he has modeled in clay. A good subject to begin with will be a simple panel, four inches square, to be ornamented with a scroll.

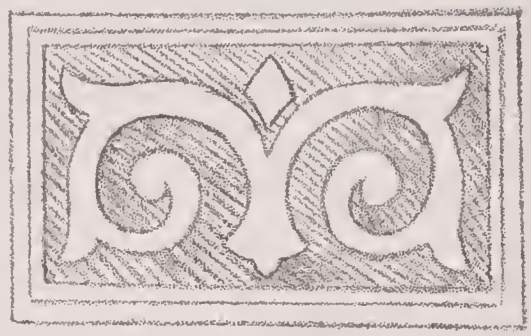


Fig. 2

The first thing to do is to draw the outline of the design on the wood. Mark out, on the surface of the block, a plain edge or border half an inch wide. Inside this border, the scroll may be drawn and redrawn until it is well-balanced and symmetrical. The preliminary drawing should be made with chalk, which can be rubbed off again and again, until the design is satisfactory. Then the outline should be marked with a soft lead pencil. These lines must be heavy so that they will not be rubbed out by the constant friction of the hands and sleeves. When the outline has been thus drawn, the background should be roughly scored with the pencil so as to shade the parts to be cut out. This will serve as a ready guide for the eye in carving, and if it is not done, the chisel will sometimes be applied by mistake to the wrong part of the wood and will cut out that which is intended to be left as a raised surface. This precaution may seem unnecessary, but it is really very important, for the eye does not take in the entire design at every glance, and it needs a reliable guide in applying the gouge or chisel.

The design on the wood should invariably be drawn free-hand. In some schools, pupils are allowed to trace the design by means of a tracing wheel or transfer paper. When the designs are so traced, half the educational value of the work is lost. The carver does not develop his own sense of form when he depends on some other person. The carved work made after such design will always be the feeblest kind of imitation. It will certainly lack the qualities of individuality, strength, and boldness,—qualities which carving is intended to develop. In time, the carver should have so keen a sense of form that in imagination he will constantly see his design in the wood, as it will appear when finished; the pencil marks are to him, therefore, a precaution, not a pre-requisite. Again, there is infinitely more satisfaction in work which is originated and carried through to completion without borrowing the ideas of others. If a boy can say of a piece of work that he designed as well as carved it, his pride in that work will stimulate him to still better and more original work. The mere copyist misses this pleasure and this stimulus.

It is true that designs are furnished to professional carvers who work on furniture and like articles, and the chief thing required of them is skill in execution. But wood-carving, as a factor in Manual Training, is not intended to produce professional wood-carvers, any more than shop practice is expected to make every pupil a carpenter. It is general education that is sought, and this should not be forgotten.

PRIMARY INSTRUCTIONS IN CARVING

Place the work-bench so as to have good light. Take the block on which the design has been drawn and secure it firmly to the bench by means of the clamps. The clamps must not slip. At times there will be considerable pressure on the wood, and if the block should move, the design might be spoiled.

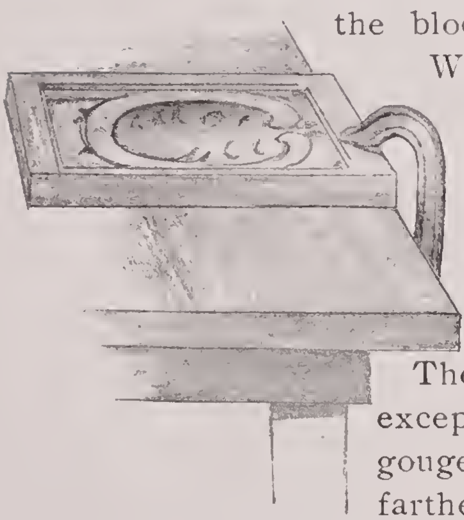


Fig. 3

With a gouge, cut a groove around the design. The groove should not be made deep at first. Then follow with a series of grooves until the entire background has been roughly "scored." Then gouge out the background to a depth of a quarter of an inch and for the present leave it in the rough state. Take care not to cut too deep.

There is no invariable rule for holding the gouge or chisel, except that both hands are employed. One hand pushes the gouge into the wood, while the other, grasping the tool farther down, steadies it and prevents it from going too far. An extraordinary degree of toughness in the wood may necessitate the use of the mallet, which is used to strike forcible, but not violent, blows on the head of the tool. The beginner should dispense with the mallet at first, and use one hand for striking the tool, or rely altogether on pushing it through the wood. Though carving is real work, it is not severe or exhausting. But a certain amount of force must be used. It is excellent discipline for the muscles and develops the strength.

A knowledge of wood — its formation and resisting properties — now comes into practical use, because in carving it is necessary to cut sometimes with the grain and sometimes against it. In shaping a delicate curve, the tool must be held firmly, lest it take off too large a splinter when going with the grain, or bite in too deep when cutting against it. The right amount of force can be learned only by experience, and this experience develops the sense of touch in a remarkable degree. After a little practice, the hands push the tool forward or hold it back with a precision that insures clean, firm lines. In learning to carve wood, do not be in a hurry. Remember that there is plenty of time. "Haste makes waste." It is better to spend three days on a single piece of work and do it well than to finish it, after a fashion, in a single day and then be ashamed of it. This does not mean that the work should lag, or that the cutting should be done by "pecking" at the wood in a succession of short, choppy strokes. The strokes should be bold and continuous, so as to leave no irregular, patchy marks; but only a small amount of wood should be removed at each stroke.

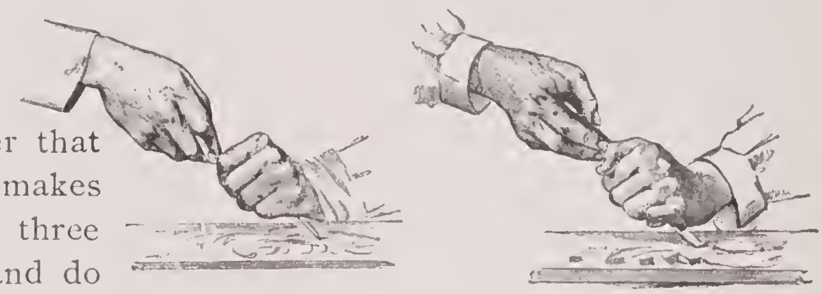


Fig. 4

When the background has been roughly gouged out, the next thing is to shape the curves according to the penciled design. With a chisel whose curve is not too abrupt, cut the wood to a clean, sharp edge along the line. In doing this, the chisel is held vertically and tapped with the mallet. Be careful not to cut the edge too deep. It is important to select the proper tool for this work. A tool whose curve is more abrupt than that of the design will make a "scalloped" edge, which cannot afterward be successfully smoothed. If the curve of the chisel is too slight, the projecting angles left by successive applications of the tool may be more easily cut away; but it will be found that a set of chisels which offers a choice of five or six curves, includes tools to fit almost any curve used in design.

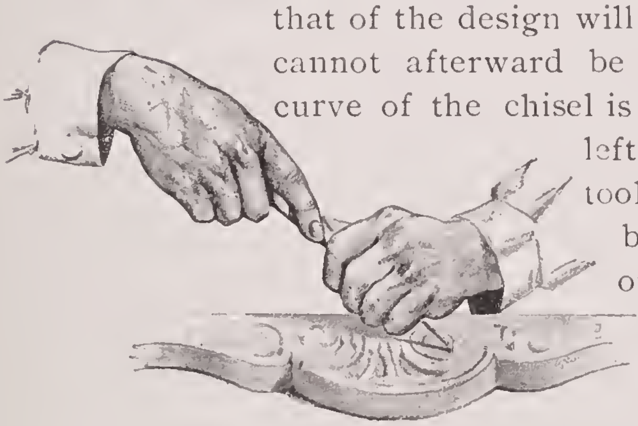


Fig 4

When the entire background has been gouged out, and the design cut to sharp edges, the carver is ready to shape the raised surface. At this point, the work becomes more difficult. Previous knowledge of modeling, gained from working in clay, is of great assistance, for the carver must now model the wood as really as he modeled the clay.

The edge of the design is now at right angles to the plane surface. It is desired to form the curves. Draw lines on the wood to show how far from the edge the wood is to be cut away. Select a gouge whose curve is suited to the curves to be shaped, and then, with a firm, even stroke, begin to cut off the inner edge of the curve. A thin shaving only should be taken off at each stroke. This work must be done with close attention to the progress of the tool through the wood. The edge should be cut away to about half the depth of the wood above the background.

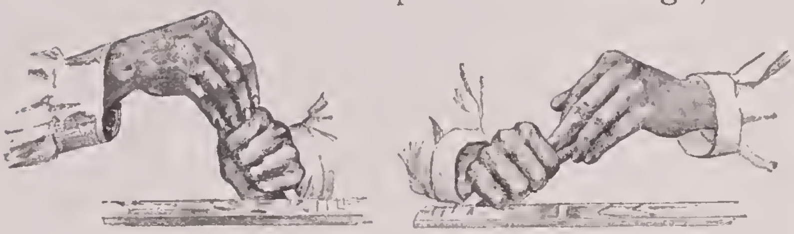


Fig. 5

To shape the outer edge, select a chisel that is nearly flat, and bevel the wood to the line previously drawn. If there are crockets on the scroll, be careful not to chip them away by accident. Let one hand push the tool forward while the other checks it, and the wrist, resting on the wood, serves as a center support. If by accident you chip off one of the small projections, let it go for the time being. In first attempts, the thing most desired is familiarity with the use of the tools.

When all the curves of the design have been neatly rounded, and no more work remains to be done on the raised surface, a finish may be given to the background by chipping it, allowing the chisel marks to show, but making the surface fairly even throughout. Another way to finish the background is by "stamping." A large nail the end of which

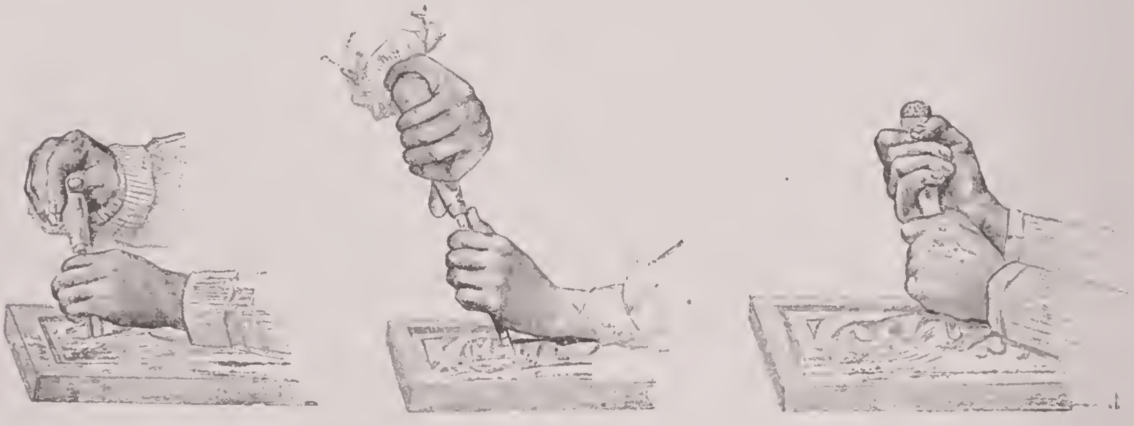


Fig. 6

has been filed to the shape of a diamond, a circle, or a square, may be used for this work. Hold the nail in a vertical position and tap the head with the mallet, going over the entire background and taking care not to make the indentations too deep. This will produce a pleasing effect, like that obtained in painting by stippling with the brush.

When the first panel has been completed, it may, after all, be a disappointment. Probably it will be, and it is desirable that the carver should see where his work might have been made better. But the parent or teacher should give encouragement, not by insincere praise of the work itself, if it is crude and rough, but by expressing interest and urging the learner to press forward. Every beginner needs this encouragement. It is most depressing to plod along without having some notice taken of honest effort. When it is practicable for him to do so, the pupil should go and watch a practical wood-carver at work, noting how easily the wood yields to his skilful strokes, and how rapidly the work assumes beautiful form. What he does, anyone can do who has had the necessary experience.

Wood sometimes seems to the young carver to be possessed of "evil spirits." It is tough, and the grain seems to play fantastic tricks with the tool, now leading it to make too deep a cut and again refusing to yield the proper curve. Patience paves the way to skill. The carver may require several hours for shaping his first scroll; when he has acquired more skill, the same amount of work can be done in a fraction of the time.

It is necessary, in carving a scroll, to change the direction of the tool several times, in order to humor the grain of the wood. Sometimes the wood will develop a "soft" place, the tool will slip and the lines of the design will appear ragged. But it is not well to throw the panel aside as soon as an error has been made. The first panel should be completed as if it would be perfect when done, and greater care used in carving the remaining portion. This gives the needed training, and the second panel is more likely to be free from errors.

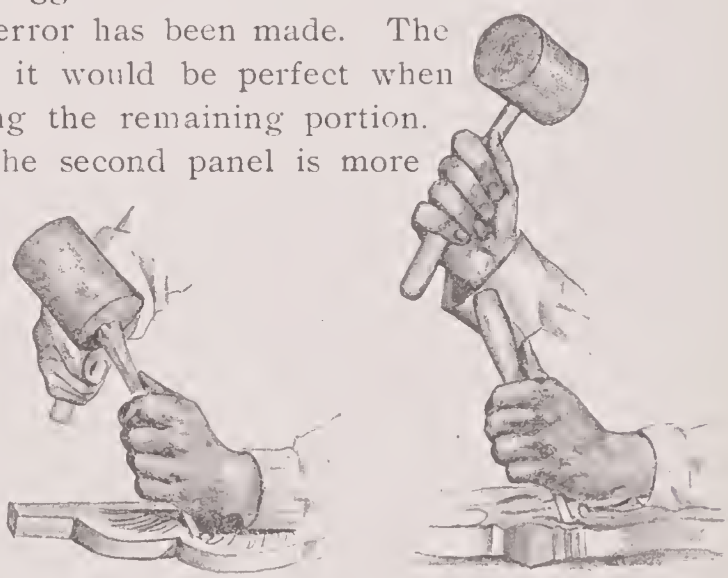


Fig. 7

Whoever has it in charge to see that the young carver is encouraged in his work, should insist on his following a definite line of progress. The simple panels will not long satisfy the learner. After the first few attempts, he will be anxious to take up a more ambitious piece of work — a large mirror-frame, for example, or a chair. This will not do. Only when he attains real skill, and fully understands the peculiarities of wood, will it be possible for him to do such work well. It should be the rule to begin with the first simple panel and progress gradually through a series of forms, each a little more difficult to execute than the one preceding.

ELEMENTARY WORK

Scrolls, and conventionalized forms of nature, are largely employed in designs for wood-carving. Elementary work in carving is largely based upon the use of these forms, which may be very simple at first and then more complex and full of detail, as the carver improves.

For the first lesson, take a panel on which a spiral is to be carved. Draw the design, first in chalk and then in pencil. Gouge out a groove around the outline and then roughly cut out the background, according to the instructions already given. Now comes the second stage, when the edge of the design is carefully chiseled and lines are drawn to serve as a guide in shaping the curves. In the third stage, we have the gouging out of the inner side of the spiral and the beveling of the outer side. Figure 10 shows the completed work with the edges carefully finished, and the background stamped to an even surface. A glance at the completed form shows its value in training the hand to make free, sweeping curves with the tool. It is necessary to acquire facility in this before it is possible to make substantial progress in carving.

Fig. 8

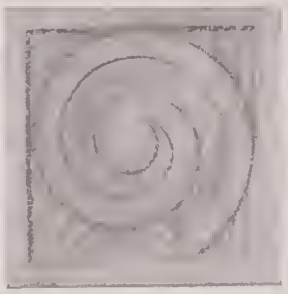


Fig. 9

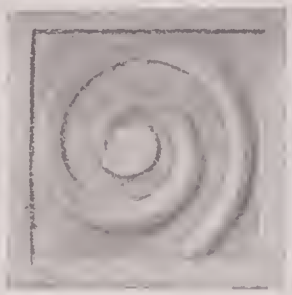


Fig. 10

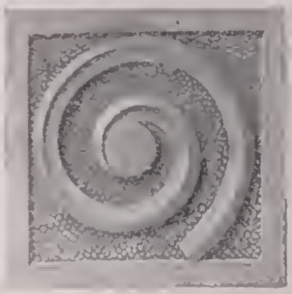


Fig. 11

Fig. 12

For the second lesson, the carver may undertake a panel presenting the same spiral, embellished with crockets. This is a much more difficult piece of work. The tool cannot sweep so freely around the curves, owing to the interruption of the crockets. Unless care is taken, the tool will gouge into the crockets and spoil their form. If one of the crockets is thus

Fig. 13

injured, do not attempt to better it, but be more careful in carving the others.

The third lesson may be upon a leaf panel. If the pupil has already modeled a leaf in clay, he will find the carving easier than it would be otherwise, because his sense of form will have been developed directly along this line. The steps in this work are the same as in the preceding. When the background has been removed and the outline chiseled, the surface of the leaf may be partially modeled; then, with gouges of suitable curve, the rounded surfaces should be formed, and finally the ribs of the leaf neatly outlined with the parting tool.


Fig. 14

The fleur-de-lis offers a good subject for the fourth lesson. This is not so easy as it looks, for the rounding of the surface must be done with great care, and to make the curves of the lobes uniform will test the carver's skill. For finishing the lobes, use a chisel with a very slight curve. It is always desirable, especially in this work, to have the tools sharp.

After the pupil has become skilful in carving the simple leaf forms he is ready to undertake a rosette. A glance at almost any piece of carved work will show to how great an extent various styles of rosettes are used. The rosette affords a good starting point for almost any piece of work, and is frequently used to ornament corners, to break a long border in the center, or at intervals, and in many other ways. The first figure shows the preliminary work. A circle is drawn with the compasses to show where the circumference of the rosette will be, and at the center a smaller circle to indicate the space reserved for the boss. A groove is cut inside the large circle and the edge of the boss is cut off sharply. Between the two, the wood is then scooped out with a gouge, so as to present a concave surface. The gouge must not plunge too deep, or there will not be sufficient wood for carving the design. This is now drawn, first with chalk and then with pencil. A leaf form, repeated four, six, or eight times, with stems centering at the boss, gives a pleasing effect. It must be remembered that all parts of the rosette will be lower than the wood surrounding it, and so the chisel must not go too deep when you begin to carve.

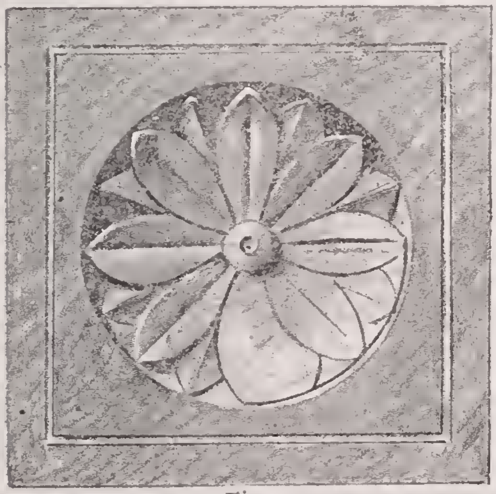


Fig. 15

Select a chisel of suitable curve and cut down the edges of the leaves. Use the parting tool to cut out the ribs at the center of each leaf. The finishing work will present some new difficulties, because of the hollowing surface, and the wood should be taken out in thin shavings. The boss may be rounded, like a ball, or hollowed out, or beveled from the center.

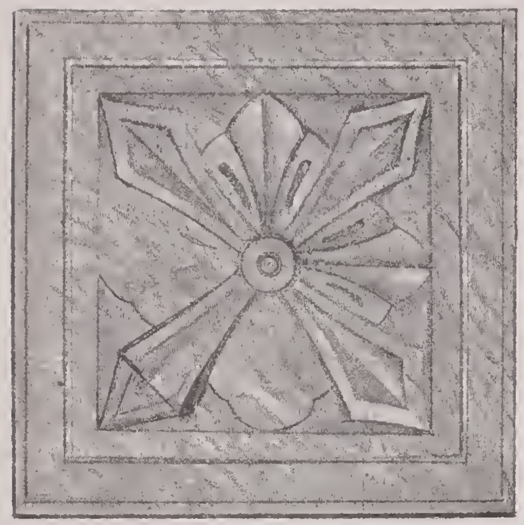


Fig. 16

Square rosettes are often employed. In making these, the diagonals may be drawn with a ruler and the spaces marked off with the compasses. The design is then completed by free-hand drawing. First cut out the background; then form the edges of the leaves. Cut out the inner parts of the leaves and make the background deeper. In finishing, use a nearly flat chisel to form the outer surface of the leaves, and a gouge of proper curve to shape the inner portions.

Conventionalized shell forms are good subjects for carving. These may be made according to the methods already described for rosettes, or they may be fluted. Fluted work is very beautiful. It calls for clean, even chiseling. A fluted rosette is shown in the illustration. The wood should be scooped out and the design be drawn as already indicated. The parting tool is then used to model the rays, and the

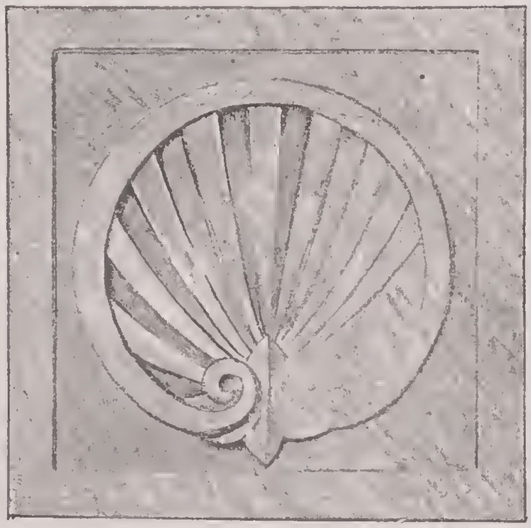


Fig 17

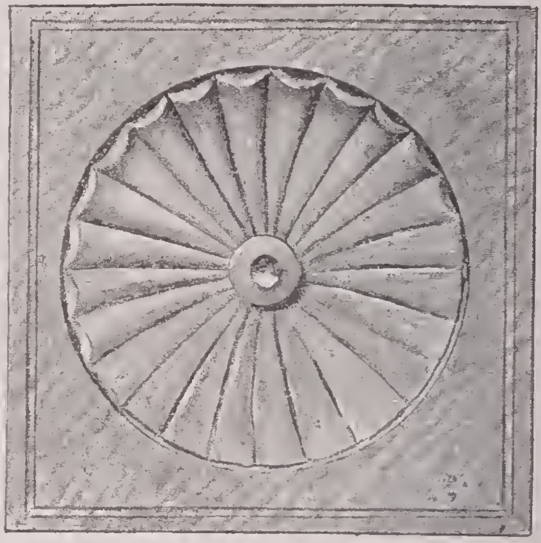


Fig. 18

edges are rounded with a curved chisel. The parting tool is used in the same way in modeling the concave shell forms, an example of which is illustrated in Figure 18.

Thus far, work has been done upon flat surfaces only. As the pupil grows more skilful, he will be prepared to take up carving in relief and to work on curved surfaces, which is much more difficult than making simple panels like those already described.

The making of ornaments for furniture demands skill in advanced work of this kind. Look at any common bookcase and you will see that it has at least some pretense of ornamentation by carved work, even if the latter is no more than a simple border. Much of the "carved" work on cheap furniture is now produced with the aid of machinery, but the original carving must have been first executed by hand. The machine can follow, but it cannot create.

On a strip of wood suitable for a border, mark off a series of equal spaces, some a quarter of an inch in width, some half an inch. Do this with the compasses, so as to secure accuracy. With a flat chisel, make an incision in the wood at each of the points marked by the compasses. This will indicate the division-point between the beads. Flat chisels of various sizes may now be used to shape the beads into balls, or rounded points. The beauty of the bead-work will depend upon the regularity of the beads in size and shape. If one is cut too small, it may be left until the strip has been completed. Then cut it out altogether and glue in its place a piece of wood which, when dry, may be modeled to conform to the other beads. It is often necessary to repair carved work in this manner, and the repairing can be done so neatly that the patchwork will not be noticed. The young carver should learn to do this, and by correcting his mistakes in this way, he will save himself from the discouragement that would otherwise come from the failure of his work as a whole. Beadwork of this kind is good practice, for it teaches accuracy; and as beadwork is employed more or less on all carved work, from picture-frames to chairs and tables, it should be mastered at an early stage.

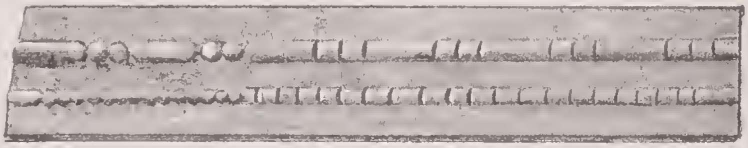


Fig. 19

Fig. 20

A more ornate form of border is the egg-dart molding, which is shown in Figure 20. This is a common molding and therefore a good one for practice. When we have learned the forms of common things which are all about us, yet are never or rarely noticed, we are better able to see and to carry away impressions of new forms.

Strips of wood which have been shaped into plain moldings by machinery may be had from dealers in mill-work, and these should be purchased. It is a waste of time for the beginner to take a squared stick and groove it by hand throughout its length. The same amount of practice may be had in design work and there is little compensation for the time lost. Moreover, it is very difficult, even for a good workman, to groove a long stick as accurately and as neatly as it can be done by a machine.

With the molding in hand, the first work is to space the stick with the compasses, and then to draw the outline of the design with a soft pencil. With a parting tool form the edge of the eggs and the darts, as shown in the illustration. Now cut out the background with a sharp gouge and curve the darts. The cutting should not be done to the full depth until the form has been brought out. Then the background may be sunk to the proper depth and the finishing work be done, with great care to have the darts look alike and the eggs rounded so evenly that none will look too wide or too narrow as compared with its neighbor. Work of this character, where the same form is repeated several times in succession on the same piece of wood, is excellent training for the eye as well as for the hand, and is very effective in imparting a correct sense of form. Instead of carrying the first form through from beginning to completion before attacking the second, it is better to do the preliminary work on all before undertaking to finish a part. This will insure greater uniformity.

Fig. 21

Do not limit the work to one form of molding, but work on several forms. In one, introduce a series of interlocking curves, like that shown in Figure 21. This work will bring into use the practice obtained in making the first scrolled panel. A more difficult form is a leaf molding, in which the top of the leaf is curved forward. After drawing the design on the wood with a soft lead pencil, form the outline in a shallow groove, with a curved chisel. With the parting tool form the rib in the center of the leaf. Then hollow out the wood between the two leaves from a line midway between them, which also represents the rib of the leaf partially concealed behind the two. Curved chisels and gouges may now be used to give the leaf the necessary depressions. To carve the projecting tops of the leaf is not an easy matter. Have a care that the projection be not broken off altogether. But if such an accident should happen, a new piece may be glued on, as already suggested. Gouges of different shapes may be used to hollow out the under part of the leaf-top and for forming the upper surface. The edge may be shaped with a curved

Fig. 22

chisel. To make these projecting tops uniform will seriously test the skill of the carver at first, but after practice the work is not formidable. The chief difficulty in mastering this part of the work arises from the fact that the eye cannot take in the outlines of all the leaf-tops while work is being done on one of them. They must, therefore, be frequently compared while the work is in progress.

By the time the pupil has thoroughly mastered the carving of the work already suggested, so that he can carve boldly, skilfully, and accurately, he has learned to control his tools and knows all there is to know of carving, except that delicacy of touch and sense of form which come from long experience. But so far as knowing how to attack the work is concerned, he is ready to undertake more elaborate pieces. Before he puts his gouge to the wood, however, he will do well to model his work in clay. With the knowledge of modeling, previously acquired, and his recent experience in carving, fresh in mind, he will be able to do this quickly and well. Original design is desirable, but this should be guided by correct taste. There are both good and bad forms in carving, and so far as the carver has opportunity, he should study the approved work of experts. In architectural iron and marble work, and in furniture, there are beautiful designs which he may study before making his clay model. If he has no regular instructor, this will be an essential part of his training. Even in the smallest and poorest towns there are always some designs worth studying. In cities they are found on every hand, in the stone, wood, and metal work of fine buildings, in museums, libraries, courthouses, churches, and in federal buildings. Go to a store that carries a stock of the best furniture and study the carving of tables, chairs, and cabinets. Some pieces will be very elaborately carved; on others, the carving will be quite simple, yet withal very beautiful. When the young carver examines these objects, he will see that they were modeled by men who used the same sort of tools that he uses, and made the same strokes that he has learned to make. The superiority of their work comes partly from their greater dexterity and skill, but more from the greater development of their sense of form and their appreciation of art — the ability to distinguish between good form and bad form. All these beautiful forms the young carver may reproduce, giving them a touch of his individuality, if he will put thought, care, patience, and self-discipline, into his work.

A picture-frame offers a good subject for advanced work. Before designing this it is a good plan to select the picture for which the frame, when completed, will be used, and have in mind the effect that will be produced by the framed picture. If it is a small water-color in which neutral tints predominate, the frame may be a simple border. If it is much larger, an oil painting, or an etching rich in strong contrasts, a much heavier frame will be suitable, and it may be more richly carved. The frame for a mirror may be made of heavy wood and it will bear an elaborate design. The beauty of such a frame, carved from a solid piece of wood, and its superiority over a frame made of mitered molding nailed together, is apparent to any eye, and such a piece of work, skilfully executed, will afford great satisfaction to the worker.

Fig. 23

Blanks for chairs—backs, seats, arms, and legs—may be purchased, and on these careful work may be done. In work of this kind, simplicity of design is most effective, for the beauty of the finished object will be seen not so much in a multiplicity of details as in graceful curves, delicate modifications of leaf and shell forms, and the like. The first pieces attempted should not be too ambitious or difficult, but they should be within the scope of the carver's capabilities.

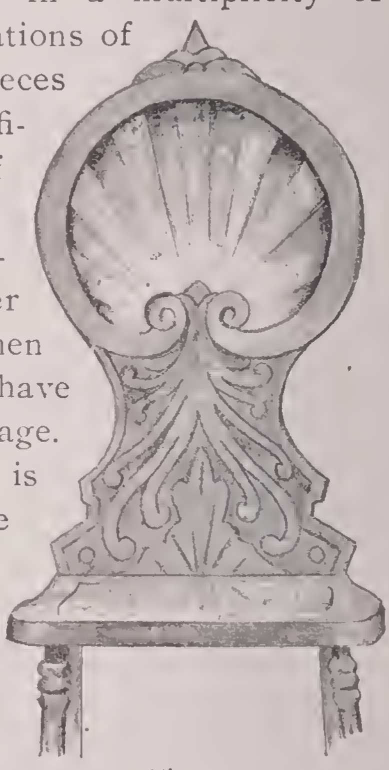


Fig. 24

While wood-carving, as outlined in this chapter, is intended to serve an educational rather than a utilitarian purpose, bear in mind that when the carver has made sufficient progress he will have no difficulty in selling his work to good advantage. Where the original outlay for tools and blanks is a tax upon the purse, this feature is not to be despised, although it should always be held secondary to the real purpose of education. There is, too, a substantial satisfaction to the carver in the thought that he is producing work that will undergo the candid test of commerce—that is, that people are willing to pay money for it. Clock-cases, frames for mirrors and pictures, cabinets, book-racks, chests for linen or silver, chairs, tables, and many other articles, may be carved and sold at good prices. The demand among all classes of people for more artistic surroundings has increased phenomenally in the past few years, and there is an individuality about carved work that makes it especially attractive.

By diligent application in this field, the student who must count his coins carefully, and husband the pennies, may earn the means to pursue his studies further and so work his way through, as we say of self-supporting college men.

But there is another use which the wood-carver may make of his products, a use which is more important than the financial consideration. He may decorate his home. He will naturally begin with his own room, and little by little extend his decorations to the hall, the parlor, and throughout the house. This will enable him to live, as it were, in an atmosphere of art. His parents will have just pride in him. The visitors will share in the pleasure of his artistic work. The home will be *his* home in a more profound sense. His thought, his labor, his skill, will be visible on every side, and every member of the family will feel the subtle influence of the consecration of art.

Even more valuable than this should be the influence of the work on the character of the worker. He sees some beautiful form in nature, adopts it as his own, and then sets out to reproduce it in the terms of his art. With loving patience, with manly earnestness, he brings all his skill to bear on this task. It is the creature of his affection and devotion. Slowly it grows toward perfection and embodies the beauty that was imaged in his own heart. When it is complete it is a joy to the worker. Its beauty is a part of his reward. This work, when done in the right spirit, cannot fail to have a deep reciprocal influence on his own character. Far more than the artist guessed, he was, while carving those outward forms, adding the beauty of spiritual grace, and the strength of enduring manliness, to his own character.

The value of wood-carving is thus seen to have a wide reach. Its influence is visible in the culture of skill in the hand, in the drill of certain intellectual qualities, in the encouragement of esthetic taste, in the indirect but powerful influence on character, and finally in the wide diffusion of pleasure. Such work is more than mere pastime: it is education of the best type.

TOY FISHING BOAT

WHAT healthy boy does not love to fish? And what boy who goes a-fishing has not been tantalized often by the knowledge that the best fish are beyond the reach of his hook and line? Here is a trick by which he may get some of them, even though unprovided with a boat himself. It is easy, and there is plenty of fun in it.

Take a piece of plank from two to three feet long, and from half an inch to an inch thick. With knife or saw, fashion one end into a bow. As it is only a toy fishing boat and not a toy sailing boat, it is not necessary to take much pains with it. Stick a couple of masts in the boat and to each attach a square sail made of paper or cloth. The boat can be depended on to run only before the wind,—but that will suffice for such fishing as is to be done. To aid in keeping the boat to a straight course, a long rudder should be used—a strip of tin made from a discarded tomato can, flattened out and stuck in the stern, will answer the purpose excellently—and yards should be attached to the mast so that the sails may be kept trimmed square to the wind. Into the stern drive a couple of nails, and to these the fish lines should be fastened, rigged with spawn or live bait, as best suits the judgment of the fisherman.

When all is ready, the toy fishing boat is set adrift from the bank of a pond, or lake, or creek, where it will have a clear course before the wind to the opposite bank. It has one decided advantage over the real boat from which fishing is done. Being so much smaller its passage over the water does not scare the fish. But it is open to the disadvantage that if a big fish bites, he catches the boat, instead of the boat catching the fish, and tows it off. Even then, however, a spry lad will manage to keep his boat in sight and in the end is pretty sure to recover both boat and fish.

AN INVALID TABLE

There is no household entirely free from illness. Whenever the sufferer is compelled to take meals in bed, the invalid table, or bed table, is very serviceable. It is easy, at a trifling cost, to make one that will serve the purpose as well as those advertised in the magazines, costing several dollars. The boy who makes one for father, or mother, or sister, will get just as much pleasure out of it as he does out of the sled or rabbit-hutch that he makes for himself.

This invalid table is practically a tray provided with side supports which admit of placing it across the bed, in front of the patient, who may thus eat a meal from it without the inconvenience that comes from having to support a tray on his lap, or from twisting around to reach a table placed by the bedside. The dimensions should conform to the width and height of the bed. Any wood can be used, but if something pretty and, at the same time, substantial, is desired, black walnut will answer best.

SLED

THE first snow never fails to excite in the healthy boy a desire for coasting. A sled is necessary for his peace of mind, and, incidentally, for that of the family.

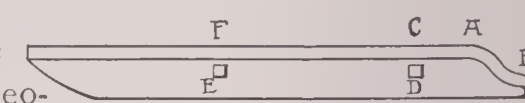


Fig. 1

The bob-sled, or double runner, is the best kind of sled, for it carries more people and goes further than any other kind.

To make a bob-sled, get 12 feet of $\frac{1}{2}$-inch pine, $3\frac{1}{2}$ inches wide. On your plank mark off four parts of 3 feet each. Cut out of a piece of brown paper a design like Figure 1. Using this as a pattern, trace round it on your pieces of wood and cut out with a draw-knife, making from A to B, 4 inches, and from C to A, 3 inches. D is a hole an inch square, made with a chisel. The top of D is $\frac{1}{2}$ an inch from F A. E is another inch-square hole 15 inches from D and likewise $\frac{1}{2}$ inch from F A. E and D are holes made to receive the cross-bars of the sled. Now cut out your other pieces of wood after the same manner.

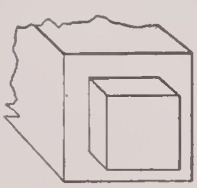


Fig. 2

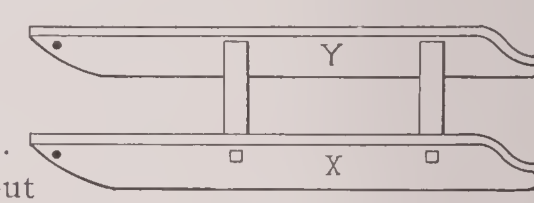


Fig. 3

Next obtain some oak — four pieces, 11 inches long and $1\frac{1}{2}$ inches square. Mark off $\frac{1}{2}$ inch from each end, cut out the ends as in Figure 2, making the shaded portion 1 inch square, so that they will fit into the holes E and D in Figure 1, as in Figure 3. The ends should fit tightly in the holes, as it would not be strong unless they did. Then drive a good wire nail through each to keep them in place.

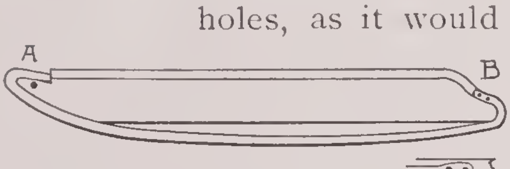


Fig. 4

Now get four common iron hoops; get a blacksmith to cut them in two pieces and shape them so that they will fit tight at the ends of X and Y, and leave a little space between the iron runner and the wood, to act as a spring. (See Fig. 4.) Screw the ends A and B of the iron runner to the wood, but do not put any more screws in it or it will not be springy.

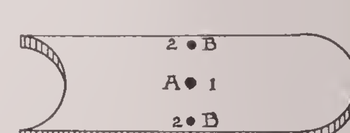


Fig. 5

Then you will need some more wood: A piece of elm, 4 feet long and 10 inches wide and $\frac{1}{2}$ inch thick. Cut this in two to make the top boards of the sleds. Cut them out to this design. Now screw them on the cross-bars of your runner. Next make a hole in the middle of your first seat, and two about $1\frac{1}{2}$ inches from the edges of the boards and at the middle, as in Figure 5. You will now have two strong sleds. (See Fig. 6.)

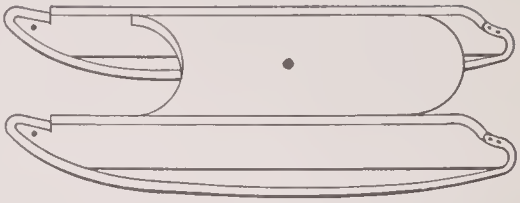


Fig. 6

Now you will want 9 feet of 1-inch planking 10 inches wide, and two blocks 12 inches by 7 inches by 4 inches. The blocks had better be made of pitch-pine. Bore a hole in the center line about 10 inches from the end, and bore two holes about 10 inches from the other end, and each about $1\frac{1}{2}$ inches from each side, as in Figure 7.

Fig. 7

Bore a hole through the center of your first block, lengthwise, to correspond with the hole A, Figure 7. Then bore two holes in the second block, lengthwise, to correspond with the holes B and C in your plank. Next, you will want three bolts 14 inches long to go through the 1-inch plank and then through the 12 inches of the block and then through the $\frac{1}{2}$-inch board of the sled, as in Figure 8. Screw a nut on each of the bolts under the sleds, and your double runner will be complete.

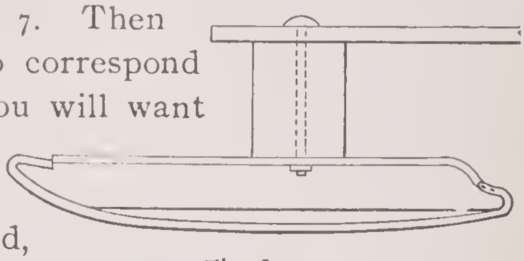


Fig. 8

SAILING PUNT

BEFORE a boy is intrusted with the management of a sailboat, he should learn to swim. Learning to swim is not hard for a boy who has a good chance, nor is it hard to master the art of sailing a boat. But how to get a sailboat of his own presents usually a much more difficult problem. It generally involves the expenditure of more moncy than the average boy ever has at his disposal. But there is another solution of the problem for the boy who has learned to use his tools: it is to make a boat. I propose here to tell him how he can make a small sailing punt that will be both seaworthy and speedy. It is assumed, of course, that he knows something about boats to begin with. Otherwise he would better get some nautical friend to make things a bit clearer than can easily be done on paper.

To begin with, obtain four good, sound boards of yellow pine, 11 inches wide and $\frac{5}{8}$ of an inch thick, planed down to $\frac{1}{2}$ inch; some $\frac{3}{4}$-inch stuff for cutting up; and a piece of hard wood, say oak, about 3 feet by 3 inches by 2 inches, for stem and stern posts. Then proceed to cut up as follows: Cut two of the boards into sides (Fig. 1); make two pieces to form a well amidships to carry canvas decks fore and aft. (Fig. 2.) The stem and stern posts will follow, 12 inches by 2 inches, made in the form of an angle (as shown in section in Fig. 4), with a groove into which the sides fit nicely. (Figs. 3 and 4.)

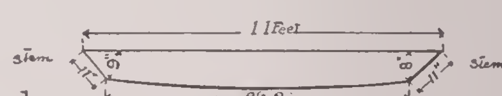


Fig. 1

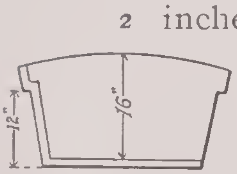


Fig. 2

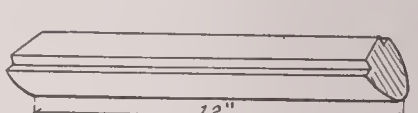


Fig. 3

Fasten the sides with brass screws to the stem and stern-posts, binding them carefully over the two well-pieces or bulkheads, and it will assume the form indicated.

Fig. 4

Out of the two remaining boards a bottom must be cut and fitted. To make this wide enough, two small lengths of hard wood are fastened at A, A, A, A, (Fig. 6), which will also act as a defense when being hauled over the stones. To make the bottom firm, some crosspieces, B, will be needful inside. These must be fitted in after screwing on the sides.

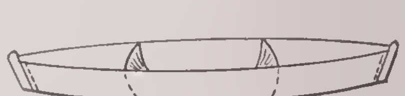


Fig. 5

The keel consists of a straight piece, 6 inches by 9 feet $3\frac{1}{2}$ inches, shaped to fit the bottom, and rounded at the stem and left sharp at the stern. It may be fastened to the boat with galvanized 3-inch screws and washers, easily procurable. Four galvanized holdfasts must be also fitted into keel and bottom. All the joints and seams should be made water-tight by a layer of brown paper smeared with white lead, placed between the junctures. Two side-pieces to raise the bulwarks will be needed, $5\frac{3}{4}$ inches by $3\frac{1}{2}$ inches, and rounded as shown in Figure 10. Two pieces will also be required, one 6 inches by 23 inches, for the mast-hole forward, and one $22\frac{1}{2}$ inches by $1\frac{1}{2}$ inches for supporting back rest of seat aft. The seat is a board $22\frac{1}{4}$ inches by 11 inches, raised 1 inch from the bottom, and $1\frac{1}{2}$ inches away from the aft bulkhead. The back rest of the seat is of two pieces, 18 inches long, and two pieces, one 10 inches at the top, and one 8 inches at the foot. This is let into the seat board and made to lift out.

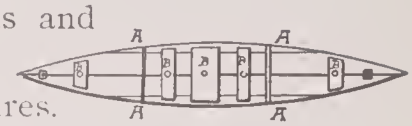


Fig. 6

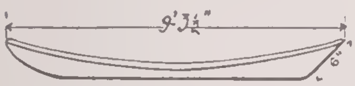


Fig. 7

A good thick piece of rope painted white is put round all, as in Figure 10, and passed through a hole in the sternpost, hauled tight, and spliced at the bow as ornament and defense. The rudder should have the yoke lines carried through eyes (Fig. 10), and fastened with a figure-8 knot to prevent them from slipping. A thick leather ring, which should be passed through an eyebolt in the stempost, is needed for the painter and for hauling up. Canvas decks should be provided fore and aft, and nailed with brass brads. Two ropes should be fastened over the coamings of the well. These compartments, of course, should be made water-tight, or filled with virgin cork cuttings. Bladders may be substituted. A door, 1 foot by 6 inches, in that event may be made in the bulkhead, transforming it into a locker. The bladders fastened into pairs, with strings a yard long, may be found useful. If shipwrecked, you will simply draw your sheath-knife (which you will always carry in your belt for all purposes), rip up the canvas and pass the string round the breast and under the arms, and you will swim, even if you can't swim. With such compartments, you will not mind shipping seas.

The paddle is made of a good 6-foot pole, $1\frac{1}{8}$ inches in diameter, shaped so as to be thickest in the center. At each end a slot is made, into which the blades are screwed; the blade having been strengthened (Fig. 8) with a band of iron or brass. Two rubber rings will keep off the dripping of the water.


Fig. 8

A pine mast, planed almost to a point, 6 feet long and $1\frac{1}{4}$ inches in diameter where thickest, will answer well. A child's spade, cut into gaff-jaws and carefully let into a bamboo 39 inches long, and bound with wire, will make an excellent gaff. The boom, also of bamboo, is 6 feet long.

Instead of a gooseneck, a piece of leather strap, whipped to the mast with copper wire and passed through an eyebolt let into the boom, will do admirably.

The mainsail and jib, of calico, must be cut as shown in Figure 9. The mainsheet must run up the mast upon brass rings, and be laced on the gaff. The halyards will pass through the piece with mast-hole (Fig. 10), and fasten to cleats along the bulwarks.

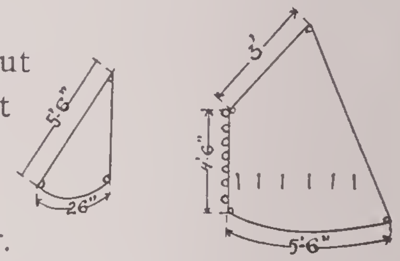


Fig. 9

A galvanized-iron center board, bolted to keel, 3 feet long by 7 inches deep and $\frac{1}{8}$ inch thick, is a necessary help in sailing to windward, and for steadying ballast. Wood, of course, may be used instead of galvanized iron, but it does not steady so well.

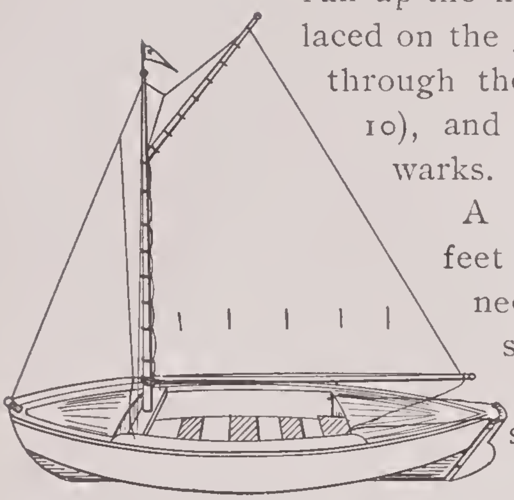
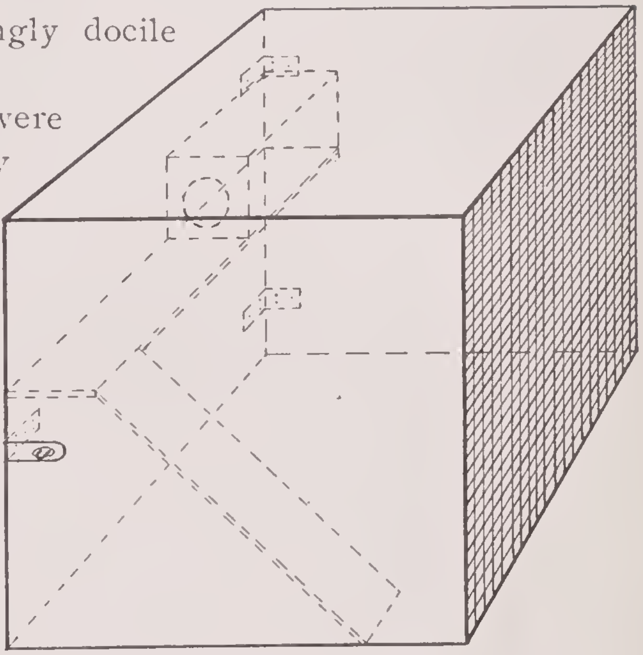


Fig. 10

When all is completed, the boat should be painted French gray outside, the canvas decks white, and the inside of two shades of blue, the bottom and seats being of the darker shade. The final effect and appearance will be an agreeable surprise.

HOUSE FOR PET RATS

There are rats — and rats. To spare the sensitive feelings of the ladies of the family, let it be understood that the rats to which I refer are not of the variety with which the cat wages a war of extermination. They are what are commonly called by animal dealers, "fancy rats." They can be had all white, all black, or mixed black and white. They are much smaller than the ordinary rat, and make exceedingly docile and intelligent pets.



The first pair I got hold of as a boy were very savage for a while, and would bite my finger if I ventured to touch them. That was because the boy from whom I bought them had not fed them properly and had kept them in dirty quarters. Contrary to popular notions, the rat is personally a very cleanly animal. After a week of kind treatment, good feeding, and cleanliness, not a trace of their savagery remained. They were so docile that I could carry them around in my pockets, or concealed in my coat sleeves; and never again did they try to bite me. But it is about the house I built for them, rather than the rats themselves, that I wish to tell.

I obtained, to begin with, an empty tea-chest, about two feet square. A soap box would answer the purpose just as well, and the exact dimensions are immaterial. For one side of the box, I substituted wire netting. The entire opposite side I made into one big door, which greatly facilitated a thorough cleaning of the rat house whenever necessary. Then across the door end of the box, about three-fourths from the bottom, I nailed a strip of wood six inches wide. Upon one end of this I constructed a room about six inches square, with a hole for an entrance opening into it from the platform, or upper floor. This room constituted the private apartment of the rats, where they could conduct their housekeeping, build a nest and rear their young, while screened from the scrutiny of inquisitive boys.

A strip of wood, an inch wide, did service as a stairway leading from the ground floor to the platform. It was a pretty sight when the mother rat followed by half a dozen little snow-white baby rats, tramped down this stairway to get their breakfast or dinner, or to indulge in a romp.

The illustration will make much clearer than my description what the rat house was like. It was very simple and easily made; but it answered its purpose just as well as a more elaborate structure would have done.

PICTURE FRAMES

IN THESE days of cheap publications, good pictures are much less expensive than suitable frames. By following the instructions given below, novel, inexpensive, and artistic picture frames can be made, and the boy who makes them may succeed in satisfying his elders that the time he has spent on his tools has not been wasted. To make the frames, will require only a few simple tools, such as an ordinary saw, with fairly fine teeth, a tenon-saw, a small hammer, brad-awl, screw-driver, pair of scissors, some glue, glue-brush, screws, nails, and glass-paper. Any kind of wood may be employed, but wood that is easily cut, renders the task of the young frame-maker less difficult.

Fig. 1

The next matter to be decided is the size of the frame, which, of course, is governed by that of the picture. Suppose, for instance, that the opening for the picture in Figure 1 is twelve inches long by seven inches high, and the width of the wood three inches. Proceed by selecting pieces of wood near these measurements, then with your ordinary saw cut them into the correct widths, the saw being guided by a black lead-pencil line, which has been marked upon the wood by the aid of a straight-edge or ruler. Now comes the miter, or corners, of the frame, which should be fitted accurately. To do this cut out from some stout cardboard or tin a triangle as A, in Figure 2. Then place it upon the top end of the left-hand piece of frame, carefully mark with pencil where the line C is shown, next cut carefully through with the tenon-saw. Then turn the triangle over to B, which is the top of the frame, proceeding as before. These two corners, being thus treated, and carefully cut, will fit evenly together; the operation, of course, is to be repeated at the three other corners of the frame.

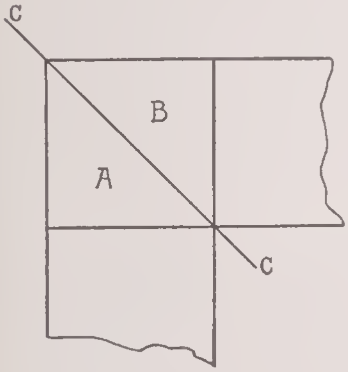


Fig. 2

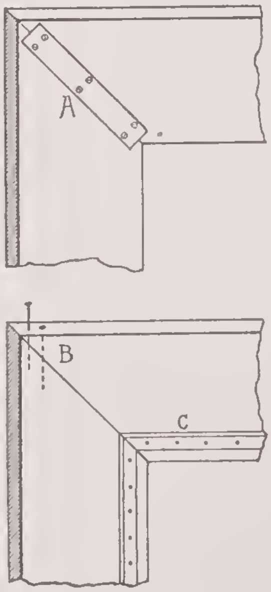


Fig. 3

Figure 3 gives two methods of joining the frame together. First use glue, next bring the two corners of the frame closely together. Then a piece of wood, A, about three-eighths of an inch thick, is screwed on the back of the frame as shown, using short screws that will not go through the frame. The second method is to glue up as before, and then nail the corners together as seen at B; one nail is shown driven home, the second partly in.

All frames, whether for prints, water-colors, or oils, will require a rabbet, or resting-place, for the glass and the picture, which is a piece of wood, shown at C, Figure 3. When used for prints and glass, the rabbet should be about one inch wide, and a half inch thick. For oil-paintings no glass is necessary, but the thickness of the wood should be at least one inch. A quarter of an inch of frame all around will be quite enough for the glass and picture to rest against. In the case of prints and water-colors, a stout cardboard backing will be required to support the picture in its place, and prevent the dust getting in; the whole is now tacked into the rabbet C—the latter itself being held in position by the aid of glue and brads.

Having made the frame, the decoration must be attended to. Figure 1 shows a rope pattern around its inner and outer edge. This is either genuine rope, or very thick and well-marked string. Cut off a sufficient length, next carefully glue around the frame where the rope is to be fixed, then lay down one end of your rope upon the moist glue, driving a pin through it, and so right round the frame, using the pins at the distance of one inch apart.

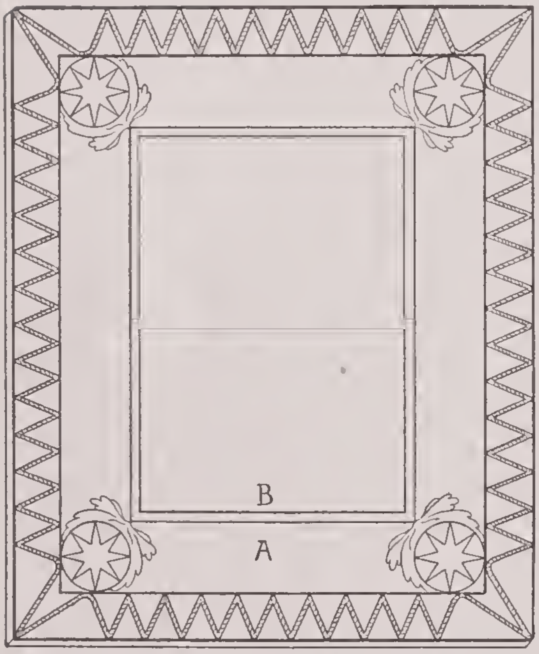


Fig. 4

When the rope patterns are finished, paint the whole frame yellow with distemper color, made by mixing one-third of size to two of water, which must be made hot,—don't boil it; then add some powdered chrome, until the whole is about the thickness of cream. Both the size and color can be purchased from most oil-shops. Use it while warm, and cover well the whole of the front and sides of the frame. When dry, paint over the front of the frame with gold paint, of which there are many excellent varieties. Use a soft brush, and take care to be continually stirring the gold paint when applying it, so as to get an even and equal surface all over the frame. If properly laid on, one coat should be sufficient.

Figure 4 shows another rope-pattern frame, the rope being fixed on by the same method as in Figure 1. First carefully mark the pattern with pencil. A is a very thick cardboard frame fixed down upon the wood frame with stout glue; B is also another frame, but composed of a narrow and thin strip of wood, held in its place with glue and brads. The four corner decorative pieces are cardboard glued upon A. This frame, if painted gold, has a very pretty effect.

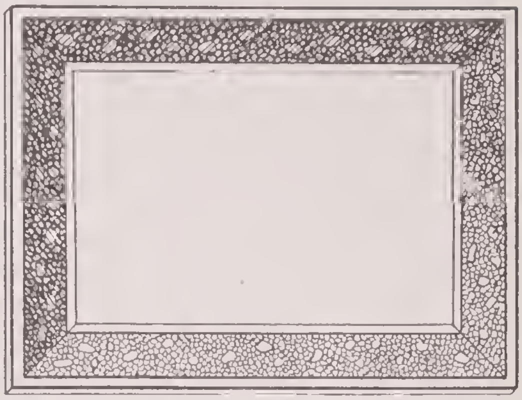


Fig. 5

Figure 5 is a sand frame. The plain wooden frame should be well coated with hot, thin glue, then quickly sprinkle thickly upon it some clean and dry silver sand, gently pressing it down upon the glue. When dry, the surplus sand can be shaken off; and the whole painted with gold paint. This makes a pretty, sparkling gold frame.

In Figure 6 is shown a frame with an outer and inner border quite plain, and made of wood about three-quarters of an inch in thickness, which must be securely fixed upon the frame with plenty of brads. Have ready a quantity of small fancy sea-shells, which must be well cleansed by washing them in several waters; also some small pebbles, sand, and a few dried starfish. Then cut from stout brown paper and thin cardboard various pieces to imitate seaweed; when the borders are fixed upon the frame, they will form a kind of tray nearly one inch in depth. In a basin, mix some plaster of Paris with water — a small quantity at a time, as it very soon sets, and then becomes unmanageable. It should be about as thick as milk. Pour some into the frame, about half an inch in depth, and then quickly, before it hardens, set your shells, pebbles, sand, and starfish upon it, pressing them just far enough down to fix them securely. If the various objects are well and

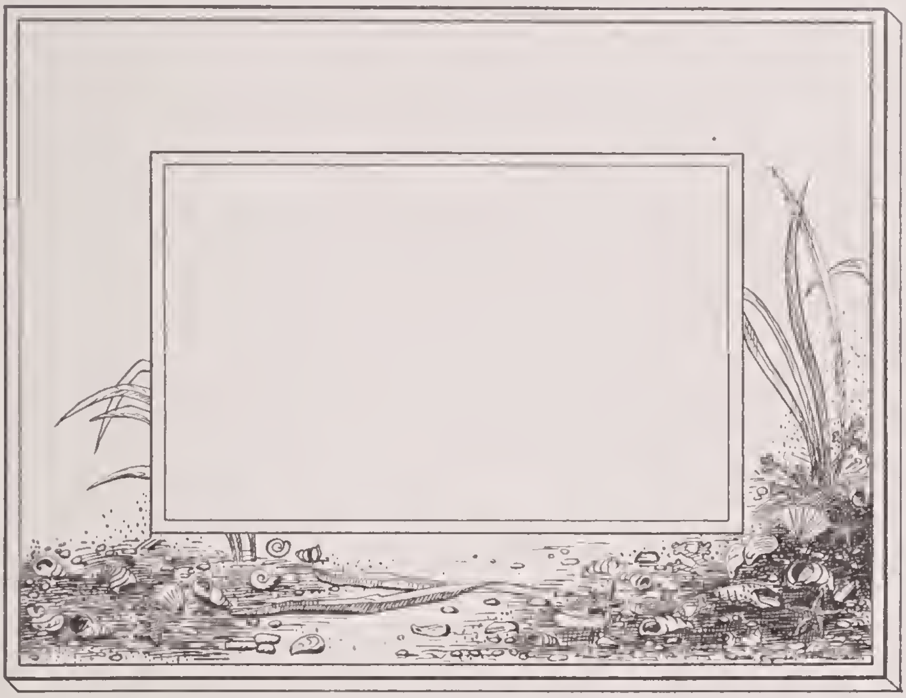


Fig. 6

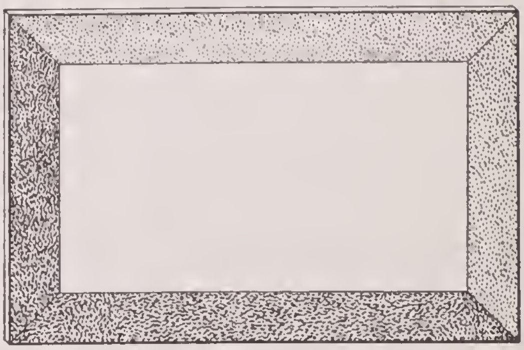


Fig. 7

tastefully arranged, they will form a capital gold frame, especially for marine pictures.

Figure 7 shows a frame to be treated in exactly the same manner as the above. The only difference is that nothing but pebbles of various shapes and sizes are used. This frame in gold has a very neat and pretty effect.

RUDIMENTARY DRAWING, MODELING, AND HANDICRAFT

Children who have acquired the use of compasses, rule, and square, may proceed to model forms and make articles of considerable intricacy, as soon as they have learned to draw correctly the Square, the different Triangles, the Hexagon, Octagon, Rhombus, and Rhomboid.

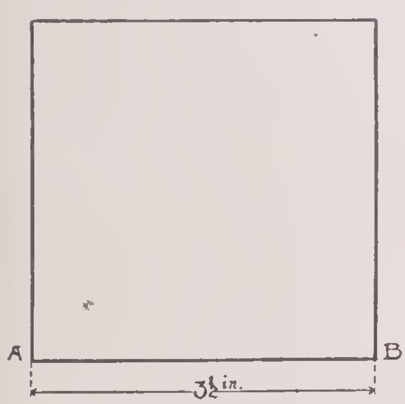
The following examples are intended to furnish them with this preliminary training:—

SQUARE

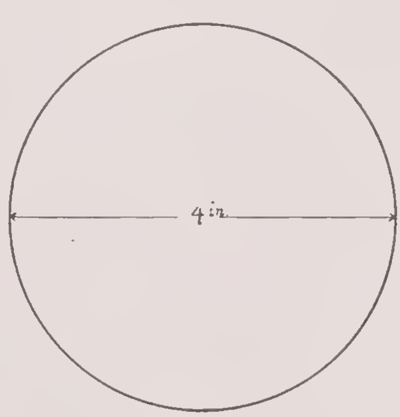
1. Draw a horizontal line 3½ inches long.
2. Erect perpendiculars 3½ inches long at A and B, using triangle.
3. Complete square.

CIRCLE

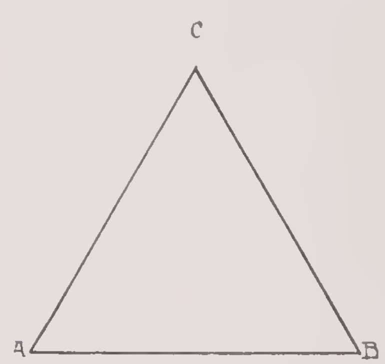
Describe a circle, 2-inch radius.



Square



Circle



Equilateral Triangle

EQUILATERAL TRIANGLE

1. Draw a horizontal line AB, of any length.
2. Take B as center and BA as radius and describe an arc.
3. Take A as center and AB as radius and describe an arc.
4. From the point C, where the two arcs cut one another, draw lines to A and B.

ISOSCELES TRIANGLE

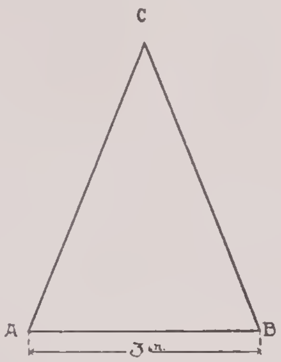
1. Draw the base AB, 3 inches long.
2. With center A and radius 4 inches long, describe an arc.
3. With center B and the same length of radius, describe an arc.
4. From C, the point of intersection of the arcs, draw lines to A and B.

NOTE.—Any length of radius greater than one-half of the line AB may be used.

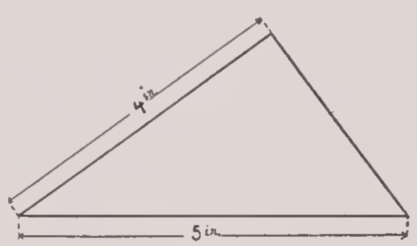
SCALENE TRIANGLE

(A triangle having its sides of unequal length.)

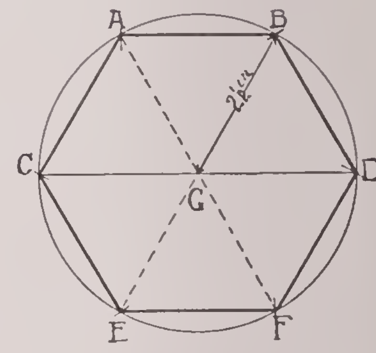
1. Draw a line, 5 inches long.
2. With one of the extremities of this line as center, and radius 4 inches long, describe an arc.
3. With the other extremity of the line as center and radius 3 inches long, describe an arc.
4. From the point where the two arcs intersect, draw straight lines to the points the extremities of the line.



Isosceles Triangle



Scalene Triangle



Hexagon

HEXAGON

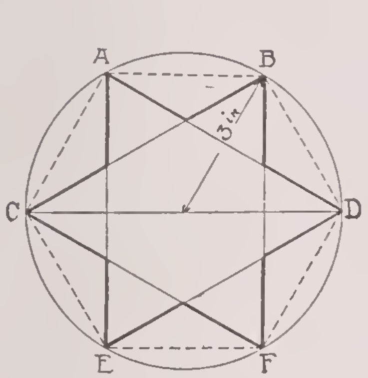
1. Describe a circle, radius 2½ inches.
2. Draw the horizontal diameter CD.
3. With center C and radius equal to that of the circle, describe arcs cutting the circle at the points A and E.
4. With center D and with the same radius, describe arcs cutting the circle at the points B and F.
5. Draw in the lines AB, BD, DF, FE, and EC.

HEXAGONAL STAR

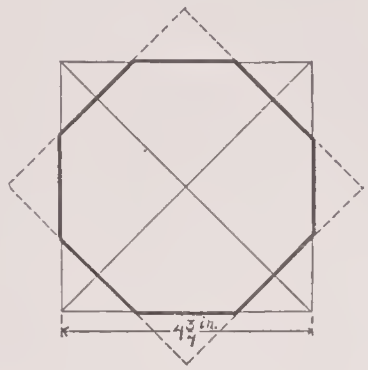
1. Describe a circle, radius 3 inches.
2. In it construct a hexagon as in the preceding exercise.
3. Draw the triangles AED and BCF.

OCTAGON

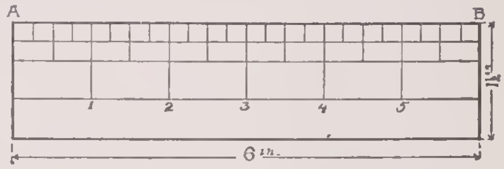
1. Construct a square.
2. Draw the diagonals.
3. Describe arcs, using the corners of the square as centers and a radius equal to one-half the length of the diagonal.
4. Connect the points where the arcs cut the square and thus complete the octagon.



Hexagonal Star



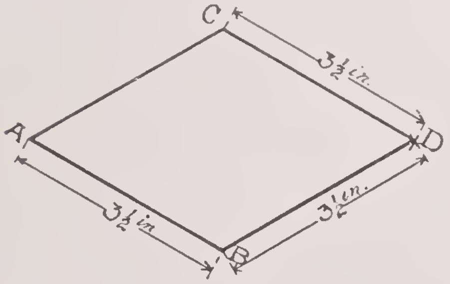
Octagon



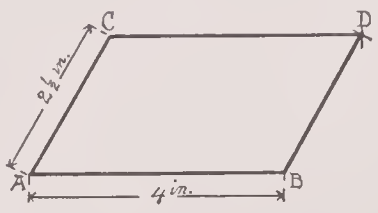
Six-Inch Rule

SIX-INCH RULE

1. Draw a horizontal line AB 6 inches long.
2. Upon it construct a rectangle 1½ inches deep.
3. Along AB mark the inches and half-inches.
4. On AB mark ¼-inch spaces.
5. Draw a line ¼ of an inch from AB, and connect it with the ¼-inch divisions by means of perpendiculars let fall upon it.



Rhombus



Rhomboid

RHOMBUS

1. Draw the base AB.
2. Draw an oblique line AC, length = AB, through A at any convenient angle to AB. (60 degrees.)
3. Take AB as radius, and B and C respectively as centers, and find D.
4. Connect D with B and C.

RHOMBOID

1. Draw the base AB, 4 inches long.

2. Draw AC, of any length greater or less than AB, at any convenient angle to AB. (60 degrees.)

3. With C as center and AB as radius, describe arc.

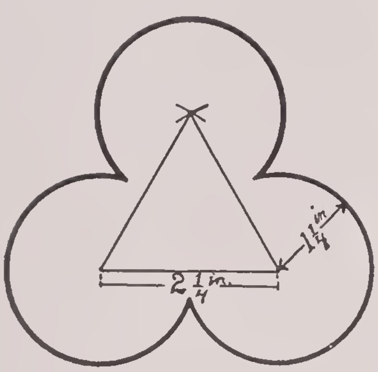
4. With B as center and AC as radius, describe arc, the two intersecting at D.

5. Connect D and C, and D and B.

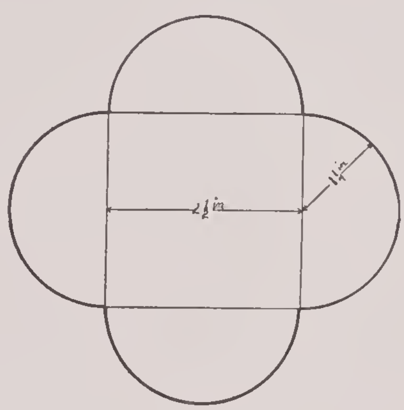
QUATREFOIL

1. Construct square, side 2½ inches.

2. Find center of each side and construct semicircles.



Quatrefoil



Trefoil

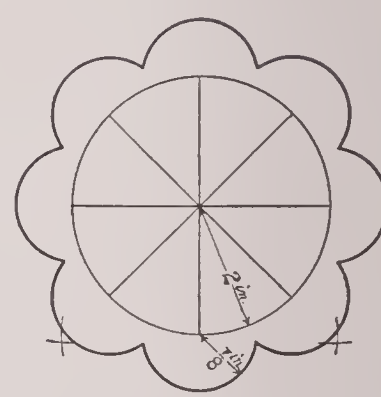


Table Mat

TREFOIL

1. Construct an equilateral triangle, side 2¼ inches.

2. With corners of triangle as centers and 1¼-inch radius, describe the arcs.

TABLE MAT

1. Describe a circle, 2-inch radius.

2. Draw the horizontal and vertical diameters.

3. Bisect quadrants, using the compasses, and draw the diameters.

4. With extremities of diameters as centers, describe the arcs forming the outline of the model.

FOLDING EXERCISE

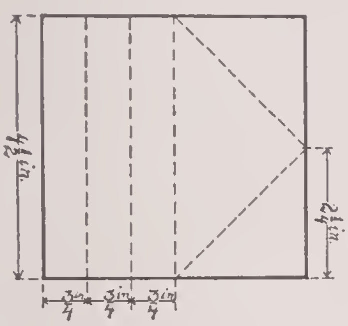
1. Construct square 4½ inches.

2. Draw dotted lines ¾-inch apart.

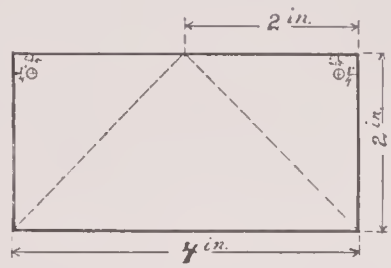
3. Fold on dotted lines.

BOOKMARK

1. Construct the rectangle 4 x 2 inches.
2. Find the center of one of the long sides and connect it with the ends of opposite side.
3. Fold on dotted lines, and tie with twine or ribbon through holes ¼-inch from the edge.



Folding Exercise



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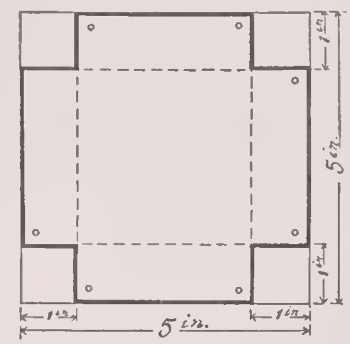
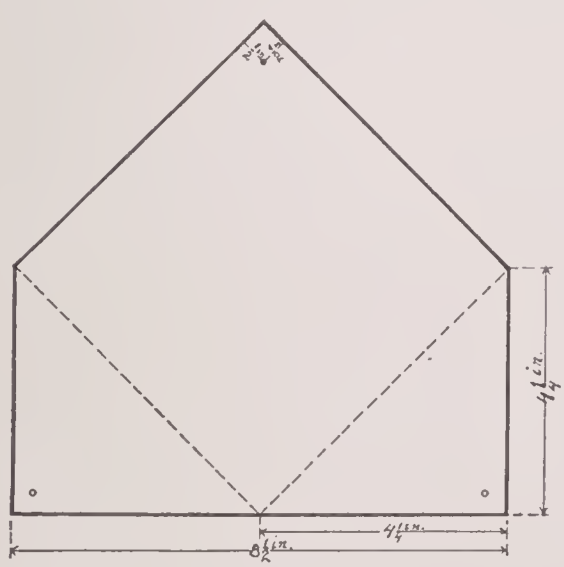


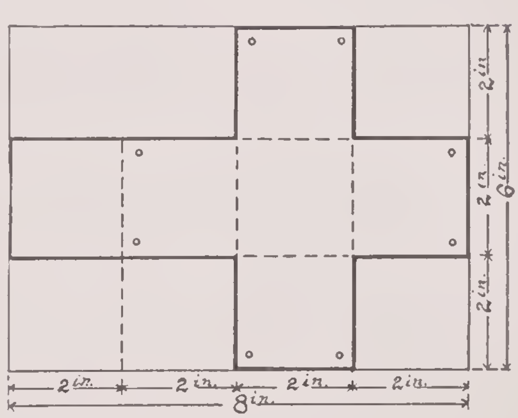
Square Box

SQUARE BOX

1. Construct square 5 inches and draw lines inside square.
2. Cut out the corner squares, fold on dotted lines and tie.



Wall Pocket



Cubical Box

WALL POCKET

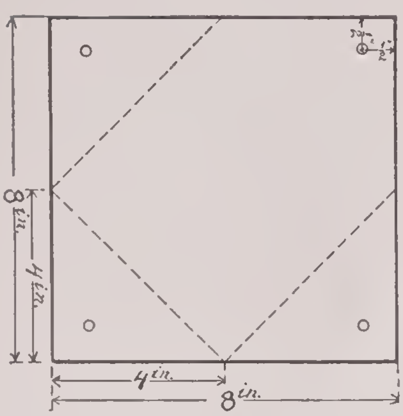
1. Construct square 8½ inches.
2. Find center of sides and connect.
3. Cut away the upper triangles, fold on dotted lines and tie.

CUBICAL BOX

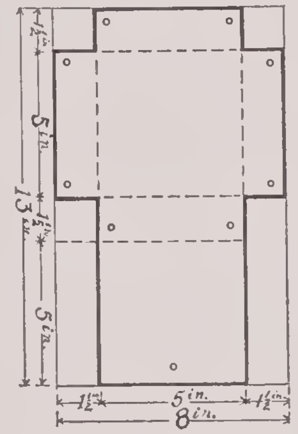
1. Construct rectangle 8 x 6 inches.
2. Divide sides into 2-inch spaces and connect opposite points.
3. Cut away the parts outside of the heavy lines, fold on dotted lines and tie.

CATCH-ALL

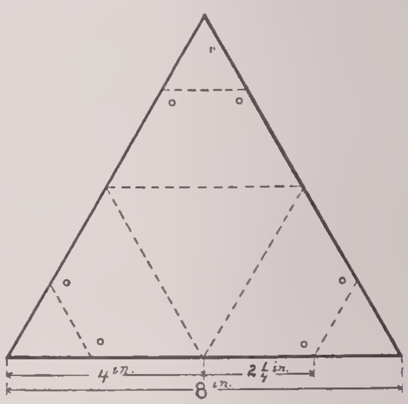
1. Construct square 8 inches.
2. Find centers of sides and connect.
3. Fold on dotted lines and tie.



Catch-All



Handkerchief Box



Candy Box

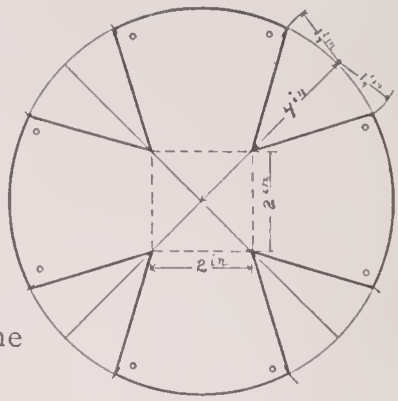
HANDKERCHIEF BOX

1. Construct rectangle 13 x 8 inches.
2. Measure off on long sides 1½ inches, 5 inches, 1½ inch spaces; on short sides measure off 1½ and 5 inch spaces.
3. Connect opposite points.
4. Cut, fold on dotted lines, and tie.

CANDY BOX

1. Construct equilateral triangle, 8-inch base.
2. Connect centers of sides with dotted lines.
3. Draw dotted lines 2¼ inches from and parallel to those just drawn, measuring on the sides. These last lines should be on the other side of the cardboard, therefore they have to be drawn on the cardboard after the 8-inch triangle is cut out.
4. Fold on dotted lines and tie.

BASKET



Basket

1. Construct a 2-inch square, and draw diagonals.
2. With radius 4 inches, and center the intersecting point of the diagonals, describe circle.
3. Extend diagonals to circumference of circle.
4. Measure off 1¼ inches on the circumference on each side of the diagonals, using compasses.
5. Connect these points with corresponding corners of the square.
6. Cut out on black lines, fold on dotted lines, and tie.

MODELING—THE CUBE

Figure I.

The diagram at the head of this paragraph is that of a cube. The sides of it are all alike in length and breadth. You often see objects of this shape — blocks of stone or parts of a building. Each face is a square, having equal sides and equal angles.

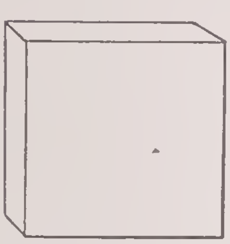


Fig. I

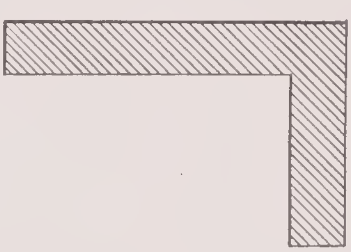


Fig. II

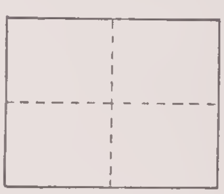


Fig. III

Figure II.

The equal angles of these squares are called right angles, and when a carpenter wishes to draw such angles he uses what is called a "carpenter's square." You may make a carpenter's square of cardboard as follows: Take a sheet of stiff paper, letter size, fold once with even edges; fold it again, evenly across the first fold. When you open it out you will see that there are two straight lines crossing each other from edge to edge. These lines form four right angles. Fold the paper twice again, and on unfolding it you will find a carpenter's square, traced by the folds down one side and across one end of the sheet.

Figure III.

Along the edge of your carpenter's square make a copy of the rule given in your measures of length, metric or English as you desire.

HOW TO MAKE THE MODEL OF A CUBE

Figure IV.

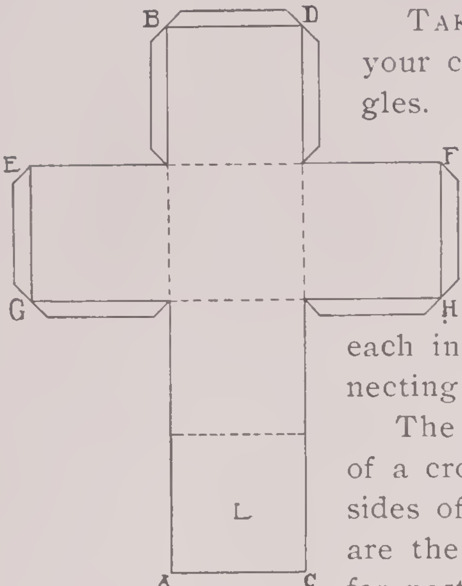


Fig. IV

Take a piece of cardboard, 8½ x 6½ inches. By means of your carpenter's square see that all the angles are right angles. Take a point A, 2¼ inches from the left edge and draw the line AB perpendicular to the bottom of the paper. Do it so as to have the point B 2¼ inches from the left edge. Take a point C 2 inches from A, and draw CD, making D at 2 inches from B. You will find that the lines AB and CD are 8 inches long; divide each into four parts. Draw the lines BD and dotted lines connecting points of division.

The figure now consists of six squares arranged in the form of a cross. Change those parts of BA and DC which form the sides of the central square into dotted lines. The dotted lines are the lines of folding. Lapels must be left (as in Fig. IV.) for pasting the model together. These lapels are to go inside. In cutting out the model you will find it best to lay the cardboard on glass, and cut with a sharp knife. L in our diagram is the last side to be pasted.

Horizontal Surfaces. You may tell whether your polished table is horizontal or not, by placing upon it a ball of ivory or other smooth substance. If the ball stands still, the surface is horizontal or level. The water in a small lake is horizontal when at rest.

Parallel Surfaces. If you place your cube on a level table you will find that the base on which it rests is horizontal, while the top surface is also horizontal. These are called parallel faces or surfaces.

When carpenters want to know whether a floor or table is level or horizontal they test it by a spirit level, *i. e.*, a straight bar of wood, in which is a glass tube, slightly arched and almost filled with alcohol. When this is laid on the floor a bubble appears in the exact center of the tube — if the surface be horizontal.

Vertical Planes. Vertical means from the head down. A vertical line crosses a horizontal line at right angles. A vertical line is that taken by a pendulum at rest or by a cord hanging free with a weight at the end of it. This last is called a plumb line.

When the cube is placed on a horizontal surface, all the vertical lines of its sides will be found parallel with a plumb line, and therefore parallel with one another, and the surfaces of the sides between these lines, which are vertical planes, are also parallel.

A Test of Geometric Equality. Place a cube on a piece of paper and trace the outline of the base with a pencil. Turn it and trace the outline of all the other sides on the same spot. If the cube be true and the tracing accurate, all these tracings will present the appearance of a single square outline.

The Three Dimensions in Geometry. The distance between the upper and the lower sides of a cube is called its thickness, height, or depth. When you look at the face fronting you and consider the distance of that face with the face parallel to it and farther from you, you call it length. When you measure the distance between the right and left lines of the face fronting you, you call it breadth or width. These dimensions are, of course, all equal in a cube.

Figure V.

Areas. Draw on a paper or blackboard a square with sides five inches long; divide each side into parts of one inch. Draw lines parallel with sides, connecting these opposite points of division.

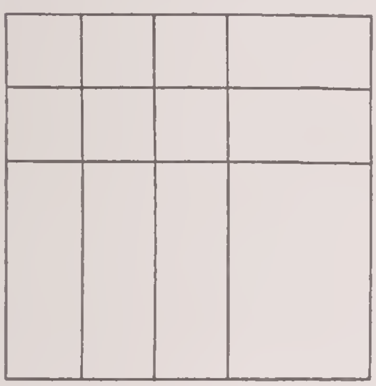
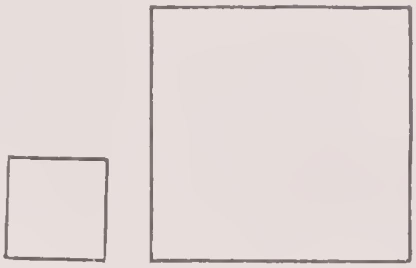


Fig. V



Square centimeter

Square inch

Fig. VI

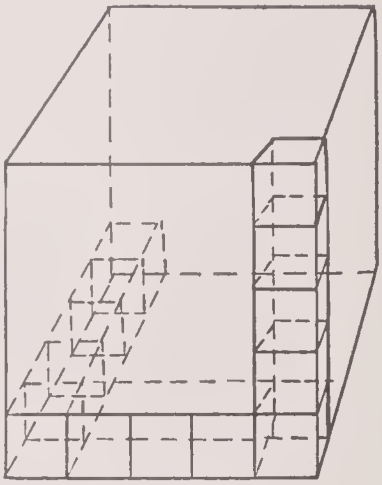


Fig. VII

Figure VI.

Draw a square with sides three inches long, and one with a square of four inches, and divide the sides of each in parts of one inch; connect points of division, as in the previous square.

The squares will present somewhat the appearance of checker-boards, and since each of the smaller squares has four sides, each one inch long, each is a square inch and the larger square containing them is said to contain so many square inches. Figure VI. shows the relative sizes of a square inch and a square centimeter.

Figure VII.

In the same way may be measured the solid contents or volume of a cube. If your cube had each of its edges divided into five equal parts, you could slice it off into five layers; each of these layers could again be cut up into twenty-five little cubes, called cubic inches, so that the large cube would be shown to contain 125 cubic inches, which we call the contents or volume of the cube.

A PARALLELOPIPED

Figure VIII.

(1) The above diagram represents a parallelopiped, *i. e.*, a figure with smooth parallel surfaces. The six surfaces are not equal, and this is the chief difference between this figure and a cube. Four are longer than the other two and each of these four is called in geometry a rectangle. Most buildings have some of their parts built in this form.

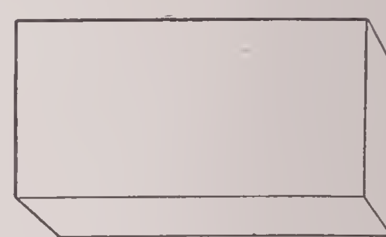


Fig. VIII

Figure IX.

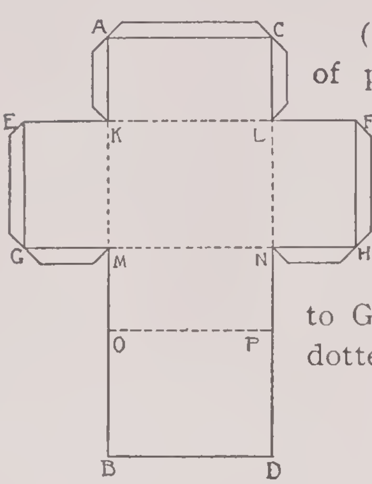


Fig. IX

(2) To make a model of the parallelopiped, take a sheet of paper 10 ¼ x 8 ½ inches. Make AB and CD 10 inches long, and the interval AC between them 4 inches. Then divide them as follows: 2 inches down from A and C to K and L, 3 inches from K and L to M and N, 2 inches from M and N to C and P. Then lengthen out two inches on each side of KL to E and F, and MN to G and H. Draw EG and FH. Fold as before on the dotted lines and paste.

Figure X.

(5) *Quadrilaterals. Parallelograms.* The term Quadrilateral means four-sided, and is applied to figures of that form. A Parallelogram is a figure with parallel sides, the opposite sides being equal.

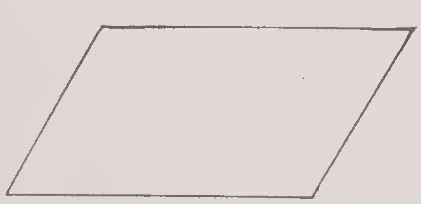


Fig. X

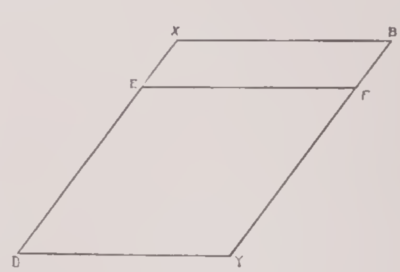


Fig. XI

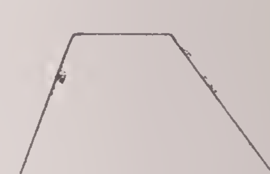


Fig. XII

Figure XI.

The Rhombus is a parallelogram the sides of which are all equal, but its angles are not right angles.

Figure XII.

The *Trapezoid* is a four-sided figure of which only two sides are parallel.

Figure XIII.

Of four-sided figures the *Trapezium* has none of its sides equal.

The meeting of surfaces or edges of two bodies forms a line, and, although a line has only one dimension in geometry (length without breadth), is represented by the mark of a pencil or a pen. A straight line is formed when two plane or even surfaces meet, thus, when two cubes are set closely together they form a line, vertical when they are set side by side, horizontal when one is set upon another.

A straight line is the shortest distance between two points.

Fig. XIII

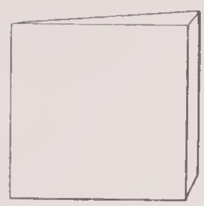


Fig. XIV

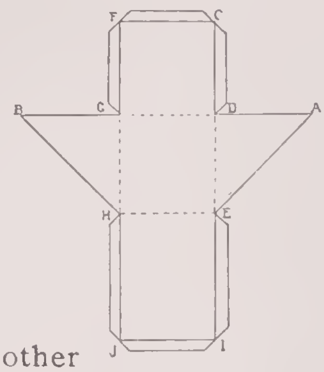


Fig. XV

Figure XIV. The Prism

A *Prism* is, as its name implies, a part of some other figure; something "sawed off," a cube. Two sides are square, one a rectangle, the fourth a triangle.

Figure XV.

To make a model of the triangle prism we take a sheet of paper 7¼ x 6 inches. AB is made 6 inches long and is divided into three equal parts, BG, GD, and DA.

CE and FH are 4 inches long. They cross AB vertically at D and C, where they are bisected, *i. e.*, divided into equal parts. AE and BH are next drawn, and CE and FH prolonged to make EI and HJ equal AE and BH. The diagram is completed by CF and IJ.

Prisms are of infinite variety; but they all agree in having two faces equal and parallel, and the others parallelograms.

The bases of the prisms are, as we have seen, triangles, and of these latter there are many kinds; *viz*:

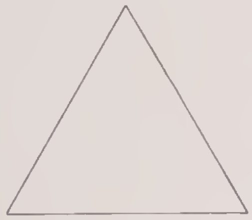


Fig. XVI

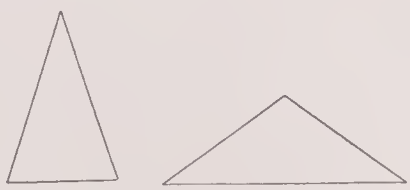


Fig. XVII

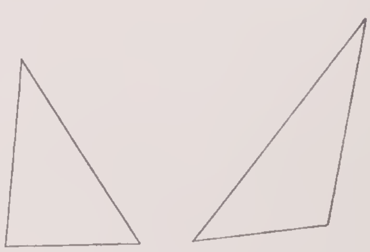


Fig. XVIII

Figure XVI.

The Equilateral (equal-sided) triangle is so called from its shape.

FIGURE XVII.

The triangle called Isosceles, *i. e.*, having equal legs, has two of its sides equal.

FIGURE XVIII.

The Scalene, "Crook legged," triangle has all of its sides unequal.

FIGURE XIX.

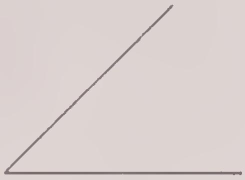


Fig. XIX

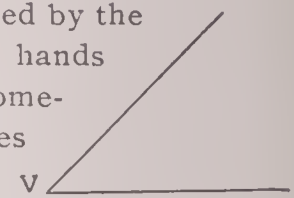


Fig. XX

It will be noticed that an angle is formed by the meeting of two lines at one point. The hands of a clock make angles of all kinds, for sometimes they are close together, sometimes stand perpendicular to each other, and sometimes form a very wide angle, as when the small hand is at twelve and the large hand at twenty or twenty-seven minutes past twelve.

FIGURE XX.

The point where the two lines meet in the center of the clock-face is called the vertex of the angle.

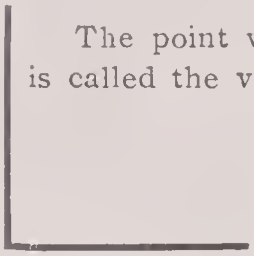


Fig. XXI

FIGURE XXI.

A Right angle is formed when two lines are perpendicular, one to the other.

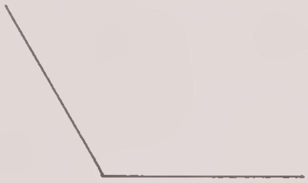

An Obtuse Angle

Fig. XXII

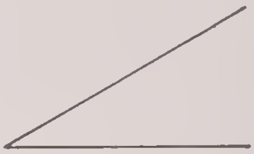

An Acute Angle

FIGURE XXII.

An Acute, or sharp angle is less than, or sharper than, a right angle. An Obtuse angle is greater, or blunter, than a right angle.

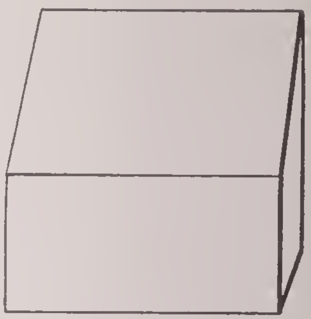


Fig. XXIII

FIGURE XXIII.

The Truncated Prism is one from which a part has been cut off by a plane inclined to the base.

FIGURE XXIV.

To make an outline model of this form take a sheet of paper 7½ x 6½ inches. Our diagram XXIV. shows the construction. A, B, C, and D are squares with sides 1 inch long. From the two upper corners of A are drawn lines to points O and F, which cut into two equal parts the sides, GH, and NQ, respectively. E is a rectangle with the longer edges equal to the lines OI or LF.

This gives an outline model for drawing.

Figure XXV. shows the mode of construction for a model to be cut and pasted. The dimensions and mode of construction are the same as in Figure XXIV., but the lapels are added to allow for pasting.

The base of the Truncated prism is the base of the prism of which it was a part.

The face formed by the cutting plane is called the *inclinea section.* The other faces are called *lateral* or *side faces.*

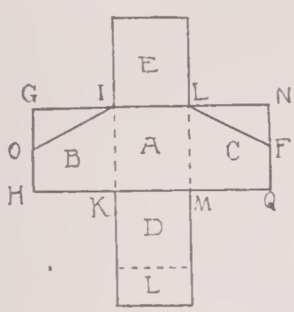


Fig. XXIV

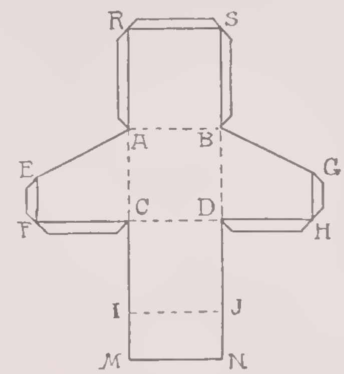


Fig. XXV

Figure XXVI.

A Pyramid (Fig. XXVI.) has all its triangular sides meet at the top or apex. The base is of many forms.

To form the model of a pyramid take paper 6½ x 6½ inches. Draw a square with sides 2 inches long, and bisect these sides at M, N, R, and S. Then draw the perpendicular lines MX, NY, RZ, and SW, each 2¼ inches long. Draw XA, XB, YB, YO, ZO, ZC, WC, WA — Figures XXVII., XXVIII.

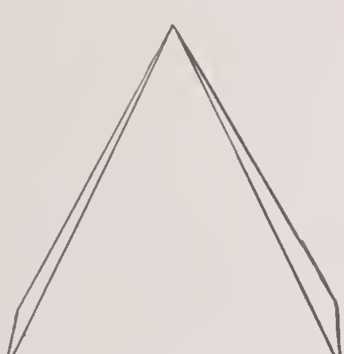


Fig. XXVI

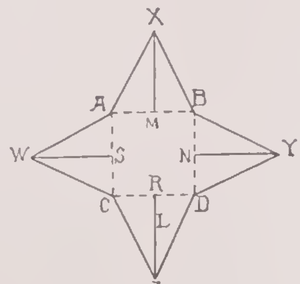


Fig. XXVII

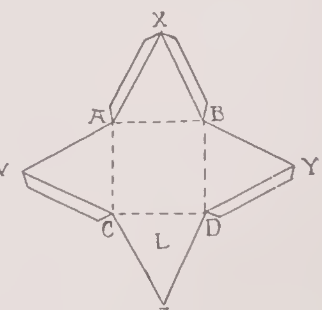


Fig. XXVIII

Figure XXIX.

A Triangular Pyramid has three faces or sides and a triangular base as shown in Figure XXIX.

Figure XXX.

To form the model of a triangular pyramid, draw an equilateral triangle ABC, 6 inches on a side. Bisect each of the sides, and join the points of bisection by dotted lines. This forms four equal equilateral triangles. On cutting out, make allowance for the lapels. Fold on dotted lines and paste.

Figure XXXI.

A Pentagonal Pyramid is one which has five triangular faces or sides and a five-sided base.

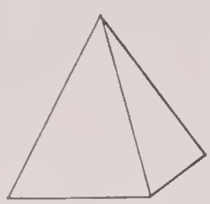


Fig. XXIX

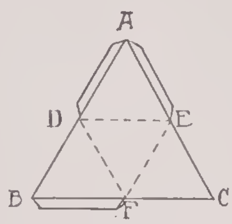


Fig. XXX

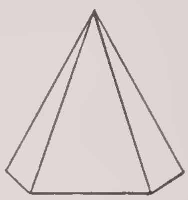


Fig. XXXI

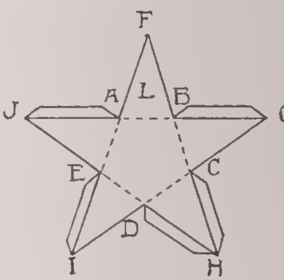


Fig. XXXII

Figure XXXII.

A Pentagonal Pyramid is modeled on paper 6 x 6 inches, and the diagram (Fig. XXXII.) explains its general construction.

Draw AB; at A draw AE making the angle BAE 108 degrees.

At B draw BC making the angle ABC 108 degrees.

Join CD; at E draw ED making the angle AED 108 degrees.

Produce the lines AB, BC, CD, DE, EA, until they form the pentagonal star FGHIJ. Provide for the lapels, as shown in the figure. Cut and paste.

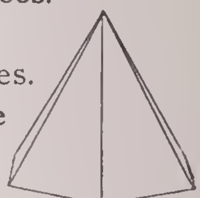


Fig. XXXIII

Figure XXXIII.

A Hexagonal Pyramid is one which has six triangular faces or sides and a six-sided base.

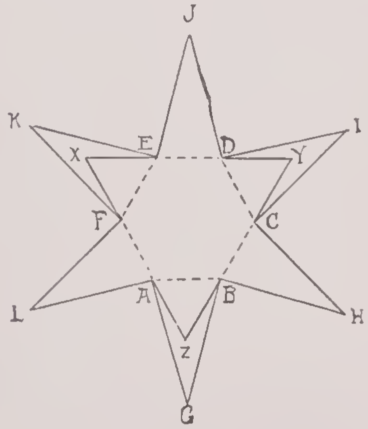


Fig. XXXIV

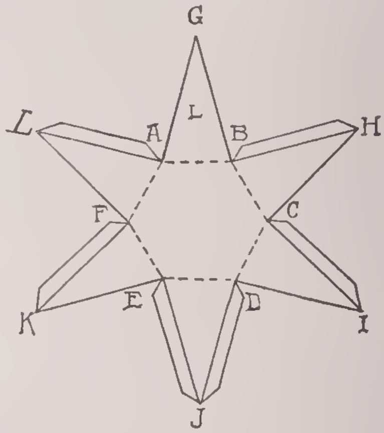


Fig. XXXV

Figure XXXIV.

A Hexagonal Pyramid requires paper 6½ x 6½ inches.

Draw the equilateral triangle (Fig. XXXIV.) XYZ, with sides 4½ inches in length.

Divide each side in three equal parts at A, B, C, D, E, and F. Join the points EF, DC, AB, thus completing the hexagon.

Upon each of the hexagonal sides construct an isosceles triangle, each vertex being 78 degrees.

Unite these vertices. This gives an outline model for drawing.

Figure XXXV. shows the mode of construction for a model to be cut and pasted. The dimensions and mode of construction are the same as in Figure XXXIV., but the lapels are added to allow for pasting.

FIGURE XXXVI.

The Frustum of a Pyramid. Frustum means "bit" or "piece," and when a pyramid has its apex, or peak, cut off deep down, a frustum of a pyramid is left.

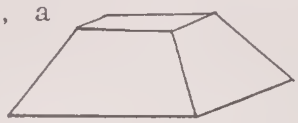


Fig. XXXVI

To model this, take paper 5½ x 4 inches.

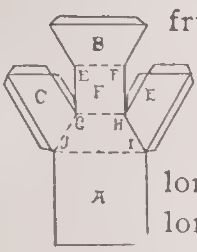


Fig. XXXVII

In Figure XXXVII., A is a square, with sides 2 inches long. B, C, and E are trapezoids; one side of each is 2 inches long, the other sides are each 1 inch long. The angles at the end of the corners are all 60 degrees.

F is a square with sides 1 inch long. The lines of folding are EF, GH, GJ, JI, IH.

FIGURE XXXVIII.

A Truncated Pyramid is a pyramid cut down by a plane not parallel to the base.

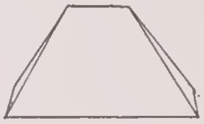


Fig. XXXVIII

To construct a model of the truncated pyramid paper is required 6½ x 5½ inches.

In Figure XL., A is a square, with sides 3 inches long; on each side erect an equilateral triangle, *i. e.*, with angles of 60 degrees.

B is a trapezoid formed by joining two points in the sides of the triangle at 2 inches from the base. D and E are trapeziums formed by joining two points on the sides of each triangle, one at 1 inch the other at 2 inches distant from the base.

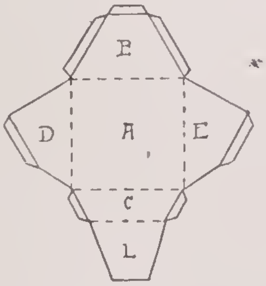


Fig. XXXIX

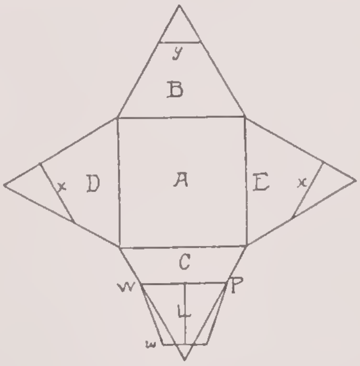


Fig. XL

C is a trapezoid formed by joining two points, W and P, for the sides of the last triangle, each at 1 inch from the base.

L is a trapezoid formed by drawing a line to the apex of the triangle perpendicular to WP, at 1⅝ inches distance from the base of this line; let it bisect a line 1 inch long drawn parallel to WP. Fold on the dotted lines in Figure XXXIX.

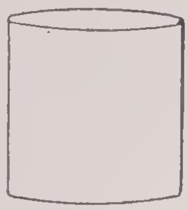


Fig. XLI

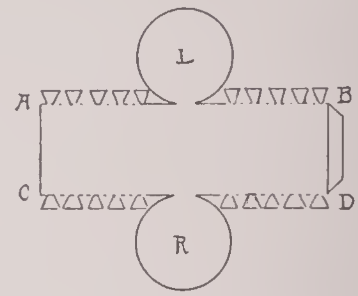


Fig. XLII

FIGURE XLI.

A Cylinder, literally "roller," is a body with three surfaces, two of them being parallel circles; the sides curved.

To construct the model of a cylinder we use paper 6½ x 6 inches. Figure XLII.

The rectangle ABCD, is 6 9-32 x 2 inches.

Draw circles L and R, at a radius of 1 inch, touching the lines AB and CD at the point of bisection.

First paste edges AC and BD. Then paste the other wedge-like lapels on the outside of the circular ends.

Fig. XLIII

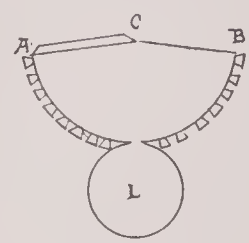


Fig. XLIV

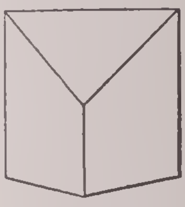


Fig. XLV

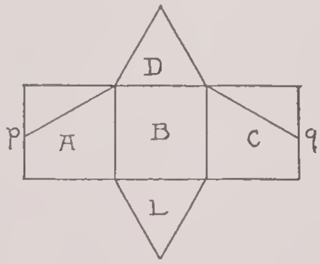


Fig. XLVI

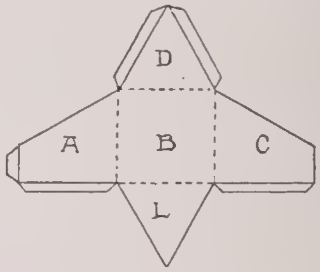


Fig. XLVII

FIGURE XLIII.

A cone, Figure XLIII. has two surfaces, one plane, *i. e.*, the circular base, the other curved. The curved surface begins at a peak and descends to the base as an isosceles triangle.

To construct the model take paper 5½ x 4 inches. Make an angle ACB of 160 degrees. With the vertex C as center, draw the arc AB at a radius of 2¼ inches. With L as center draw, at a radius of 1 inch, the circle L, just touching the arc. Unite as in previous example. Figure XLIV.

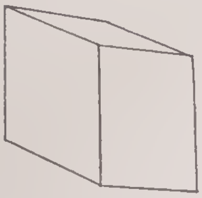


Fig. XLVIII

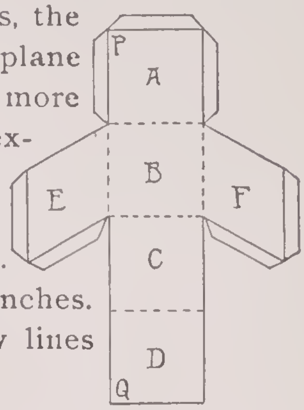


Fig. XLIX

The following figures are various polyedrons, the name usually given to solid objects having plane faces. To construct models of these figures is more difficult than the construction of preceding examples.

A Triangular Truncated Prism (Fig. XLV.) will need for its construction a sheet of paper 6½ x 6 inches.

In Figure XLVI., A, B, and C are equal squares of 2 inches. Bisect the outer sides of A and C at the point P and Q; draw lines from each of these points to the upper corners of B.

Erect on the upper side of B a triangle whose apex is an angle of 50 degrees.

L is an equilateral triangle — 60 degrees; join on the dotted lines; Figure XLVII.

A Quadrangular Prism (Fig. XLVIII.) requires for the construction of its model a sheet of paper 8¼ x 6 inches.

Four squares, A, B, C, and D are arranged on the same perpendicular.

Construct on each outer side of the square B, two equal Rhombuses with angles 60 degrees, and 120 degrees — and sides 2 inches long.

Unite on dotted lines.

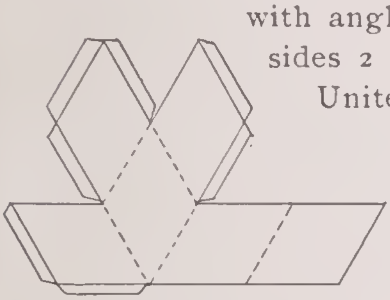


Fig. LI

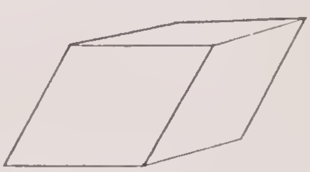


Fig. L

FIGURE L.—A RHOMBIC PRISM

On paper 8 x 5½ inches, draw six rhombuses arranged as in Figure LI, and unite by bending on the dotted lines.

FIGURE LII.

The Regular Octahedron, i. e., the figure with eight faces.

The diagram (Fig. LIII.) will require paper 7½ x 6 inches, consists of eight equilateral triangles, or two equilateral triangles, with sides 4 inches long, and the model is formed by bending on dotted lines, and joining the edges.

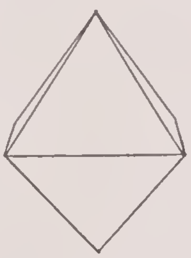


Fig. LII

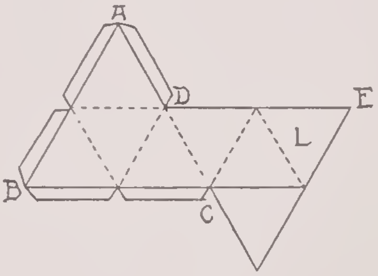


Fig. LIII

FIGURE LIV.

The Regular Icosahedron, i. e., the figure with twenty faces, which requires for its diagram a sheet of paper 6½ x 3 inches, is constructed as in Figure LVI.

ABCD is a parallelogram with angles 60 degrees, and 120 degrees—with sides 5 inches and 3 inches long. Each side is divided by points into parts of 1 inch. These points are joined by parallel lines, forming thirty equilateral triangles, which are cut down to twenty as in diagram LV.

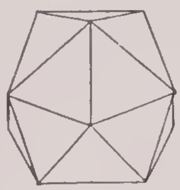


Fig. LIV

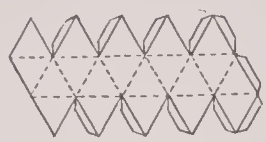


Fig. LV

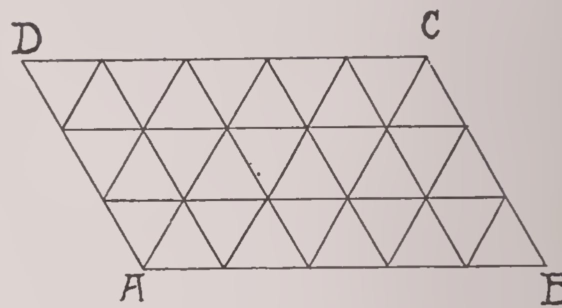


Fig. LVI

FIGURE LVII.

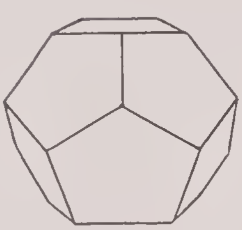


Fig. LVII

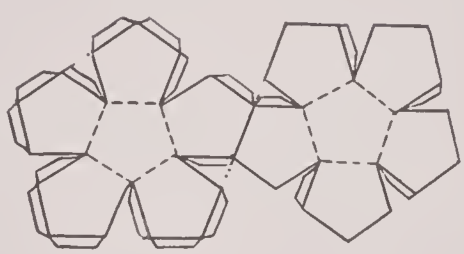


Fig. LVIII

The Regular Dodecahedron, i. e., twelve-sided figure—Figure LVII.

Paper for diagram must be 7 x 4 inches.

The construction is seen from Figure LIX.—ABCDE is a regular pentagon, each angle being 108 degrees and each side being 2 inches long. The opposite angles of the figure are joined by the lines AD, AC, BE, BD, CE.—a small encentral pentagon is thus formed.

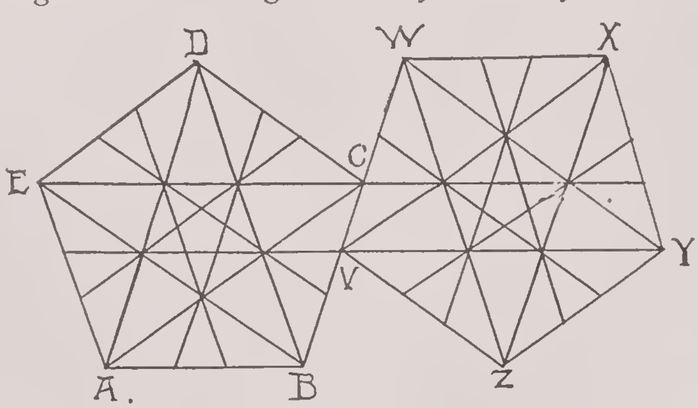


Fig. LIX

Draw the diagonals of the smaller pentagon, and prolong to the sides of the larger one—thus forming five more pentagons.

Next, draw the regular pentagon VWXYZ, VC being the vertical side of one of the smaller pentagons, prolonged so that VW may be equal to BC. Then draw diagonals, as before. Cut out and fold as in Figure LVIII.

FIGURE LX.

A Pentagonal Prism (Fig. LX.) may be represented in diagram on a sheet of paper 5 x 5 inches. (Fig. LXI.)

The faces consist of rectangles and regular pentagons.

The rectangles have sides 2 inches and 1 inch long.

The pentagons have sides 1 inch long, and angles of 108 degrees.

FIGURE LXII.

Crystal of Spinel. The diagram will need paper 7½ x 6½ inches.

ABC (Fig. LXIII.) is an equilateral triangle with sides 7 inches long.

Divide each side into seven parts of 1 inch each. Draw lines parallel with sides of the figure connecting the points of division, thus forming smaller equilateral triangles.

In Figure LXIV. is shown how these triangles lend themselves to the formation of the exact diagram of the crystal.

Fig. LX

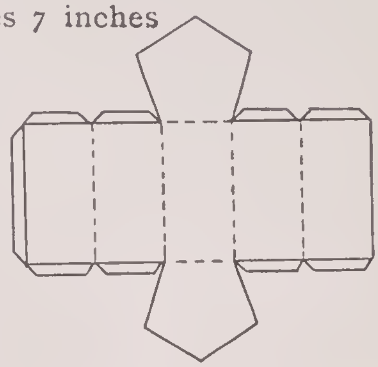


Fig. LXI

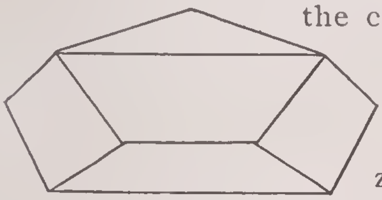


Fig. LXII

The face consists of equilateral triangles with sides 2 inches long; rhombuses with angles 60 and 120 degrees, and sides 1 inch, and trapezoids with angles 60 and 120 degrees, and edges 2 inches and 1 inch long.

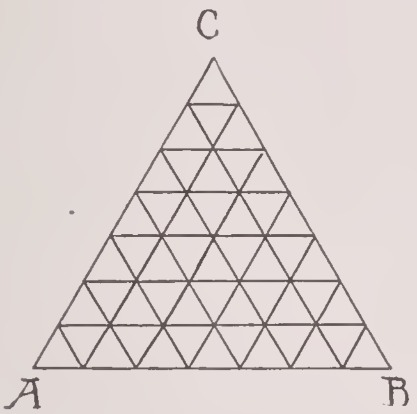


Fig. LXIII

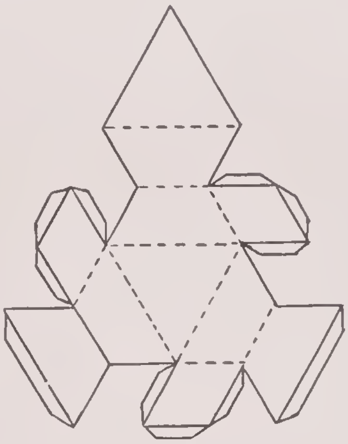


Fig. LXIV

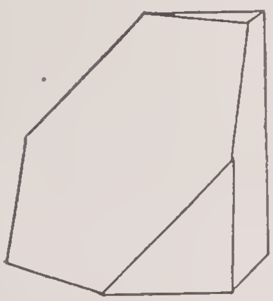


Fig. LXV

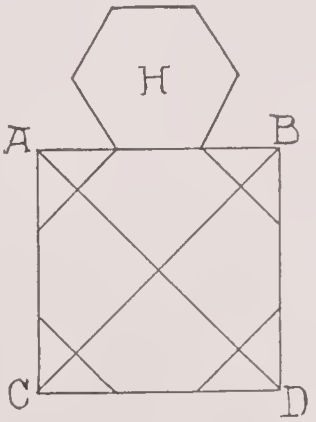


Fig. LXVI

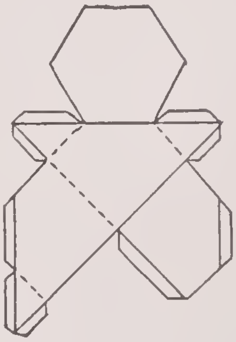


Fig. LXVII

FIGURE LXV.

Crystal of Copper. (Fig. LXV.) The diagram will need paper 5 x 3½ inches.

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In Figure LXVI, ABCD is a square with sides 3 inches long. Divide each side into three parts of 1 inch. The parallel lines are drawn from corner to corner, and between corresponding points of division.

Construct a regular hexagon on the middle division of any side of the square.

Cut out the paper until Figure LXVI. is changed to Figure LXVII.

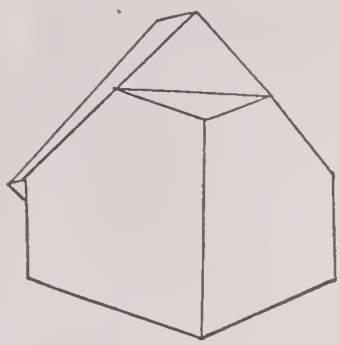

Fig. LXVIII

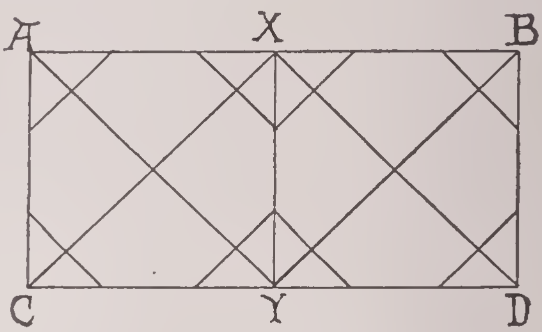

Fig. LXIX

FIGURE LXVIII.

Twin Crystal of Calcite. The diagram requires a sheet of paper 6½ x 3½ inches.

The construction of Figure LXIX. is the same as in the preceding example, with the omission of the hexagon. ABCD is a rectangle with sides 6 inches and 3 inches, divided into squares by the line XY.

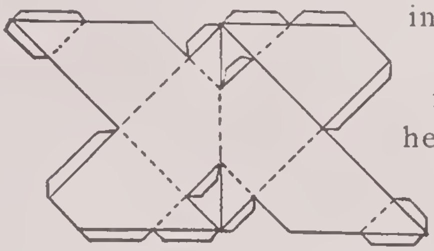

Fig. LXX

Treat in the same way as in preceding model.

Change Figure LXIX. into Figure LXX. by cutting. Fold on dotted lines and paste.