Triumphs of Enterprise

WOOD AND WHAT
WE MAKE OF IT

BY CYRIL HALL

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FELLING A DOUGLAS FIR, NEAR NEW WESTMINSTER, B.C.

The men on the planks are under-cutting the tree on the side on which it will fall

Wood and What We Make of It

BY

CYRIL HALL

ILLUSTRATED BY THIRTY-TWO REPRODUCTIONS FROM PHOTOGRAPHS AND NUMEROUS TEXT CUTS

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MEIFOD,
MONT.

Illustrations

WOOD AND WHAT WE MAKE OF IT

CHAPTER I

A Tree-Trunk in the Making

One of the most wonderful things in our wonderful world is the ubiquity of wood. Even if we wanted to, we could not get away from it. Indeed, an attempt has been made to do without it on some of the 'tube' electric railways, where, to lessen the danger of fire in the narrow tunnels, carriages have been built all of steel. At least they are called 'all-steel,' but they are not really, since wood chemically treated to make it fire-proof is used in them for a dozen insignificant purposes, for which steel, or any other material, would be less serviceable. No, we can never get away from wood. We might build our houses of steel or concrete, and rigidly exclude wood in every shape and form; but even then we should have to acknowledge our indebtedness to wood, for is not the steel made from iron smelted with coal or coke? And is not coal the remains of forests of ages past? Perhaps you think that concrete can have no connection with wood, in which case I can assure you that it has. Fire—and hence coal—is necessary in the making of cement, which is one of the ingredients of concrete, and the cement itself has for one of its ingredients alluvial clay or mud, which is pretty sure to contain disintegrated particles of wood—trees that have decayed, pulverised, and have been carried down by the winds and rains of time.

Let us turn from the multitudinous applications of wood to the trees which supply our need of it. We know well enough what a dull, miserable, sinister thing is a landscape without trees, and of how poets have sung throughout the ages of sylvan glades and shady glens. And well they may have done so, and may they continue to do so, so long as poetry remains a part of human thought and expression. Trees arouse some emotion in the breasts of all of us; it may be indistinct, intangible, so that we hardly recognise it, or it may be sweet, or poignant, or bitter; but whatever we feel or fail to feel, it is there. Come, let us take a few peeps into the hearts and thoughts of our fellow-creatures, and see the visions that come to them when we whisper 'trees.'

First, the lover,—but no, perhaps we had better leave him severely alone. Well, then, the philosopher. Ah! here's a picture that will take more time to dissect than we can afford, but what a wonderful picture it is! The battle of life, the growth of the

tree, the growth of things little and big—things that we can't understand, things that frighten our ignorance—the teeming inexhaustible multitudes of living, growing, fighting things that are here for a purpose beyond our ken. An emblem of Life is the tree in this vision. Another picture—your own—you, the boy who spent his holiday in the country, and, facing odds in the shapes of a gamekeeper and a board with TRESPASSERS WILL BE PROSECUTED, explored with dauntless courage the big wood behind the squire's mansion. Do you not remember how startled you were when the cock pheasant, a glorious fellow in regal robes of red and blue and sun-shot gold, rose with a terrific whirr-r, and warned his queen with a 'cack-cack, cack-cack' that was more terrible than the subsequent shout of the keeper? Do you not remember the scrunch of dry leaves under foot and the murmur of wet ones overhead—all the strange sounds and scents of that wonderful day? And how you marvelled at the temerity of the tiny field-mouse that sat still and stared at you; and how you laughed at the ludicrous rabbit? And how you heard a strange noise overhead, and standing very still, looked up and saw the jolliest little fellow that ever wore a russet coat. (I know him well enough, mischievous Master Squirrel; while I write he is backwards and forwards past my window a dozen times an hour, each time with one of my best and primest walnuts from the big tree by the orchard. The wind is shaking them off, and Master Squirrel is making hay, or rather harvest—not while the sun shines, for it doesn't, as though discountenancing theft—while opportunity, in the shape of my absence, serves him well. Incidentally he is doing a great deal more work than you or I will ever do, young man. Master S. weighs about eight ounces, my prime walnuts about half an ounce each; Master S. carried each one about 100 yards; ergo, to do as much work as Master S. you or I, who weigh, we will say, eight stone, would have to carry a walnut weighing seven pounds —Master S. carries his in his mouth—a distance of about eleven miles in an hour; or, to put it another way round, nearly three-quarters of a hundredweight one mile in the same time.) And somehow we are back in our vision. The wood in some unaccountable way made you think of the end of the holidays, of going back to school, of how nice it would be to live in a wood always, and then of what your father had said about duty an evening or two ago. Again you were startled, I think, by a new noise—not the pheasant this time; no, nor the squirrel, nor the mouse, nor the rabbit, nor the hare, nor the sleek blackbird, nor the gorgeous jay, nor the magpie, looking, with his long spreading tail, a far finer fellow than he really is; nor the '*take two sheep, Taffy, take*' of the plump wood-pigeon, nor the fox that passed so stealthily that you saw him not, nor scarcely heard; nor the creature formidably big and like a giant squirrel that chased the smaller squirrels from the trees, at whose coming every creature was quiet, and

which, as you afterwards learnt, was the bloodthirsty marten. No, it was not these that startled you, was it? But a sudden, sharp, painful, and very rapid rat-tat-tat-tat-tat-tat, for all the world like the drawing up of a Venetian blind. Then you saw the source of the noise; and what a sight was that first glimpse of the great green woodpecker! You had no idea that his back was such a vivid green, or the top of his head such a brilliant crimson.

But some of us, I think, would have sterner pictures shown to them. One man I know would think of the trees upon which he gazed once when he was very poor and friendless. He was a settler in one of our great colonies, and the trees had to be felled before he could put plough to earth. Another sees a picture of a tropical forest, of huge luxuriant growth that hindered his weary footsteps, hears the buzz of frightful insects, sees again the glitter of gorgeous wings. The big game hunter feels the thrill of excitement as memory recalls the tiger's eyes of fire shining in the thicket, or the crash of the elephant as he plunges into the jungle clearing. The trooper of the French Foreign Legion would think of his first mirage—of the awful journey through the Algerian Sahara when, hopeless, despairing, almost dead of thirst and exhaustion, he saw green boughs of palm-trees waving before him. We might go on indefinitely thinking and talking of our associations with trees; for to every one of us the trees bring living memories. Why! you know what a number of the old romancists laid the scenes of their adventures among the trees of the forest. Were not the haunts of Robin Hood and his merry men the greenwood glades of Sherwood and Barnsdale forests? And does not the tree or the forest have a vital influence on the fairy tales and folk-lore of all times? Did not remote ancestors hold mystic rites among the trees? And did not *their* remote ancestors skip and sport among the branches? Small wonder that we love the trees and think of them with something of the reverence of past days, as epitomising all that is good and noble in life. And if you like to give thought to these things, the humblest chair or the plainest table can bring to you the essence of the tree that provided it. I once knew an old old man who regarded with profound admiration and affection a couple of rather clumsy and ugly old chairs. They were of a fine rich red colour, a little lighter than good old Spanish mahogany, and the wood had a wavy grain. My old friend would pat his chairs gently and fondly; and, in spite of the stiff uprightness of their backs and the amazing hardness of their seats, would draw them forward for the accommodation of honoured guests. One day I asked him why he seemed so fond of them. 'Well, you see,' he said, 'I made them myself out of an old apple-tree. Yes, and I planted the apple-tree when I was a boy—a fine cropper it was too—but it grew too big and took up too much room in the little orchard yonder, so I had it down. And the missus, she wanted to use it for firing, but I wouldn't have none of that, and it lay in the ditch there for a year; and what might ha' happened to it there's no bounds,[1] till I took it into my head to make a chair, which I did (being handy with my tools from a boy), which there they are, sir, two of them!'

I am sure that his apple-wood chairs helped the old fellow to forget the feebleness of his own rheumatoid limbs and to look back to the days when he was as strong and as straight as the trees which he cared for and loved, to the days when he was a wood-reeve; and when, as he and his trees grew old together, they taught him, so I think, something of their beauty and dignity and usefulness.

Quite near to where I live there is a big wood. As a matter of fact, there are several big woods, although the proverbial crow would find it less than a fifty-mile journey to a great midland city; but the biggest is very big indeed. It covers an area of many square miles, and right in the very middle of it (so they say) lives a little old man in a little old house. Some day you and I must explore this wood and find out whether the little old man is not a myth, as I half suspect he is. A wood is about the pleasantest place in which we can find (or lose) ourselves on a summer's afternoon. A very ancient ballad runs—

> When shawes beene sheene, and shradds full fayre,
>   And leeves both large and longe,
> Itt is merry, walking in the fayre fforest,
>   To hear the small birds' songe.

[1] Kentish, meaning 'no knowing.'

'Shawes' and 'shradds' have disappeared from our language since those lines were written, somewhere in the sixteenth century, and the writer of them would not be able to recognise the 'fayre fforest' in which he walked and sang, wherever it may have been; but let us walk together in the big wood, the one which harbours the little old man. Here the leaves are as large and long as those in the ballad, and the small birds' song is no less sweet. But there is something in our wood which was not in the song-writer's — there is the knowledge of subsequent generations. Five hundred years of learning and understanding of men have given the trees in our wood a very wonderful something which the trees of the sixteenth century had not: the power to tell us the stories of their lives. Come, as we have to spend a good many pages in company with trees and their products, let us get them to tell their life histories while we walk among them in our wood. They say that the mysterious little old man is a great botanist, that he knows his friends the trees inside out and upside down, so to speak. We might get him to lend us his learning and his microscope to make the trees speak truth. What! Did I hear you mutter *botanists be blowed*? Well, well! Blow them if you like; you will do them no harm. Indeed, I rather fancy that they will take any attention as a compliment, even though it be impolite. But we must have our tree-lore, indeed we must; we will dip into the wood, and as we walk among the trees we

will get them to disclose something of their inner history.

This timber that we see all around us—this timber that has so many disguises that often we cannot recognise it—what is it all? Where does it come from? Mighty questions these to be answered in a single chapter! Do you think that if we gave our lives to finding the answer we should ever be able to cry 'Eureka!' with Archimedes? I do not think so; for what is hidden from the greatest philosophers and physiologists is hardly likely to disclose itself to you or me.

Although we cannot know all of the wonderful processes that make the birth and life and growth and surging activity of a tree, or for that matter of any other *living* thing—be it as humble as the creatures that swarm in a single drop of stagnant water, or as highly organised as ourselves—there is much that wise men have shown us; much that is marvellous and awe-inspiring; much that will lead us to an intelligent answer to some part of our great question. Let us take this acorn—a pretty thing beloved of pigs, and (when it happens to have grown on a particular variety of oak-tree) by the ladies of Turkey. We know that our acorn is the seed of the oak; we know that, given favourable circumstances of warmth and moisture, and immunity from accidents, such as the premature eating of the acorn by a rat or a squirrel or other creature, or the boring away of its vitals by insects, there is no reason why it should not grow into a healthy tree. A thing that is growing, or is capable of growth, must, we know, be a living thing. Do you ever think of this pretty polished brown acorn as a living, breathing, struggling unit of life? It is one of countless billions which Nature in her superbly extravagant bounty showers upon the earth every autumn—a little insignificant, unheeded thing that owes its life to the mysterious protoplasm that gives to you also, not merely the power to live, but to walk and think and enjoy things, to be infinitely more complex and wonderful than the lordly oak or its humble seed. But, I can hear you say, how and why does the acorn grow? How does it become a great tree, in course of years to have acorns of its own? Let us learn what we can of this problem, even though in the next few pages we shall be allowed no more than to touch the hem of Nature's skirt.

You must know, first of all, that the oak-tree belongs to the great class of plants called exogens, or exogenous plants. This is a hard word, meaning a good deal more than appears from its derivation. *Exo* means *outside*, and *gens* is the root of a word meaning *to be produced*; we have it in genesis and in generate, and literally exogenous means *growing outwards*. An exogenous plant is one which grows by successive layers of cells placed on the outside of a permanent centre, and is branching in habit. Also, what concerns us more closely just now is that the seeds—as the acorn—of such plants contain two sharply defined parts, or cotyledons, the books call

them. If you cut in half an acorn, or a bean, or a poppy seed, you will find inside the pith-like substance beneath the shell the embryo, the germ which is eventually to grow into the tree or plant as you know it. The embryo consists of the two parts we just spoke of—the cotyledons; on one side of one of the parts is a little shoot. This is called the radicle, and will develop into the root. (Radicle is a very simple word: *rax*, *radis*, a root, gives us both *radicle* and *radish*—the hot thing we eat.) Between the two cotyledons, and connecting them together, is another little shoot called the plumule—a pretty word which comes from *pluma*, a feather or plume. The plumule forms the stem of the young plant, and holds out the plant's primitive leaves—the cotyledons of the embryo—when they emerge from the shell of the seed and timidly begin life on their own account.

So much for the parts of the seed. There is nothing to suggest a resemblance between the tiny thread-like root, and the tiny plumule and the quivering, helpless, unprotected seed-leaves of the newly-burst seed, and the massive grandeur and dignity of the oak which it will become some day. It will live, perhaps, for a thousand years, and will weigh hundreds of tons. For what nourishment it takes from the earth that nursed it when it was a lowly acorn, and feeds it still, it will repay with full measure in the form of bushels upon bushels of its fallen leaves. But for man's axe and the shattering sword of lightning, there is scarcely an enemy that can harm it after about twenty years of growth. Far more wonderful than this transformation is the fact that inwardly the embryo of the seed from which it sprang is the same as any other seed. Is it not astounding that the white contents of the acorn should become an oak eventually, and not a chestnut or walnut-tree, the seeds of which appear to be made of just the same stuff? Suppose that it were possible—fortunately it is not, nor ever likely to be—for a clever chemist to make a seed. He would take one as a pattern, and analysing it would find that it consisted of certain proportions of constituents A, B, and C. Thus far, indeed, he can go. Let us suppose something more: that the chemist takes these constituents and mixes them in the right manner and the right proportions, and has added to them an artificial protoplasm, the living, moving, ever-changing substance which is the basis of life. When he has done this the chemist has produced a seed which will grow; but he could never tell how it would grow, or what it would become. Why the acorn becomes an oak and the sunflower seed a sunflower, is a mystery which no wise men can fathom; a mystery which the Good God who holds the key of all life, who made all things what they are, shall disclose in His own good time.

If we put our acorn in the ground, and had the power to watch the processes it underwent, to watch it grow, in fact, we should see something that would certainly startle us out of our self-conceit, and give us a wider conception of the immensity and grandeur of

the common things of our world. But first let us see what is this ground, what is this soil in which our acorn falls and grows, that feeds and nourishes the nodding grass as well as the noble tree. This handful of soil that I have grubbed up with my fingers—of what is it made? Do you know? Tiny grains of rock worn down by the hard and grinding hand of Time, disintegrated particles of quartz and limestone and clay—you know that soil contains these things as well as vegetable or organic matter, the changed remains of the leaves the trees throw down with such gracious prodigality, and water and the nitrogen which has been 'fixed' to prevent it from floating away. All this is common knowledge, and you know it, or ought to know it. Is there anything else in my handful of soil? Is there not something that we cannot see, unless we are fortunate possessors of powerful microscopes; something far more vital to the existence of trees and plants than the things just mentioned? What! There is nothing else? My dear friend, have you never heard of soil bacteria? This handful of soil is literally swarming with them, unthinkably tiny living units, so tiny and so plentiful that we cannot realise how small they are any more than we can realise the vastness of the sun or the planet Jupiter. There may be a million or more—they are counted not by ones and twos, or even tens and twenties, but by thousands and tens of thousands—in the soil I am holding; and each one is a living, breathing, feeding organism performing its allotted share of the world's work. When the primroses clustering round the old tree's bole wither and die; when the tree itself shakes off its summer coat and stands gaunt and naked against the winter winds; when the hapless mouse falls victim to the fierce talons of owl or kestrel; when any or all of these things happen they merely mark a stage in the great pageant of life. Nothing is destroyed, nothing lost; the primrose flower, the autumn leaf, the carcase of the mouse is merely changed. Life in one form gives place to life in another. We say that *decay* takes place. The fallen leaf is attacked by hordes of the invisible microbes in the soil and pulled to pieces; warmth and moisture assist in the process of decomposition, and in course of time the character of the leaf is changed. It is a leaf no longer; true, the beautiful skeleton remains, to make us marvel at the exquisite art which Nature puts into her handiwork, but the rest has vanished from our sight. The bacteria swarms have resolved it into half-a-dozen constituents which the leaf borrowed from the soil to enable it to grow. They have stored or 'fixed' the fickle nitrogen which forms the stable diet of all plants. By and by they will lend it to the tree again to enable it to put forth new leaves.

The discovery of living organisms in the soil is without question one of the very important ones of modern times. Science helps us every day to a better understanding of our earth, ever teaching us how we may most usefully control its forces. And it is certain

that sooner or later man will have 'harnessed' the soil bacteria to the chariot of progress. Just what these infinitely little organisms are, how they do their work and why, science has not yet discovered. We do not even know whether they belong to the animal or vegetable kingdom, so that there would be some risk in choosing them as a subject in a game of 'twenty-questions.' But enough has been discovered about them already to set aside all doubt as to their useful influence on the growth of plants. The number and activity of the bacteria contained in the soil are largely responsible for its fertility; and it may not be very long before the barren wastes of the earth are made to bring forth good fruit by the introduction of a few bottles of bacteria taken from fertile soils.

We have left our acorn; let us get back to it and watch what happens when we put it in the complex soil. We say that it germinates. Roughly, this is what happens. The warmth and moisture of the soil, aided by the bacteria, bring about a very marvellous change in our acorn. When it left the tree its parts were all ready for development, as we have seen, but it was inert; one might almost think that it did not want to live and grow to be a big tree. What, then, have the warmth and moisture and bacteria done to it to encourage the cotyledons to creep out of their shell and survey the world? They have changed the mealy part of the acorn surrounding the embryo into a different substance altogether. The process of fermentation has been set up, and myriads of minute organisms which were latent in the grains of starch composing the acorn have suddenly started into life and ceaseless activity. These living organisms which have been urged into growth and division and multiplication by the changes brought about by the soil bacteria are themselves changing the complicated starch cells or grains of the acorns, breaking them up and resolving them into simpler constituents. Organic ferments play a very important part in many of the manufacturing arts. As yeast they are cultivated by every baker in the country. They help to convert the grains of barley into the malt used for making beer; they change the starch and sugar of the grape into alcohol and carbonic acid. And in the acorn the ferments are helping to grow an oak-tree by encouraging the embryo to begin its campaign of life and activity. The little plumule and the cotyledons and the radicle become infected by the struggle of the organisms around them. Living organisms—you can call them germs if you like—take charge of the embryo, and break up its cells, and bring together chains of new ones, and add to these and pull them down again in a most amazing manner, which it is quite beyond my power to explain clearly to you. In a word, however, the wonderful and mysterious protoplasm or life-giving cells are brought into sudden and tempestuous activity; and the little radicle pushes its way downwards in the earth, and the plumule and its cotyledons push their way upwards towards the light. The tiny plant is a living,

pulsing, growing thing; breathing—respiring is the word to use—oxygen as you do, and exhaling carbonic acid gas; and, since nothing can grow without nourishment, it is feeding ravenously on the chemicals into which the ferments have changed the starch of the acorn.

In a few days the little cotyledons—the plumule and its two seed-leaves—will have forced themselves above ground; and as soon as they make acquaintance with the bright light of day another change will take place: a change in the functions of the plant more marvellous, if that be possible, than the change from inert, sleepy acorn to the actively growing baby oak. So long as the cotyledons were beneath the surface of the ground, the ferments in the acorn supplied it with food which they had so prepared as to render it easily digestible. The parent tree had, in fact, stored up in the acorn, all ready for the use of the embryo, a certain amount of nutritious organic compounds, nicely suited to the taste of the rapidly multiplying cells of protoplasm. If you have anything to do with poultry or canaries or other birds, you will know that chicks do not require to be fed for about twenty-four hours after they are hatched. Just before they leave the shell the yolk of the egg, or part of it, is drawn into their little bodies, and they are thus supplied with a preliminary meal which serves to give them warmth and energy until they are able to feed themselves. It is just the same with the germinating seed. By the time the cotyledons have forced themselves above the ground the food reserve of the fermented acorn has come to an end, and the young plant has to start on its own career of foraging for food. If, however, it were left entirely to its own resources our baby would have a short and weakly career. It could not thrive ; certainly it would never grow into a great oak-tree. Fortunately there is a friend waiting to help it as soon as it has got through the ground. A good friend is this, for he never forsakes the trees throughout their long periods of existence—a good friend indeed to every living thing on earth ; and you and I, as well as the ancient oak and the bursting acorn, have to own him master, from which you may guess that he is none other than the sun himself. It is the sun, or the light that he diffuses, that helps to feed the plants ; and we may pause for a minute to consider in what manner it is that he does this. Certainly we shall not find that it is the least interesting part of the life history of our tree. Plants that are grown in the dark—there are a few exceptions —are not green in colour, but a whitish-yellow ; but they turn green almost immediately they are brought into the light. Obviously, therefore, the light is the cause of the change. You may prove it for yourself by a common but interesting experiment. Go to a chemist and ask him to make you an iodine solution. If he asks you what you mean, you may show your superior knowledge by telling him to make a strong solution of iodide of potassium and distilled water, then to add some crystals of iodine, and finally to

dilute the mixture until it is a clear brown colour. Next you will want a strip of tinfoil and a sharp knife. What you have to do is to cut in the tinfoil any design or arrangement of letter you like — your name, perhaps, though the words CHLOROPHYLL or ASSIMILATION would be more appropriate. These words must be cut in the silver paper so that the letters are blanks, like those of a stencil-plate. Now take the stencil you have made and wrap it round a leaf of a tree so that the word is on the top side, and leave it for two or three days. The longer you leave it the better for the purpose of our experiment. When your patience is exhausted pick the leaf, take off the foil, and dip the leaf first into boiling water and then into methylated spirit. These agents will bleach it, so that it appears white. Now wash it in cold water, dip it in the iodine solution, and you will witness a very remarkable development. The part of the leaf that was covered with tinfoil will become a pale yellow colour. The iodine stains it but does nothing more, whereas the letters which were formed by the blanks in the tinfoil, through which the light could reach the leaf, will appear to be printed on the leaf. You will have a leaf with whatever you cut on the tinfoil written in clear blue letters on a yellow ground.

So much for the experiment, which shows that light has an important influence on the leaves of plants. For an explanation of the phenomenon of the blue letters you must appeal to your chemistry master, for there is no space to speak of it here. What happened was that starch grains were present in those parts of the leaf upon which the light could act, and absent from those which were covered up. This fact, the necessity of light as an agent in making starch is a very important one in the nutrition of plants, and is one which I hope you will find time to read about and investigate some day.

We have strayed rather from our cotyledons; let us get back to them. As soon as they make their first appearance above ground the yellow seed-leaves become the vivid green colour we know so well. We know that this change is directly due to the action of the light, the green colouring matter being produced by the presence of many minute specks or granules of a soft substance which is called by the descriptive name *chlorophyll*, which means, literally, plant green. Before the plant came into the light it had no chlorophyll; whence, then, have these green granules come? In other words, what have the sun's rays done to the plant to bring into it something which was not there before? Before we can find an intelligible answer to our question we must enquire a little more deeply into the manner in which it lives and feeds and breathes. First of all, let us look at the root, the radicle of the embryo, and see what is happening there. If we examined the roots of a plant under the microscope we should find that it was provided with a number of very fine hairs. These hairs are in close contact with the grains of soil, and with the water which lies between the grains of soil; they are hollow and are able to take into the plant some of the materials which it requires for its nutrition—for its food, in fact, since food is as necessary to a plant as it is to us. The plant's little root hairs absorb water from the soil and convey it to the cells which contain the wonderful substance called protoplasm. In the water which the plant thus absorbs are dissolved some of the substances which it requires for the building up of new cells and tissues, in other words, for its growth. It gets rid of this water again, or some of it, at all events, through its leaves, by the process known as transpiration; indeed, it has been calculated that a large oak-tree will give out several gallons of water in a single day. The water is a vehicle containing the plant's food in solution; when these foods have been extracted it has no further use for the water, and so it gets rid of it again. But the plant cannot get all its food from the water in the soil; and here it is that we may follow something of the wonderful process of *assimilation* that goes on in plants, and see how and why the mysterious green chlorophyll is manufactured.

I want you to imagine the plant—our baby oak—not merely as a root and a stalk and a couple of leaves, but as a highly organised living thing, in which the most astounding activity is going on. Exactly what goes on, how inorganic substances are changed inside the cells of the plant into highly complicated organic ones, I am unable to explain, and so, I am afraid, is everyone else; though there are several theories, to be obliged to listen to which would weary you. It is difficult to make quite clear to you in a single chapter what is this living substance called protoplasm, and how cellular tissue, that is, the fabric of the plant—leaves, stem and root—is built up. But from what I have said, I think that you ought to be able to understand that the changes from the inorganic food of the plant—the dead, lifeless molecules of hydrogen, oxygen, and nitrogen, the iron, sulphur, and other things that the plant wants for its nutrition—to living cells, these changes from the elemental gases and soluble compounds to the starch, or sugar, or cellulose which we find in plants, are principally brought about by the intense activity of the protoplasm. Currents course through the sap absorbed by the roots, the granules of protoplasm form webs between the cells, connecting them together and adding to them bit by bit. But all this would be quite impossible without the help of the sun in converting the sap drawn from the soil by the microscopically small root hairs, and sent pulsing to all living parts of the plant, or some part of this circulating sap, into the green granules called chlorophyll. Perhaps you have thought that leaves were green because that was the prettiest colour; but the chlorophyll has a far more important function than the mere colouring of the leaves, although, doubtless, nature made trees, and nearly all the members of the vegetable kingdom wear green clothes because that is the most soothing and restful

colour on which the eyes of men and beasts can gaze. The greenness of the chlorophyll, however, is, as I have said, not its principal function in plant economy. It is the instrument by which plants are able to assimilate a food without which they could not exist.

If you were to analyse a plant, to split it up into its component parts, you would find that it was largely composed of carbon. To be able to analyse a plant you would need to be a chemist, and being a chemist you would know that the carbon which you found in the plant could not have come into it, along with its other component parts, through its roots. How, then, did the carbon get there? is a question which you might well ask.

The leaves of a plant and the chlorophyll contained in them are instrumental in obtaining for it the necessary supply of carbon; and, as I have already said, they could not do it but for the help of our good friend the sun. What happens is that when the sap reaches the leaves it absorbs some of the sun's rays, and its nature is completely changed. You know, or ought to know, that light is composed of different coloured rays, and that the different rays can be broken up and separated by a prism—the spectrum, which plays so important a part in many sciences. Well, then, the sap in the leaves, or a certain substance called etiolin contained in it (but we need not bother ourselves with any more long words than we can help) stops the red rays of the light, and makes them do the work of converting it into chlorophyll. The chlorophyll in its turn is a much more complicated substance than was the sap before it was influenced by these rays, and is able to obtain from the air the carbon which the plant requires for its growth. The plant is said to 'assimilate.' The leaves take in the carbon di-oxide which, as you know, is one of the constituents of our atmosphere; the chlorophyll separates the carbon from the oxygen, the former is 'assimilated' by the sap and taken away to make the carbon compounds necessary for the manufacture of the starch of which the plant cells are mainly built up, while the oxygen is given back to the air by the leaves as being of no use to them.

You ought now to have a pretty clear idea of how growth takes place in a tree. We have watched our acorn germinate and grow into a tiny tree, and you must understand that the life processes just described go on so long as the tree lives. Before we close this chapter, however, I want you to bear with me a little longer while we see how wood is made, that is, wood in the sense of timber, which we can cut up and make into things. Wood, then, as we know it, is made up of what are called fibro-vascular bundles, which do not sound half so terrible when we know what that long word means. Fibro comes from *fibra*, a thread; vascular from *vas*, a vessel. Most people call them woody fibres, a term which is less descriptive but perhaps more easy to remember. All the hard parts of a tree—and of almost every other flowering plant—

are made up of these bundles. They are hollow—minute canals, in fact, as their name implies—and so are able to conduct the sap from the roots to all parts of the tree. In the centre of the tree is a permanent cylinder which is called the pith, or medulla. Around the pith the vascular bundles arrange themselves close together in other and smaller cylinders, and so form a broken ring round the centre of the tree. The bundles themselves consist of three separate parts. The part which is nearest to the pith is the wood, or *zylem*; the part nearest to the outside of the tree is the *bast*, and is composed of hard and exceedingly tough fibres which are riddled with little holes, through which passes the sap to the growing parts of the tree; while in between the wood and the bast is a layer of cells which is neither wood nor bast, but will ultimately become both. These intermediate cells are *cambium*. They contain protoplasm, and are in a state of activity so long as they are supplied by the tubes in the bast with the sap which has been 'elaborated' or acted upon by the chlorophyll. Of course, you must understand that the vascular bundles lead from the leaves to the stem, and so form a skeleton-work connecting all the members of the tree. As soon as the leaves unfold in spring the chlorophyll in them forms carbon compounds, and these are led to the layer of cambium which lies between the wood and the bast of the vascular bundles. The cells of the cambium are constantly dividing and forming new cells. Those nearest to the wood form new wood by adding themselves to the outside of the last layer formed; while those cells nearest to the bast go to add to the bast, though these are few compared with the cells which make wood. When the leaves fall off the tree in autumn the cambium becomes inactive, and no new cells are formed until the new leaves are put forth in the following spring. A ring or layer of wood is thus added to the tree every year, and you can see the rings plainly in a section of a branch of a tree that is more than two or three years old, and calculate the tree's age from their number. Sometimes these rings are called annual, from the fact just mentioned; and again you will sometimes hear them spoken of as annular, from the fact of their being rings. In the sense that we use them when speaking of trees these two words, annual and annular, are interchangeable; but in spite of their similarity they have not the same meaning, as your dictionary will show.

In the preceding pages I have not been able to do more than to give you, at best, a rough and designedly unscientific explanation of how trees grow and how wood is formed. We have seen that wood, like all living things, be they large or small, is made up from pith to bark of many different forms of cells, which have the power to break up and divide, and so carry on the marvellous process of self-increase which we speak of as growth. I have said nothing of the mechanical processes to which the fibro-vascular bundles are submitted by Nature before they become

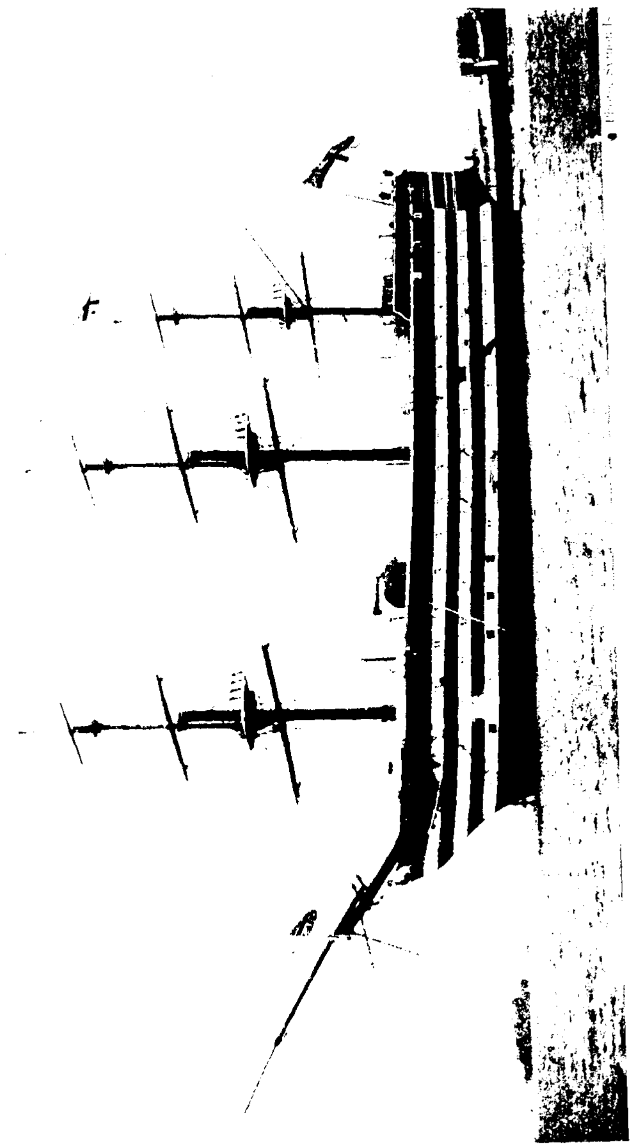
the hard, homogeneous timber which we are to fell and take to the sawmill in a subsequent chapter; of how the increasing pressure of the multiplying cells makes the wood firm, of the differences between heart wood and sap wood, of the influence of the seasons on the wood; of these things I have said nothing, because I think that I have told you enough to stimulate your imagination and your interest to a deeper and more lasting study of these things. There is much in the world that is beautiful; but nothing in the world is more beautiful than the working of God's hand in the moulding of the trees and the flowers with which our little earth is so lavishly bedecked. Life would be very pleasant if we might wander always through fields and forests, seeking from the flower its beauty and the tree its strength. But that is not the purpose for which life was given to us, and we should be cowards if we pretended that it was. Rather let us say with the English essayist, whose reverent love for the trees and flowers and birds, and not least for his fellow-men, we may well try to emulate: 'From the littleness, and meanness, and niggardliness forced upon us by circumstances, what a relief to turn aside to the exceeding plenty of Nature!'[1]

[1] John Richard Jefferies, *Meadow Thoughts*.

CHAPTER II

The Trees of Britain; their Cultivation and Uses

IN the north-west corner of Montgomeryshire, just where that county joins Shropshire, and England and Wales run into one another, there rises abruptly from low-lying ground a hill, not very high, but remarkable for its shape and prominence. This is the Breidden Hill; it calls forth from every Aberystwyth-bound traveller entering Wales for the first time, by the railway which runs through Shrewsbury, the exclamation, 'Look! Here's a mountain! We're in Wales now.' The Breidden Hill is a very insignificant mountain, for it is not much over 1000 feet high, and England can claim almost as much of its area as can Wales. But the hill is worth looking at, none the less, though for a reason which does not occur to one in ten thousand of those who see it. On its summit, in bold outline against the sky, rises one of the remarkable monuments of the world. Ask a native of those parts for what it stands, or, with less trouble to yourself and none to him, consult a map, and you will learn that it is 'Rodney's Pillar.' What



H.M.S. VICTORY

Rodney? Why, who but Admiral Rodney? Did he live there? No, he did not. Did he go there? Never. Was it erected in honour of one or another of the great sailor's historic victories? Again no. Suppose you ask the aforesaid native why Rodney's Pillar was erected on the Breidden Hill; if he is any ordinary sort of a native he is sure to answer that he doesn't know, and is probably blessed about it into the bargain, from which you may rightly infer that Rodney's Pillar was put up without much reference to Rodney. If it were called the 'Oak's Pillar' instead of Rodney's Pillar the purpose for which it stands would be less puzzling to discover. The pillar is, in short, a monument to the one-time magnitude and value of the oak forests of Montgomeryshire. People called it Rodney's Pillar because Admiral Lord Rodney, in his capacity of one of Britain's most famous and furious fighting seamen, required for those exploits, which brought so much fame to himself and so much glory to his country, a large number of ships of war. In Rodney's day men-of-war were built of oak, and the more ships that were built the more oak there was used. It so happened that the gentlemen of Montgomeryshire possessed large forests of oak, and were able to obtain very good prices for their timber. In gratitude to Lord Rodney, or rather for the fortunes which he had been the indirect means of putting in their pockets, they erected the pillar on the Breidden Hill to commemorate his enterprise.

For myself, I think it is better to forget the landowners' fortune part of the story altogether. For, although a fortune is a highly desirable thing, we should be able to entertain a far greater respect for the Breidden monument if it commemorated the generosity of Montgomeryshire landowners who had given to their country the timber of the ships that were destined to strike terror to every French and Spanish flag upon the main. But, after all, what oak requires a monument? I think that if we were asked what was the most appropriate monument that those landowners could have put up we should say now, 'Plant again, that other trees may bud, and so perpetuate the British oak that served so well in its time of need the land that saw it grow!' But unfortunately for our generation, that sentiment does not seem to have commended itself to the landowners of Rodney's day. Montgomeryshire is still one of the best wooded counties in Great Britain, but the area now under trees must be small in comparison with the extent of forest no further back than the days of Rodney. Oak-trees grow to be fine specimens in a hundred years, and they would be infinitely more valuable now than then, in spite of the fact that no longer are our men-of-war 'hearts of oak.' It is indeed very difficult to forgive our forefathers for cutting down the trees without planting others to take their places. There was plenty of wood for their purposes, and it never occurred to them to enquire whether succeeding generations might not find themselves in the terrible

position of living in a world with an exhausted timber supply.

I am going to tell you a story which will show you the necessity of planting trees when trees are cut down more surely than words of mine can tell you. It is a story of another of our great admirals, Lord Cuthbert Collingwood, whose ship was the first to break through the enemy's lines at Trafalgar, and who took command of our fleet after Nelson's death. I take it from *Rodney Stone*, an interesting novel by Sir Arthur Conan Doyle:—

'" . . . Where have you been, Sir Cuthbert?"

'"With my wife and my two little lasses at Morpeth, in the north country. I have but seen them this once in ten years, and it may be ten more, for all I know, ere I see them again. I have been doing good work for the fleet up yonder."

'"I had thought, sir, that it was inland," said my father.

'Collingwood took a little black bag out his pocket and shook it.

'"Inland it is," said he, "and yet I have done good work for the fleet there. What you suppose I hold in this bag?"

'"Bullets," said Troubridge.

'"Something that a sailor needs even more than that," answered the admiral, and turning it over he tilted a pile of acorns on to his palm. "I carry them with me in my country walks, and where I see a fruitful nook I thrust one deep with the end of my

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'"Something that a sailor needs even more than that," answered the admiral, and turning it over he tilted a pile of acorns on to his palm. "I carry them with me in my country walks, and where I see a fruitful nook I thrust one deep with the end of my cane. My oak-trees may fight those rascals over the water when I am long forgotten. Do you know, lieutenant, how many oaks go to make an eighty-gun ship?"

'My father shook his head.

'"Two thousand, no less. For every two-decked ship that carries the white ensign there is a grove the less in England. So how are our grandsons to beat the French if we do not give them the trees with which to build their ships?"'

Although we do not now build our ships of oak, nor think of fighting our good neighbours across the English Channel, oak is just as necessary as it was in Collingwood's time or Rodney's. And if all those who helped to make the wooden walls of old England so famous in history had shown Collingwood's foresight, we should not now be crying out that the world will soon be short of timber.

The neglect of our ancestors to make good their denudations of our woods and forests is no excuse for neglect in our own time. Indeed, it behoves us to do all we can to ensure that our present supplies of wood shall not be depleted without thought for the needs of the future. For every tree that we cut down we ought, in strict justice to our descendants, to plant another.

Trees have a very important influence on climate, since they condense the moisture of the atmosphere, and help also to drain the soil in which they grow. It was at one time thought that the cutting down of trees growing in marshy situations was responsible for the

terrible fever which we now call malaria. Malaria has since been traced to a mosquito, and not to the vapours arising from marshy lands, although there is a direct relationship between marshes and mosquitoes. But the cutting down of trees in marshy districts has none the less a direct influence on malaria, for the same reason that the trees influence climate.

There is scarcely a country in the civilised regions of the world that has not suffered from the reckless destruction of timber trees. In some parts of the United States of America forests that once formed a great natural asset and source of wealth have been entirely wiped out. Again, the island of Cyprus was once famous for its forests. The trees were cut down without thought for the future, to the great disadvantage of the climate and fertility of the country. Unfortunately, nothing has been done to replant the mountain slopes, and it is said that the trees which try to grow naturally are unable to do so because goats eat off the young growth as soon as it appears!

As the world has suffered for want of foresight in tree planting, so it has certainly gained in those parts where foresight has been shown. By the judicious planting of hardy trees many years ago, great forests have sprung up on parts of the coasts of France, Germany, and Denmark, and wastes of shifting sand by the seashore have thus been converted to valuable land. In case what I have said about the destruction of forest lands may give you a false impression, I must hasten to explain that the systematic planting of trees is very far from being a modern attempt to make good the depletion of natural resources. Your history-book will tell you how the Saxon and Norman kings of England, and the great nobles of their day, depopulated wide tracts of country in order to make themselves playgrounds, wherein they might hunt the deer and the wild boar. But you must understand that a deer forest is not necessarily a densely-wooded tract; and that, although the New Forest and Epping Forest and the rest of them were thickly wooded, the trees were there before the Normans came, and it was not until much later—the sixteenth century, perhaps—that men began to plant trees in earnest, and to introduce new species brought from foreign lands. Comparatively few of the trees of the English country-side are really natives, only about thirty species being in fact indigenous, the rest having been imported at various times. In the United States of America there are about ten times as many kinds of trees as in Great Britain, for it is said that in the States there are three hundred varieties which grow to a height of 30 feet or more. India, however, comes far and away above all other parts of the world in the number of its different trees, having no fewer than nine hundred species.

The old forest laws of England and Scotland were very harsh and oppressive; while they took land and property from the peasants they gave special privileges to the lords and barons. Sometimes horses, cattle, and sheep were forfeited, under the pretence that all

things belonged to the king that were found in any particular tract of land which the monarch was pleased to consider one of his forests for the time being. To-day there are only two royal forests, Windsor and Wolmer; but we are told that King John had 18 forests, 13 'chases,' and 781 parks. In the reign of Henry III. the forest laws were modified, and the penalty for stealing game was reduced from execution, or maiming of the poacher by the cutting off of his ears or thumbs, to imprisonment for a year and a day. One clause of the Forest Charter of 1217 (Henry III.) reads: 'Whatsoever archbishop, bishop, earl or baron, coming to us at our commandment, passing by our forest, it shall be lawful for him to take and kill one or two of our deer by view of our forester if he be present; or else he shall cause one to blow an horn for him, that he seem not to steal our deer.'

Arboriculture, that is, the planting of young trees, either for their timber, their gums, resins, or other products, or the shelter they afford, has recently been developed to a fine science. In Norway, India, Canada, the United States, Scotland and other countries tree planting is systematically carried out under the ægis of the State. In France and some other countries sylviculture—by which is meant the raising of new forests and the preserving of old ones—is more generally followed than arboriculture. Whichever method is followed, those who are responsible for planting trees and caring for them during their growth have to be specially trained for their work. One might not think, at first sight, that there was very much to be learnt about tree growing, since, so far as ordinary people can see, Nature herself looks after the trees. As a matter of fact, however, several books the size of this would not be able to hold very much of the information which scientists have amassed about trees and their care. At the College at Cooper's Hill, where young men are trained for the different branches of governmental service in India, the curriculum includes a special course of lectures and classes on forestry. This course extends over two years, and has to be taken by candidates for the Indian Forests Department.

If you will think for a minute, you will realise what a vast field of research arboriculture or forestry opens out. You have only to walk in any wood—indeed, you need hardly leave the high-roads—to find trees which might be growing to better advantage. Here, let us say, is a group of pine-trees, of which the individual members are growing so closely together that already they have lost their lower branches; if the trees are not allowed more light and air they will not reach maturity. Here, again, is a tree of stunted growth; there is one which does not find the soil to its taste. Here is a fine oak which will soon be rendered useless by decay, for disease has fastened upon a wounded bough; and opposite is an elm which will not see many more winters, judging by the rotten state of its bole. Disease

COWTHORPE OAK

attacks trees quite as readily as it attacks animals, and part of the labour of the forester is the discovery of methods of prevention and cure. Equally important is the selection and growing of those trees which are best suited to the needs and climatic conditions of particular countries and districts, and the improving of trees to make them yield the best quality of timber. There is, indeed, an enormous field for the further study and investigation of trees, their habits and diseases, which it is beyond my province to enter upon here.

In Great Britain the men who look after trees are called either wood-reeves or foresters. Their business is to plant trees, to keep old plantations thinned out, the trees free from parasitic and other pests, to watch their growth and to decide when trees are in proper condition for felling. Trees are cut down in winter, when the sap in them is dormant, the wood being then in the ripest condition and most easily preserved. Very pleasant it is, on a bright frosty morning, to hear the ring of the woodman's axe, and better still to be allowed to join in the exciting game of bringing down the giant. Tree-felling is dangerous work, although the woodman knows exactly in what direction and at what moment the tree will fall. A custom that has grown up in England, and has been in vogue for many centuries, gives to the landlord the right to the trunk of a fallen tree, the lesser boughs to the tenant, and the chips to the 'chipper,' that is, to the woodcutter.

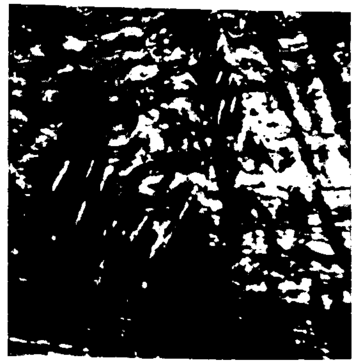
After the trees are felled they are stripped of their branches, and sometimes of their bark, and allowed to lie where they have fallen, propped up so that they are off the ground, for some months. In time come the hauliers, with their beautiful team of horses and their curious trollies. They bring with them special tackle for lifting the tree-trunk, and cart it away to the sawpit, where it is split up into baulks or planks either by hand or steam power. In some parts of England portable engines fitted with sawing machinery travel about from one place to another, after the manner in which threshing-machines pass from farm to farm. In this way the cost of carrying timber to the sawmills, perhaps long distances away, is avoided; and the wood is wrought into its final state close to the spot where it grew. These are the primitive methods of dealing with the small quantities of timber felled in Great Britain. In other parts of the world, where trees are cut down not by ones and twos but by thousands, elaborate machinery saws up the trunks and prepares them for market; and we shall visit a great sawmill in the next chapter.

After the tree has been sawn it has to be seasoned; and on the thoroughness with which this is done, and the means adopted for doing it, the durability of the timber largely depends. If you visit a sawmill or a builder's wood-yard, you will see planks of timber arranged in stacks, with spaces left between each plank. This is the natural method of seasoning, and the best. The planks are arranged in horizontal layers with air spaces between and around them, and are allowed to remain thus for six months or longer, to allow the sap completely to dry out of them. They are of course covered up, so that the rain cannot get at them. When the proper time comes the stacks are taken down, the planks are arranged in vertical layers and left for another six months to complete the seasoning. The wood is then ready for ordinary joinery work; but for cabinet-making it is thought necessary still further to prolong the drying, with which object the wood is put in ovens or cylinders heated with steam to a high temperature. Owing to the long time which passes before wood is fit to be used when seasoned naturally, and to the increase of price caused by the cost of storing it for a year or more, timber users have for long been trying to discover a shorter and cheaper method by which it can be seasoned. One process sometimes adopted is to steam or boil the wood for several weeks; but it is only serviceable when the wood is not required for purposes where durability is necessary, and it is generally thought that no artificial process will ever succeed in doing away with the more lengthy natural one. It is of course very important that timber should be thoroughly seasoned. Unless all the sap is dried out it is liable to decay, apart from the fact that wood that is still sappy is very difficult to work up with tools.

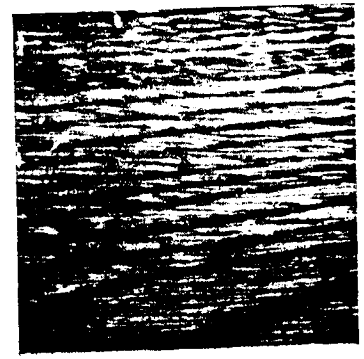
Builders and joiners, and, indeed, all those who have much to do with wood and wood-working, are able to tell from the appearance of wood whether it is good or bad, and whether it has been properly seasoned or not, while they can also tell from what part of the tree it was cut. To be able to discover these things by merely looking at a board requires, of course, the expert eye—and nose, for timber is judged by its smell as well as its appearance; and the expert eye and nose are only acquired after long practice and experience. Generally speaking, the amateur is able to select fairly sound timber by paying attention to a few simple and common-sense rules. He should discard boards of soft woods, such as pine and deal, which show a very wavy or uneven grain, many knots, and a great deal of turpentine or resin. Sound timber, which has been well seasoned, should possess the smell which is peculiar to the tree from which it was cut; for instance, wood of the pine-tree will smell of resin, and oak will have the acrid odour of tannic acid; it should be firm and close-fibred, and should show a soft silky lustre after it has been planed. Wood with a natural 'twist' and that which seems soft and sappy should be carefully avoided.

Almost every schoolboy if asked the question, 'Which is the most useful tree?' would answer, without hesitation, 'The British oak'; and they would be quite right, although, strictly speaking, there is no such thing as a 'British' oak. The common oak of our country-side is one of two closely allied kinds which are distributed all over Europe. These two varieties of the common oak can only be differentiated

Red Deal or Fir



[illegible] Brown Oak



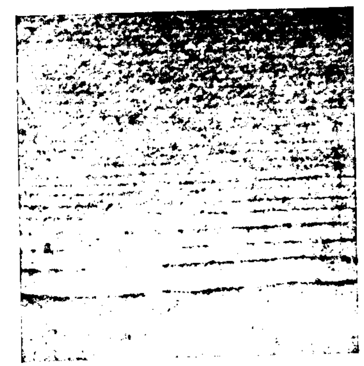
Stettin Oak

Californian Red Wood

Teak

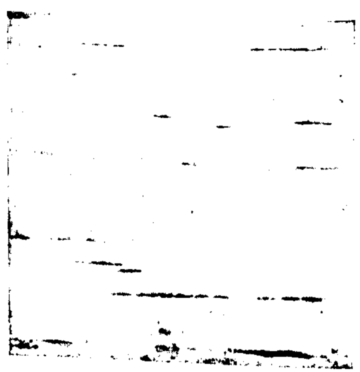
Spanish Mahogany

Ash



White Deal

African Mahogany



Canadian White Pine

Pitch Pine

[illegible] W[illegible]

PHOTOGRAPHS OF VARIOUS WOODS SHOWING DIFFERENCES OF GRAIN by the critical observer, although they present strongly marked differences, and may sometimes be seen growing side by side. Next autumn, when the acorns are on the trees, you should remember to look closely at the trees to see if you can discover this difference, although it may happen that only one variety grows this: one variety, called *quercus robur pedunculata*, in the district in which you live. The difference is has stalkless leaves or leaves borne on very short stalks, and carries its acorns on long stalks, while in the other, *quercus robur sessiliflora*, just the opposite occurs, the leaves having long stalks and the acorns none at all, or only very short ones. By noticing little peculiarities like this, not only in oaks and other trees, but in flowers and birds and rocks and stones, and even men and women, we are able to derive much pleasure and interest which is lost to other people, and at the same time gain for ourselves a reputation for using the powers of observation with which nature has endowed us.

I remember how, some years ago, in the Botanical Gardens at Edinburgh, my own ignorance of a subject in which I thought myself fairly well versed was brought home to me. I was wandering through that section of the garden called the Arboretum, in which the different trees are grouped according to their families, when I noticed a beautiful little oak tree with leaves much bigger than any I had previously seen. I wondered to what country it belonged, and said so to a companion. 'Pooh!' said he; 'that's not an oak, it's a broad-leaved maple. Am I not right?' turning in inquiry to an official of the gardens. 'No, sir,' said the official; 'that is so-and-so, an oak from Japan.' 'Oh!' said my companion; 'what then is this tree?' pointing to one near by. 'That,' was the reply, 'is another oak—also from Japan.' 'And this?' (pointing to another tree). 'Also an oak, sir—so-and-so from such-and-such a place.' 'And this?' 'All the trees in this quarter are oaks, sir,' said the official, who was getting tired of answering questions. 'Dear me!' said my companion, 'I had no idea that there were so many different kinds of oaks!' I thought that my turn had come to show that I could impart information on the subject, so I said: 'Very few of the oak species are in these gardens, for there are altogether about a hundred different kinds.' 'How many species did you say there were, sir?' asked the official, who overheard. 'About a hundred,' I repeated. 'I think, sir,' he said with a smile, 'that you will find that there are about three hundred *known* species of oak.' The emphasis on the *known* was cruel, and I felt that I disliked the practice of planting well-informed officials among the trees in Edinburgh Botanic Gardens; for the official was right and I was wrong.

Of all the trees in the world I think that the oak must come first in point of general usefulness. Although there are trees which are harder and tougher, better able to resist the attacks of insects and climatic changes, there is none that can beat the oak for all-

round utility. It must be said against the oak, however, that its timber is variable in quality, depending for its strength and durability on the soil in which it is grown more than any other tree perhaps. Of the marvellous durability of good oak there can be no two opinions. I am living in a house which was built in the sixteenth century and is now nearly four hundred years old. Yet the original timbers, even in positions exposed to the rains, frosts, and winds of centuries, are still perfectly sound. When the house was built the spaces between the horizontal and upright beams in the outer walls were filled with what is called 'wattle and daub,' which is much akin to the modern lath and plaster. In time the wattle and daub decayed, and brickwork was put in to take its place. Presently the brickwork succumbed to the influences of time and was replaced with stonework. Throughout these changes the old oak stands firm, supporting the whole fabric of the house, and I do not think it is likely to give way for a century or two yet awhile. I question whether the steel girders, which the modern builder prefers to dear good wood, and cheap bad wood will bear their burdens as nobly as my old oak beams have borne theirs. Our forefathers may have known but little of the relative strengths of materials, but they took good care to be on the safe side.

Oak has been used for shipbuilding for centuries. It is said that it was first used in the British navy by King Alfred, the founder of that great institution. It is used largely in the construction of railway carriages and wagons, for general constructional work, and for a hundred and one purposes where a wood of great strength and durability is required. The bark of the oak provides the tan for the tanning of leather, and once was used, and I daresay is still, for dyeing. Although the fruit of the British acorn is not fit for human food it is readily eaten by pigs, and until quite lately it was thought to be a good food for all kinds of cattle. In 1911, however, the acorn crop was extraordinarily plentiful and grass was scarce, so that horses and cows were obliged to eat the acorns. In some places they ate more than was good for them, and it was reported that one farmer in the Midlands lost two thousand pounds' worth of cattle by acorn poisoning. In some parts of the world acorns are good to eat; and some of us may think that it is a pity that the Maana oak, which comes from Persia, cannot be acclimatised in Britain and planted in every school-field. This obliging tree, we are told, secretes in its leaves a sweet juice which provides a most delicious sweetmeat; but this sounds almost too good to be true. Most of us, I think, would rather have this variety in our gardens than the species that supplies the useful but unattractive gall nuts, or that which is grown for its cork, or another for its dye. If I wished I could copy for you out of a big book a long list of oak-trees which have commercially useful products other than timber, but I do not think that such a list would interest you.

One of the attributes of the oak that has endeared it to all peoples and all times is the great age which it is supposed to attain. I say supposed to attain, because we have no actual records of the age of a tree beyond a few hundred years or so, and can only judge a tree's age by comparing its size with one which we know to be a definite age. For instance, the King's Oak in Windsor Forest—a tree that is said to have sheltered William the Conqueror—was probably not much less in girth in ten-sixty-something than it is now; and the historic oak at Cowthorpe near Knaresborough, which is nearly fifty feet in circumference three feet from the ground, is thought by those who consider themselves good judges to have come into existence some two or three hundred years after the dawn of Christianity. Assuming these calculations to be correct within a century or so—and, mark you, no one says that it *is* as old as that, but merely that it may well be—the Cowthorpe oak must have celebrated his thousandth birthday during the reigns of one or other of the Tudor kings of England. To my mind there is something quite appalling about the thought of that hoary yet living wreck of a monster at Cowthorpe. I should not mind if his veins were not filled with living cells as mine are; if, in a word, I had not to own him to be some sort of a primitive relation. He makes me think of a retort I once overheard in the grounds at the Crystal Palace, in which are some admirable reconstructions of prehistoric beasts. A young man directed the attention of a fair lady, his companion, to a particularly hideous dinosaur, with the unfortunate remark: 'Do you realise that that fellow is a distant ancestor of yours?' The girl looked at the creature for a moment, and then said, 'Well, if he's my ancestor, I should like to see one of yours!'

What changes in the manners, customs, and speech of the people must that old tree, and all old trees, have seen. Who knows but that some of his branches and twigs may not have helped to make the fagots for the burning of some Christian martyr or some wretched hag condemned to die for witchcraft? Who knows what he thinks of the march of Time? Or what strange friends were his—skin-clad, woad-stained men—Druids who made to him sacrifices of human flesh, wolf and wild boar, and, perhaps, the bear. These he has changed for men and women, different in build and nature but just as strangely clad. And the snort of the boar has given place to the snort of the 'road-hog,' a different genus altogether; and for the birds he once knew, a weird thing with great outstretched wings which it cannot fold, and a whizzing, whirring tail, may now circle over him. The strangest thing of all is that he himself has not changed with the changing ages, except to grow a little stouter and rather infirm.

We still venerate the venerable oak, because of all our native trees it is the most noble. But there are others in comparison with whose age the oak is a mere chicken. The yew is said to live for 2880 years, though why it could not have made it 3000

or even 2900 and have ignored the odd tens is not quite plain. The dragon-tree is remarkable among all living things in that its span of life, if not actually unlimited, is at least beyond the power of man to discover. It is remarkable also among trees for the peculiar and unorthodox manner of its growth, and for its gum, the dragon's blood of commerce. There was, until about forty years ago, a very wonderful dragon-tree in the island of Teneriffe. It was about 75 feet high and 50 feet in circumference, and had a vast cavity inside. It was calculated by comparing its rate of growth with that of younger trees, that its age was probably not less than *five thousand years*, and was more likely to be nearer six thousand. Now comes the anticlimax. This prodigious dragon was blown down after having withstood the gales not of centuries merely, but of millennia. Most dragons, one would think, would rather be hacked to death for the sake of their blood than suffer such a humiliating fate as befell their kinsman of Teneriffe.

What were we talking about before the dragon led us astray? Ah! oaks, to be sure. Well, what shall we talk about now? What tree comes next in order of popular favour?

> The oak and the ash and the bonny birchen tree,

sings the ancient songster, who seems to have forgotten all about the elm. I think we might take the elm now, if only because the poet has ignored emblem of the universe we may just outline its conception as the Yggdrasill. Its branches spread all over the world and reached to the heavens. It had three roots; one of which stretched to the nebulous world in the far North, from which our earth was thought to be partly formed—a terrible region of icebergs and chilling vapours; another root went into another world, to the fountain of wit and wisdom; and the third to a third world, in which was the sacred fountain of the past. The gods lived in the third world, and they rode daily across the bridge formed by the rainbow to the fountain. At the fountain dwelt the three fates, the Past, the Present, and the Future—the Norns they are called in Scandinavian—who wove with strands of golden thread the destinies of men's lives. From East to West stretched the Norns' thread, 'from the radiant dawn to the glowing sunset of man's horizon.'

For centuries after the Yggdrasill had ceased to have any significance the ash was regarded with superstition, even in England. An ash herding-stick had power to drive cattle where they were required to go, without effort of the herdsman. Ash sap was given to babies with their first food, under the belief that it would guard them against harm from witches, fairies, and other supernatural forces; and in some parts of England the adder was attacked for preference with an ash stick, which had power to kill it with a single blow. Even to-day, in the district in which I live, it is 'unlucky'

to chop or burn ash wood; though I have tried the experiment of burning it many times, not to test its magical powers, but because of all fuel it makes the brightest and most cheerful fire.

The timber of the ash is much used for carriage building, for constructional joinery, and for the handles of striking tools, such as hammers, axes, spades, and forks. It is white, close-fibred, tough, and durable, but not very easily worked. Some kinds of ash are finely figured, and are used for making furniture. Hungarian ash is beautifully marked, and can be worked to a fine finish, and is used for inlays and other decorative purposes.

I have no doubt that there is in your household one of those round wooden platters with 'Bread' carved on it, presumably so that people shall know that its purpose in the world is to hold bread, or perhaps that it is bread to which they are helping themselves, and not butter or cheese; at least I suppose that is the object of the legend. Neither do I doubt your knowledge of the fact that these platters are often made of beechwood. But I do doubt whether you have ever realised that beechwood takes the place of leather in the shoes of many thousands of your fellow-countrymen, and of many more thousands in other countries. In France, Belgium, and Holland shoes carved out of a single piece of wood, and called 'sabots,' are largely worn by the peasantry. These wooden shoes are generally made of beechwood in preference to any other, because the closeness of beech fibres makes the wood practically water-tight. Some little time ago, when passing through an English beech-wood, I saw stacks of neatly sawn little blocks, all ready to be made into clogs for the mill lasses of the industrial north. The clogs are not always made entirely of wood, like Jaques' *sabot*, but have leather 'uppers' and beechwood soles.

Of course, as we should expect to be the case, a majestic forest tree like the beech, which sometimes grows to be a hundred feet high, has more important uses than the making of clogs and sabots. It is largely used in furniture making, for turnery, such as bowls and a hundred articles which are shaped in the lathe, and for planes and carpenters' marking gauges. The beech-woods of Buckinghamshire are famous, and have given rise to the great chair-making industry of High Wycombe in that county. Between one and two million chairs are turned out of the factories at High Wycombe every year, as well as a great quantity of other furniture. Buckinghamshire's name may possibly have come from the beech forests that covered it at one time, through the German word *buche*, meaning beech; but this is by no means clear, for some authorities trace it to the Anglo-Saxon *buc*, a buck or male deer.

Beechwood is not very much used except for the purposes just mentioned. It is extremely hard and close-grained, easily worked. Unlike most woods, it can be planed across the grain, and is not given

to warping when well seasoned, a very important property, and one which makes it useful for tools. It is, however, rather brittle, and liable to decay rapidly.

In oak, ash, elm, and beech we have dealt with the four principal home-grown trees. Walnut, you will say, has received no mention. But the walnut grown in Britain is not of commercial importance, and you are not likely to want to use the foreign variety which is imported by cabinet-makers. Then there is the lime; what of that? Well, there is not much to be said about lime, beyond the fact that it is a very white wood, soft and easily worked, and much sought after by wood-carvers, who can only obtain it in small quantities. There are also the sycamore (the sycamore we know, by the by, is not the *real* sycamore; this grows in the East, and is a sort of fig-tree), the maple, and the plane, and we can dismiss these with mere mention because they do not supply useful timber, the maple which is used by cabinet-makers coming to us from Canada. Leaving out the willow and the poplar, the hornbeam and the hawthorn, we have left the holly, the box, and the yew. The holly, so dear to us from Christmas associations, supplies a wood which is much prized for its colour and its texture. It is beautifully white and silky, hard and close-grained. It is used for wood-carving, sometimes for tool handles, and—one of the little things we seldom think about, but which yet have to be considered and settled to the best advantage by somebody—for the handles of metal teapots and hot-water jugs, because it is a good non-conductor of heat. The box is one of the hardest of all woods. It has a pretty yellow colour, and can be highly polished. Like holly and beech, it, too, is used for tool handles, but in days before illustrations for books and newspapers were engraved on metal by chemical and photographic processes, boxwood had a wider application, for it is the most suitable medium for engraving woodcuts. Box trees do not grow big enough in England to supply much wood, and what is required for the few purposes to which it is now put is mostly imported from Turkey.

The yew-tree should be endeared to all of us, because it was the tree from which the bowmen of old England cut their bows. Nowadays it is not of much use except to wood-carvers and as an ornament to old-fashioned gardens, and in some counties, as in Kent, to the common hedgerows. It is one of the most slow-growing of trees, and attains a great age. There is a specimen in Darley Dale, in Derbyshire, which is said to be 3000 years old, and there are others which are said to have surpassed even this prodigious longevity.

The last three trees—the yew, the box, and the holly—are evergreens; while the other trees, such as the oak and the ash, are deciduous, so-called because they shed their leaves in winter. We have yet to speak of the great class of trees called conifers, which includes the pines and the firs. From the commercial

point of view the conifers are the most valuable of all trees, because they supply the bulk of the world's timber. As but few of these trees grow in Britain, except in small quantities, let us take a new chapter, and go abroad to see them.

CHAPTER III

Around the World in Search of Timber

Two boys stood on the jetty of a little harbour on the south coast of England. Said one to the other, 'Look at that brig just turning in; I've never seen her before.'

'Nor I,' said the other; 'let's go round in the dinghy and have a look at her.' They were in the dinghy inside a minute; the painter released its embrace of a ring in the quay wall, the sculls went into the water with a splash, and boys and boat were heading for the incoming brig with the speed of pirates on a desperate errand.

They knew most of the boats that came into Littleport harbour, for they were true sons of Littleport, and had a proper interest—in holiday time—in its maritime affairs. They knew the master of the harbour tug, they welcomed the coasting schooners when they returned, and the few little second-hand steamers that brought in coal and exchanged it for fireclay. Now there had come a boat which was quite a stranger, and had to be skulled round and critically examined. A

queer-looking stranger, too, was the brig which was being taken in hand by the pompous harbour tug. She had a bright green hull with a curiously high poop, a red and yellow deck-house; and, as if to emphasise her rotundity, a heavy black strake ran right round her, just above the water-line. She was laden high with stacks of timber, and her stern bore, in scarlet characters, '*Imatra*, HELSINGFORS.'

The next day the *Imatra* began to unload her cargo, and the two boys were early on the quay side to superintend the operations, at least until such time as they should be turned off. It so happened, fortunately for them, that their friend the harbour-master was also present, under the pretence of helping to superintend the unloading. 'Captain,' said one boy, 'aren't those queer-looking ropes on the *Imatra's* deck?'

'Aye,' answered the harbour-master, 'they are; and I don't believe you'll ever guess what they are made of.'

'Of wood, perhaps!' said the boy laughingly.

Captain harbour-master whistled. 'Bless us and save us!' he ejaculated—at least, I think he did, though, of course, it may have been 'shiver my timbers'—'bless us and save us, there's no knowing what learning boys won't pick up nowadays! Wood it is those ropes are made of, sure enough.'

The boy stared. 'I didn't know they were really made of wood,' he said. 'I say, captain, you're joking, aren't you?'

'Honestly, no,' answered the harbour-master. 'They are made of wood sure enough; and I dare say from the same sort of wood as those Finns are unloading now. Finland, you know, is practically one huge forest.'

The odd-looking *Imatra*, her cargo, her crew of blue-eyed stolid-faced Finns had a new interest for the boys. What wonderful wood was this from which ropes were made! Surely, thought they, it was worth having; and before they left the quay each had picked up and pocketed one of the odds and ends of wood which became littered about during the process of unloading the *Imatra*. Some days later both boys were proud possessors of model boats which they had roughly carved from their scraps of wood; and for a long time these treasures would be brought before the gaze of admiring relatives and friends with, 'It's made out of real foreign wood, you know, the sort they make ropes of!'

This little story points a moral, which is this: It is unwise to believe a thing to be really extraordinary without taking the pains to discover whether it may not be very ordinary and commonplace. By assuming a knowledge which they did not possess the boys in our story made themselves look very foolish. By vaunting their pieces of the wood brought from Finland by the *Imatra* as something to be praised and wondered at, they simply showed themselves to be profoundly ignorant of matters that should be common knowledge; for their bits of wood, though they had

come from Finland, were no different from most other bits of wood which they might have picked up in almost any English wood-yard. You see they assumed too much on too little. The harbour-master did not tell them quite enough. He ought to have told them that some part of the cordage, not only of the *Imatra*, but of all ships, is made from the bast or inner bark of one or other of a few sorts of trees. He might have added —what would, on the whole, have been more interesting—that in Norway and Finland and in other countries some part of the bark of trees is mixed with grain, ground into flour, and made into bread. He might have told them that the *Imatra's* cargo was but an infinitesimal proportion of the timber which other ships bring into our country every day from the forests of Northern Europe; that they could hardly touch a single wooden object, from a cotton reel to the floors, doors, windows of their home, from the match that was used to light the kitchen fire to the firewood that helped to make the kettle boil, as well as a thousand other things they saw and used and touched, that did not claim their poor bits of precious wood as Scandinavian brothers. True, they were 'foreign wood, the sort that ropes were made of,' and yet—alas! I grieve to say it—they were but common deal!

I suspect that few of my readers have ever realised how utterly dependent on foreign countries we are for our timber supplies. We know that we have to buy our corn from abroad because we cannot, or at all events do not, grow enough at home to feed us all. So it is with wood. A few years ago a Royal Commission was appointed to go into this matter, and to find out whether something could not be done to afforest those parts of the British Isles which are at present not particularly profitable. The members of the Commission came to the conclusion that there are nine million acres which might be planted with trees, an area which is more than twice that of Wales, and is roughly equal to the whole of Wales and the seven English counties of Cheshire, Shropshire, Herefordshire, Monmouthshire, Gloucestershire, Warwickshire, and Worcestershire! It has yet to be seen whether the Government will act upon the Commissioners' report, wherein it is suggested that the State might in such case be put in possession of property worth about £560,000,000. The fact which remains is that we have yearly to pay to other countries a matter of £23,000,000 or more for timber which might be grown in our own.

Of this vast quantity of timber which comes to us from abroad, by far the greatest proportion is that which is cut from coniferous trees like the pines and firs. We speak generally of this timber as deal, although we ought not to, for deal is simply a board or piece of wood of a particular size. However, we shall have to perist in the use of this misnomer, since it is a term constantly used when speaking of wood. The coniferous timbers are generally called soft woods, although they are not all soft. Commercially the

most important of them are those which are sold under the names Baltic redwood and Baltic whitewood, so called because they are shipped from the ports on the Baltic Sea. Baltic redwood is the best, of which all carpenters, whether they be amateurs or not, use the largest quantities. It is very puzzling for the amateur to know which wood is what, since many have different names in different districts, and no one of them is distinctive. For instance, 'Baltic' redwood is the wood of the 'Scotch' fir, which is not a fir-tree, but a pine; the wood is not red, but of a pale, yellowish colour, and it is generally sold as yellow 'deal,' although we know that strictly speaking there is no such thing as 'deal'-wood. It is important, therefore, to remember that Baltic redwood, Scotch fir or Scotch pine, and 'yellow deal' are one and the same wood, which comes from the tree that has the proper name *Pinus Sylvestris*. It is the most valuable of the common woods, and although it is a little more expensive than the others, readers are strongly advised to use it for all structures which will be exposed to the weather, that is, for such purposes as the making of fowl-houses, dog-kennels, bicycle sheds, and the like. It is soft and easily worked, can be planed to a fine silky finish, and does not twist or warp very much when it is well seasoned. Neither this wood nor the others of its family are used for cabinet work or fine joinery, one reason for this being that the wood is too loose fibred to take French polish well.

Baltic whitewood, or as it is often called common deal or white pine, is a very inferior wood, cheap in the sense that it costs little to buy, and therefore much used. The jerry-builder puts it into his rows of cheap suburban houses in large quantities, where it is to be seen in the forms of joists, beams, roof timbers, and floor boards. This wood lacks durability, and among its disadvantages may be mentioned a tendency to split, to twist, and to tear in the direction of the grain unless worked with very sharp tools, though none but very sharp tools should ever be used on any wood. Except when it can be had for nothing out of old packing-cases, amateur carpenters should rigidly exclude it from the workshop. Two useful pine woods come to us from America. One of these is American yellow pine, which is strong and easily worked. The other is pitch pine, which is used largely for the interiors of churches, chapels, and similar buildings. It is very durable, but rather more expensive than the others mentioned. It can always be recognised by its bright colour, its strong resinous smell, and its distinctive stripey grain. If it were not that we must be getting on with the actual processes of working up the wood into manufactured articles, we might devote a very interesting chapter to the coniferous woods, their varieties and peculiarities. But if we are to say anything about the multitude of other woods which are in common use, we must leave behind us the waving pines and firs of northern Europe, and pay a fleeting visit to the forests of warmer latitudes.

Of all foreign trees which yield useful woods, mahogany is at once the most useful and the most romantic. The best and most expensive variety comes from Cuba, and is called Spanish mahogany; the next best is the bay mahogany from Honduras; and there are other sorts which, though they are not true mahogany, are so called, which are imported from the East Indies and from Africa. The chief value of mahogany lies, most of us would say, in its rich colour and appearance. It is very heavy, rather brittle, and hard to work; but it is none the less the amateur carpenter's highest ambition of craftsmanship to make some article of furniture from this beloved and expensive wood. Few of us realise how greatly finely figured pieces of the wood are coveted by the best cabinet-makers, or what high prices they are willing and eager to pay for them. It is said that single logs of mahogany have sometimes been sold for as much as £2000. Whole pieces of furniture are seldom made of it, on account of its value and its great weight, and it is more often used for veneers, although the inferior kinds—its quality varies enormously—are not more expensive than other furniture woods. An interesting story is told of how it first came to be used for furniture-making. It is said that the first consignment of mahogany that reached England came in the form of ballast in a ship from Cuba. The supercargo, thinking that the wood might be put to some more useful purpose, offered it to some carpenters, who, when they tried to cut it, were astounded at its hardness and refused to have anything to do with it. It was thereupon handed over to a cabinet-maker, who made from a piece of it a little casket. The fineness of the craftsman's work and the great beauty of the unknown wood created much interest; with the happy result that the cabinet-maker set to work to shape the remaining wood into other articles, by means of which he established for himself a fortune, and for mahogany a great and lasting reputation.

Next in importance to mahogany comes walnut, valued for its delicious fruit hardly less than for its beautiful timber. Walnut trees grow to a great size, and an old, well-grown specimen is a very valuable asset, the fortunate possessor of such an one sometimes realising £500 or more for its sale. Walnut wood does not need any description, except to say that the best of it is cut from old trees, which yield a wood which is much darker in colour than young ones, and that the value of the wood to cabinet-makers lies in its peculiar and distinctive 'veinings,' as the dark bands are called. Walnut wood is very hard and fine grained, but rather brittle and not very durable. On account of its light weight, combined with strength, it has long been used for making gunstocks. The best walnut comes from Italy and the Mediterranean countries, but much is also imported from America. The roots of walnut trees yield a wood which is even more beautifully coloured and marked than that from the trunk, and pieces of this root wood

are in great demand for carving and for making into small ornamental articles.

Apart from oak (which comes right at the head of the list of timbers, whether used for constructional purposes or decorative) and a large number of little-used 'fancy' woods, about which we will not trouble ourselves, there are only three woods that are much used for cabinet-making, in this country at all events. These are rosewood, satinwood, and teak. There seem to be several varieties of rosewood, the best known being Brazilian, and the rest Indian. The wood is very beautiful in grain and colour, and is much used for veneers and for making the better classes of furniture. It has no connection with rose-trees, although it is said that it derives its name from the fact that the wood when newly cut from the tree gives off a scent which resembles that of the rose. Like rosewood, satinwood is largely used for inlaying, complete articles of furniture being seldom wholly made of it. It is frequently used for the interior decoration of railway carriages and ships' cabins, and is a very beautiful wood. It is a light wood of a yellowish colour, and possesses a beautiful silky lustre. Teak is an Indian wood which is carefully watched and fostered by the Forests Department of the Indian Government, because it is one of the very valuable timbers which are growing scarcer every year, owing to the thoughtless depletion of forests. The wood is immensely strong and in point of general usefulness comes only after oak, than which it is less strong and less hard, but more durable in some situations. It is a very difficult wood to work, on account of a gummy secretion to which it owes some of its advantages. This gummy property of teak is said to make it obnoxious to the insects which sometimes cause havoc in other woods, so that they leave it severely alone: while it also protects from rust iron with which the wood is kept in contact. For the latter reason teak is frequently used for the backing of armour-plate in warships. This curious property which teak has of preserving iron is a direct contrast to that of oak which, so far from preserving, actually destroys iron. Iron nails are never put into oak work which is meant to last, wooden, copper, and zinc nails and fastenings being used instead.

You are unlikely ever to have much to do with teak because it is expensive and difficult to work, and there are many other woods which are more suitable for the amateur's purse and powers; but it is none the less an interesting wood, and it seems to bring with it on its long voyage from the Bay of Bengal a breath of the forests in which it grows. But to most of us probably teak has a romantic charm in virtue of its association with the elephant. You could scarcely pick up a piece of teak that had not been helped along on its journey from a Burmese forest by the modern mammoth. He is employed (on small wages, I am afraid) in the forest and at the sawmill and on the voyage down-river to the coast. He picks up a great round log of teak and carefully deposits it just where

HAULING LOGS IN A BURMESE TEAK YARD

THE RANSOME STEAM TREE FELLER

RIVAL FORCES: A CONTRAST IN POWER SUPPLY it is wanted on the saw bench; when the log has been cut into a square-sided balk it is again picked up by our friend and piled up with others in an orderly stack. He can lift a log weighing half a ton quite easily on his tusks, and can drag three or four tons over uneven ground without undue exertion. He works very hard and for long hours; and he is very good-natured and does not seem to mind not having any half-holidays. On the whole, perhaps, this is just as well for those engaged in the native teak trade, for an elephant 'on strike' would seriously interfere with business arrangements, to say the least.

So much then for the principal timbers which come to us from abroad. There are dozens more, nay, hundreds more, but they are of less use, if of no less interest than those of which we have spoken, and regretfully we must leave them out of this book altogether. Some day, perhaps, when men know more about these lesser denizens of tropical and subtropical regions, some of them strange, many of more exquisite beauty than any woods we now know, these trees that we here ignominiously dismiss without names may have a book all to themselves; and I am by no means sure that this book, when it does come (it is now long overdue) will not confer a very great and lasting benefit upon the million arts of men.

I suspect that every schoolmaster who asked his class the question, "Whence come our principal supplies of timber?" would not have to wait long for an answer. Russia, Finland, Norway, Sweden, Canada—the names would be tripping over one another in their frantic hurry to be heard. But if the question were altered to which country has the largest timber resources, I am not sure that the answer would be half so ready. Canada, you think? I think so too, for I know that of the estimated area of 3,000,000,000 acres of the world's forest lands, Canada (including British Columbia) can account for no less than nearly 800,000,000 acres, and that the United States comes next with 545,000,000 acres. But this does not convey very much to our minds, for of these vast areas of forest millions of acres are of no commercial importance at all. They may consist of the wrong kind of trees, or they may be inaccessible; and when we are told, as we are too often told, that Canada has more timber than all other countries combined, we must not believe it, but reject the statement as worthless and impossible. Ridiculous people are ever ready to make ridiculous statements, and we are too often willing to accept what they say without regard to common sense. A foolish writer once suggested that Aristotle believed the bat to be a bird, and generations of still more foolish writers believed that Aristotle believed a thing which Aristotle was far too deep a thinker to believe. So it is with the forests of Canada; and when next you read or hear that Canada has the greatest amount of merchantable timber in the world, you may say—mentally of course, so that you may not hurt anybody's feelings—"Rubbish, nobody knows accurately

how much merchantable timber there is in Canada." No statements, whether founded in fact or imagination, as to Canada's resources can alter the indisputable fact that the lumber industry of Canada is a great and prosperous one, likely soon to become more prosperous still. We in Great Britain, who grow no timber to speak of, and cut less, we who import roughly as much as any other three nations put together, not because we use more of it, but because we have no timber resources of our own, have no conception of the magnitude and importance of the Canadian lumber trade. Doubtless you have read exciting stories of the exploits of the lumberman; how he climbs a two-hundred-foot tree with an axe in his belt, in order to cut off the top so that the living tree may serve as a support for the aerial ropeway by which the logs are hauled; how he courts what looks like imminent destruction by walking unconcernedly over huge rolling logs floating in the river; and how he balances himself on the flimsiest of makeshift platforms while he wields the saw which brings about a giant's downfall; how great is his dexterity with the axe, and how small his fear of the perils of his calling; of all these things we have read, and I think that as we read there arose in the breasts of most of us a strong desire, well—if not actually to join in the fun, at least to be allowed to look on from a safe distance. What do you say then to a short trip to a Canadian forest, now, while we are on the subject? A good idea! Let us get up steam first in a mental steamer—puff!

we have crossed the Atlantic in a flash and are steaming up the St. Lawrence River. More steam to be got up, this time in an imaginative locomotive of unheard-of power and speed (we drive it ourselves, so we ought to know), and with screaming whistle and jangling cow-bell we race over the Prairie and snort up the Rockies and down again, and can only contrive to bring up, such is the curbless spirit of our engine, within a foot or two of the Pacific Ocean! This is a nuisance, for we have to walk back a considerable distance into the forest. *What forest?* Well, any forest; we are in British Columbia, you know, and we do not need to go far to find forests there.

What a wonderful sight is that upon which we now gaze. Trees, trees, trees as far as the eye can reach, stretching away in every direction without a single break. The dim light of the vast forest, the mournful murmur peculiar to conifers, the absence of the birds' song, the absence of every sound we know combine to create in us a very eerie and rather terrible feeling. This dim, moaning world into which we have come seems more lonely than the deepest coal-mine or the remotest snow. How easily it could swallow us up! We remember the stories of explorers who have been lost in similar forests, of pioneers perished beneath the awful whisper of the pines.

It is not until we are actually in touch with the woods of the north-west that we realise what a magnificent, nay, what an awe-inspiring thing is an

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FIXING CABLE FOR THE LIDGERWOOD "FLYING MACHINE"

The first stage in the construction of the aerial ropeway is the fixing of the cable from which the logs are suspended. A suitable tree is selected for carrying the rope, which is fixed 7[illegible] feet or more from the ground by a man who, armed only with an axe and climbing irons, first cuts off the top of the tree.

army of tall pine-trees. The dignity of their immense height, the virility implied in their straight clean stems,—there is something irresistible in the call of the woods, that he who has never seen nor heard will never see nor understand. Imagine, if you can,—it is a thing not lightly to be accomplished—trees, not one, not two or three, but thousands of trees, miles of trees, each taller, taller far than any trees you have ever seen in this country; taller than the spire of your church, taller than the spire of Canterbury Cathedral, of Notre Dame, of exquisite Ely,—trees so tall that some of them would overtop the three-hundred-foot spires of Norwich and Lincoln. Think of this when next you buy a piece of yellow pine, my budding carpenter, and have a little pity in your chisel-hackings and saw-scrapings, and remember that your little-valued board came (probably) from some giant who lived for mournful centuries in the dim solitudes of a vast Canadian forest.

But let us push into our forest. We come at length to a clearing; a collection of wooden huts and a railway, an aerial ropeway perhaps, and other signs of inexorable civilisation among the trees. Nature has been storing treasure in the woods for hundreds of years, and now man has come to claim this treasure. He has found the trees that he knows are valuable, he has been joined by other men; together they build a railway to Nature's treasure-house, unless, indeed, as sometimes happens, Nature gives them a golden key in the shape of a navigable river; for timber, common timber at least, is of no value to anybody unless it can be easily and cheaply transported to the markets of the world. Now we can see these men at the goal to which they have fought their way; we hear the sharp click of the axe, hear the rasp of the saw, hear the shouts of the pigmies as they battle with the giants, and yes! bravest thing of all, see with our eyes, feel with all our senses the awful carnage of the warfare.

What should we do if we wished to fell a tree? Do you think that we should 'borrow' axes, and hack our tree down, assuming, of course, that our tools were not prematurely taken away from us? Of course we could bring him to the ground in that manner, but being unskilled in its use we should find that our axe was a particularly heavy and unwieldy instrument. Of course it is more romantic to fell a tree with an axe, but I think that the saw would help us more easily to attain our end,—the big cross-cut saw with teeth like M's upside down is the tool which is generally used for wood-felling, although the axe is none the less an indispensable member of the woodcutter's outfit. A tree which is to be felled is first undercut with the axe, that is, a hole is cut in with the axe on the side on which the tree is to fall. Then come the sawyers, who cut inwards to meet the gap made with the axe, small wedges being inserted behind the saw to tilt the tree in the direction in which it is decided that it shall fall. This is the general

method, but there are variations in different parts of the world.

The most graphic description which I have ever read of the actual fall of a great tree was given by a writer in *The Times* for May 24, 1911. It made my blood tingle to read it, and, indeed, none of those who picture the scene can remain unmoved by the thunder of the monster's fall:—

'Rhythmically and unconcernedly, the bodies of the two men standing on those narrow boards[1] swing on until the teeth of the saw are but a few inches from the under-cut. Then from one the ringing cry goes out (like the "fore!" at golf), which warns all within hearing to stand clear—"timber-er-er!" A moment later the tree begins to creak, and you see the thin slit made by the saw gaping. Slowly it yawns wider; the remaining fibres tear with a crackling like the sharp sound of thunder close overhead. You are aware that the two men have slipped from their boards to the ground; but your eyes—all eyes within range of vision—are up aloft, where the gigantic plumed head is slowly wheeling against the sky.

[1] This description is written of a British Columbian forest in which the trees are felled about eight feet up from the ground, because the extra girth of the spreading butt or base of the tree adds enormously to the difficulties of transporting the timber. The men who work the saw stand on boards fixed in holes made in the tree a few feet from the ground. 'As the keen-toothed saw eats its way into the wood they necessarily have to shift their positions, when, without interrupting the rhythmical movement of the saw, by a little skip and kick of the feet, they shift the plank on which they stand, not disengaging the one end from its niche in the tree-trunk, only causing the outer end to move an inch or two at a time through the arc of a circle in the air': so the writer quoted above.

So slowly it goes at first! Then, quickening, with a roar, deafening and indescribable, it seems to fling itself outward and away from the place where it had stood for centuries, and, stripping, breaking, crashing through the smaller trees, plunges, almost like a diver, to the ground, striking it so that the earth shakes for a quarter of a mile around, rebounding visibly, the whole huge bulk of it, into the air, amid a cloud of dust and debris and of the falling limbs of other trees through which it has ripped its way, only to sink back again and lie, measuring its length a hundred yards or so along the earth.'

It takes two expert sawyers half an hour or more to fell a tree about four feet in diameter, if the tree belongs to the soft woods, such as pine and fir; if a hard-wood tree like oak has to be felled it takes of course much longer. In order to reduce the time taken in tree-felling steam-driven saws are often used. Messrs. A. Ransome & Co., Ltd., of Newark-on-Trent, have been kind enough to lend me the photograph which appears at page 66. It shows the Ransome patent steam tree-feller actually at work, a very ingenious machine, which is light and portable—it can be carried about by four men—and is almost incredibly rapid in its action, for it can cut down an oak-tree three feet in diameter in less than five minutes. Attended by its gang of four men, one machine will with ease fell eight trees, averaging two feet six inches in diameter, in an hour, including the time occupied in moving and fixing it. It can fell

AN AERIAL ROPEWAY IN EAST AFRICA

This ropeway was built by Messrs. Adolf Bleichert and Co. [illegible] trees in any position, will cut them off quite close to the ground, and can do (so its makers proudly affirm) more work than thirty woodmen! Altogether I think that the Ransome patent steam tree-feller ought to have a prominent place in the list of ingenious appliances which, while working for us out of sight, contribute largely to our comfort and help to protect our pockets.

This little machine, which can accomplish so much in so short a space of time, is quite an insignificant affair as machines go, and its capabilities for hard work are out of all proportion to its size; for a Ransome steam saw which can deal with trees four feet in diameter weighs only five hundredweight. The manner in which it works is interesting. It consists of a steam cylinder of small diameter, having a long stroke, attached to a light wrought-iron frame. In order that the saw may have free travel as it cuts its way through the tree the cylinder is pivoted to the frame, which is, of course, firmly fixed to the ground and incapable of movement. The saw—which may be nine or ten feet long—is fixed directly to the end of the piston-rod. The saw thus moves rapidly backwards and forwards as steam is admitted first to one side of the piston and then to the other. Of course a special type of saw is used, with teeth so shaped that they cut only on the inward stroke. A portable boiler is brought into the forest, and one boiler may feed several saws working on different trees at the same time, the steam being supplied through flexible pipes. Large saws are sometimes used, capable of cutting down trees up to seven feet in diameter.

Having brought low our tree, the next thing to do is to carry it out of the forest to the sawmill. A tree which is four or five feet in diameter at the butt-end, and between two and three hundred feet long, is not a thing to be carried about under one's arm, and must therefore be cut up into smaller logs, which can be moved more or less easily. First of all we cut off the top (or 'blossom,' as it is picturesquely called in some parts of Canada), strip off the branches, and saw up the trunk of the tree into logs from twenty to thirty feet long. Such logs as these will weigh anything from fifteen to forty tons, according to the variety of wood, the amount of moisture contained in it, and, of course, the girth of the log; and I think that most of us, were we confronted with the necessity for moving for half-a-mile or more such a weighty and cumbersome thing as one of these logs, should find the problem rather a puzzling one. But the lumberman and the engineer—the world would cry in vain for its timber if it were not for this partnership—like moving heavy things, and make no more bones about the business than the boneman of his bag. Needless to say, mechanical power has to be used for moving the huge logs, unless, indeed, the ground on which the trees grow is on a slope, in which case they are probably cut into much shorter and lighter lengths, and rolled down the hillside or shot down a chute.

In most cases, however, a track or 'skid-way' of logs, laid closely or firmly side by side, is constructed from the railway or waterway to the particular part of the forest in which the lumbering is carried on. Along this track the logs are dragged by giant chains, or ropes wound round a drum, worked by a portable engine. The chains, of course, have a limited length —three or four hundred yards, perhaps—and if the distance over which the logs have to be 'skidded' is longer than this, two or more winding engines have to be used. If the communication with the sawmill is by water, the logs are simply shot down a chute into the river when they reach the end of their painfully bumpy journey along the skid-way. Man's indebtedness to Nature is always before our eyes, so that we may never forget it; and it is worth while to remember that many of the natural products most indispensable to our daily lives are found just where we should like to find them. You know that iron ore is useless unless we have the coal wherewith to smelt it, and that these commodities are frequently found next to one another in the earth; but it may not have occurred to you to notice the fact that those parts of the world which are richest in forest lands are also generally well supplied with rivers. The rivers may not be navigable in the sense in which we commonly use the word, but they are quite serviceable for floating timber from the forest to the factory.

The Canadian lumberman, and the lumberman of other countries for that matter, is as much at home with his logs whether they are on land or in the water. The competition called 'rolling the log' which sometimes has a place in the programmes of regattas and water sports in England would be child's play to the lumberman, who walks about on floating logs with greater ease and complacency than you or I can walk about on one, even when it rests on dry ground. It is true that he has great spikes in his boots, but a floating log is an awkward customer to deal with as it rolls and bobs about, and it requires great skill and long practice to be able to keep one's balance, and at the same time to wield the long spiked pole with which the lumberman steers now here now there, pulling this one in or pushing that away, and by degrees getting his logs together so that they can be made into a gigantic raft ready for floating or towing down the river to the mill. The 'skid-way' of which I spoke just now has one grave disadvantage, inasmuch as it requires for its construction an enormous quantity of sound timber which could otherwise be sold, and much time and money have to be spent in clearing and laying this track before the proper lumbering operations can be started. I think that I have read that the only roads worthy of the name to be found in some parts of eastern Russia and in Siberia are those made of tree-trunks cut from the never-ending forests, and laid side by side to form a track, over which a journey in a rude, springless 'boat on wheels' involves a torture never forgotten by the unhappy traveller who makes it. Such wooden roadways

were laid down many years ago when timber was not so valuable, and nowadays the man who has a tree-trunk prefers to sell it if he can, and with the proceeds to make a road of metal, over which he can take other tree-trunks to market. A wooden roadway is a very desirable thing, and a very costly thing, but most of us prefer the trunks to be cut up first into paving blocks. The lumberman wants the cheapest and most efficient roadway to his trees, and he often makes it of metal, by which, of course, I do not mean the road-maker's 'metal' of stones, but the metal of steel. A railway, then? To be sure, a railway, but not the sort of railway you mean, for it is hung up in the air instead of being laid upon the ground.

When lumbering operations are being carried on on a large scale some form of aerial railway, or, more correctly, of aerial ropeway, is generally laid down (hung up, rather should one say) in preference to the old-fashioned skid-way. Indeed, when mountain forests are being felled an aerial ropeway, by which the lumber can be carried to the river or railway in the valley below, is almost indispensable. Sometimes these are very substantial and costly erections. One built recently in German East Africa cost £75,000. Its building took three years to accomplish, and involved some very interesting engineering problems into which we cannot enter here. It was built in order that cedar wood from the forests nearly 7000 feet up in the mountains might be brought down to the railway for transit to the coast.

Doubtless, most of my readers know what an aerial ropeway, or telpher, as it is sometimes called (look up 'telpher' in your dictionary; its derivation will interest you), looks like, and how it works, but for the benefit of those who have never taken the trouble to enquire, I may explain that a strong steel rope, made up of many strands, is stretched between steel towers to support it. This ropeway is the equivalent of the rails of an ordinary 'terrestrial' railway, for on it run little trucks on grooved wheels. The cars in which the timber, or coals, or even, in some cases, human beings, travel are suspended from these trucks, or 'carriages' as they are called. You can understand that if the cars rode unattended and unchecked on the ropeway they would soon be hurled to destruction, for the gradients on these aerial lines are sometimes terrific. Each car is therefore hooked on to a traction rope which runs immediately below the main rope from which the cars are suspended. This rope is endless, and passes round revolving drums at each end of the line. It is always moving, sometimes as fast as 500 feet a minute, and the cars are attached to it as they are loaded. Generally, the only force required to work these railways is the force of gravity. In other words, the weight of the loaded cars coming down hill is more than sufficient to drive the rope with sufficient power to carry the empty cars up to the top again. Sometimes, as when the ropeway has to cross a ravine, the span of the suspension wire between two supports is very great—it may be over

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A TRAIN OF GIANT LOGS LEAVING A BRITISH COLUMBIAN FOREST

2600 feet or more—and a ride in one of the slight-looking cars in which the logs are carried over a mountain line, on which there are big spans, is a very exciting experience. Describing a journey on the aerial railway in East Africa which I mentioned just now, a writer in *The World's Work* recently gave a graphic account of his sensations. He says: 'One involuntarily clung more tightly than ever to the slender-looking car as we swung off the lower mountain and were being slung out over a deep valley. The weight on the rope gave one the impression of falling as the car whizzed down the sag. The engineer was very comforting. If anything broke in the middle we should have a good dive of about 550 feet through the air before we landed in the jungle. . . . It was like being whirled up in a lift, and the sensation of swinging gently to and fro was certainly liable to make the hair rise.' The aerial railway of which this is written has on one section the terrific span of 2950 feet, and on another the steepest length of aerial cableway in the world; the line makes an upward jump of 1750 feet, and the car rises 85 feet every time it travels forward 100 feet.

There is another form of aerial cableway which is a toy compared with that just described, although I am not sure that one ought to call 'toy' a thing that can pick up and carry about, as though they were straws, giant logs perhaps thirty or forty feet long, and of many tons weight. Yet this is what is done by the Lidgerwood Cableway Yarder, a form of aerial ropeway which is very popular in America for shifting lumber for short distances. It is much less substantial than an ordinary aerial railway, and can be moved about from place to place. This machine is generally used on level ground, and as gravity is not available for hauling the cars, steam engines are used instead. The chief interest of the Lidgerwood Cableway Yarder lies, however, in the fact that the suspension rope on which the cars or trollies travel is actually fixed to the trees of the forest in which the timber is being felled, and there is thus no necessity for costly and elaborate towers for supporting the rope. The log is not carried in a car, but is picked up and hauled along by tongs which hang from a steel rope, which lowers or raises them.

The writer in *The Times* whom I quoted a little while ago says of this 'flying machine,' as it is called in the woods: 'Out runs the little carriage nimbly into the woods, until, some 700 feet away, it is almost lost among the trees. It stops, and the tongs, which have been swinging below it as it ran, are seen to lower themselves to the ground. Out there two men —only two—are waiting; and they are known as tong-hookers. There is only a delay of a few seconds before one of the two, perched on a stump, where he is in sight from the engine, gives the signal to haul away, and again the tongs rise, but this time they lift with them into the air the end of a mighty log. A moment more and the log is careering towards you, one end aloft, the other bumping and trailing on the ground, advancing with great kangaroo leaps, snapping waist-high a 10-inch tree that stood in its way, ploughing through the brush, grinding to pulp a windfall log that lay across its path, plunging into a pool of water and throwing mud and water in fountains 20 feet into the air. The awful devastation that it makes tells the weight of it; otherwise it is hard to comprehend that this thing, which is thus ignominiously, yet terrifyingly, being yanked (there is no other word) towards you, is a log which weighs, it may be, half-a-dozen tons or more. And it is all done in a few seconds!'

We have been told often enough how perilous is the lumberman's calling; and after reading *The Times* correspondent's account of the carriage of these smashing, tearing logs, which sometimes break away from the cruel embrace of the tongs and hurl destruction right and left, we may well believe that accidents frequently happen. There is continual danger in the work in the woods, danger from falling branches and falling axes; danger (one cannot help thinking) to the men who—armed only with climbing irons and a piece of rope—swarm up the trees which are used for supporting the cableway and cut off the tops at a height of more than a hundred feet from the ground. 'Altogether it is a truly "dreadful trade," compared to which the work of the ordinary steeple-jack looks luxurious and commonplace'—again I quote from *The Times*. But the greatest danger of all is the danger from fire.

There is always a certain amount of waste in lumbering operations; the tops and limbs of trees are cut off and left where they lie, because they are not worth the trouble of carrying away. The sap soon dries out of the wood, and by the end of the summer the forest is littered with debris which is as dry as tinder, and is only waiting for an accidental spark to start a fire which it is beyond the power of man to check; a fire which will lay waste hundreds of square miles of valuable forest, and may wipe out towns, villages, and settlements.

Sometimes, even in our own country, in hot dry weather, a match carelessly dropped, or a spark from an engine, perhaps, will set fire to furze and bracken on heath or moor; and if you have ever taken part in the generally futile attempts to beat out the flames, you will know what a hot and exciting business it is. But only those who have seen and—no, not 'fought,' for that is impossible, but *fled from* a real forest fire have any idea of the horror such a fire inspires.

These great forest fires, such as sometimes devastate enormous areas of country, have their stories of heroism as well as of cowardice, misery, and death. One of the most awful of the many forest fires which have occurred in America laid waste parts of the States of Wisconsin and Minnesota in the year 1895. In the fires of this year hundreds of people were burned alive, and thousands more lost all their property. I think that the story of how Edward Barry, an engine-driver on the East Minnesota Railway, raced the flames and

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LIDGERWOOD "FLYING MACHINE" ENGINE

The Lidgerwood "flying machine" and the engine that drives it. This view shows clearly the improvised ropeway used in Canadian forests for hauling the logs from the forest to the railway heroically brought his train to a place of safety deserves to be repeated here. Barry volunteered to drive a passenger train that had unknowingly come into the fire zone back along the line on which it had come. Ahead the fire raged with vicious fury ; behind and on both sides of the line the forest had been caught by the contagion of the all-devouring flames. Every moment was of vital importance if Barry's train was to retreat along the line—every moment reduced his chances of getting it to a place of safety—and Barry deliberately waited in order that he might take with him as many as possible of the fugitives who were seeking a means of escape from the burning towns behind him. He waited and he waited until he was satisfied that no more people could reach the train. At last he saw that the stream of men, women, and children who still raced frantically towards the line were doomed to death. Before they could reach it the fire circled round them and they were lost in the flames.

'Meanwhile the heat was growing so intense that fears were entertained that the cars might be set on fire. So he pulled across the bridge over Grindston River. Once there, and in comparative safety, he stopped and took more people up. Then he saw that the ties under the rails were on fire and also that two bridges in front were burning. He glanced back at the town whence they had just escaped; it was a huge mass of flames! A hurricane was blowing, and at that moment he nearly relinquished all hope of saving the train. He started again, but after going a mile he saw men and women on horseback galloping towards the line. Again he stopped. By this time the train was surrounded by flames. The heat and the dense smoke were blinding. Directly these last arrivals had entered the already overcrowded train, he started once more and raced at full speed with his precious human freight between the walls of fire. He ran as "fast as wheels could turn" for eight miles, knowing that the only hopes of escape lay in crossing the fast-consuming bridges before they gave way and in heading the flames.

'During this time of terrible anxiety his presence of mind did not desert him for a moment. Brave, resolute, and calm he kept to his post. The woodwork of his engine took fire and also his clothes. At Sanstone he was forced to draw up and put out the fire, which had taken good hold of the engine. Then he started to race the flames once more and save five hundred lives. He soon reached the Kettle River Bridge, which was on fire and burning vigorously. Its length was 700 feet. Barry realised that the only chance of escape lay in attempting to cross it. He knew that if the bridge held out all would be saved. If not, the whole train would be precipitated into the river, 140 feet below. There was no time for hesitation; the terrible risk had to be faced. He put on full speed and reached the other side in safety. Five minutes later the bridge gave way.

'But he had not yet emerged from the burning forest. So great was the force of the hurricane that was blowing that the burning trees were uprooted. At last he succeeded in "heading the flames" and drew up for a few minutes at Patridge Station.'[1]

Thus ended one of the most thrilling railway journeys known to history. What must have been the feelings of the wretched passengers, parched, scorched, and smoke-blackened, only those of us can imagine who have barely escaped from the clutches of fire. Many of them never recovered from the shock of their awful experience; others, including the driver, Barry, were blinded by the stinging wood-smoke; and to this day the story of the race with the flames, the dash across the burning bridge, is told with hushed voice. The dwellers in the forest states of America have the danger of fire ever before them, but they may not always have a Barry to help them when the dreaded hour of peril comes.

1 From a contemporary American account.

CHAPTER IV

Some By-Products of the Forest

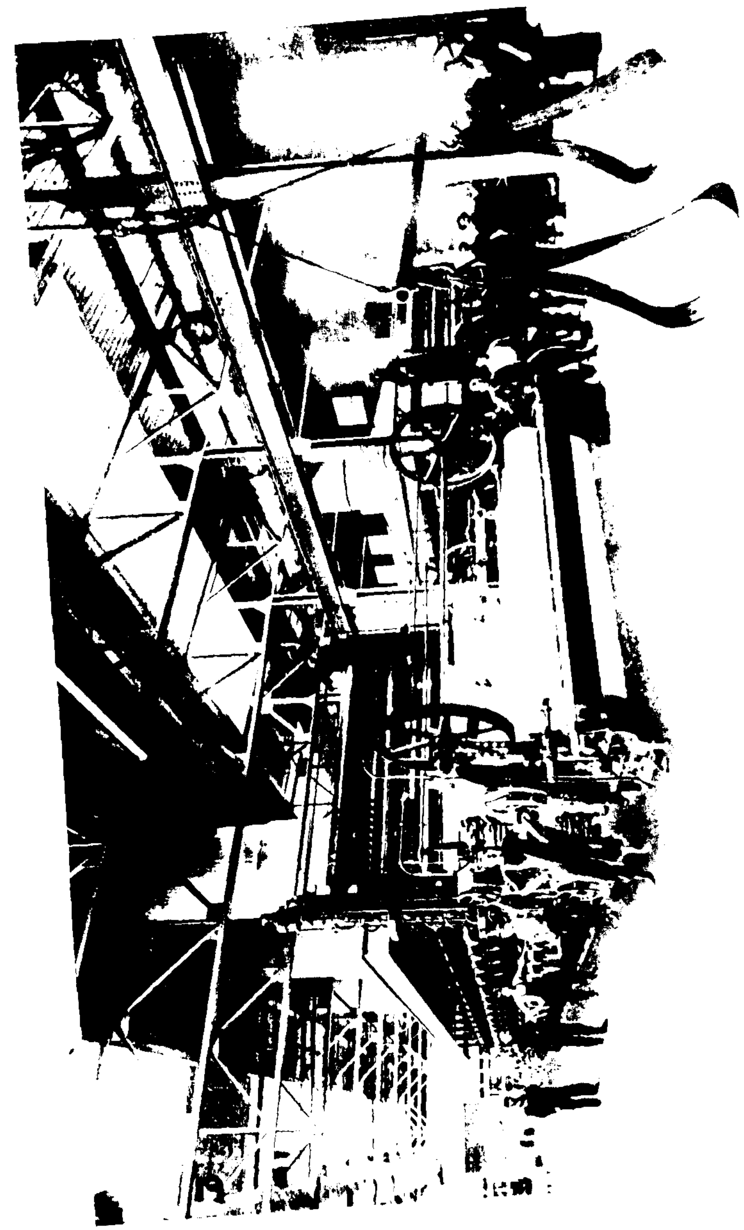
YOUTHS of simple tastes and active bodies occasionally find amusement in the game of touch-wood. The last time I played it was in a country road bordered on each side by a row of elms. I have cause to remember the occasion, for in dodging across the road to touch a tree I inadvertently touched a horse. It was drawing a carriage containing a fat coachman, a fatter footman, and an old lady who was the fattest of the three, and its own girth was as ample for its species as that of its owner was for hers. The horse having knocked me down, forbore to trample on me, but two wheels rolled over my extended shanks as I lay on my back wondering how I came there—or rather, how the carriage came there; for in the excitement of the game I had neither seen nor heard its approach. The obvious moral of my tale is 'Don't play touch (or any other game) in the King's highway.' As for touch-wood it is scarcely worth playing at all nowadays, for wood is present in so many articles of personal use as to be almost always within arm's reach. Your hat, I dare say, is stiffened with a lining of paper made of wood; your tie is perhaps of

artificial silk made of wood; the 'wool' with which a pitying tailor has padded the shoulders of your jacket, in the vain effort to give you the figure of the Apollo Belvedere, is probably wood-fibre; the chances are about even that your buttons are made of wood-pulp; and I would not venture a random assurance that there is no wood in the 'leather' of your shoes.

Wood, indeed, masquerades in so many disguises that we are constantly touching without recognising it. Of these disguises by far the most important is paper. Not all paper, of course, is made of wood. The best paper—writing-paper, for instance, and drawing-paper—is made from rags; and second-best paper is made from esparto-grass, or from a mixture of esparto-grass and rags. I may safely say, however, that all the halfpenny newspapers, and most of the penny newspapers, are printed on paper made from wood. Indeed, but for the discovery that paper can be made from wood the production of a daily newspaper for a halfpenny would be a commercial impossibility.

With wood, as with cotton and esparto-grass, the characteristic feature that concerns the paper-maker is the fibrous structure of the substance. The timbers which present this structure in the most suitable form are the pines, spruces, and poplars. The first step in converting them into paper is to reduce them into what is called 'wood-pulp,' and this is generally made in the countries where the trees are grown. Wood-pulp forms a very important article in the commerce of some countries, especially Canada, Nor-suitable for the particular kind of paper into which they are to be made. During this operation various materials are added to the pulp, to make the paper suitable for the purpose for which it is intended. China clay thus added makes the paper softer and enables it to take a more even surface. Some colouring matter, too, must be introduced to remove the unpleasing yellowish tinge with which the pulp emerged from the bleaching process.

From the beater the pulp passes into a shaking vessel, which keeps it moving until the time comes for its admission to the paper-machine. Its whole career, as you will have seen, is an agitated one. It is constantly being crushed or beaten or shaken, and knows no peace from the time it is torn from the tree until it settles down into paper. The machine which makes paper from pulp of wood is in most of its essentials similar to the machines which make paper from the pulp of other vegetable substances. Its most obvious differences are in its greater width and in the greater speed at which it is run, and these differences are due rather to the purposes for which the paper is intended than to any peculiarities of wood-pulp. Like other paper-machines, it consists of a great number of rollers, round which the pulp passes in a maze of circles until it finally emerges from what is called the 'dry end' as finished paper. Let us try to follow it in its bewildering travels. First it is pumped from the shaking tank into a strainer, from which it is allowed to ooze out upon a cloth or india-



way, and Sweden, as you will recognise when I tell you that the United Kingdom buys every year from Canada 110,000 tons, from Norway 350,000 tons, and from Sweden 225,000 tons of wood-pulp—in other words, of compressed forest—the greater part of which is here turned into paper for home and foreign use.

Two kinds of wood-pulp are prepared for paper-making. They are distinguished by the terms mechanical and chemical. Mechanical pulp is the coarser of the two, and is only used for cheap newspapers. It is made by pressing slabs of pine against rapidly revolving mill-stones. A stream of water plays upon the slabs and carries away the fibres as they are torn off by the stone. The water then passes through sieves of different meshes which separate the fibres according to their sizes. The fibres are finally pressed into pulp, and the product is ready for the paper-mill.

The manufacture of chemical wood-pulp is a much more scientific process, and results in the production of a finer and cleaner fibre. Trees intended for the manufacture of chemical wood-pulp are first cut up into logs about four feet long. Machinery designed for the purpose strips off the bark and scoops the knots out of the wood. The logs are then passed through a series of revolving knives, which cut them up into cubical chips about the size of lumps of sugar. These are crushed between heavy iron rollers, from which they fall on to an endless band of wire gauze, which screens away any loose dirt. The wire-band conveys

them to the boiler, where they are mixed with chemicals and subjected for several hours to a steam-pressure of more than a hundred pounds to the square inch, the object being to shred-out the fibre from the other constituents of the wood. The liquor is then run off and the fibrous sediment conveyed to the washing-machine, or 'potcher' as it is called. This is something like a large sausage-machine, and carries revolving knives which make mincemeat of the woody fibres. A stream of water runs through the machine to wash away the chemicals which had been added in the boiling process. As soon as this has been done the flow of water is stopped, and the man in charge adds to the contents a bleaching solution which turns the fibrous mass a creamy-white colour. Four or six hours are allowed for the bleaching solution to act completely. The water is then turned on again and the mass is once more thoroughly washed. It is then run into tanks, from which it is pumped up on to the 'sand-table'—a long, narrow, winding trough fitted with little wooden obstructions or weirs so disposed as to catch any sand or other impurities, which if not removed would make unsightly specks or blemishes in the paper.

The operations of washing, bleaching, and straining, already described, are sometimes left to the paper-maker, but the process of paper-making does not really begin until the pulp reaches the beater. This is a machine very similar to the potcher, and its object is to reduce the fibres to the length most suitable for the particular kind of paper into which they are to be made. During this operation various materials are added to the pulp, to make the paper suitable for the purpose for which it is intended. China clay thus added makes the paper softer and enables it to take a more even surface. Some colouring matter, too, must be introduced to remove the unpleasing yellowish tinge with which the pulp emerged from the bleaching process.

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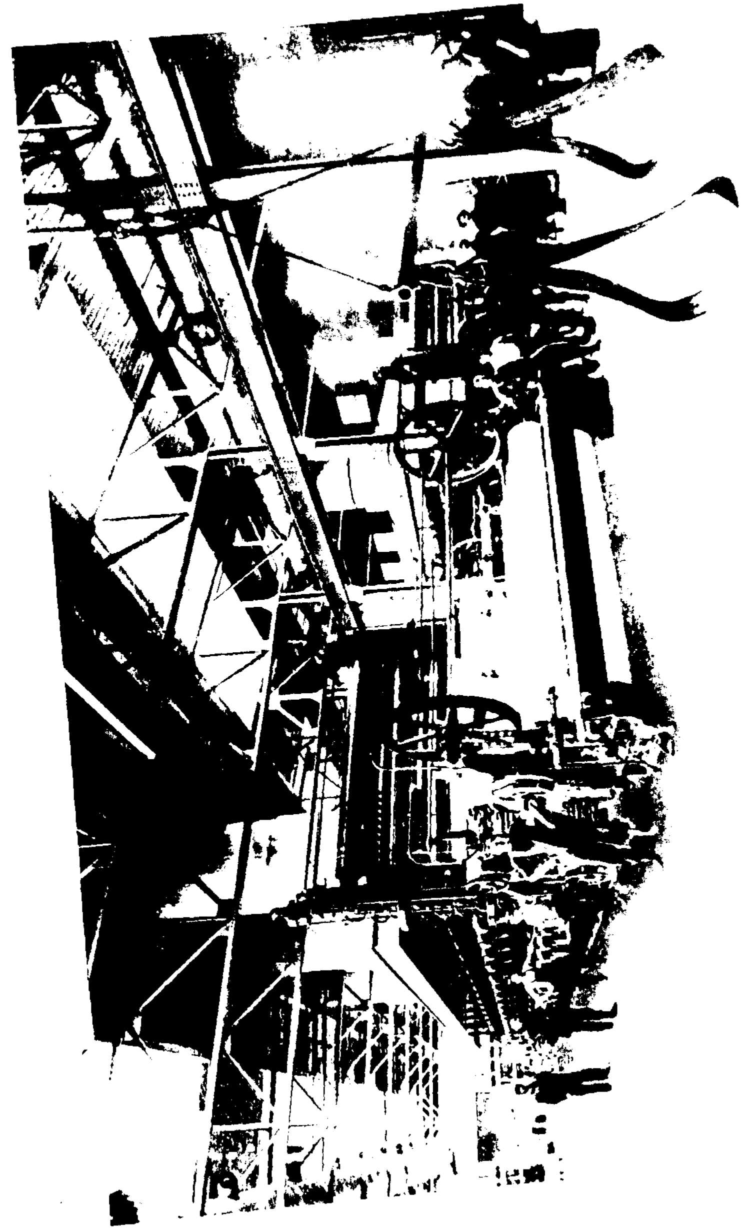


rubber apron. Flowing over the apron, in a stream the full width of the paper-machine, it soon reaches an endless sheet of fine wire gauze, which travels forward for some distance and at the same time rocks from side to side so as to distribute the pulp-stream evenly over its surface. The water in the pulp drains through the wire gauze, leaving the fibres spread out in a thin film, which is still saturated with moisture. The film has not travelled far, however, before it is carried over the open top of a vacuum or suction-box, which extracts a good deal of the remaining moisture. A little further and the film meets the first roller which it has to pass under. This is the 'dandy roll'—a skeleton roller covered with wire gauze which, by making the places where it presses thinner and consequently more transparent than their surroundings, imprints what is called the water-mark. Now we come to another suction-box, and then the pulp-film leaves the wire gauze and is taken into custody by a band of felt. There is stern discipline in store for it, for it has to pass between the couch-rolls. One of these is made of brass and the other of mahogany, and the upper one is pressed against the lower by means of weights and levers. Two iron press rolls come next, and by the time it has passed them the paper has become as dry as squeezing can make it. The remaining moisture must be driven off by heat. To this end the paper is carried over and under six or seven hollow metal cylinders heated by the exhaust steam of the engine which drives the machine; then comes another pressure roll followed by three or four more steam-heated cylinders. Having passed these the paper is perfectly dry, but its surface is rough, and must be polished. This operation is effected by the calender rolls. These are heavy iron cylinders with brightly polished surfaces. They are heated by steam and are kept in close contact by powerful hand-screws. The paper is drawn between them, and the effect is very similar to that of the laundress's hot-iron upon a collar or shirt-front. The paper is now finished. It is wound upon a reel holding perhaps three or four miles; is covered with strong packing-paper to protect it from dirt and injury, and is then ready for despatch to the newspaper office.

I hope I have made it clear that the process which I have described, from the flowing of the wood-pulp into the 'wet end' of the machine to the reeling of the finished paper at the 'dry end,' is one continuous operation. You would perhaps like to know how fast it proceeds. At what rate is the wood-pulp turned into paper? The answer is that the speed depends to some extent upon the quality of the paper to be manufactured. Ordinary 'news' is turned out at the rate of a hundred yards or more a minute; that is to say, that you, if walking beside the machine, would have to put your best leg forward to keep up with the stream of paper.

Wood-pulp has many other uses besides that of paper-making, and not all of them are so peaceful. It is known to chemists as cellulose, and forms, with

the addition of nitric acid, nitro-cellulose, formerly known as gun-cotton, and now the basis of cordite and other military explosives. Nitro-cellulose dissolved in ether forms collodion, a liquid which has the property of drying rapidly when exposed to the air and leaving behind it a tough, elastic film. Before gelatine dry-plates were invented every photographer had to coat his own plates with collodion, and a very nasty task it was. Collodion is still used in some photographic processes; it is also used in surgery as a temporary protection for small wounds; but one of its most interesting applications is the manufacture of 'wood-silk.' In this process wood-pulp, having been converted into collodion, is forced under great pressure through glass tubes of very minute bore. The threads as they issue from the tubes dry almost immediately. Ten or twelve of them are twisted into a single thread, which is wound into a skein and then 'de-nitrated'—that is to say, the material is treated with chemicals in such a way that it is reconverted from nitro-cellulose into cellulose. This is necessary because nitro-cellulose is so highly inflammable that ribbons and dresses made of it would be very dangerous things to wear. Having thus been rendered harmless the artificial silk is ready for weaving into fabric, and a very beautiful fabric it makes, though it cannot compare for strength and lustre with the product of the lowly silkworm.

Cellulose is also the basis of the substance known as celluloid or artificial ivory, from which so many useful and ornamental articles are made. The cellulose is first converted into nitro-cellulose and then dissolved in melted camphor. The result is a substance which can be moulded while hot into any desired shape. If suitable colouring matter is added it can be made to represent coral, amber, ivory, or malachite. Its most serious disadvantage is its inflammability, and it should never be used for making buttons or other articles intended for personal wear.

Shavings and sawdust may seem untidy and unprofitable products, fit only for the fire or the dustbin. There are, however, many useful purposes to which they are applied. If you have read Charles Dickens's *Mugby Junction* you will remember 'the Boy at what is called the Refreshment Room at Mugby Junction, and what's proudest boast is that it never refreshed a mortal being.' The Boy declared that the 'sangwiches,' as he called them, were made of sawdust. I am inclined to doubt the Boy's veracity on this point, and in any case the Adulteration Laws would prevent the deliberate use of sawdust in any food intended for human consumption at the present day, though it is sometimes mixed with molasses and fed to cattle. There are more legitimate openings for its employment. It is pressed into bricks for fuel, and large quantities of it are used by the makers of pins and steel pens for cleaning those useful articles. Moreover, as a form of cellulose, it

is employed together with shavings in the manufacture of oxalic and acetic acids and other useful chemicals.

Wood is not the only, nor in every case the most valuable, product of the tree. What, for instance, would the tanners do without bark? There are other tanning materials, but there is none so cheap and so efficient. Without it our boots would cost us more and would sooner wear out. The value of bark to the tanner consists, as I daresay you know, in the fact that it contains tannin or tannic acid in a form which readily combines with the tissue of hides and converts them into leather. The bark most in demand for this purpose is that of the British oak. It gives to leather a firmness and solidity which no other bark can produce, and it is said that for this reason English sole-leather is the best in the world. Unfortunately there is not enough British oak-bark to supply all the tanneries, so other tanning agents have to be used. Among these are the barks of other species of oaks, of acacias, Scotch firs, and willows, as well as a variety of leaves and acorns. Whatever the material it is first ground into pieces of a uniform size and then passed through a series of pits or tanks, in which it is mixed with water. The principle is similar to that of making tea or coffee. The product is an infusion, in which the hides to be tanned are immersed for many months. You may be surprised to learn that it took the tanner more than a year to make the sheet of leather from which the soles of your boots were cut.

Some trees are cultivated solely for their bark. Of these the most important, from the commercial point of view, is the cork tree. It is an evergreen species of oak known to botanists as Quercus Suber, which grows in Spain and Portugal and on the northern coasts of Africa. Cork trees are not stripped of their bark until they are sixteen or seventeen years old, after which age the operation is repeated at intervals of eight or ten years. The trees do not seem to mind it; on the contrary, they are said to thrive under it, and to live to 150 years or more. When stripping time comes the operator cuts a ring right round the trunk of the tree near the ground, and another just below the lowest branches. Then he makes three or four perpendicular slices from the upper ring to the lower one, and with the wooden handle of his knife levers off the bark between the cuts. The cork taken from a sixteen-year-old tree is coarse and rugged stuff, known as 'virgin' cork, and is of little use except for tanning or for the decoration of rustic summer-houses and window-boxes. The coat taken eight or nine years later is of somewhat better quality. It is good enough to make floats for fishermen's nets, or life-belts, or insulating material for boilers and refrigerators, but is not sufficiently smooth and elastic to be used for bottle-stoppers. At each subsequent stripping, however, the quality improves. To pre-

PAPER MAKING MACHINES FOR NEWSPAPERS

pare the slabs of cork for market they are scraped, heated over a fire, so as slightly to char the surface and 'close the pores,' and finally pressed out as flat as possible. The importance of the industry may be judged from the fact that the world uses about 135,000 tons of cork every year, at an average price of from £10 to £15 a ton. Of this quantity about half comes from Portugal. Most of it is cut up into corks for bottles, but it also plays another important part in domestic economy as one of the chief components of the clean and durable floor-covering called linoleum.

Originally the word linoleum was the name of a preparation of oxidised linseed oil, but it is now generally applied to the floor covering made by the mixture of that preparation with cork. The cork is ground by mill-stones into a fine flour, and in this condition it is thoroughly mixed in a sort of pug-mill with the proper proportion of oxidised oil. On emerging from the pug-mill the mixture is sliced by a revolving knife into shavings, which are spread out and pressed by steam-heated rollers into thin sheets. From the last of these rollers the crumbling mixture is scraped off by a cylinder bristling with steel points, and falls in powder into a trough, the width of the floor-covering to be made. The trough delivers the powder on to the web of jute canvas which is to form the backing of the linoleum, and on to which it is squeezed by powerful rollers.

There is a valuable class of products which, though they come from tree-trunks, are neither bark nor wood. I mean the gums and resins. Their varieties and the purposes for which they are used are innumerable. Some of them command a very prominent place in the economy of the modern world. I need only mention rubber and turpentine. About thirty-five years ago 5000 tons of caoutchouc, or raw rubber, sufficed for the annual requirements of the world. Since then the development of the electrical industry, in which large quantities of rubber are used, the invention of the pneumatic tire and the coming of the motor car have increased the demand twenty-fold. To meet it the rubber tree is being planted in every part of the tropical world suitable for its culture, and chemists are vieing with one another in their efforts to produce caoutchouc cheaply by synthesis. Synthesis, I should explain, is the putting together of the substances of which a natural product is known to be composed in such a way as to construct that product artificially. There are many vegetable products which the chemist can reconstruct in this way out of animal or mineral substances, and there are many more which he cannot. He can make indigo, for example, more cheaply than it can be grown; he can make acetic acid in a manner sufficiently economical to compete with the process of direct distillation from wood; he can even make sugar and alcohol, though only at a cost enormously greater than that of their production from vegetable substances. He knows that rubber consists of carbon and hydrogen, and he has

even succeeded in combining those elements in such a way as to make caoutchouc. It remains to be seen, however, whether the caoutchouc of the chemist will produce rubber as good as that which can be made from the caoutchouc of Nature's laboratory, and, if so, whether it can be manufactured as economically. Until these results have been obtained, the cultivation of the rubber tree will remain one of the great forest industries of the world.

I have spoken of the rubber-tree, but from the strictly botanical point of view there are several kinds of rubber-tree belonging to different natural orders. The one characteristic which they have in common is that of yielding a milky juice which, when rubbed between the fingers, coagulates into an elastic fibre. This milk is the 'latex' from which rubber is made. The methods of collecting it differ widely in different parts of the world. The valuable Para rubber of South America is collected by making a perpendicular incision in the trunk of the tree with slanting incisions on each side of it, the series of cuts somewhat resembling the feathered end of an arrow. Small cups are stuck with clay to the trunk of the tree to receive the latex which oozes from the incisions at the rate of about two ounces a day. In Nicaragua a spiral incision is made all round the trunk from top to bottom, and at the bottom an iron trough or spout is driven into the tree to collect the latex and guide it into a pail. Ceara rubber is collected by stripping the bark off the tree and allowing the latex to coagulate upon the trunk until it can be pulled off in shreds. There are as many ways of preparing the latex for market as there are of collecting it. In making Para rubber, the native workman heats some palm nuts in an earthenware pot over a fire until they begin to give off a thick white smoke. He then takes a sort of ladle or paddle, of which the 'business' end is of clay and the handle of wood, and dips it into a pailful of the latex. He holds the paddle in the smoke of the palm-nuts, turning it slowly round and round until the latex is dry, and then dips it into the pail again for another coating. As soon as the second layer is dry he adds a third, and so on until the paddle is as heavy as he can handle. The lump of rubber is then cut off with a wet knife, and, when further dried, is ready for market. It is known as Para biscuit, and is the best rubber the world produces. During the rubber 'boom' of 1910 it fetched as much as twelve shillings and fourpence a pound in London.

Much remains to be done before the raw rubber as it reaches the market is fit to be made into motor tires or tennis-balls. The first step in its eduction is the removal of impurities—such as bits of bark, earth, and clay, which may have entered accidentally, and other substances which may have been introduced purposely, either to facilitate the coagulation of the latex or to defraud the purchaser. To remove such impurities the crude caoutchouc is softened in hot water and then cut up into slices with a sharp knife.

These slices are passed and repassed between grooved rollers, over which a stream of water flows. The rollers crush the impurities and the water washes them away, while the purified rubber is squeezed into a sheet. This is hung in a warm room for some days to dry, and is then passed through a kneading or masticating machine. After this it is passed between a pair of heated rollers, moving in opposite directions at different speeds, the object being to incorporate thoroughly with the rubber about a tenth of its weight of sulphur, as well as any colouring matter that may be desired. The addition of sulphur is the first step in the important process known as vulcanising. Most articles of rubber would be of little use if they were not vulcanised, for they would get sticky in warm weather and brittle in cold, and would soon perish. Vulcanising has the effect of hardening rubber and making it more durable, but since rubber, once vulcanised, cannot be softened sufficiently for moulding into any desired shape, it follows that the moulding must be done before the vulcanising. The process of vulcanising consists in combining the rubber with sulphur by heat. The mere mixture of the two substances does not effect this combination or deprive the rubber of its pliability. It can still be softened by a gentle heat and pressed into moulds. Then while still in the mould it is subjected to the temperature of high pressure steam, and sulphur and rubber combine to form one substance—the finished material of the motor-tire and the garden hose. If an excessive quantity of sulphur is mixed with the rubber, the mixture when subjected to prolonged heat becomes hard enough to take a fine polish, and is known as ebonite or vulcanite — a material which, as I have no doubt you know, is largely used in the making of electrical instruments, photographic dishes, fountain pens, and a variety of small articles of everyday use.

Turpentine, the only other fluid product of the tree-trunk with which I have space to deal, is yielded by several coniferous trees both European and American. The turpentines known respectively as Bordeaux and 'Common,' come from different species of pine; Venice turpentine comes from the larch, and Chian turpentine from the terebinth tree. Venice turpentine, which is regarded as the best variety, obtained its name from the fact that, being obtained in the Alps of the Savoy and the south of Switzerland, it used to be sent to Venice for shipment. The Swiss peasants collect it by boring holes in the trunks of suitable trees and inserting little wooden troughs or gutters. At the end of each gutter is hung a wooden cup, into which the turpentine slowly drips. The dripping goes on all through the summer months, the cups being emptied as often as they are full. A good tree will yield from six to eight pounds of turpentine a year for thirty or forty years, but the repeated withdrawal of turpentine renders the wood of the larch valueless as timber. In Sweden and Russia turpentine is largely obtained from the pine (Pinus sylvestris), but the

GATHERING CRUDE TURPENTINE

product is not equal to that obtained from the larch or the silver fir. The pine is, however, the chief source of the odorous but useful fluid known as Stockholm tar. This is obtained chiefly from the roots of the tree, from which it is distilled in a primitive but efficient fashion. A funnel-shaped pit is dug in the side of a steep hill or bank, and from a point lower down on the side of the hill a pipe is driven through to the bottom of the pit. The pit is then filled up with pine-roots and firewood which, having been lighted, are covered with turf. As the fire burns the tar slowly oozes out through the pipe into barrels placed to collect it.

It is scarcely within the scope of our study of wood and what we make of it that we should look above the tree-trunks and discuss the manifold uses of the leaves and fruits of the forest and orchard. But a departure is justified in the case of one tree, of which it has been truly said that a ship may be built and laden with its produce. The tree, as you will have guessed, is the coconut palm (Cocos nucifera). 'A vessel may be built by layers of rafters from the trunk; the seams may be caulked with coconut fibre; the masts may be made of the well-seasoned trunk; the ropes, hawsers and sails of the fibre. Then the vessel will be built from stem to stern entirely of the coconut tree. It may be laden with coconut wood, coir, yam, mats, rugs, brushes, coconuts, arrack, copra, palm-oil and poonac. Thus it will be wholly built and laden with the coconut tree.' It is calculated that in the Eastern and Western hemispheres together more than three million acres are devoted to the cultivation of this extraordinarily useful tree. In some parts of the world it affords meat, drink, clothing, light and fire to the inhabitants.

A recent American writer, Mr. Charles Melville Brown, thus describes some of the manifold purposes to which the various parts of the tree are applied in the countries of its growth and elsewhere:

'From the roots is extracted a febrifuge; the trunk is used for house building, sailing boats, laths, furniture, firewood, and when divided into two it is used as gutters. The lower part of the stem becomes very hard and takes a beautiful polish. It is known in the market as porcupine wood and is used in the manufacture of fancy articles. A powerful oil is extracted from the bark, which is employed as a linament in cutaneous diseases.

'The undeveloped leaves cut out of the heart of the tree are used in the same way as we use cabbage; the brown fibrous network around the base of the leaves is used for sieves and also made up into fishermen's garments. It is also woven into odd-shaped hats and bonnets, and used for cushions, mattresses, and many other purposes. The developed leaves are used for roofing, mats, baskets, torches, fuel brooms, fodder for cattle, and manure. The stem or peticle of the leaf is used for fences, yokes, oars, carrying burdens on the shoulders, fishing rods, and numerous domestic utensils. The leaves are plaited into mats and

screens and also made into baskets, and the natives of the Friendly Islands make combs of the midrib. In the Laccadive Islands mats are made of the leaves, of fine quality and much esteemed when exported. These islanders also employ them for the sails of small boats. The Sinhalese split the fronds in halves and plait the leaflets neatly, so as to make excellent baskets; they form the usual covering for their huts, as well as of the bungalows of some Europeans. The dead fronds are sometimes used as torches or for fuel; the midribs, fastened together, are used as brooms on the decks of vessels, as the fibers of the stalks are tough and woody.

'From the spathe and flower a liquid substance is obtained resembling watery milk, and which is called "toddy." This is sweet and cooling when fresh, but after exposure to the sun for a short time becomes soured and intoxicating. The spirits obtained from this liquid is known as *arrack*, and in Ceylon forms a source of revenue to the British Government. Medicines and sweetmeats are made from the unformed nut; and the young nut and its milk are used for drinking and dessert, and its green husk is used for preserves.

'The ripened nuts are used for eating, for curry, milk, and for cooking. The milk of the ripened nut is boiled and evaporated, thereby obtaining oil, which is used for rheumatism, anointing the hair, in the manufacture of soap, candles, for lighting, lubricating, and cooking. The *poonac* or refuse of the grated nut, after expressing the oil, is used for fattening cattle and hogs and as a food for poultry. The shell of the nut is used for drinking cups, basins, lamps, charcoal, tooth powder, lampblack, artificial coffee, spoons, medicine, beads, bottles, and knife handles.

'The external husk, after having been soaked in water for a certain period, is beaten out into a fibre called *coir*, of which are made mattresses, cushions, ropes, cables, cordage, yarn, canvas, brooms, plasterers' brushes, bags, fishing nets, oakum, floor mats, and fuel.

'A much-prized dish of tropical Americans is made of the *esponja*, or sponge of the coconut. This is the germinated embryo within the inner shell, which is eaten raw or made up into a salad. The milk of the unripened nut is deliciously refreshing, and in it the tropical traveller is assured of a fresh, cooling, uncontaminated drink. Millions of nuts are consumed in this manner.'

So important is the oil to the soap-industry that several British firms of soap-makers have acquired coconut estates in Ceylon, and one firm owns a palm island in the Pacific.

There are surely few seeds which from outward appearance seem less likely, as the saying is, 'to come to anything' than the coconut. Yet on and near the equator there are few that grow more readily or in less promising conditions. Plenty of sand and sea-moisture are all that it requires for its growth,

though the careful cultivator generally provides it with a richer and softer soil. Within four or five months of planting the nut, if ripe and sound, begins to sprout. How the tender shoot and the delicate roots have got out of the coconut is as great a miracle as the time-honoured poser of how the milk got in. But there they are, and in five years time the green shoot, if it thrives, will be bearing a few coconuts of its own. At twelve years of age it should be bearing from 50 to 250 nuts annually.

CHAPTER V

Marvels of Modern Joinery

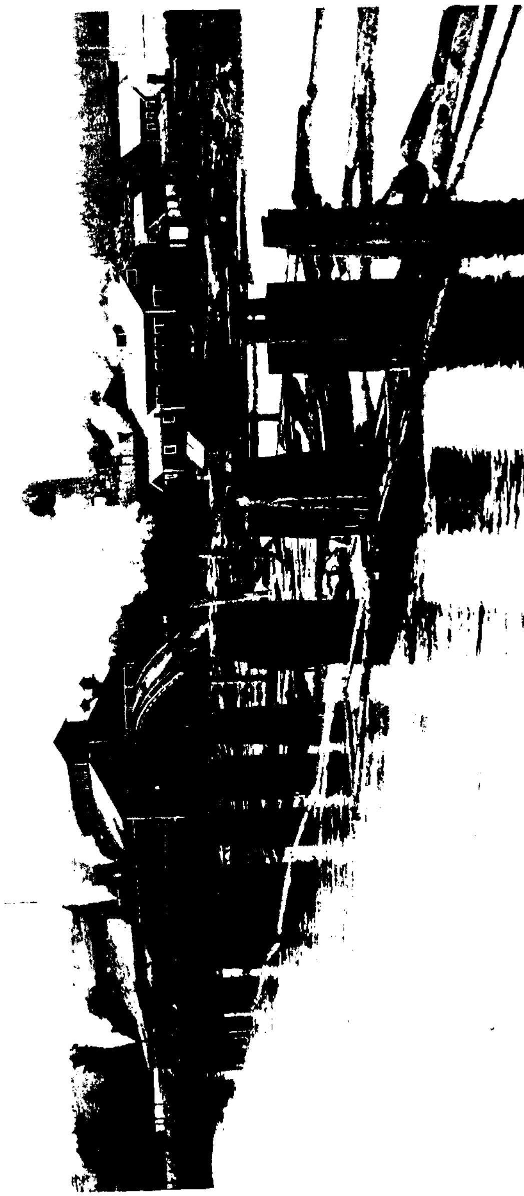
YOU will remember that in Chapter III. we felled our timber and brought it down to the railway or the river for conveyance to the mills, where the giant logs are cut up into the nice smooth boards which we see carpenters putting into our houses. The lumber has many processes to pass through before it is fit for the carpenter to handle; and in this chapter I propose that we shall follow it through some of the vicissitudes of its journey.

It is not until we give our minds to ponder on such things that we discover that our chairs and tables, cotton-reels and match-sticks, packing-cases and penholders—and the hundred other common things which to most of us are merely 'wooden'—come to us by a voyage through a world of wonders hidden from the gaze of ninety-nine people out of a hundred. The places—ever so small and ever so indispensable—which those things occupy in our lives are given to them as the result of perpetual warfare between men and machinery. The penny penholder with which I write speaks to me of some great invention without which my penny penholder could not exist; the chair

in which I sit whispers of a mighty machine which made it at less than half the cost of a similar chair which came into being half a century ago. Since we see that machinery can make things more cheaply than men can make them, it follows that the less men have to do in handling them the cheaper they will be; and we find therefore, what we should expect to find, that machinery takes our penholders and all our other wooden commodities in hand right at the very beginning of their careers and nurses them jealously through all their changes, from the giant log to the final form. It would take men working with manual tools a tedious time to convert a tree trunk into hundreds of thousands of penholders; machinery can do this with a few flashes and whippings. To see the first stage in the processes of manufacturing wooden things of every kind we must visit the saw-mills wherein the trunks are cut up into boards.

The first thing, of course, is to get the trunks inside the mill; and as they are far too heavy to be lifted by hand, they are picked up by a crane and placed on a carriage which takes them directly to the saws. Sometimes the logs move over revolving rollers, or, again, they may be taken in hand by endless chains having great spikes in them. This is the method in vogue at the Mills of the Canadian Western Lumber Company at Comox in British Columbia. As these mills make the proud boast of being the largest in the world it is well that we should stop to see what goes on in them. I take the following information from an article which appeared in *The Times* of May 24, 1911.

The logs for the Canadian Western Lumber Company's saw-mills come down by water, and are shepherded in the boom or enclosure immediately fronting the mill. Leading from the mill into the water is an inclined plane, up the face of which a massive endless chain is continually moving. This chain is studded at intervals with great steel prongs curving upwards; and when one end of a floating log is coaxed by the lumberman up against the chain, the great prongs coming up from beneath dig themselves deep into the bark of the log, so that it has no choice but to move up the inclined plane and into the mill. 'Arrived at the top, the hooks disengage themselves and the log is left lying comfortably in a trough or bed, where, one may well believe, it finds rest pleasant, in the cool of the mill, after its long climb. For some placid minutes it reposes so; but its peace is rudely broken. Without warning, coming up through the floor and hitting it most unfairly on its underneath side, there rise huge steel arms ("niggers" they call them) which hustle it unceremoniously from its couch. It is not until the log has rolled itself over to one side that you see the great black up-thrusting arms that have dislodged it; and already it is rolling sideways down a gentle incline to where, though it does not know it, it will soon cease to be a log any more. It brings up on the deck of what is known as a log loader, being in effect a moving platform or



FRASER MILLS (CANADIAN WESTERN LUMBER COMPANY), BRITISH COLUMBIA carriage, looking, when stationary, innocent enough. No sooner has the log come to rest upon it than long steel arms seize it and jerk it round and slap it into place; and then the carriage begins to move.'

The carriage takes its load straight away to a revolving band saw, which is provided with teeth on both sides. The end of the log meets the flashing steel ribbon, which screams as it tears its way through the onward-moving log. The awful journey over, the carriage stops. The log, from which one side has been stripped clean off, is again picked up by steel arms and turned round on the carriage, which now moves backwards to the saw. And so, bit by bit, but in an incredibly short time, the carriage moves its charge backwards and forwards past the inexorable saw, until the log is a log no longer, but a pile of gleaming-white and strongly-smelling boards.

Probably the greatest revolution which has taken place in wood-working machinery of late years has been the substitution of band saw machines for log frames and circular saws. In the log frame there are a dozen saws or more working vertically up and down and cutting the log up into as many boards as there are saws; and I do not think that I need explain what the circular saw is like. The band saw has many advantages over both these types of saw. It can be run at a greater speed, the saw is thinner and consequently wastes less wood, while it can be adjusted to cut boards of different thicknesses from the same log, and the log can be moved and examined after each cut. A big band saw must be seen at work before its powers can be realised. There is something uncanny in the speed and ease with which the whirring ribbon of steel—a mere shred of a thing not more than five inches wide and $\frac{1}{16}$ of an inch thick—cuts its way cleanly and evenly through a giant log of the hardest wood. Needless to say the saws used in these machines have to be of the very finest and toughest steel. Some of us have had painful experiences of the effect on our saws of an old nail which has happened to be in the way when we have been cutting up a packing case or some such thing. But to the powerful band saw a few nails more or less in the wood appear to be all in the day's work, and certainly not worth making a fuss about; for Messrs. A. Ransome & Co., Limited, who are makers of all sorts of wonderful wood-working machines, including band saws of the largest and newest type, tell me that they know of an instance in which, during a single cut, a band saw passed through no fewer than sixteen nails and spikes; and that, after having been sharpened and set, a process which occupied less than an hour, this amazing saw was cutting as well as ever! In some cases the saws have cut through pieces of iron with a sectional area of more than one square inch, with no further damage than could be put right in less than an hour.

'Pooh!' I think I can hear some of you say, 'that's nothing. The man who came to mend the pipes last winter cut bits off them with quite a little hack-saw; and I have read of machine saws which cut through steel bars and girders without winking.' True enough, my friend; but permit me to remind you that wood saws and metal saws are quite different, as are also the conditions of their work.

If you have ever attempted the task (as I have) of 'converting' or 'breaking up' quite a moderate-sized oak or elm armed only with axe and saw, you will have, I am sure, a great respect for the Ransome and Lavo Patent Horizontal Log Band Saw (to give this wonderful machine its official title), when I tell you that it will make a true cut right through the centre of an elm log three feet in diameter and twenty feet long in less than a minute. I should not care to calculate how long you or I would take over a similar operation; for I suspect that we should give it up after a month or so. Assuming that we used a rip-saw which made a cutting stroke of two feet at every cut, but only on the downward stroke; and that we sawed at the rate of sixty strokes a minute—which is fast—our saw would have an approximate speed of 120 feet a minute. But we should require much more time for resting than for cutting; and herein lies the great difference between our work and that of the Ransome saw, which never thinks of resting so long as there is work to be done, and travels, moreover, at the prodigious speed of *7000 feet a minute*; or, to put it another way, at the rate of just under eighty miles an hour. Have a good look at the Ransome saw which is illustrated opposite page 120. It appears innocent enough, does it not, to have to deal with that formidable log? But I can assure you that its placid expression belies the sharpness of the teeth on its frail-looking saw, and the speed of the big wheels. Messrs. Ransome have kindly supplied me with the following particulars of three hours' regular work with this saw. I think you will agree that the performance is sufficiently interesting to have a place here. The time of three hours included the necessary stoppages for changing saws and putting on logs. The machine was worked by one man, while two labourers removed the sawn boards as they were cut, and assisted in fixing the unsawn logs on the carriage. Every board produced was straight and flat, of even thickness throughout, and with the surface practically smooth:—

	Superficial Feet of Sawing.
An elm log, averaging 33 in. diameter by 14 ft. 4 in. long, cut into 27 1-in. boards and two slabs in 40 minutes	899
A white-wood log, 28½ in. square, 16 ft. 5 in. long, cut into 51 ½-in. boards in one hour	1989
A mahogany log, 15 in. square × 20 ft. 7½ in. long, cut into 19 boards of various thickness	492
A wainscot (oak) log 12 in. × 18 in. × 13 ft. 7 in. long, cut into 17 1-in. boards . .	232
A kauri-pine log, 18 in. square by 15 ft. 2 in. long; 6 ½-in. boards only were cut from this log	134
Total production in 3 hours .	3746

How does this wonderful saw work, do you ask? Well, I think the plate is so self-explanatory that we

By kind permission of The Canadian Western Lumber Company

THE LAST STAGE OF THE LOG'S JOURNEY

The logs are seen entering the mill of the Canadian Western Lumber Company. The man with the pole is guiding the logs on to the "jack-ladder", which conveys them into the mill, where they are immediately converted into boards.

need not spend much time in describing it. The big wheels around which the saw travels revolve on spindles which are fixed to a massive beam which can be moved up and down the pillars on either side of the log by means of gearing. The wheels themselves are driven by the self-contained electric motor shown behind the wheel on the right-hand side of the picture. If no electric power is available, the saw can, of course, be driven by steam or water or any other form of motive power transmitted through shafts and belting to the driving pulley. The travelling table which carries the logs is made up of rolled-steel girders of great strength, having both top and bottom sides accurately planed to ensure that the distance between the saw and the log is always relatively the same. The carriage runs freely on a series of turned rollers, power being transmitted to it through a system of gearing which enables the operator to regulate the speed forwards or backwards to a nicety. The log is held firmly on the carriage by means of 'dogs,' with a grip surpassing that of a bull terrier; and these dogs are so arranged that they will fall low enough to allow a board as thin as half-an-inch being left after the last cut has been made. When the log has been fed past the saw, the carriage stops before beginning its backward journey, while the operator, by simply turning a hand-wheel, lowers the saw a distance equal to the thickness of the board which is next to be sawn. There is no space here in which to write of the many other interesting forms of machine saws. Indeed, there are so many varieties and types, and they are put to so many different uses, that it would require a big book to hold descriptions of all of them. There is one kind of circular saw which presents a striking contrast to the rapacious monster we have just left, for the saw itself and the work it performs are totally different. It is a regular dandy among saws, and its purpose is to saw work accurately to the finished dimensions, wherefore it is called a dimension saw bench. Such saws as these are used for all kinds of the accurate sawing required in pattern-making, cabinet-making, and fine joinery. They will cut compound angles, and will do ripping and cross-cutting, grooving, mitreing, and bevelling—in fact, it would be difficult to say what they cannot do. This diversity of work is due to the great number of different positions which it is possible for the saw and wood relatively to occupy. The bench itself can be canted, and there is a number of guides or 'fences' which can be arranged in a variety of positions and at almost any angle, while strictly accurate measuring scales help the workman to adjust bench, fences, and saws to suit exactly the operations to be performed.

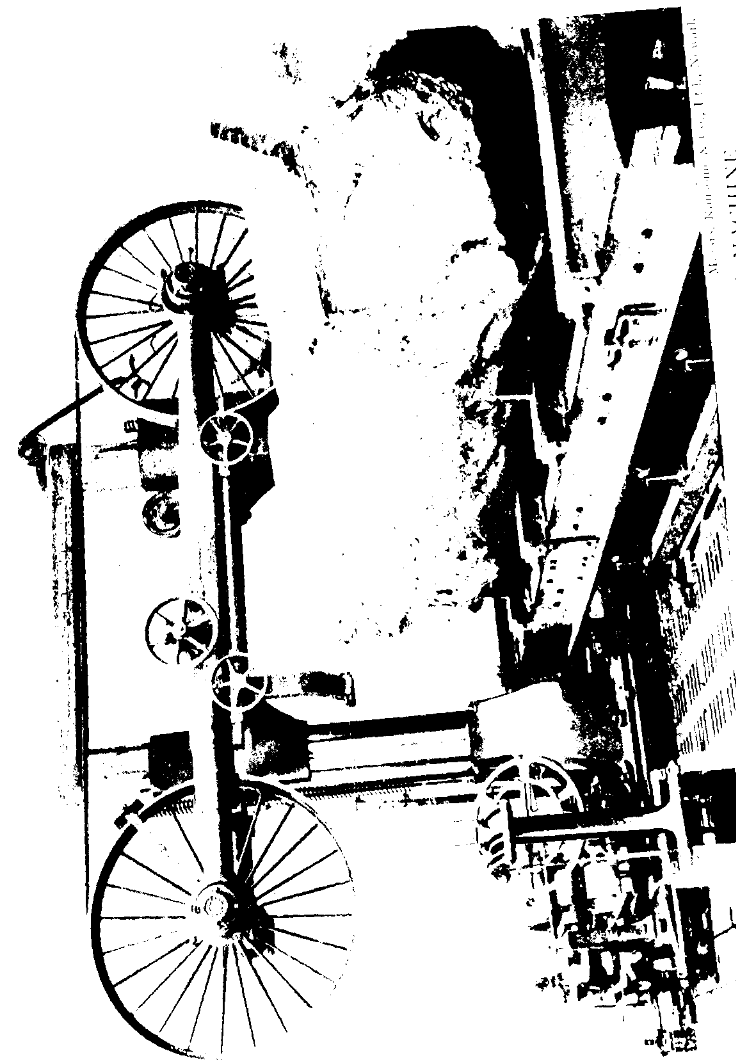
A far more complicated machine, capable of a great many more applications, is that known as a 'Universal' wood-worker, of which there are many types. These machines are most interesting in view of the manifold operations which they are capable of performing. Here is a list of some of the things which can be done on one of these wonderful machines—

the 'Complete Joiner' made by Messrs. A. Ransome & Co.—rip- and cross-cut sawing; planing (including grooving, tongueing, edging, thicknessing, and beading, all of which can be performed at one operation); the making of straight and circular mouldings, tenoning and mortising; and boring. In this machine the saws and cutters used for planing and moulding revolve on separate spindles, but on other machines the saws and the revolving cutters—the nature of which will be explained when we come to speak of the larger planing machines—are interchangeable on the same spindles.

There seems to be no end to the number of different sawing appliances which are continually called into being to meet the demands of the modern manufacturer. There are special saws for shipbuilding, carriage- and wagon-making, cask-making, pavement-block and parquet-floor making; for large joiners and small joiners, for timber works and private states, and for hundreds of other purposes. One of the most recent devices has just been introduced by Messrs. A. Ransome & Co. This is a reciprocating feed for circular-saw bevelling, by which thick short pieces of wood are sawn up into thin pieces for box-making. It is claimed for this machine that it will do in a given time twice as much work as any plain saw bench will do in similar circumstances.

When the timber leaves the saw it is 'wet,' that is to say, the cells in the wood are full of sap; and before it can be used for anything this sap must be dried out of it. You will remember that in a former chapter we just mentioned the subject of the seasoning of timber. As this is a very important matter indeed, and bears greatly on the future usefulness of the wood, this will be a good place to take a passing glance at the kilns in which the wood is dried. Our ancestors allowed several years to elapse between cutting and using the timber. But nowadays mill-owners do not care to leave capital represented by the stocks of wood they have bought lying idle for a long time, and in most places ground space is too valuable for other purposes to encumber with stacks of timber. It was found necessary, therefore, at all events in large mills, to substitute some form of mechanical drying for the slow natural weathering process.

The pioneer of warm-air drying was Mr. B. F. Sturtevant, an enterprising American, to whom we are considerably indebted for the cheapness of our timber. Mr. Sturtevant was able to obtain results which were so satisfactory that his system became generally adopted in the timber trade, by far the most numerous and largest kilns being of his design. For his kilns he used fans and steam heaters, and with these imitated the best atmospheric conditions for drying the timber. Unlike Nature, he was able to maintain these conditions night and day all the year round, instead of only a few weeks in the year, which may or may not be afforded by favourable weather, when the drying is dependent on natural conditions, and so brought down the time of drying



THE RANSOME AND LAWO HORIZONTAL BANDSAWING MACHINE from years to weeks. With the most modern adaptations of B. F. Sturtevant's system a tree can be cut down, sawn into boards, these dried, planed, tongued and grooved, and shipped within a week.

The drying of hard woods, such as oak, beech, or teak, is a more serious problem. For such woods a special arrangement is necessary, with fans giving dry air, both hot and cold, and also moist air. When the freshly sawn wood is first put into the dryer only warm moist air is admitted. This warms up the wood without letting the skin get hard. Little by little dryer and warmer air is turned on, until the wood becomes nearly dry and is less sensitive. Then hotter and dryer air can be used without damaging the material.

As the wood leaves the saws it goes straight through the dryers. The removal of the moisture reduces the weight of the wood by some 30 per cent; and this in turn means a material decrease in the cost of transporting it. In the progressive dryers, so-called because the output is continuous, the 'wet' material is piled on trucks in such a manner that there is an air space above and below each board. The trucks enter at one end of the dryer and are moved slowly through against the current of air, eventually emerging dry at the hot end.

Sometimes a dryer has to deal with many different varieties of timber—hard wood, soft wood, thick and thin for joinery and general purposes. One room may be filled with balks of timber 8 in. thick, while another is drying pine or poplar wood, and a third medium planks of oak. This variety of conditions is rendered possible with the Sturtevant Patent Triple Duct Dryer. The apparatus necessary for supplying hot, cold, and moist air to such a dryer consists of two fans. One takes wet air from the dryer and re-circulates some part in the rooms where the new wood has just entered. The other fan sends a current into a cold-air duct, and also through a steam heater, which gives the necessary heat required for evaporating the moisture.

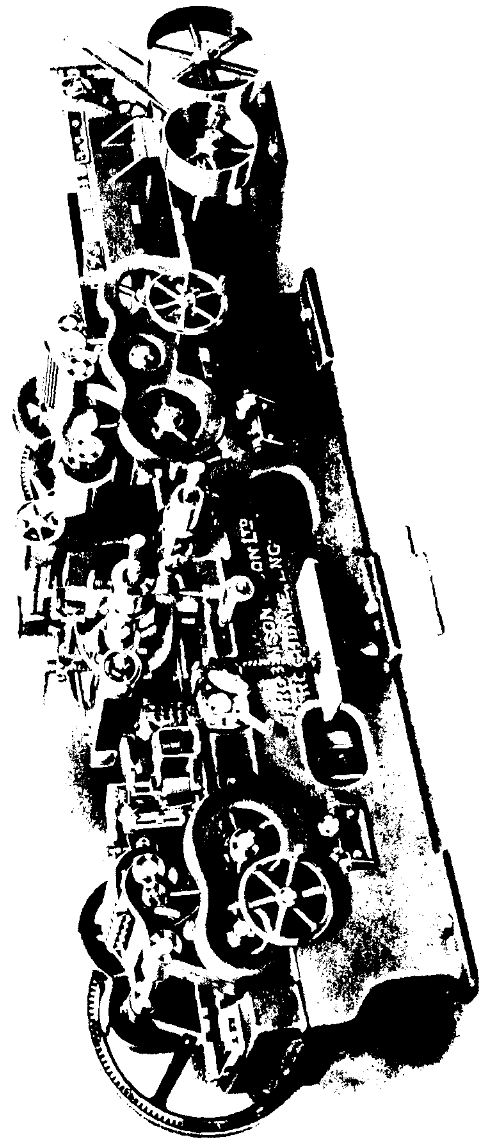
Fans are not always considered necessary for the production of the air-currents which are required in timber-drying sheds. With the Patent Automatic Timber Dryer of Messrs. A. Ransome & Co., a rotary but mainly horizontal circulation of very moist air—in fact, resembling a moving fog—is produced by natural means. At first sight it seems paradoxical to speak of the use of *moist* air for timber *drying*; but the humidity of the air is none the less regarded as the secret of successful drying. By its use the wood is dried from the centre outwards, and the surface is not hardened as it would be if dry air were used. In the Ransome Automatic system the dryer building is a long narrow shed, with doors at each end and rails for the cars. This building is kept filled; and as a truck of dried wood is removed at the discharging end, the train of trucks is pushed down and a truck of fresh wood introduced at the loading end. Therefore there is always much more moisture in the wood at the loading end than at

the discharging end. It is due to this fact that a circulation of moist air is produced by this system without using any mechanism whatever. A series of steam-radiator coils, specially designed for free expansion, is placed under the rails at the discharging end of the dryer building. Air is admitted under these coils, and rises as it is heated by them. But as it travels down the building, it rapidly absorbs extra moisture from the wood, thereby increasing in weight and diminishing in volume (thus causing a partial vacuum), and thereby inducing fresh, hot, and relatively dry air to succeed it, and to push the very moist air downwards to the earth floor near the loading end. Provision is made here to discharge a part of the highly saturated air to the atmosphere, but the bulk of the air deposits its surplus moisture on the absorbent earth floor, when the air flows back to the steam-radiator coils; and, after reheating, it resumes its rotary travel through the trucks of wood as before.

Perhaps we have spent rather longer in the drying sheds than we ought to have done; but as the problem of drying and seasoning wood indirectly affects every one of us, and as, moreover, it is one which eminent engineers have earnestly studied for our benefit, the least we can do to show our gratitude is to try to understand their work.

After the sawing and the seasoning comes the planing. Such, at least, is the general order of operations; and we must take a passing glance at the great machines through which our floor-boards and match-boards, and door-frames and window-frames, and almost everything else have to pass before they become what they are. The principles of hand and machine planing differ essentially; for whereas the carpenter works his plane backwards and forwards over the wood, which is held stationary, in the machine-planer the movements are reversed, the wood being moved past the cutters. Some of these cutters are stationary and others are rotary, being made to revolve at a high rate of speed, and most planing machines combine both fixed and rotary cutters.

One might think perhaps that the planing machine was a modern invention, but such is not the case. Sir Samuel Bentham, to whom a great many of the principles involved in wood-working machinery can be traced, invented and patented a planing machine as long ago as 1791. A rotary planer, worked by hydraulic power, was erected for the Government at Woolwich Arsenal in 1803 by Ernest Bramah, the inventor of the hydraulic press which bore his name; and the far more famous Brunel afterwards turned his attention to this type of machinery. All modern planing machines are carried on a very strong and heavy framework, for they have to withstand great strains. The wood is fed into them by rollers, and the pressure necessary to hold them in place and keep them flat is provided by weighted levers and springs and similar devices. The cutters by which the actual planing is done are knives similar to the ordinary hand plane iron, but larger, firmly fixed in revolving



A TYPE OF PLANING MACHINE MADE BY MESSRS. THOMAS ROBINSON & SON, LTD.

In the machine planer the wood is fed underneath revolving cutters, which impart to it perfect smoothness and a silky finish. A system of weights and springs supplies the necessary pressure to the cutter blocks. The machine shown is a very powerful but complicated example of a large class.

cutter blocks at the proper angle. The action of the irons is not therefore continuous, as in hand planing, but rather a series of very rapid chippings or scrapings, if one may apply such terms to a machine which produces a bright, lustrous finish on the roughest boards. The plate opposite page 124 shows a modern planing machine made by Messrs. Thos. Robinson & Son, one of the leading firms of wood-working machinery makers. This machine planes both sides of the wood as it is fed into it, and if necessary tongues and grooves them at the same time. You can judge something of its capacity when I tell you that it can perform this work at the rate of two hundred feet a minute, an extraordinary speed when you compare it with that attained by a man working with manual tools.

Closely allied to the planing machines are the moulding machines, which work on the same principle, but have cutters with shaped edges instead of straight edges. These moulding machines turn out a vast variety of work. They make the rails for our banisters, the architraves for our doorways, the mouldings and beadings for our doors and windows, our picture rails, and even the picture-frames. A moulding that would take a competent workman several hours to produce can be completed on a good machine *in less than a minute*. Then there are also thicknessing and surfacing machines, which are used for imparting to wood which is to be used for fine joinery and cabinet-work a dead-smooth, true, and level surface. These machines take the place of the trying, jointer, and panel planes used by hand. They differ somewhat from the machines just described. In the ordinary thicknessing machine the wood does not pass over rollers, but is fastened on to a perfectly true bed which travels backwards and forwards under the cutters. Such machines turn out their work exactly true and out of 'winding,' and with a surface so fine as to be unattainable by any but the most skilful of joiners. Needless to say there are many different sorts of planing machines for performing different operations. Some deal with specially thin wood, such as is used for making cigar boxes and fancy articles of furniture, others with work peculiar to trades which are probably unknown to you.

It is manifestly impossible, within the limits of a single chapter, to do more than make a rough survey of some of the more interesting of the wood-working machines and appliances used in modern factories. We might, had we the space, spend a very interesting and instructive chapter in company with the different patterns of machines which cut mortises and tenons from the monsters required for making parts of all sorts and sizes; of railway carriages to the daintier patterns invented for the convenience of cabinet-makers. There are dovetailing machines, machines for cutting out and putting together the parts of boxes, machines for sand-papering, machines for making wood pavement blocks, machines for cutting up firewood, machines for making blind slats, for making felloes and spokes of wheels,

wonderful machines for carrying out all the processes of making casks and barrels, and so on. Indeed, the trouble is to find a single operation associated with wood manufacturing industries which cannot be performed by machinery. Even your cricket-bats, golf clubs, model boats, gun stocks, the handles of your garden tools, of the humble broom, are shaped by machinery. Such articles as these—the class is so large that it would be difficult to exhaust it—are made on machines called copying lathes. A copying lathe has two spindles, one of which carries an iron dummy of the article to be made and the other the wood to be shaped. Revolving cutters mounted on an oscillating frame follow the form of the dummy, and exactly copy it on the wood as they move gradually along from one end of the lathe to the other.

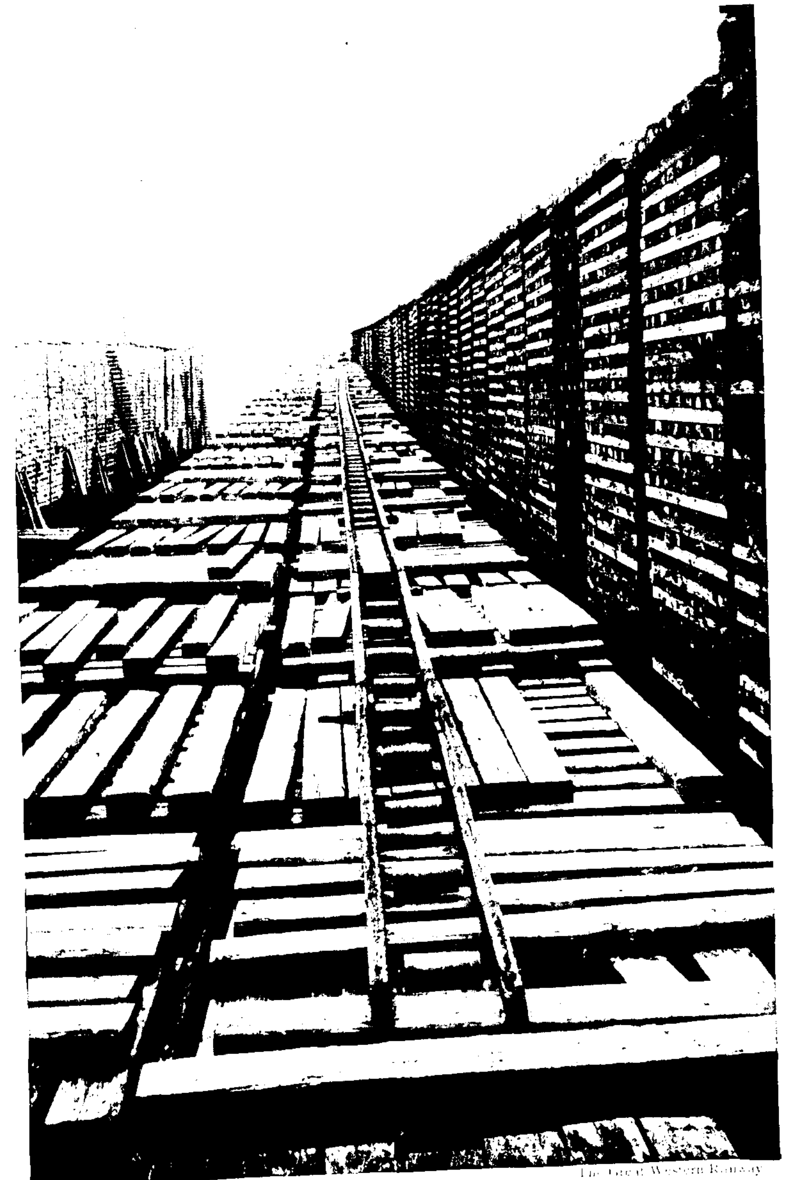
A remarkably ingenious application of the principle involved in the copying lathe has recently been applied to the making of wooden chair seats. You know the sort of chair I mean, having a dished or recessed seat; I believe they belong to the Windsor family, and there is probably one in your kitchen. The shaping or 'recessing' of these chairs looks, and is, a complicated operation, and a complicated machine has been called into being for doing the work. It is made by Messrs. Broom & Wade, Ltd., of High Wycombe. This chair-seat recessing machine has an output of about six dozen elm or beech chair-seats an hour. The working of the machine would take too long to describe in detail, but I mention it because it shows the ingenuity of inventors and manufacturers of this type of machinery. Briefly, the shaping of the seats is performed by a rotary cutter, the work being carried on a face-plate, which has three distinct motions, which are combined in order to bring successive portions of the surface of the seat under the cutter and cause it to form the peculiar contour required. The three motions of the face-plate consist, in the first place, of a rotation around its vertical axis, so that the cutter begins by forming a cup-like depression in the centre of the seat. This depression is then enlarged, owing to the second motion of the face-plate, which consists of a horizontal travel forwards towards the front of the machine. It is obvious that these two motions only would result in a regular depression in the seat, and in order to form the irregular depression required a third up and down motion is given to the face-plate.

Enormous quantities of timber are used by the railway companies. Apart from the building of carriages and waggons, of stations, houses, and other buildings, there are vast numbers of sleepers to be renewed every year, and many hundreds of trees fall to the axe and the saw in order to provide them. The Great Western Railway alone turns out some ten or eleven thousand sleepers a week, a matter of 520,000 a year. We shall find it interesting to pay a brief visit to a great railway company's sleeper depôt. Let us choose that of the Great Western Railway, which is situated at Hayes in

Middlesex, not many miles from London. Views of this yard have been lent to me by the courtesy of the Great Western Railway, and are reproduced opposite pages 130 and 134.

The sleepers are made of our old friend the Scotch pine (*Pinus sylvestris*), and are imported from the Baltic ports. They reach the Hayes yard in canal barges, and as it is unloaded each sleeper is carefully inspected and tested for gauge. They are then arranged in huge stacks, which are separated one from another by avenues, and are intersected by tunnels, and are encompassed on all sides by railway tracks. The sleeper stacks are highest at the end adjoining the wharf at which the sleepers are unloaded, and are added to at the lowest end. The means adopted for conveying the sleepers from the wharf end of the stack to the end at which it grows is interesting, and is illustrated at page 130. The sleepers are hauled up from the wharf by derricks, and are then tipped on to a roller-path, down which they travel to the place where they are wanted—surely a cheap and expeditious way of getting them down. A journey down the roller-path must be a thrilling experience, though there must be a nasty bump at the bottom. The stacks are built up very carefully, partly to ensure stability, and partly to allow a free-air circulation between the sleepers, which are roofed in with sleepers laid closely together, and allowed to remain for at least six months in order to dry them thoroughly. When one huge stack has been carried as far as there is room for it, the roller-path is taken up and relaid in another portion of the yard, and another stack is called into being.

There is a great deal to be done before the sleepers are fit to take their place on the railway track. The next step in their education prepares them for receiving the chairs in which the rails are held. They are taken from the stacks and are handed over to the tender mercies of a machine which provides a nice easy seat, true and level, for the accommodation of the chairs, and also bores the holes for the bolts with which they are held down. The machines which perform these operations are called adzing and boring machines. There are, of course, different patterns of such machines, but they all work on similar principles, and the following description of an automatic adzing and boring machine made by Messrs. Ransome & Co., Ltd., will convey a good idea of the manner in which the sleeper is treated ; this machine can adze and bore two sleepers a minute. It is quite clear that each sleeper must be adzed and bored exactly in the right places, and it is to attain this precision that makers of such machines exhibit great ingenuity. In the machine just mentioned the sleepers are placed on the machine and are immediately caught by a pair of 'dogs,' which carry them first over the adzing cutters, thus forming the two seatings, and then over the augurs, which bore the four holes all at once. One of the principal features of this machine is the arrangement for stopping the



By kind permission of The Great Western Railway

THE HAYES CREOSOTING DEPOT: THE ROLLER PATH

The stocks of sleepers are highest at the end near the canal wharf where they are unloaded, the stock being continually added to the lower end sleepers when they are in precisely the right position over the four augurs, and for again moving them on after they are bored. By this system, which is entirely automatic, the 'dogs,' after having carried the sleeper over the adzing cutters, come to a standstill when it is in the exact position to be bored, and as soon as it is at rest the four augurs are raised simultaneously and bore the four spike-holes to the required depth. Immediately after the augurs have fallen clear of the sleeper the 'dogs' automatically remove it and another sleeper is brought over the adzing cutters, and is in its turn stopped over the augurs.

Let us get back to the Hayes creosoting depôt. As the sleepers leave the adzing and boring machines they are packed on to trolleys and hauled away to be creosoted, the object of which is to preserve them from the effects of the weather. The sleepers are run into a cylinder and are charged with oil of creosote, a product obtained from the distillation of coal-tar or of wood. Although we most frequently speak of *creosote*, this word is incorrect, and should strictly be written and pronounced *creasote*. It comes from two Greek words, *kreas*, 'flesh,' and *sōzō*, 'I preserve,' and is so called on account of its remarkable powers of arresting decay. However, as engineers persist in the misspelling of the word, we must do so likewise, for fear of pedantry. Engineers are such very useful persons that we must not pick bones with them ; but they have a nasty habit of misusing old words and of coining new ones without regard to the science of etymology. They spell 'tyre' with a *y* instead of using the good old English *tire*, which means a thing that binds or ties. This is but one example of many etymological transgressions which it is as well to avoid.

A writer in the admirable little *Great Western Railway Magazine* recently gave (January 1912) an interesting account of how the creosoting of sleepers is done at Hayes.

He says: 'The trolleys are taken right up to the open cylinder, and the cradle loads run in. When the cylinder is fully charged, from 300 to 350 sleepers in all, the door is closed, hermetically sealed, and the air extracted by a vacuum pump. Then the connection from the cylinder to the oil-tanks beneath is opened and the oil rushes in. A quantity of it is readily absorbed by the dry sleepers, but is always less than that required, hence a force-pump is set working, a pressure of about 80 lbs. per square inch being usually reached before impregnation is complete. This process takes about 1¼ hours to perform. The oil is steam heated up to about 120 deg. Fahrenheit prior to entering the cylinder, as this makes the oil more mobile. The requisite quantity of creosote is 3½ gallons, or 37 lbs. per sleeper of 9 ft. by 10 in. by 5 in.

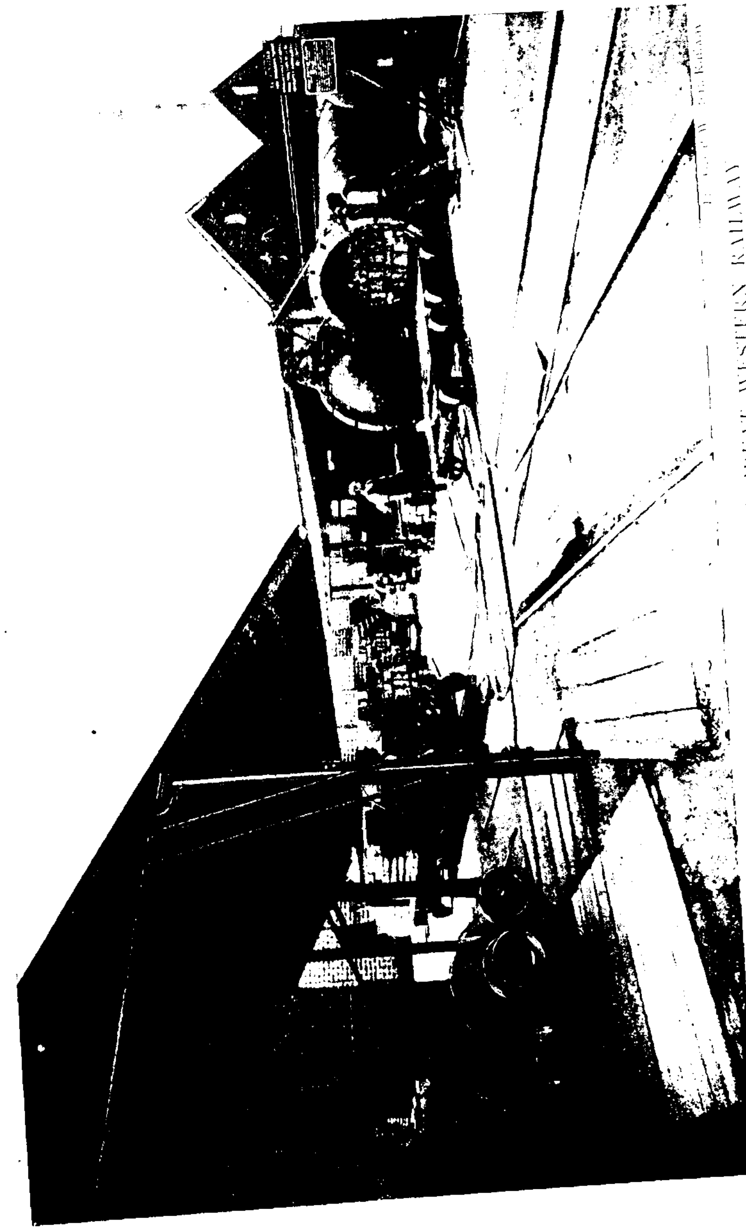
'The method of measuring the oil consumed deserves mention, and is as follows: In the power-house is fixed a vertical graduated scale with two copper wires strained from top to bottom, and on each wire works a pointer, one of which can be clamped at any particular reading; the other is a movable one

connected to a float in the oil-tank. Before oil is admitted to the cylinder the position of the movable pointer is read off to the nearest one-sixteenth of an inch, and again after the cylinder is completely filled, which is indicated by a valve on the top of the cylinder. The other pointer can now be fixed at a point above the movable one, one inch difference representing 125 gallons of oil, allowance being made for absorption during the filling of the cylinder.

'The force-pump is then set working, and as the oil level sinks in the tank so the lower pointer rises until it just touches the fixed one, an electric current is set up by the contact of the wires, and a gong is sounded. The engineman then shuts off the force-pump and the pressure is taken off. The surplus oil is run back into the tank, the quantity being approximately equal to that necessary to fill the cylinder at the outset. After the door of the cylinder is opened the cradles of sleepers are drawn out by a steam winch and loaded up again on the trolleys.'

The trucks of sleepers are next run into the building in which work the chairing machines. The bolts are driven into the holes prepared for them, and the chairs are placed over the bolts. Then the sleepers are centred in a machine; hydraulic rams engage the jaws of the chairs, accurately fixing them to gauge on the sleeper and forcing them on to their seatings with a pressure of nine tons each. Now descend four revolving spanners which screw down the nuts to a uniform pressure, the spanners automatically ceasing to rotate when the nuts are screwed tightly enough, and the sleeper is ready to take its place in the railway track. One may think that it finds its long rest pleasant after the strenuous times through which it has passed!

Unless special precautions are taken to dispose of the dust which is always present in sawmills, there is great risk of fire. The dust arising from wood-working machinery is as highly inflammable as that which is an ever-present source of danger in coal-mines and in cotton and flour mills; and it is said that, so far from needing an accidental spark to fire it, it may, in certain circumstances, ignite by spontaneous combustion. Needless to say, there is grave danger to work-people who have to inhale this dust-laden atmosphere, quite apart from the danger of fire; and it is therefore necessary to get rid of the dust as expeditiously as possible. What is actually done is to prevent it from reaching the air at all, by collecting it immediately at the point where it rises from the wood at the machine. At page 138 is shown a view of a wood-working factory in which a dust-removing plant has been installed by Messrs. A. Ransome & Co., Ltd. You will see that there is a hood over the cutter of each machine, and that each hood is connected with the big pipe which runs down the centre of the workshop. By means of fans a strong current of air is set up in the pipes, and the dust and shavings are drawn through them to a receptacle outside the building.



By kind permission of [illegible]

THE HAYES CREOSOTING WORKS OF THE GREAT WESTERN RAILWAY

The sleepers have been adzed and bored [illegible] they will be impregnated [illegible] under pressure

CHAPTER VI

A Talk about Tools

ONCE upon a time there was an Ardent Carpenter. There came to him one day, quite unexpectedly, an irrepressible desire to 'make something.' To you, too, if you have not already suffered its agonies, will come, sooner or later, this same desire. That your sufferings may be less severe, listen to the story that is here set down.

The ardour came from youthfulness, almost excessive youthfulness; the carpenter was made by the purchase of a heterogeneous collection of tools. Such tools they were! The gloss of the wooden handles rivalled the glint of the blades; they were new, resplendently new; they were pretty, decidedly; they were expensive, they were indispensable. The last quality seemed indisputable: it was averred time and time again by the shopman who fished them out of obscure drawers. But somehow they looked unbusinesslike; and they were. The shopman said they were indispensable. He was a good shopman, who ought to have got on well in the tool line. You see, he put it this way; he said, of course the Ardent Carpenter must have so and so—strongly recommended—couldn't do without it—most important item—in fact, absolutely indispensable; said the Ardent Carpenter—why yes, of course he must! It was simply a matter of exchanging a few bits of stamped metal for a few bits of forged metal; the former left a particularly airy pocket and went into a stuffy cash-register, the latter came out of obscurity and were done into a parcel. The Ardent Carpenter thought he heard them chuckling and nudging one another as he carried them home, but it was not until much later that it occurred to him that they were laughing at him.

For the next few weeks those tools were the bane of the Ardent Carpenter's existence. They worried him to distraction; they haunted him by day and by night. They were malicious, ill-tempered, pugnacious tools; and they were incompetent. A more utterly useless, pig-headed, inadaptable, incompetent collection of tools was never before brought together. They got up and hit him when he wasn't looking. They barked him and grazed him and chipped bits out of him when he tried to show them what they were meant to do. And when he gave up this task in despair they simply lolled about and grinned at him.

The Ardent Carpenter did the only thing he could do in the circumstances. He arranged the tools in a row, and sat down and blamed them. Idiot? Not a bit of it. He talked to them seriously for half an hour or more, and made them feel thoroughly uncomfortable and ashamed of themselves. Then he

bundled them up and went to see the shopman. That shopman suffered from a perverted sense of humour; he seemed to think there was something quite funny about the Ardent Carpenter and his tools. First he laughed, then he said he could not take them back; after that he laughed again.

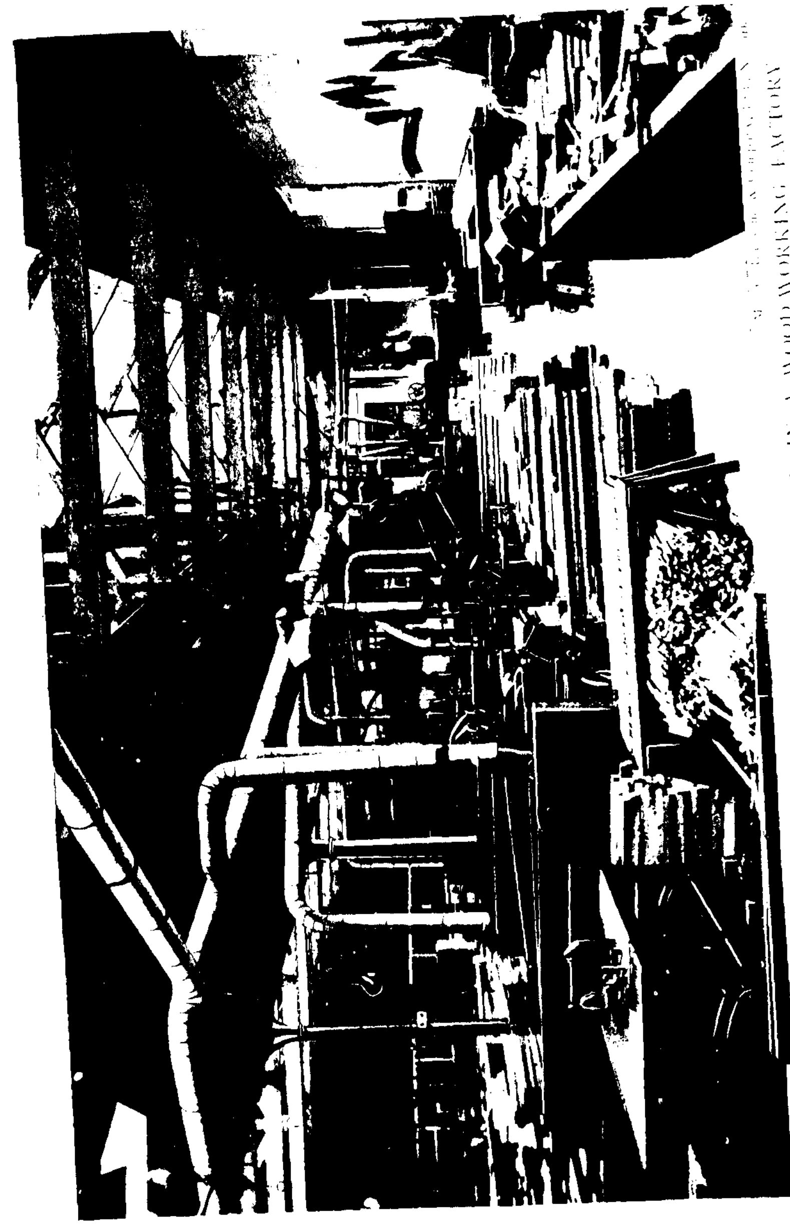
In spite of long and weary warfare with his recalcitrant tools the Ardent Carpenter persisted in his determination to 'make something.' And after a time an armistice was held; the Ardent Carpenter said he was tired of going on like that, and the tools said *they* were tired of going on like that; was it not time that they tried to understand each other better? There were apologies all round, and things began to go much more smoothly. Indeed, so smoothly did things go that in time the Ardent Carpenter's desire to 'make something' was actually fulfilled. The 'something' was called a cabinet by its maker, and, although many were heard to question the description, it may be presumed that it materialised a peculiar notion of a cabinet's nature.

There came one day to the house of the Ardent Carpenter an ordinary Vulgar Carpenter, to whom the other took the opportunity to show his cabinet. There was no false modesty about the long-suffering maker of that cabinet, none of the half-ashamed 'I know it's very poor, but I'm only a beginner' apology about him. He took his vulgar brother of the bench by the apron and led him proudly to his masterpiece. 'See,' he said, 'I made that!' What the Vulgar

Carpenter saw worked strangely upon his emotions; strangely he expressed himself. All he said (he was a very Vulgar Carpenter) was—'Help!'

'So,' the Vulgar Carpenter said to the Ardent when he was calmer, 'You made that, did you, sir? Very pretty, I'm sure, but it's not carpentry. Why, sir, in the time it must have taken you to make that box on legs you could have made two cabinets, and have taught yourself how to plane into the bargain. You see, sir (begging your pardon if I speak too plainly), there are some joints for one thing and others for another, and they are all made to hold a thing together; whereas your cabinet might be held together by the putty round the glass door for all the good that match-me-if-you-can arrangement round the corner is doing. You invented it yourself? If I were you, sir, I'd give up carpentry and take to fret-work; it is a far less exhausting occupation.'

The morals to be deduced from this sad story are quite clear; and stories as sad, or sadder, with equally potent morals—which are objectionable things when applied to ourselves—could doubtless be drawn from the personal experience of most of us who have tried 'to make something.' All of which goes to show that tools will not make a carpenter any more than a mast will make a ship. It may be taken as an axiom of wood-working that the quality of a man's workmanship increases in proportion with the quality and condition of the tools he uses, and decreases in proportion to their number. To make this clearer, let us



MESSRS. RANSOME'S DUST-LAYING PLANT INSTALLED IN A WOOD-WORKING FACTORY say that the craftsman who has a few good tools, kept always in the pink of condition, will show greater versatility in his work, and so produce better work than his brother who has a different tool for every operation, but does not keep them in proper fettle. You will see in almost every tool-maker's catalogue a great many tools which are advertised as 'a most useful and necessary adjunct to the bench' or as 'quite indispensable.' So they may be to the workman who has to turn out a large number of chair-legs, let us say, or table-tops, or blind slats, to the man who has to do a great deal of 'repetition' work in as short a time as possible; but to those who, having made one thing, set themselves to make something different, most of these tools are not only unnecessary but expensive bug-bears. 'I can nearly always tell a good workman,' an architect once said, 'by his tool bag. If it is poorly furnished I conclude that he knows how to use the few tools he carries with him; and I mistrust the workman who finds it necessary to put in his bass all the tools he can lay hands on, for I feel that he has more confidence in his tools than in his head or hands. And experience has shown that I am generally right.' You may broadly divide carpenters into two classes. The watchword of the one class is 'speed,' and the watchword of the other 'soundness.' Class number one is mostly confined to the town and has to match itself with machinery. It works without thinking, it works quickly, it works with the latest tools and devices that will enable it to compete with its mechanical rival; it will eagerly snatch up anything that can be devised to enable it to knock minutes off the performance of this or that operation. The second, the 'soundness' class, jogs merrily along in country corners. It employs old tools, old methods half forgotten in the busy places of the world. It is a leisurely, rumbling, rambling, unsophisticated old class, casting but half a glance or none at the slipping sand in the hour-glass. It is an exasperatingly deliberate, complacent, self-satisfied, don't-care-if-I-don't-get-on old class. It is ill-paid; it is much abused; but there is one very remarkable circumstance about this very remarkable class of carpenters—it fully justifies its motto. There is no shadow of doubt about that; there are bad carpenters in the country as there are good carpenters in the town; but the fact remains that the workman who works with one eye on the clock will come off second best if pitted against one who does not know what the clock says, though the former be armed with the latest tools, the latest methods, and many of both, and the latter be content to use his father's tools and his father's ways of using them, and few of them at that.

Good tools are very useful to the carpenter, be he the professional or the Ardent Enthusiast fired with the desire to make something; but knowledge of how to use them is more useful still. And I think you will agree that to master a few tools well is a more useful accomplishment than to half-master a great many

tools. Unfortunately for their peace of mind most Ardent Enthusiasts seem to nurse the fallacious theory that the range and number of 'somethings' that can be made bears a direct relationship to the range and number of tools in their tool chests. It is to dispel this fallacy that this chapter is written. Its object is to show that *the fewer the tools the better the work*. As this statement is likely to arouse a chorus of disapproval, perhaps it will be as well to qualify it by adding that it applies less to professional carpenters than to amateur; and that it applies most particularly to young amateurs. To the latter, let it be said at once that the tyro in the wood-working crafts who sets about his hobby by the simple expedient of buying a lot of tools most certainly wastes his money, and still more certainly does he waste time. Three tools which he has learnt how to handle properly will enable him to do better work, and more of it, than a whole boxful of tools which he does not know how to use.

In some of the cities of Switzerland and Bavaria—and indeed of many other countries—the traveller may buy, very cheaply, beautifully wrought little figures of wood; and even in the streets of London, when the damp fog shrouds the traffic and muffles its roar, when the afternoon pretends to be the evening, and busy, brightly-lighted shops remind us that Christmas is coming, there are to be found on the curbstone ragged, hungry-looking creatures ever-imploring the passer-by to stay and examine their trays of penny toys. Most of those crude penny toys, and most of the artistic little wood-carvings to be seen in continental cities, are made with only one tool —a sharp knife. Perhaps you say, 'Penny toys and wood-carvings have nothing to do with carpentry.' Perhaps they have not; but I am inclined to the opinion than most of the makers of those articles can do more with their sharp knives than you can do with all the tools at your disposal. It is not the tool that makes good work but the workman's mastery over his tool, and to those of my readers who feel that they would like to make something let me add one more word of moralising. It is this: a good tool is the workman's best friend when he knows how to use it and understands its limitations, and no tool can be a good one to the workman who has not mastered this rudimentary principle. By all means make something—even if it is only a mess. Think of the romance of the wood you will use, which can bring to a city garret a breath of the murmuring forest; think if you will of the romance of the commonest tool, of the romance of the craft you are entering. Drink deep of the joys of the well-set plane, echo the song of the saw. Yes! make something, and dream of making others, and you will taste one of the sweetest joys of life—less liable to cloy, I think, than any other in the whole realm of pastime. Let the cricketer bleat about bats, and the fisherman rave of his rods! Smile, supercilious gardener! There is no scent in your nostrils that is more dear to you than the scent of the fresh-

cut wood to us. Squint on, you with the microscope! What you find beneath your lens we found there long ago! We say that you none of you derive so much pleasure, so much benefit, so much health and strength and entertainment from your hobbies as we do from ours. Thus the amateur carpenters.

Well, you may believe them or not as you please. They may be right, but there is a strong probability that they are wrong, being for the most part young and ardent. We love our gardens—at least I love mine, when I can keep out my neighbour's pigs; and Isaac Walton was a fisherman and a most amiable fellow. And cricket is a capital game, and microscopy an absorbing science; and on the whole we must admit that all these are admirable things in their proper seasons and places, and that carpentry does not differ from them in this respect. What any one may say or think about this matter does not make carpentry one whit the less useful or deprive it of any of its interest. By all means, therefore, let us be carpenters, and other things as well.

Assume, then, that this question is settled or shelved; we want to be carpenters—at least we want to make something—and carpenters we will be, without more ado. What tools shall we buy? Or, in view of what has gone before, what tools shall we avoid buying? Saws we must have, and planes and chisels, and a hammer and a box of nails; screw-drivers and gimlets? Oh! and a glue pot? Perhaps; but let us take them one at a time. Saws. Did it ever occur to you that a saw is a remarkable tool? It is remarkable alike for the simplicity of the principle on which it works, for its wide applications, for its amazing diversity of types, and, not least, for the ignorance people show in their use of it. There are, I believe, about a hundred different kinds of saw teeth; here are a few of which, probably, you never heard: half-moon, hook, dog, lance, seg, gullet, parrot bill, hog mane, bird tail, false tooth,—all quite distinct, and each used for a different purpose. You do not need to be told, of course, that carpenters' saws, and for that matter all other saws as well, depend for their power to cut on three attributes—the sharpness, cutting angle, and 'set' or angle of divergence from the horizontal plane, of their teeth. Without these things a saw would be little more useful as a cutting tool than a piece of old iron with a serrated edge. A saw depends on the sharpness and the face-bevel or cutting angle of the teeth for its power to cut accurately and rapidly, while the set of its teeth enables it to clear itself as it is worked. Unless the kerf, that is, the passage which the saw makes in the wood, were wider than the blade of the saw, it would stick so that it could not be moved. When you find that your saw begins to jam and stick when you have sawn half-way through a piece of wood, you may take it that the saw is demanding in the plainest possible language that it shall be re-set before it will do another stroke of work. The shape, size, number, and face-bevel of a saw's teeth vary with the work

it was called into being to perform. But as—for the present at all events—we shall have to do with a single saw different sorts of work for which experienced carpenters would use several different saws, let us confine ourselves to the one which will be most generally useful to us. We will therefore choose a hand-saw; between 24 and 30 in. will be a suitable length, and it should have four teeth to an inch, although most hand-saws used for cutting soft woods have five teeth and for hard woods six teeth to the inch. A saw with a lesser number of teeth

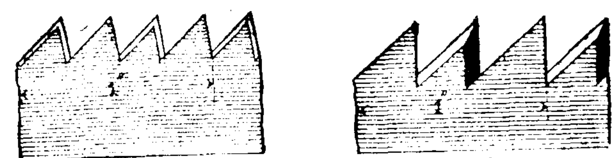


FIG. 1.—Ordinary Teeth of Cross-cut Saws (for soft wood). A, four teeth per inch; B, three teeth per inch.

will be more useful to us because we shall sometimes require to use it for ripping, that is, for sawing wood in the direction of the grain, and for this purpose a few large teeth are better than a larger number of smaller ones. A hand-saw is properly used for cutting wood against the grain, that is, across it. The carpenter who may be called upon to do all sorts of different jobs, from rough joinery—post and fence work and the like—to cabinet-making, arms himself with a regular magazine of saws. He will even have several different kinds of cross-cut saws. One, used only for sawing pine and other soft woods, will have five teeth, or the points of five teeth to the inch, and the face-bevel of the teeth set at an angle of about 45°. He will have another saw, with teeth having their face-bevels at a lesser angle, which he will use for angle-cutting. He will have another one with different shaped teeth, and fewer of them, for cutting hard woods, and still another for cutting very hard woods. Mind you, I do not say that every carpenter has all these kinds of cross-cut saws; some, doubtless, at least among the 'soundness' class, would not be able to tell which was used for what, any more than you could; but I know some carpenters (though they would not care to be called carpenters, since most of them follow, so they would tell you, the far more advanced craft of pattern-making) who actually use all these saws, and who would consider it a great hardship to have to do without any one or another of them. I had very nearly forgotten about one kind of cross-cut saw, which is in such common use that it slipped my memory for the moment. Here it is—the most aristocratic member of its family—the panel saw, rather delicate, very slender, having many teeth, and boastful of its capabilities of fine work. It is one of the 'indispensable' tools in the shop.

The workman who has to cut up thick wood longitudinally brings, as I just said, the rip saw to his aid. This is a larger and thicker saw than the cross-cut patterns and materially differs from them in the shape of its teeth. In this saw the teeth have their

faces at right angles to the blade, and are sharpened dead square on the face. The rip saw may be regarded as the coarsest of all saws. The finest is not to be found among those we have mentioned, but among either the back saws or the frame saws. The back-saw class includes the tenon and the dovetail saws. They have very thin blades, which would buckle in use if they were not strengthened by iron or brass 'backs.' Their names imply the uses of these saws. They have many fine teeth, the number varying from eight to twelve or more points to the inch. The frame saws are also very fine and delicate. They are used for cutting out spaces from the inside surface of work, and are made very narrow, for they sometimes have to saw out small curves and corners around which they must be able to turn readily. They are thus called turning saws or frame saws or bow saws from the fact that strength to do their work is given to these frail and slender saws by virtue of a frame which holds them in tension. The fret saw is a form of frame saw, and the most fragile of all. Nor, while we are on this bewildering subject of saws, must we forget to mention the compass saw, a very fine and narrow saw used for cutting curved surfaces. It has a little brother called a keyhole saw, so called because it is small enough to cut out keyholes and other small pieces of wood. Several shapes and sizes of these little compass saws are sometimes made to fit into one handle or 'pad,' whence they are sold as pad saws. Should you ever be beguiled into buying a pad saw, see to it well that the pad is so formed that the sharp 'tang' or spiked end of the blade cannot slip through and jab you in the palm of the hand while you are using it.

So much for the saws which the carpenter and joiner and cabinet-maker, the wheelwright, the shipwright, the musical instrument maker, the cooper, the pattern-maker, and the rest of the wood-workers generally use with their hands. We will suppose that we have not sufficient pocket-money to buy more than one of these saws, or that we are not quite sure whether the desire to make something will last long enough to justify a greater expenditure; or, if you prefer it, suppose that we were cast on a desert island, and were fortunate enough to have with us (being in this respect lucky, like the Swiss Family Robinson) one saw: assume any of these things—which saw should we prefer to have? Which should we find the most generally useful? Ah! I have a nasty creepy feeling which tells me that I have let myself 'in for it,' as vulgar people say. I know enough of carpenters and carpentry to be quite sure that whatever kind of saw I mention here in answer to our question, I shall be howled down and commanded to take the very last of back seats by a battalion of indignant sawyers, each armed with a saw superior to any other. So I am going to shirk the responsibility of expressing my opinion and will tell you instead what my 'odd-jobs' man thinks about it. He is a very competent 'odd-jobs' man. True, he has a mania for putting up unnecessary

fences, but he is really great on poultry-houses, and likes to exhibit his skill on household repairs. He can put new vigour into the most wobbly of hard-worn tables and the crankiest of ill-used chairs; and he seems to do everything with only one tool—a time-honoured saw. 'Turner's "Farmer's" saw, that's what it is, sir; and the best as ever I used.' I am inclined to think that it is the only one as ever he used, which probably accounts for the diversity of uses to which he is able to put it.

You might do a great deal worse than follow the 'odd-jobs' man in his choice of saws. For my own part, I have a great regard for the saws of Disston's manufacture. These are American, while Turner's come from Sheffield; and I have a feeling that the British boy's choice will be guided by patriotic motives as much as by anything else. So we will suppose that we invest 3s. 6d. (I think that is the price) in a 'Farmer's Saw' made by Thomas Turner & Sons of Sheffield. It is 26 in. long—a nice convenient size—having four points to the inch, and is a capital all-round saw. Whatever saw you get, no matter by whom your choice is guided, it will have a beautifully bright finish to begin with, and one of your duties will be to see that its brightness is never allowed to vanish. Sometimes you will want to use your saw out of doors on a damp day, or you will saw damp wood, or a wood such as oak which has an aversion to bright steel, and shows it by trying to make it rusty. A rusty saw—or even a tarnished as well as setting, and unless you can obtain an old disused saw to practise on, I strongly advise you to watch a workman perform those delicate operations before attempting them yourself.

There is a great deal of work which we can do with our saw, but, on the other hand, there is a great deal we cannot do with it. We could build a house with it—a fowl-house at any rate—but we could not make a kitchen table or even a bookshelf for our den. But, wait a minute—we have not yet learnt how to use this simple and ubiquitous tool. That, when you come to think of it, is an even more important item of the carpenter's outfit than the knowledge of how to set and sharpen it; yes, we must certainly learn how to use our saw, and I had almost forgotten to say anything at all about the matter. Oh yes! I can hear you; you are grumbling away like an old woman. *You do not want to be told how to use a saw? You know already?* So you may, my friend, so you may. Indeed, I doubt not that *you* can use a saw excellently well. But then, you see, there are those young brothers to be considered. For all we know, they may get hold of our book; they are so very cock-sure of everything, those young brothers of ours, that we may as well take them down a peg here and now. So I tell them point-blank that they do not know how to use even the common or garden hand-saw. I have seen them at it, time and time again, wasting wood and spoiling other people's saws, as though wood and saws could be had for the asking, or picked up in the

street. I've seen them scraping and scratching and blowing, as though their bit of deal was *lignum vitae* and their saw half a hundredweight in weight. Of course, that is not the proper way to saw, as we know well. The less energy that is used in sawing the better the saw will cut. Indeed, a sharp saw should cut by its own weight alone. It should be started by running it lightly downwards against the wood, and *not* by pulling it upwards, after the manner of many people who know no better. The saw cuts on the downward stroke, and scarcely at all on the upward. Hold it at an angle of about 45° with the work, and place your thumb against the blade to guide it on the line in starting it. Then, if you hold it perfectly straight, you will find that the saw requires little or no effort to work it, and you will have no excuse for complaining that it 'cuts crooked,' after you have had a little practice, at least. Always use a scribed line to saw to, and cut alongside this line, so that there is no measurable gap between it and the saw kerf; but do not cut actually through it, or obliterate it. When you have become reasonably proficient in the use of the hand-saw you should invest in a tenon saw; but we shall speak of this later on, when the time comes to use it.

Let us now leave our saw hung up out of the way while we turn our attention to the next tool, without which the carpenter would not be able to get very far with his work—the plane. Although there are not so many varieties of planes as of saws, the plane family is sufficiently numerous to make it rather formidable to beginners like ourselves; and we ought therefore to make acquaintance with the names and uses of the commonest planes before we go any further. All planes work on the same principle, and they all consist of these three essential parts: the stock forming the body of the tool, the iron which performs the work of cutting the wood, and a screw or wedge by means of which the iron is made to maintain its correct position in the stock. The stock is generally a block of beechwood having a gap in the centre, and its inner sides grooved to take the cutting iron and the wedge which holds the latter in place. In the face of the stock is the narrow slit through which the edge of the iron projects. The iron of most planes has two parts, the cutting iron proper and the back iron, which is fixed to it by a screw. The purpose of the back iron is to change the direction of the shaving, to turn it off, that is, and to throw it upwards and out of the way through the escapement or mouth of the plane. The back iron literally 'breaks the back' of the shaving and so deprives it of its power to tear up the fibres of the wood in advance of the cutting iron.

The first plane which the carpenter uses when he starts to make anything is the jack plane, which is about 15 in. long. It takes the rough surface off the wood, the 'jacket' as carpenters call it, and it 'carries more iron' than the other planes, which, in plain language, means that more of the iron projects through the mouth, so that a thicker shaving is cut off.

A plane of the same shape as the jack but very much longer, being generally about 30 in. long, is called a trying or try plane. It is used for accurately facing up work which has had the rough removed by the jack plane. The carpenter uses this plane for 'shooting' the edges of his work, the great length of the stock taking off all inequalities and leaving them perfectly true and straight. When the time comes that you require to make a butt joint of two long pieces of wood, as for a wide panel or a table top, it

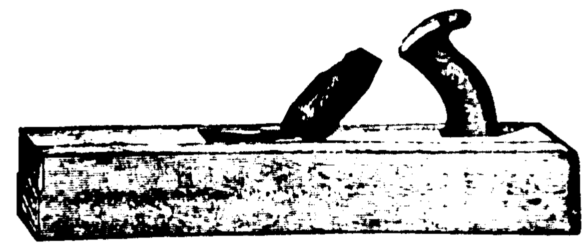


Fig. [illegible].—Jack Plane.

will be necessary for you to beg, borrow, or buy a trying plane; but until then you may safely forget that such a thing exists.

The smoothing plane is another which is in everyday use. It is much smaller than the jack or trying planes, and its sides are rounded instead of being parallel. It carries very little iron, being set to take a very fine cut, and it is used for finishing up work, removing scratches and dirty marks and the like. The three planes just mentioned, the jack, trying, and smoothing, are called the 'bench' planes, because they are used on every piece of work that passes through

Fig. 4.—Smoothing Planes. A, [illegible] Wood; B, [illegible]

Fig. 5.—[illegible] Plane.

Three Useful Planes.

the joiner's hands. There are three other planes, called fore, panel, and jointer, which belong to the same class and are variations of the trying plane, but we need not trouble about these. But there are other planes which you will need to use later on, when you have mastered the bench planes, and we may as well make acquaintance with these now. There are indeed so many more planes that it would take a long time to speak of them all, and we must therefore confine ourselves to those which are in most frequent use. The first of these is a rebating plane, which is used for cutting rebates or ledges. It has only one iron, and a narrow one at that, and as there is no back iron to turn off the shaving and throw it out, special provision is made for this in the shape of the plane. There is no opening in the top of the stock as in the case of the double-iron planes; instead, a circular opening is cut in the side. This space is tapering, being wider on the escapement side than on the other. A circular motion is thus imparted to the shaving. A more complicated form of rebating plane is called a fillister. It has a 'fence' or guide by means of which the workman can adjust it to cut a rebate of any particular width, the ordinary rebating plane being merely guided with the hands. The fillister is also fitted with a vertical knife which turns the angle of the rebate as it is cut, thus obviating the necessity for subsequent cleaning up with the chisel.

The rebating plane and its more aristocratic brother can only cut on the outside edges of work. It is, of course, frequently necessary to make a depression, such as a groove or a slot, some distance from the edge of the work, and for this purpose a plough plane is used. Like the fillister, the plough plane has an adjustable fence which can be regulated by screws to enable the workman to cut a groove at a considerable distance from the edge of the work. There is also a vertical adjustment for regulating the depth of the groove to be cut. Plough planes vary considerably in form and in the number of adjustments and tools combined in them. Some of them are very elaborate and can be made to do all sorts of work, such as tonguing and grooving, slitting, rebating, beading, and moulding, so that the owner of a plane of this kind can dispense with several others. A good plough plane is an expensive tool, and withal a delicate one, and until you enter the higher realms of joinery you ought to be able to manage without one.

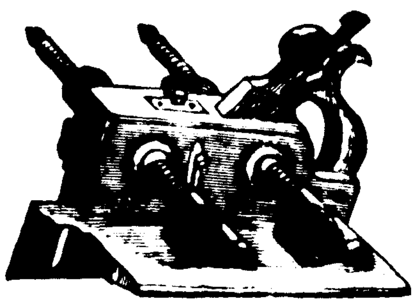


Fig. [illegible]. A Plough Plane.

A much simpler kind of plough plane is the router. It consists of an iron stock and a right-angled iron which can be raised or lowered to suit the depth of the depression being cut. The special purpose of the router is to cut depressions at any distance from

the edge of the work. Thanks to the fence by means of which the workman is able to guide the fillister and plough planes, he can cut his grooves and rebates with no other preliminary than the sharpening and setting of the plane irons; but with the router it is first of all necessary to cut down the sides of the depression to be made and to take out some of the material with a chisel. In the sunk space so made the router cuts lower and lower, its iron being lowered from time to time until the proper depth is reached. It makes a perfectly smooth hollow into which a chisel could not properly reach, and its right-angled iron enables it to work into corners.

At the beginning of this chapter we laid down, in no uncertain terms, the necessity for the embryonic carpenter to avoid buying a large number of tools, our plea being, you will remember, that he will the more readily master a few tools; and we must act up to this resolution in choosing our planes. I say 'planes,' in order not to give too great a shock to those who are not beginners. Such as these will shake their heads of superior wisdom and will tell you that you cannot manage without several kinds of planes. You must have a jack plane, they protest, and you must have a smoother, and you must have a trying plane, and a rebating and a ploughing, else how are you to do the work for which such planes as these were invented? Perhaps you think that this is incontrovertible; for, after all, say you, workmen do not buy planes and other tools just for the fun of buying them. That is true enough; but permit me to remind you that you are not yet a workman, and that this argument therefore does not apply to you. No, I insist on the limitation of tools; and that you shall confine yourself to the selection and purchase of a single plane, as of a single saw.

I mentioned just now that the bench planes are generally made of wood, beechwood being the commonest material, though the stocks of the most expensive planes are sometimes made of box wood. They are also made largely of steel and iron, and, all things considered, an iron plane will be the most suitable kind for the beginner to buy. It will have the disadvantage of greater weight than a wooden plane of the same size, but, apart from this, it will be a more useful tool, for these reasons: (1) The face is planed quite true before it is bought and needs no attention afterwards. The face of the wooden plane is not often true, and consequently has to be planed up from time to time by the workman—a delicate operation at the best of times, but an impossible one when there is no second plane with which to do it. There are other little adjustments—such as the paring of the wedge—which a workman performs on his plane before he is really satisfied with it. (2) The wedge adjustment common to wooden planes is less easily mastered by the beginner, who finds out the knack of screwing up the iron to the correct angle and correct depth more quickly. All metal planes are fitted with screw adjustment. (3) A cast-iron or

steel panel plane is rather longer than the ordinary smoothing plane, and a little shorter than the jack. Strictly speaking, the panel plane is used for very fine and accurate work, and a joiner would not dream of using it for the rough work which is the proper province of the jack. It is, moreover, a more expensive tool than either of the other planes. However, setting aside these objections, an iron plane of the size of the panel plane will be a very useful tool

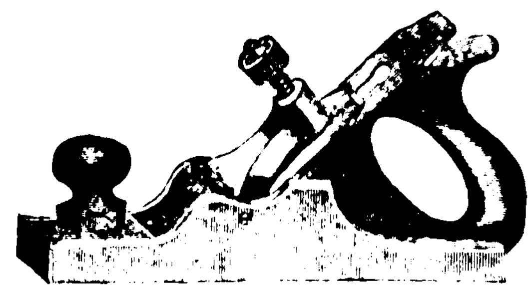


FIG. 7.—Cast-iron Panel Plane.

for the beginner. I remember buying at a sale at one of the big tool shops an iron panel plane which was a bit old-fashioned, and was consequently sold at a very low price; perhaps you might be able to buy one like it. In any case buy with your plane a duplicate cutting iron, and use one for rough work and the other for fine.

Before our plane can be of any use to us we must possess ourselves of an oilstone. Oilstones are small oblong blocks of very fine-grained sandstone, and are used for putting a keen edge on all cutting tools.

and 'wipe' it very gently across the stone, holding it perfectly horizontal. Give it a slight rotary motion and then lift it clear away from the stone, clean off the oil with shavings or a piece of rag, and it is ready for replacing in the plane. Of course the back iron must first be fixed to it in the right position. Remembering what was said about not letting the edges of the two irons come in contact, you must slip the screw through the hole, slide the iron down and screw it up as tightly as you can, using your fingers. The cutting iron should project beyond the back iron about $\frac{1}{16}$ of an inch for the jack plane (or the iron you will use to do the work of the jack plane) and about half as much for the smoothing plane. Having screwed the irons together with your fingers as tightly as you can, place them flat on the bench and use a screw-driver to make them still tighter. If you have bought an iron plane having a screw adjustment you must notice, when you take out the iron, how the adjustment works; there are slight variations in different makes of plane, and you will reverse this process when you replace the irons after sharpening them. For the preliminary rough work for which the jack plane is used rather more iron must project through the hole in the face of the stock than is allowable for finer work. For the latter, the iron must just show through and no more. You can tell how far it projects by holding the plane up and looking along it, and the knowledge of the amount of iron which is actually necessary for a particular opera-

tion can only be gained by experience. It will vary slightly according to the nature of the work, and the hardness of the texture and dryness of the wood; and you will also be assisted by your own judgment. A light tap with a hammer on the top of the iron will send it slightly forward, and a corresponding tap on the heel or back of the stock will cause it to move slightly backwards. After a little experience you will get in the way of quickly adjusting the position of the iron to suit your work. In the wooden planes, which have the irons held in by a wedge instead of a screw, the method of taking out the iron is equally simple, although it may take you a little longer to master. The wedge is loosened by a tap given on the heel of the stock. Remember this, if you buy such a plane, and do not deface it by banging it about on all sides to make the iron come out.

You will need a considerable amount of practice with your plane before you will be able to true up properly a piece of wood. There is a knack to be acquired in the sharpening and setting of the iron as well as in the actual handling of the plane, so that you must not be in too great a hurry to 'make something.' A good way to acquire practice, even though it be rather uninteresting, is to plane up all sorts of odds and ends of wood, first taking care to see that there are no nails in them. You must provide a stop on the bench or table at which you work to rest the wood against when you are planing. A couple of screws which can be raised or lowered to suit the thickness of the wood answer well; or you can buy an adjustable bench stop which can be let into the bench; or, again, you may improvise one for yourself by the useful exercise of a little inventive perspicacity. Always make a point of scribing a line on your wood to guide you when planing, or when doing any other operation, for that matter. Plane up one side of the wood and make a pencil mark on it. The side first planed is called the 'face-side,' and the edge first planed the 'face-edge,' and all measurements are taken from face-side and face-edge. Hence the necessity for putting on them an easily recognisable mark. When experience on odd bits of wood has taught you how to manipulate the plane with a fair amount of success, it is a good plan to set out and cut simple joints, such as are to be described in another chapter. These joints need not be part of anything other than apprenticeship, but they will help to develop your skill better than anything else.

There are not many tools which you need to buy other than saws and plane, and they will not involve you in any great expense. You will want chisels before you have gone very far, but the fewer you buy to begin with the better. A single firmer chisel—the firmer chisel is the ordinary sort—say $\frac{3}{4}$ in. wide, and a couple of mortise chisels—you might manage with one of the latter—will be quite enough to start with. The mortise chisel is used for cutting mortises, and is a much heavier and thicker instrument than the firmer chisel. The firmer chisel should not be

struck with a mallet, or at most very lightly struck, but pressed through the wood with the hand, a little at a time; but the mortise chisel needs heavy blows to force it through thick wood. Of course the chisels must be kept very sharp; the sharpening process being performed on the oilstone in exactly the same manner as was described for the sharpening of the plane iron. You must also provide yourself with tools for boring holes. A brace and a set of bits would be very useful. The brace is cheap enough, provided you steer clear of the highly finished tools resplendent with varnish and nickel plate; a ratchet motion is not even necessary, but the bits are more expensive, for you ought to have good ones. Cheap bits are made of poor steel and need a lot of sharpening, and they may break or bend. Twist bits are preferable to centre bits, for the former clear the drillings out of the hole as they cut it, and the latter do not. Apart from a brace and a few bits you should have a couple of gimlets, for boring screw holes, and two bradawls. One of these you will file to a very fine edge, sharpen it on the oilstone, using one of the edges of the stone so as not to scratch the face, and use exclusively for scribing lines. The other must also be sharpened—the sharper it is the better it will cut—and kept for boring small holes. In making a hole in thin wood use the awl so that the edge cuts across the grain and not along it; there is then less likelihood of splitting the wood. Screw-driver and hammer complete our tool outfit; but there are still a few measuring and marking instruments to be considered. You will want a measuring rule, the form of which is unimportant so that it has one reasonably straight edge divided into 32nds of an inch, but you must remember always to take measurements *from the same edge*. This is very important for the reason that cheap rules are never strictly accurate. A try-square, a marking gauge, and a pencil are also necessary. When you want to cut mortise and tenon joints a mortise gauge will have to be added. Choose a screw arrangement for adjusting the fences of these gauges, for you will find them easier to manage than the orthodox wedge.

CHAPTER VII

The Self-Made Carpenter

HAVING bought a few tools, our first impulse is to start to make 'something.' A very natural and a very laudable impulse it is, to be sure! But, unfortunately, we are prone to choose for our first efforts a something which it is beyond us to achieve. We start to work glibly by measuring out material for a cupboard, or a writing-desk, or perhaps a chair, and it is not until we have wasted a good deal of wood—to say nothing of the time and energy thrown into the bargain—that we realise that the making of cupboards and writing-desks and chairs demands a high degree of skill; and that somehow the skill which we had the temerity to presuppose in ourselves is conspicuous by its absence. Of course we might have known this before and have saved ourselves much vexation and vanished pocket-money; and we blame the stupid book which led us astray by telling us how we should set about making these things.

It is easy to blame a book, and possibly anathema soothes our outraged energies. That the book was really blameworthy is most unlikely; but that is another story altogether. If the writer misled us at all it was simply by supposing something which he had a perfect right to suppose; to wit, that we possessed not merely the necessary tools and materials, but also the skill necessary to the handling of both. It was one thing to have the knowledge of how an article is or can be made, and quite another thing to have the power to apply our knowledge. We can save ourselves much disappointment, and run much less risk of becoming disheartened in our carpentry, if we start right at the beginning of the craftsman's journey and realise that the things we want to make are nearer the end.

If you really wish to take up carpentry as a hobby, which will be a source of endless pleasure and lasting benefit, if you have a bigger notion of its meaning than the mere playing with tools in odd moments, the best thing you can do will be to put books on one side for a while and join a carpentry class, or get a local carpenter to give you a few lessons. The former is the better course, but in case you may not have time or opportunity to take advantage of it, let me say at once that you can teach yourself to become an expert wood-worker by diligently studying the directions given in practical books and by applying yourself to continual practice with tools.

I had a carpentry master once who would not allow me to make anything at all until he had quite satisfied himself that I knew how the simplest thing ought to be made, and the smallest operation properly performed. For a long time he compelled me to watch

how he cut up little bits of wood and joined them together in one way or another. He asked questions the while; I thought they were silly questions because I could not answer them, but I subsequently found that they were very sensible—so sensible that, had I the space, I should like to write them down to help you to become as able a carpenter as my old master was. After a time I was allowed to cut up bits of wood myself and join them together as he had done. He would look at them and say, 'No, no, *that's* not the right way! No matter, Rome was not built in a day. Try again!' I had to try again so often that I became heartily tired of Rome—and of carpentry. But he was quite right. Yes, he was quite right! And I learnt in a few months to do the things which other boys took years to learn or gave up learning in despair.

I want you to put aside, once and for all, the notion that a few tools and a box of nails will make any duffer a carpenter. You must make something, of course, but let it be as simple as possible for a start. My old master was tremendously strong on clothes-horses, and I think you might do a great deal worse for a start than make one of these eminently useful if unattractive articles of kitchen furniture. Too easy? Well, I am not so sure. If you make it as it should be made it will demand a considerable amount of care and accurate workmanship. At all events, it will not take long to make and will not require much material, while it is pretty sure to be useful in your household. Afterwards you can tackle something more ambitious.

Let us see, first of all, how much wood will be wanted for making a three-rail clothes-horse 4 ft. 6 in. high and 3 ft. wide. At all times, whatever the thing you are making, you must first prepare a dimensioned drawing and take off the quantity of the material needed. In the case of the clothes-horse this is a very simple business. The list of material works out thus:—

	ft.	in.
Four uprights (the upright members of a frame are called stiles) $4' 6'' \times 1\frac{1}{4}'' \times 1\frac{1}{4}''$	18	0
Six cross-pieces (called rails) $3' 0'' \times 1'' \times 1''$ . .	18	0

Now arises the question, How can we most economically obtain this material? Yellow pine would be a good wood to use, though we might descend to the cheaper, but less trustworthy, common deal. In any case we must provide enough to allow for waste in cutting, and obviously it must be thicker than the finished dimensions, since it has to be planed, and some part of it lost in shavings. On looking through my workshop I find that there are several pieces of material from which a clothes-horse could be made. There is, for instance, a length of 'quartering' (*i.e.* equal-sided) $1\frac{1}{2}$ in. by $1\frac{1}{2}$ in. which would do for the stiles, and a board $1\frac{1}{4}$ in. thick and 9 in. wide, from which the rails could be cut; and, again, sufficient quartering $1\frac{3}{8}$ in. by $1\frac{3}{8}$ in. which would answer the same purpose. There is also a rough piece of wood 3 in. by 3 in. by 5 ft. long which I should

certainly choose in preference to the others. If I could make you a present of this piece of wood I should be doing you a very useful service, because the sawing of it would be capital practice for you. You would find that your saw had an extraordinary predilection for sawing bevel-wise instead of vertically.

The first thing to do after you have sawn out the stiles and rails is to plane them up to the finished thicknesses. When one side of a member has been planed up truly you must remember to make all later measurements from it; but you have first of all to satisfy yourself that this 'face side' is really true and not higher at one corner than at another, and to enable you to do this you will need to be provided with a couple of 'winding' strips. The carpenter says of his work when it is crooked or uneven that it is 'in winding,' and 'out of winding' when he has planed it perfectly true. The winding strips used to find out whether the work has been properly taken out of winding are narrow pieces of wood 15 in. or 18 in. long, about 2 in. high, and triangular in section, being about an inch thick at the bottom and $\frac{1}{4}$ in. at the top. A strip is placed at each end of the work and the workman, stooping down and 'squinting' along the tops of them, can tell immediately whether or not the strips are in the same vertical plane. Any inequality is remedied by planing from the right-hand corner at one end to the left-hand corner at the other end, or *vice versa*, as may be required. When the face-side has been properly planed up you should make a mark on it so ?. The edge of the work to which the tail of the mark points will be the face-edge, and this must next be trued up. Now take your marking gauge and set it so that the cutter—which, if the gauge is new, you will probably have to sharpen by filing it—is a distance from the fence equal to the thickness to which the work is to be planed; in the case of the stiles of the clothes-horse the thickness is 1¼ in. Hold the fence firmly against the face-edge of the work and run the gauge firmly and steadily along the whole length of the stile. Now turn the wood round and scribe another line from the opposite edge, and you will have a line on each side of the wood which will show you exactly the amount of material which is to be planed away.

Having planed up sufficient wood to make the four stiles, you must cut each to the exact length, taking great care to see that the ends are quite square. The next thing to do is to set out the mortises which must be cut in the stiles to receive the tenons on the rails. There are three rails to be joined to each stile, and the mortises must be marked at the distances shown in Fig. 8. When you have satisfied yourself that the stiles are all exactly the same length take your rule and measure off two inches from one end, and with the try-square and a bradawl sharpened to a fine edge scribe a line at this distance. The fence of the try-square must be held against the face-edge of the work, marked A in the sketch, and the line scribed between edges A and B. Next scribe another line

between B and D, then between A and C, and finally between D and C. At a distance of 1 in. from the 1st line scribe a 2nd; at a distance of 16 in. from the 2nd line scribe a 3rd; at 1 in. from the 3rd scribe a 4th; at 16 in. from the 4th a 5th; and at 1 in. from the 5th a 6th line must be scribed. Each line must be drawn on four sides of the stile, and in the same order as the first. The pairs of lines thus scribed show the positions of the mortises; the next step is

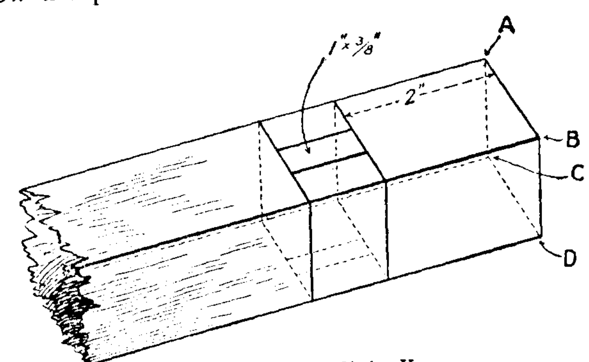


Fig. 8.—Mortises for Clothes-Horse.

to mark the mortises themselves. To do this we shall need a mortise gauge, at least we can count on greater accuracy if we have one, although it is not absolutely necessary as we shall shortly see. The mortise gauge must be carefully set so that the cutting points are ⅜ in. apart. Hold the fence against the edge B and scribe lines between the three 1-in. spaces; now turn the wood round until the opposite side is uppermost and scribe similar lines on this side, holding the fence against edge D this time. If you have not a mortise gauge you can make the marking gauge do similar service in this way. Set it, first of all, at $\frac{7}{16}$ in. and scribe a line on face AB—the fence of the gauge being against B—between each of the 1-in. spaces. Then turn the wood round and mark face CD, holding the fence against edge D this time. Next set the gauge to $\frac{13}{16}$ in. and mark in turn faces AB and CD, taking care to keep the fence of the gauge *always against the face-edge.* It is very important, because although your stiles are supposed to be square, it is unlikely that they are exactly; and if you held the fence of the gauge indiscriminately first against one edge and then another, you would be pretty sure to find that there were discrepancies when the time came to fit mortises and tenons together.

The mortises having been properly set out must now be cut, and to do this you must provide yourself with a mortise chisel exactly as wide as the mortise to be cut, *i.e.* $\frac{3}{8}$ in. The mortise is, of course, cut lengthwise of the wood. Having sharpened the chisel on the oilstone, hold it quite upright on the wood, about $\frac{1}{16}$ in. from one end of the mortise, and give it a sharp blow with the mallet. It must, of course, be quite parallel with the end of the mortise, and no part of the edge of the tool must overlap the lines at the sides. The object of starting a little in front of the line is to break down the fibres of the wood and to avoid the risk of the chisel being forced back outside the line. When you have made a couple of preliminary cuts you can put the tool actually on

SAWN TIMBER AWAITING SHIPMENT AT THE FRASER MILLS

By kind permission of The Canadian Western Lumber Company the line and drive it about half-way through the wood. Do not be afraid of hitting too hard; indeed, with wood as thick as that you are using the stronger the blows from the mallet the better, so long as you hold the chisel straight. Having made a fairly deep cut at one end, turn the wood round and tackle the other end of the mortise in the same way. Then reverse the work and cut down from the opposite side until the chisel goes right through. If any loose splinters are left in after the mortise has been made they must be removed by trimming down the sides with a sharp firmer chisel.

Now we must take in hand the six rails. If a board of suitable length and rather more than an inch thick is to be had, they can be cut out of it; though we shall not need to look far to find material from which they can be shaped. In any case they must be planed up and each one cut dead square to the exact length. When, this has been done, there only remains the shaping of the tenons to fit into the mortises on the stiles. To set out the tenons you must first of all take the rule and mark off 1¼ in. at each end, and then scribe lines at this distance on all sides of the rail, bearing in mind what has been said already regarding the use of the try-square and the importance of marking the lines from face-side and face edge. Then take the mortise gauge—it need not be reset, for as all the mortises are the same size there has been no need to alter it—and mark off the thickness of the tenon, running the gauge across the end of the wood as well as along the two sides which will need to be cut away to form the tenons. The tenons must be cut with a tenon saw. The saw should be started on the edge of the wood farthest away from the workman, and tilted so that it points downwards. As soon as the cut is about ¼ in. deep the saw should be brought gradually to the horizontal, great care being taken to hold it up perfectly straight. Saw as lightly as possible, and watch the work to see that you are cutting exactly on the line made by the gauge. When the sides of the tenon have been cut down, turn the rails round and saw the shoulders; in other words, cut down the lines at right angles to the tenon so that the saw-cuts join. The tenons must make a tight fit in the mortises, and if they are to do this they need to be carefully and accurately set out and sawn. It is unlikely that you will manage to make a first-rate fit at the first attempt, but after a little practice you will have the satisfaction of feeling that you have mastered the most important of the joints used in woodwork, and the simplest of the great mortise and tenon family. You will be introduced to some of its brothers and sisters in subsequent chapters. If you find that the joints do not quite fit when you come to try them, it will be necessary to pare a bit off the tenons here and there with a sharp chisel. Although there must be no wobble or looseness, they must not fit so tightly as to need great force in the putting together. Of course, it is better to cut them on the tight side than on the

loose, as in the latter case you can do nothing with them.

When the two parts of the clothes-horse have been framed together, they must be joined with hinges made of bits of strong cloth nailed on to the stiles with tacks or clouts. The hinges should pass from the outside of one stile to the inside of the other.

It is unlikely that the budding carpenter will be at any loss to know what to make, and the object of this chapter is simply to give instructions for the making of a few simple articles which embody useful practice with tools. Here is an idea for a nail-box, which you will find handy when you want to carry nails about from one place to another. It is quite easy to make, but every part of it should be shaped with care. Do not go to work with the idea that because a thing is of little value it is not worth while to put much time or trouble into its making. If this is the sort of spirit in which you set about a thing you are never likely to become a good carpenter, or a good anything else, for that matter.

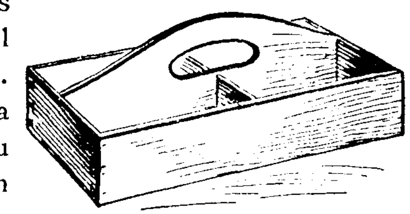


Fig. 9.—Nail-Box.

The nail-box will not require very much wood. Eight inches long by four wide and two inches deep would be a useful size, but of course you can work out the dimensions to please yourself. Half-inch wood will be quite thick enough, and you will have to provide for two sides 8 in. by 2 in., two ends 4 in. by 2 in., one partition 7 in. by 4 in., and another partition 3 in. by 2 in. Then there will also be needed a piece for the bottom 8 in. long and 4 in. wide.

The ends and sides are to be dovetailed together. There are many forms of dovetail joint, and the one to be used for the nail-box is known as the common dovetail, and is the simplest form there is. It is quite an easy joint to cut. The little dovetail-shaped pieces are cut on the ends of the box, and pins which fit in the sockets or mortises between the dovetails are cut on the sides. Let us take the dovetails in hand first.

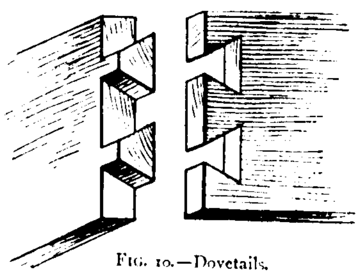


FIG. 10.—Dovetails.

Having planed up the wood and cut the ends to the exact length—taking care to see that the edges are square and all four corners right-angled—mark off at each end a distance exactly equal to the thickness of the side-pieces of the box. This shows the depth to which the dovetails are to be cut; the next thing to be done is to mark the positions of them, which must be done with a rule and a sharp awl. The ends must now be held upwards and the dovetails sawn along the lines. It is as well to make a vertical saw-cut down the spaces between the dovetails, as this enables the wood between them to be more easily removed and avoids the risk of breaking off the dovetails. The

sides of the dovetails having been sawn, the wood between them must be cut out with a sharp chisel. Take a cut from each side of the wood and afterwards trim the corners quite clean, cutting right back to the line. When the dovetails have been cut the pins must be made on the side-pieces of the box. To do this fix the side, end up, and put the dovetails against it at right angles in exactly the right position, so that they cover the end but do not overlap, and the edges of end and side are quite even. Hold them firmly thus while the positions of the pins are marked by drawing down each side of the dovetails with the awl. Then cut out the pins with the saw and remove the wood between them with a chisel.

When you have fitted the sides and ends of the box together the partitions must be made. These bisect one another at right angles, thus forming four divisions in the box. The longitudinal partition also serves as a handle for carrying the box, and this must be shaped as shown in Fig. 9. You should be able to do this quite well with a chisel, first of all cutting away some of the wood on the outside with the saw, and boring a couple of holes in the space marked out for the finger hole, so that you can get at it more easily. The partitions are joined together by slipping one over the other, and slots must be cut in both to enable this to be done. Measure off a distance equal to half the length of each and mark two lines, the distance between them being exactly equal to the thickness of the wood. These lines must be slightly longer than half the depth of the box, and must be sawn down from the bottom of the longer piece and from the top of the shorter. Cut out the pieces so sawn and join the partitions together.

When the bottom of the box has been cut out and squared the whole can be joined together. The bottom must be nailed on to the sides and ends, and a couple of nails can also be put through into the partitions to prevent them from slipping about.

A garden chair suggests itself as an article on which

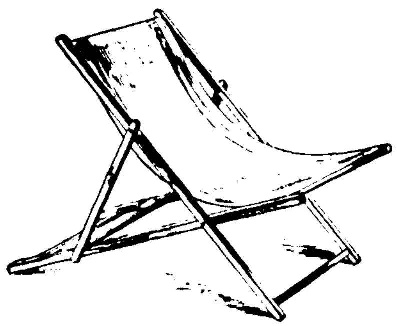


FIG. 11.—Garden Chair.

you might next exercise your skill—the sort of chair that is all legs and no body, having instead a canvas apology for one—the sort that folds up for convenience of stowing in summer-houses and similar spidery shanties, and that pinches our fingers when we are not looking. Such a chair as this is easy to make and costs little, an advantage which should give it a strong appeal to our attention.

The chair consists of three simple frames which (since I do not know their names—if they have any) I will call A, B, and C. A forms the back and the front legs; B the front of the seat and the back legs; and C is the connecting link between the two, being attached to A at its upper end

and fitting into a recess cut in B at its lower. Elm would be a useful wood to use—if you could get it—or you could use ash or oak. Choose a hard wood, as the chair is made of light stuff and is liable to severe and sudden strains—at least when given to the accommodation of portly persons. Pitch pine would be strong enough, but the experience gained from working up a harder wood ought to repay you for the higher cost of the latter. For frame A you will want two lengths of wood finished to 44 ins.

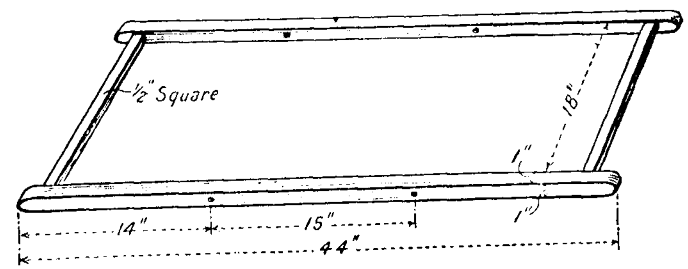


FIG. 12.—Garden Chair. Frame A.

by 1 in. by 1 in., and two cross-pieces 20 ins. long and ½ in. in width and thickness, the distance between the sides being 18 ins. Plane up the side-pieces and cut them to exactly the right length, and then, at an inch from each end, set out the mortises for the cross-pieces. There will be no need to cut tenons on the latter, so the mortises will be ½ in. by ½ in. Before the cross-pieces are fitted, however, you must drill in the sides the holes through which will pass the bolts for holding the parts of the chair together. One hole will be 14 ins. from one end and another 15 ins. from the first. The best plan would be to fasten both sides together in such a way that their ends are level and then to drill the holes in both at one operation. Thus you will be sure to get them in the right positions. Before the cross-pieces are fitted into the mortises make a slight oblique cut in them, and when the frame is fitted up drive in small wedges to hold the members firmly together.

The frame marked B is shorter and narrower than A, but is made of slightly thicker wood. For the

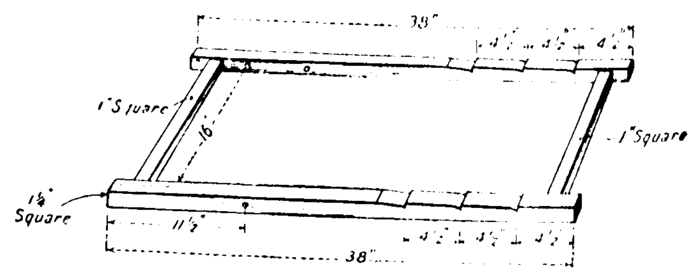


FIG. 13.—Frame B.

sides you will want two pieces 38 ins. long by 1¼ in. by 1¼ in. The cross-bars are made of 1-in. stuff and need to be 18½ ins. long, this length allowing for tenoning into the full thickness of the sides, the inside width of the frame being 16 ins. There is only one hole to be drilled in each side, this hole being 11½ ins. from one end, but at the opposite end must be cut the rack on which the frame C rests when the chair is in use. The cutting of this rack will give you no trouble, but you must be careful to mark it out and cut it accurately on each side-piece. Mark off a distance of

4½ ins. from the end and scribe a line; at 4½ ins. from this scribe a second, and at 4½ ins. from that scribe a third. On each of these lines make a vertical saw—cut half an inch deep, and cut away the unnecessary material by paring with a chisel.

The frame C which goes outside A to which it is attached at its upper end, the lower resting in one or other of the recesses on B, has only one cross-bar. The sides are 19 ins. long and 1 in. wide and thick. The cross-piece is 22 ins. long, 1 in. wide, and 1½ ins. thick.

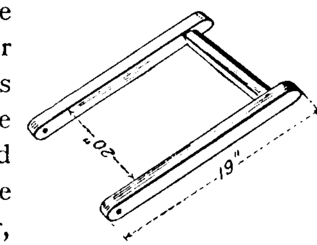


FIG. 14.—Frame C.

The lower side must be bevelled, as shown in the sketch D. The tenons will be half an inch square, and great care must be taken to set out and cut them accurately, or the cross-piece will rest on a notch at one side only. To complete your chair you will need, of course, the canvas (or other strong material) for the hammock, and as well, four bolts with nuts and washers. Any ironmonger will cut the bolts to the length you need. They should be ¼ in. in diameter.

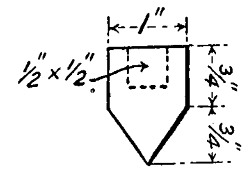


FIG. 15.—Sketch D.

CHAPTER VIII

Cabinet-Making

YOUNGER readers might be excused for supposing that the term 'cabinet-making' referred exclusively to the making of cabinets, while in fact it includes all the better-finished articles of furniture. It is in reality the practice of carpentry developed into a high art, the language of woodwork, as it were, of which carpentry is the grammar.

Some people, however, find it difficult to draw a hard and fast line between the two. Take the case of a wall-cabinet, for instance, upon which a beginner may have bestowed his greatest pains, finishing it with a shine that might even vie with that of a grand piano. How many amateurs have had their hopes dashed to the ground by some unfeeling person arrogantly describing it as 'not a bad bit of carpentry'! Carpentry, of course, stops at such things as knife- and soap-boxes, clothes-horses, towel-racks, and similar useful but not ornamental objects, and outdoor work, which could not, even by the most elastic minded, be termed 'cabinet-work.'

The chief point about cabinet-work is its scrupulous construction; from the time the saw first enters the

ARTIST AND CRAFTSMAN IN ALLIANCE

These beautiful examples of modern furniture were [illegible] at Sandringham, and were shown [illegible] first board, to the last rub of the polished surface of the finished article, every detail is planned and carried out to a nicety. No doctored-up packing-case will ever pass muster. Neither can you make a really 'handsome' easy-chair by cutting half one side away from a beer-barrel and putting in a new bottom, as I have recently seen described; for no amount of padding or covering will ever do away with the constructional deficiencies. Briefly speaking, then, the essentials of cabinet-work are: carefully selected material, sound construction, and scrupulous finish; there you have the thing in a nutshell.

If you are already a general handyman and have not only digested the previous chapters, but have by practice become quite proficient in marking out accurately, in sawing to a straight line, planing, and other rudimentary exercises, you may reasonably be expected to become ambitious enough to attempt something that will be ornamental as well as useful, and the admiration and envy of the family in general. You will not, of course, aspire yet to a 'Sheraton' sideboard, but content yourself with a small fancy table, or hanging shelves with a useful cupboard attached. You will naturally have your own ideas of the shape that it will be like, for you are not going to be governed by any slavish fashion. This is one great advantage that the home cabinet-maker has; he can please himself entirely upon the form that such and such an article may take, and need not conform unyieldingly with those stringent laws that bind the furniture-maker to put a beading here and a moulding there, so long as his productions are not ungainly in appearance and fulfil their intended purpose.

In the selection of wood one's choice ought to be governed by that used in the furniture already existing in the home, so that any addition it is proposed to make may not clash with its surroundings when in position. In some instances, of course, pine may be used stained to match another wood, but being soft it is very liable to get bruised in course of wear, and so becomes somewhat unsightly in appearance. Bass or American whitewood is a very suitable wood to use as a substitute for walnut, oak, or mahogany, where a saving in cost of material is desirable, as it both stains and polishes well and is fairly hard. Birch is also a very serviceable wood where a clean finished effect is aimed at, and takes stain and a polish quite well. Satin-walnut is softer than either birch or American whitewood. It takes a high polish, and has a rich golden-brown colour effect that is very attractive. It may, however, be hinted that a piece of furniture, once made, is generally expected to last a long time, a point which should weigh considerably with the worker and assist his decision to invest in hard wood—oak, walnut, or mahogany—and so avoid the little regret that often comes later on, that this was not done at the outset. Every care should be taken to secure stuff free from shakes and knots, and well seasoned. Several large firms cater specially for the amateur in this respect, but it is no

bad idea to become acquainted with a friendly cabinet-maker, who is most likely to have just the kind of wood required, and would charge but a fraction extra for what really would be valuable assistance to the beginner.

A handbook on cabinet-making will usually emphasise the importance of an elaborately constructed work-bench. It is true that if you are the lucky possessor of one you are to be envied; but all of us are not so placed, and we need not despair, for the raw material for one lies to hand in the kitchen table, ready for easy conversion upon the necessary permission from those in authority, without in the least making it less serviceable. The chief requirements of a bench for cabinet-work are that it should be strong and rigid enough to allow the planing of a hard board upon it, without sliding along the floor at each stroke; facilities for preventing the board itself from sliding; and an arrangement whereby the board may be held vertically for planing its edge.

Fig. 16 shows a kitchen table fitted up to answer all these demands, where it will be observed that its appearance has not been changed in any great degree: an angle-iron screwed to each leg and the floor to make it firm, two screws with good-sized heads in the top to press the boards against for planing, and an arrangement on the side that does away with the bench-screw. It is almost superfluous for me to explain the fittings in detail, but this being essentially a practical book, we will do so for the benefit of those who wish to dispense with the bench-screw.

First of all a piece of hard wood is cut wedge-shaped, but a portion is left square at the thick end. That sounds rather funny, but if you glance at the small sketch you will fully understand the meaning. The flat part is for screwing to the side

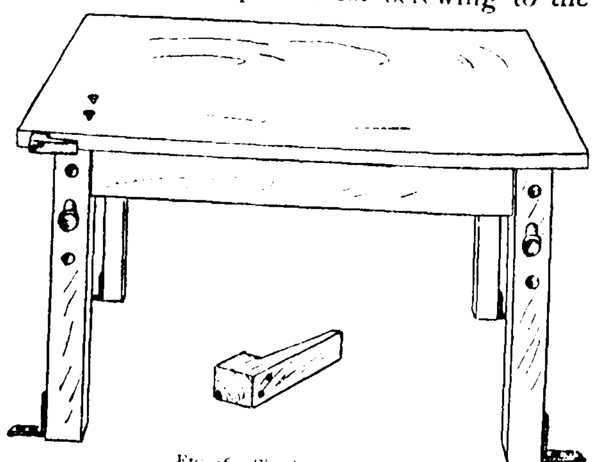


FIG. 16.—Simple Work-Bench.

of the table, and the wedge-piece forms an effective stop for different thicknesses of board. Naturally, they require some support underneath, and this is supplied by a series of holes in the legs of the table, in which pegs are adjusted to suit the width of board, a support being laid across to hold short boards that do not reach from peg to peg.

If the aspiring cabinet-maker is already in the possession of a tool-box, he will probably find that

only a few additions are necessary to put him on the road for a start; but those already possessed should be overhauled, as it will be found that many that may have served us well in the past to do odd jobs will be quite out of the running for serious cabinet-work. More particularly does this apply to edge tools, such as planes and chisels; the fact that an old plane has been coaxed to scrape the roughness off a piece of board, to mend the dog kennel, does not by any means prove that it will prepare a piece of Honduras mahogany.

The most useful form of plane to possess for such work is the smoothing plane, but for long boards a regular surface may be more easily obtained by a longer bodied plane, as the tendency of the smoothing plane, unless one is well awake to the fact, is to hollow out when used on hard wood in the length.

Another form of plane that you will require is the moulding plane. There is a very large family, all with curious names. Two useful forms are shown in Fig. 17, these being known as the Quirk Ogee and the Scotia, and the use of these planes, as will probably be guessed, is to form the various mouldings which are invariably considered a necessary adjunct to modern cabinet-work.

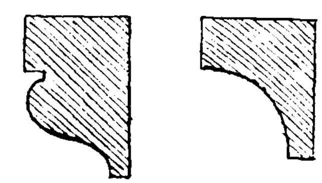


FIG. 17.—Quirk Ogee. Scotia Plane.

It is no good whatever starting to work until you possess at least two good chisels, one $\frac{1}{4}$ in. and one $\frac{5}{8}$ in., and a few between as well, if you can manage to get them. These must never be used for any purpose than that for which they are intended; an occasional insight into what it feels like to be a screw-driver will render them most likely eligible for the rubbish heap. I say this because chisels and screw-drivers do not differ in *appearance* very largely.

While speaking of 'edge' tools I must not omit the spokeshave, which is a tool for planing up curved edges. An illustration is given of it in use further along, so we will pass along now to the saws. Besides the hand-saw, one with fine teeth should be procured for sawing the narrow strips that the former would be likely to split, and also for cutting tenons, dovetails, etc. A fine tenon saw is the most generally useful kind. Its chief use is to cut clean and accurate joints. Then there should be a saw for cutting curves —either a fret saw, a keyhole saw, or a bow saw.

These tools we have mentioned are those that specially pertain to the cabinet-maker, but besides these the household tool-box will be constantly drawn upon. Also you will require sand-paper of different grades, and a glue-pot (or a substitute) and glue.

The amateur's troubles usually begin when he sallies forth to buy his timber. In the first place, unless he happens to live in a district where there is a demand for cabinet woods, he may be told at numerous places that 'we keep nothing but deals and floorings.' Most of the larger timber

yards, though, have a stock, if only a small one, of mahogany and other cabinet woods, and by judiciously approaching the yard foreman small quantities may usually be obtained very cheaply. Even though you are an amateur, don't be palmed off with split stuff, or boards in which there are great 'knots' looking at you. You will buy as much at one time as you can possibly afford, as you will save largely by doing so. When you have your wood take it home and put it in a dry place for a few days, to allow for contraction, and so avoiding the possibility of it cracking and splitting when made up. Amateurs, as a rule, fall into the grievous error of supposing that seasoned timber is ready for immediate working up, when very often it has lain in a damp yard for many months. This dampness must be expelled from the wood before working it, so a cabinet-maker will keep it for some days, or in some cases weeks, in a warm place to expel the dampness, as the shrinkage of wood in some cases is considerable.

A word about working drawings. Before starting to make any article, however small, you will find it necessary to sketch out the front and side elevations on a sheet of paper, with all the measurements carefully marked. These must be referred to constantly, to ascertain the size of the various parts. The illustrations will show you the sort of thing, and you will not require to be a great draughtsman to do this, for so long as you can understand your own drawings that is all that is required. You will find it will simplify matters if you make your drawings in some measurable proportion, and you will then be able to tell, almost at a glance, the measurement of wood required for each part.

Now, if you will endeavour to follow, we will show you the way to set about the construction of the useful writing-table shown on this page (Fig. 18), of which the front and side elevations are illustrated in Fig. 19. In making this table we have the following parts to consider: the legs; the rails that connect them—two front, two side, and one back; the top; and the drawer, which is set between the two front rails, and rests on runners screwed to the inside of the side ones.

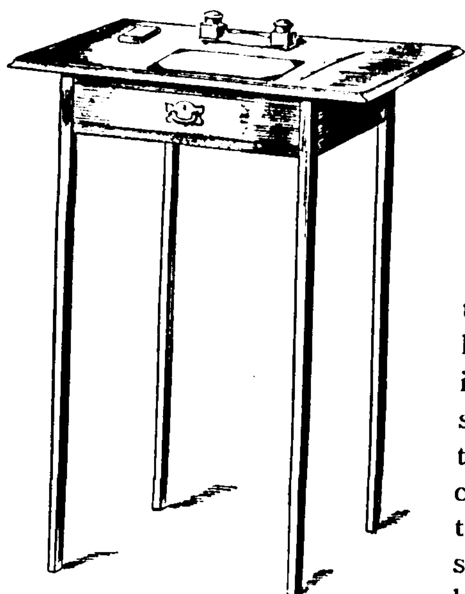


Fig. 18.—Writing-Table.

Here is your list of wood :—

For the legs . .	4 pieces, 2 ft. 5 in. × $1\frac{1}{2}$ in. square.
Side rails . . .	2 pieces, 0 ft. 9 in. × 5 in.
Back and front . .	3 pieces, 1 ft. 1 in. × 5 in.
Top	1 piece, 1 ft. 11 in. × 1 ft.

The above, with the exception of the first mentioned, should measure when purchased $\frac{5}{8}$ in. thick, which will allow $\frac{1}{8}$ in. for planing. For the sides, back, and bottom of drawer will be required the following pieces, these measuring half an inch thick when purchased :—

Sides	2 pieces, $7\frac{1}{2}$ in. × 2 in.
Back	1 piece, 12 in. × 2 in.
Bottom	1 piece, 12 in. × $7\frac{1}{2}$ in.

It must always be remembered in buying wood to allow something in the thickness for planing. Wood from the timber yard is usually in the condition that it left the saw—requiring planing on both sides, and *at least* one-eighth of an inch must be allowed for this purpose. Thus, if you require a board to finish at half an inch, it should measure $\frac{5}{8}$ in. when 'in the rough.'

Having got your wood and gathered your tools together, the first thing to do will be to make the four pieces that form the legs *exactly* the same length, and to see that the ends are so flat and true that the pieces will almost stand by themselves. If they are not, a woodworker's file or rasp should be called into requisition, if the necessary alteration is so slight that it cannot be remedied by cutting off a piece with the saw.

Now, if you look at the drawings with measurements (Fig. 19) you will observe that the legs taper, and in this matter you will have an opportunity of showing your skill in handling the smoothing plane.

First mark lines round at a distance of $4\frac{1}{4}$ in. from the top on the four sides, this being where the taper starts from, and draw a little 3 in. square on the bottom of each leg in the centre, which will indicate the lines to plane to; then set your legs one by one

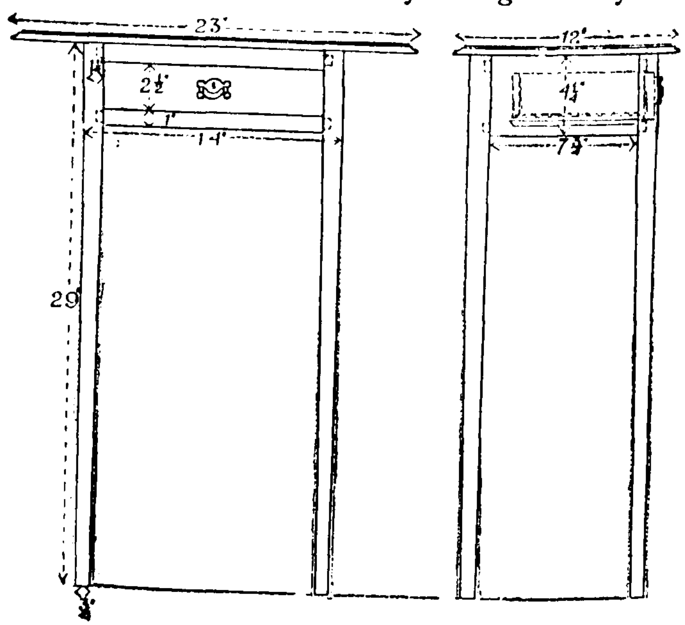


Fig. 19.—Front and Side Elevations.

in the impromptu bench-stop, supporting them on a board fixed on the pegs, the services of a chum being useful to steady the wood at one end, especially if your plane is not as sharp as it might be. A word to those who are disposed to haste; don't thrust the plane about as if you were scrubbing a floor. Plane deliberately but carefully, and keep your plane

perfectly level, and occasionally stop to see how your work progresses.

The legs completed, you have next to consider the joining of them, and the tenon joint will be best suited for this purpose. In Fig. 20 is shown the joint in use—the sketch representing one corner of our table. The tenons are in this case about half an inch in length and the full thickness of the wood. A slightly different form of the tenon joint is

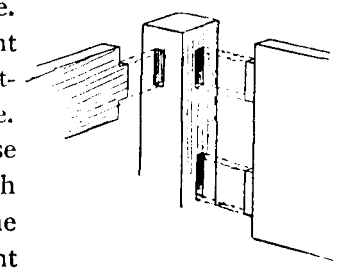


Fig. 20.—Tenon Jointing.

also shown (Fig. 21), this being technically called the 'haunched' tenon, but it does not really matter very much which of the two you employ, providing you make the joints fit tightly so as to ensure your table being absolutely rigid.

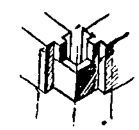


Fig. 21. Haunched Tenon Joint.

Be sure and get a nice piece of wood for the top, a piece free from blemishes and defects; it will measure 1 ft. 11 in. by 12 in., and the edge is ornamented by running along with one of the moulding planes, the sharp edges being afterwards rubbed down a little with sandpaper.

How is the top secured to the framing? will be the question that the amateur craftsman will next ask himself. Of course there are several ways that you might adopt—for instance, you might nail it down; but do not hasten to this procedure, for such a method employed for 'cabinet' work will give you away immediately as being a worker of little experience. Nails are never used where they are seen, neither are screws, except in parts where the eagle eye of the observer cannot penetrate. The method of securing the top in this instance is by means of gluing little blocks underneath at the angle where the top meets the rails, on the inside. The illustration (Fig. 22) gives a peep underneath, showing some of the blocks in question. On the same page (Fig. 23) is shown the construction of a drawer, which needs no explanation.

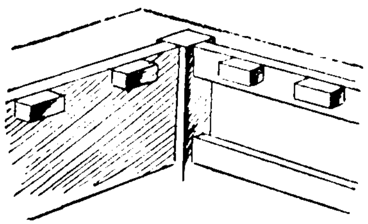


FIG. 22.—Fixing Top.

When you have prepared the various parts, try them together to see if they fit properly. You will most probably have to make slight alterations here and there, for even the most carefully calculated measurements go wrong sometimes—one piece made a very little larger and one a little smaller will, when fitted, make a rather bad error. When the parts fit satisfactorily glue up with best Scotch glue.

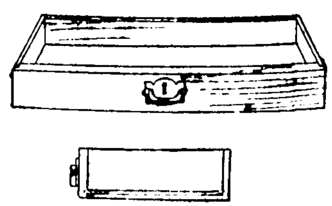


FIG. 23.—Sketch of Drawer.

The next illustration (Fig. 24) is an article of quite

another kind, but one no less useful. It would serve to hold books, or to collectors would be useful to store specimens of butterflies, minerals, &c. It has the advantage of being easily made, and the form is

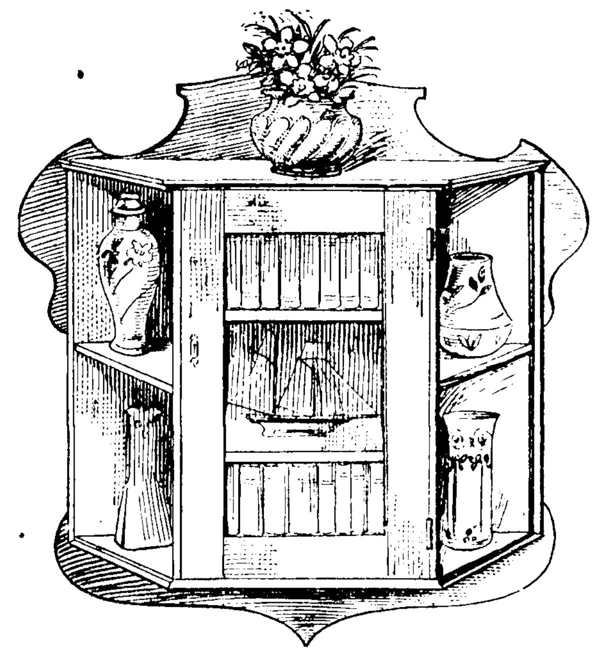


FIG. 24.—Hanging Wall Cabinet.

one that would not appear ungainly on a wall—a mere ugly blot, like many of the cheaper class of wall-shelves. Mahogany would be a very nice wood to employ, but if you have not the money to lay out for it, ordinary whitewood stained would look quite well and be serviceable enough for the purpose, as the article does not have to undergo any great strain.

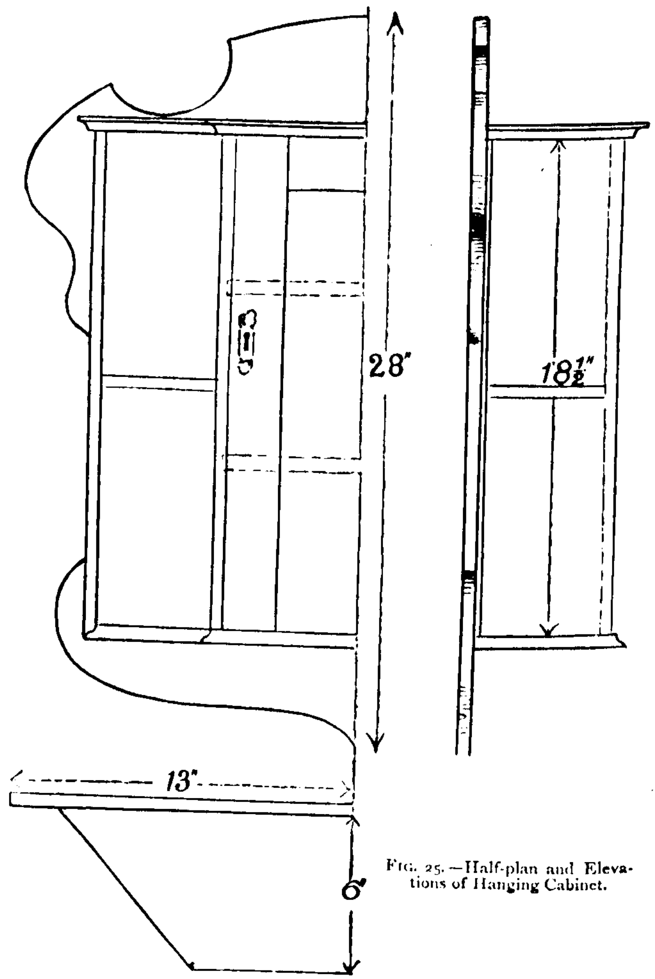


FIG. 25.—Half-plan and Elevations of Hanging Cabinet.

A glance at Fig. 25 will make it clear to the reader

that the back of the cabinet measures 2 ft. 2 in. by 2 ft. 4 in., and that to obtain a board wide enough to make it in one piece would involve considerable difficulty. So the expedient of joining together edge to edge two or three narrow boards must be resorted to. This is termed 'butting,' and the edges for forming the joint naturally require to be planed perfectly true and square. The illustration (Fig. 26) shows the method of testing the accuracy of the edges

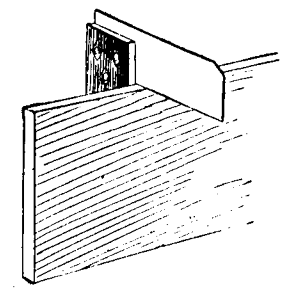


FIG. 26.—Testing Edge with Try-Square.

FIG. 27.—Badly-made Join.

with the try-square. When they are perfectly square they should coincide with the face of the blade, and when set edge to edge one board should be quite in a straight line with the other, and show no inclination to tip (see Fig. 27). In gluing, it is advisable to warm slightly the edges of the wood so as not to chill the glue on application, and to rub the glued parts over one another to distribute thoroughly and squeeze out all that is surplus. Then set under weights to harden.

The glue for forming 'butt' joints, and in fact all joints in cabinet-work, should be of the very best quality, that known as 'Scotch' glue being the strongest made. The preparation needs a little more care in melting than is usually given it; some people imagine that all it requires is to stick a few lumps in a jar on the fire, and are surprised when they find it as hard as iron, which no amount of water will bring to a working consistency. There is in fact quite an art in glue melting, and it is such an important matter that it should be given the special attention of the worker; it should in fact be first broken into pieces and steeped for about twenty-four hours in cold water previous to melting, and is then melted gradually, either in a proper glue-pot, or a substitute—a jar or tin set in a saucepan half-full of water.

The 'butt' joint should be left for about twenty-four hours to harden, during which time you can be measuring off the wood required for making the cupboard and shelves. There will be the top and bottom of the cabinet to measure off, the sides of cupboard, two outer shelves—triangular in shape—also the outside narrow strips, the door-frame, and the inner shelves. The cabinet is jointed to the back-board by means of tenons, two being cut in each section, but is further secured by screws entered from the back, which will ensure a strong job.

Now we will return to our back-board, which will by now have set. You now sketch out the curves on this; perhaps the best way being to draw one side and trace the other, so as to get the two exactly alike.

Then you proceed to cut out the shape, either with a keyhole saw or a bow saw, keeping well outside the marked line in sawing, as the saw will most likely leave a very rough edge requiring to be smoothed up with a spokeshave. This tool is held by both hands and is *worked away from the operator* (see Fig. 28). Go over the whole of the curve first and remove the general irregularities, and rather endeavour to get nice even curves than a smooth surface.

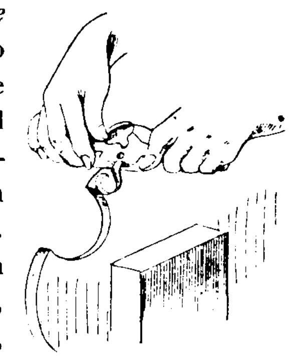


Fig. 28.—Using Spokeshave.

The final operation, when the work has been made up, will be the oiling, varnishing, or polishing. For nicely marked wood, treatment with raw linseed oil is all that is necessary to produce a nice effect. It is only necessary to apply the oil with a tuft of cotton-wool; place the work on one side for a time to allow the oil to soak in a little, and then polish with a stiff brush.

Varnish is applied with a brush; it should be used in a warm room and applied quickly. It is usual to give the work two or more coats, the first coat being half varnish and half turpentine, to stop the suction of the wood.

Polishing is more difficult than oiling or varnishing, but the better appearance will usually repay for the extra labour. For dark woods ordinary French polish is used, but for light woods best white polish should be obtained. The surface of the wood must be sand-papered to the greatest possible degree of smoothness before applying. The polishing is performed with a pad of cotton-wool which is screwed up in a piece of linen. The cotton-wool is moistened with the polish, and the linen moistened with a few drops of oil to serve as a lubricant; the surface being then vigorously polished with a circular motion. The polish soon dries, and further applications are then applied until the surface shines like polished glass. All polishing must be done in a warm room.

FIG. 29.—A useful Display Cabinet.

A very useful display cabinet for the home museum is shown in Fig. 29. It is built on a half-octagon plan, and the sketch-plan is shown for guidance in Fig. 30. There is nothing in the construction that will offer the beginner any great difficulty in making, but as a work of this kind will be constantly before the eye, the details require to be finished so as to be above criticism.

With regard to the material to use, walnut would

be the most suitable for the front, and as there is in reality quite a little required the cost will not be very

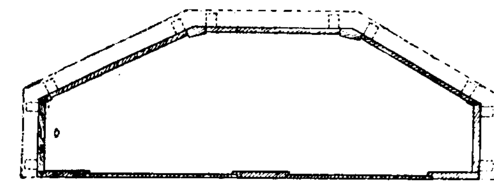


FIG. 30.—Plan of Display Cabinet.

great. The shelves and back framing can suitably be of some less expensive wood, such as whitewood, as they are finally covered with baize or some similar substance that will form a good background for the exhibits.

The framework in an early stage of completion is shown in Fig. 31. The parts that will require the exercise of your wits in making are the mitres where the three upper boards of the front join, the angle for planing to be ascertained from the plan. They are secured by means of small angle-blocks

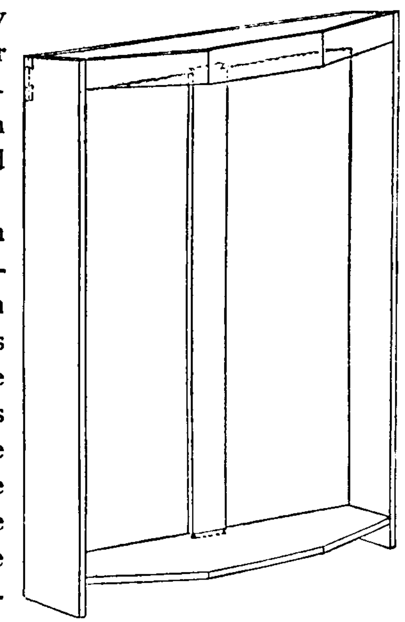


FIG. 31.—Framing of Cabinet.

screwed on from the back. It will be noticed that the back rails are jointed by means of the dovetail joint (Fig. 32), this being very largely employed in constructional cabinet-work. The compound dovetail is one of the strongest joints known; it is shown in Fig. 33, and the only difference between this and the single dovetail is that the latter has but one 'pin' and the former many.

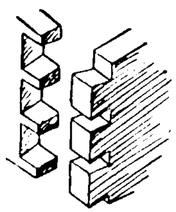


Fig. 32. Dovetail Joint.

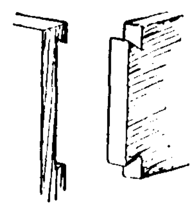


Fig. 33. Compound Dovetail Joint.

Yet another new joint is introduced to our readers in making this article—the 'dowel' joint, this being to secure the narrow front strips against which the doors close. These strips are planed to mitre in the same manner as the sections of the top were, and each strip is secured by a 'dowel' at the top and bottom. Dowels are little wooden pegs that fit into each of the parts to be united. They are cut to about half an inch in length from birch sticks, which are sold in lengths of about 3 ft. The holes are drilled slightly over the length of dowels, which, when entering, are given a thin coat of glue, and should fit tightly. The joint is shown in Fig. 34.

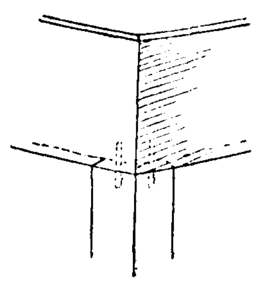


Fig. 34.—Dowel Joint.

In the sketch is given a suggestion for a little

fretwork which would make the cabinet look more attractive. An edging is left round the fretwork for letting in a shallow rebate sunk in front of the one cut for the glass. The glass is sunk in a rebate cut in the back of each door-frame, being secured by narrow strips of wood screwed in afterwards. Do not forget

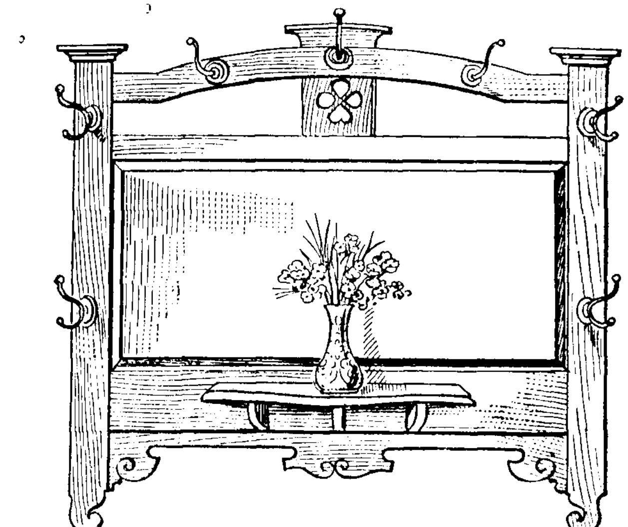


Fig. 35.—Hat and Coat Rack.

to place the door-frame on a perfectly flat surface when fitting the glass, to avoid the possible disaster of breakage; and remember that it is better to make a door-frame rather on the large side than on the small, for you can reduce the size quite easily by planing a little away, but it is very difficult to enlarge it. Finally oil or polish, and a very useful and ornamental cabinet will be completed.

Now let us proceed with the next article it is proposed to put in hand—the Hat and Coat Rack shown in Fig. 35. The dimensions are 3 ft. wide by 2 ft. 9 in. high over all, and with the exception of one or two minor pieces the whole thing will be made of 1 in. stuff to finish $\frac{7}{8}$ in. thick. The illustration of the parts (Fig. 36) will be useful for reference as we go along, and a cutting list showing the various pieces required in the construction is also added, lettered for reference, to help make things clear. Making a start with the end uprights (A), these should be got out to a length of 2 ft. 9 in. by $2\frac{1}{2}$ in., which allows a trifle for the stub tenon on the top end which enters the moulded capping (B). The lower end is shaped with fret saw and spokeshave and touched up with chisel and gouge. Instead of the short tenon at top this projection may be cut back to form a shoulder, so that the capping may

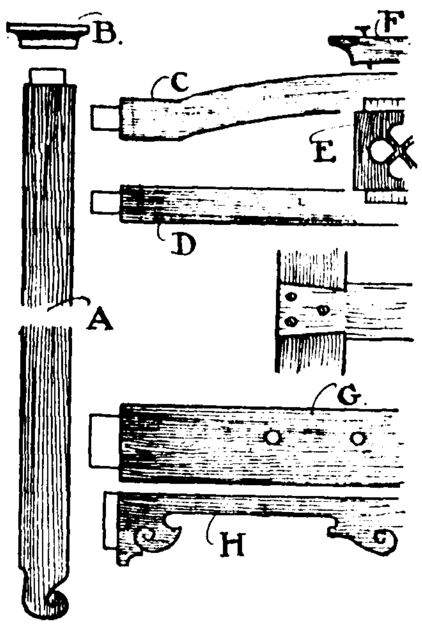


FIG. 36.—Principal Parts.

be correspondingly halved and screwed on to it at the back; or, of course, with less trouble, the part can be fixed with a couple of dowels. An easy way to mark the exact position for dowel holes is to nip the head off an ordinary pin, press it into position vertically in one of the parts to be dowelled, and then laying the other part over in the position it is to occupy, give a smart tap with the hand or mallet, so that the centres for boring with the twist-bit are exactly marked. The inner edges of uprights are also mortised to receive tenons on rails (C), (D), and (G), and grooved for a stub tenon on the lower shaping (H). The finished size for the cappings (B) will be $3\frac{3}{4}$ in. long by $\frac{7}{8}$ in. high, the back to front measurement being $1\frac{1}{2}$ in. It is shown as moulded $\frac{5}{8}$ in. hollow, which would not be difficult to return on the ends with the chisel, but the hollow can be replaced by a plain bevel if preferred. A piece fully 4 in. wide will be necessary in getting out the top rail (C) so that the flat curve may be struck. The line for it may be easily sketched in freehand or by the aid of string and chalk, and if a nail is driven in the floor it may be struck from a point 4 ft. away. The tenons should be cut to go well home into the uprights, and may then have a couple of wood pins entered into them through the uprights. The rail above the mirror (D) can finish 2 in. wide, and will finish the same length as the shaped rail (C), viz. 2 ft. $10\frac{1}{2}$ in. including joints. The tenons should enter to the same depth to stiffen the whole thing. Between these upper rails it will be noticed that a small fretted panel is introduced as a simple and effective break from the plainness of the main framing. This will come out at 6 in. long by 4½ in. by ⅝ in. A brace and 1¼ in. bit will serve to start the holes, which may then be finished by fret saw, chisel, and sand-paper. Corresponding grooves must be cut to receive the stub tenons at top and bottom as indicated. This panel may be further emphasised by fitting a capping above as at (F), 7 in. by 1⅜ in. by ⅞ in., to be screwed or dowelled flush into position. The sight size for the mirror will be 2 ft. 7 in. by 14½ in. as in the sketch, and when ordering the glass the exact size of this sight opening should be given, so that the beveller may allow the extra necessary to enter the rebate to be cut for its reception in back of D, G, and A. It will be held in position by small tapered wedges driven between the glass edges and rebate. Before inserting the glass the rebate should be blacked, otherwise the edge will reflect and look unsightly. The wide rail (G) below the mirror can finish about 4 in., and, as

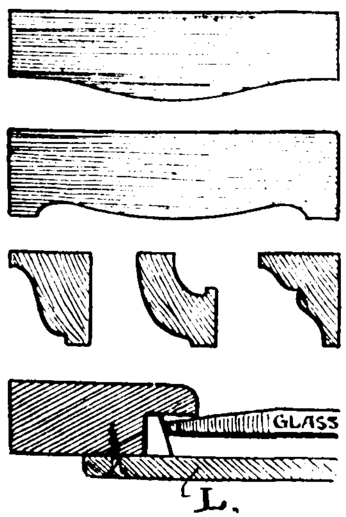


FIG. 37.—Details of Shelves, etc.

indicated, this is intended to take a small shelf and supporting brackets. It is shown with a single tenon, but may be cut with a double tenon and shouldered if preferred. The shelf will come out, as shown, at 1 ft. 2 in. by 5 in. by ⅞ in. or ⅝ in., to be shaped and screwed through from the back. The small brackets can finish 3 in. by 2½ in. by ⅞ in. quadrant- or ogee-shaped, and screwed carefully up into the underside of shelf and through from the back. The lower-shaped rail at (H) will require to be cleanly cut and will aid the upper part in imparting a little 'life' into the general effect. The back may be of ¼ in. stuff nicely finished with rounded edges, after being cut to overlap the rebate about 1 in. on all sides, to be screwed on with round-headed brass screws. Before fixing any of the parts it is best to have a trial 'fit-up,' so that any parts that may require easing may be remedied. Three hat hooks and four hat and coat hooks. are indicated, and these had better be of lacquered brass; but oxidised finish, with a coppered relief here and there, also looks well. Four glass plates—small brass plates with holes for screwing through—will serve for hanging purposes. If made in oak, the rack may be merely oiled as a finish or fumigated and polished. If in mahogany, it would look well stained to a dark plum colour and French polished. Walnut looks well if fumed and wax polished, or it may be French polished with advantage. The following cutting list will prove of use for ready reference, note being taken that all lengths are full to allow for cutting joints to a fit, but widths and

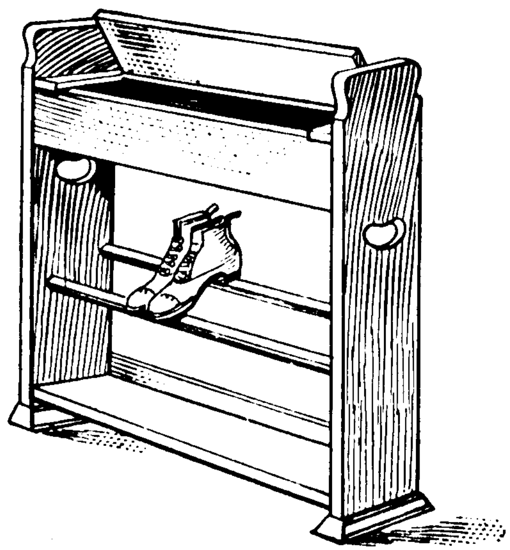


FIG. 38.—Boot-Rack.

thicknesses are *nett* finished sizes, so that a slight allowance should be made for cleaning up, etc. :—

		L.		W.		T.
A.	2 uprights . . .	2′ 9″	×	$2\frac{1}{2}$″	×	$\frac{7}{8}$″
B.	2 caps	$3\frac{3}{4}$″	×	$\frac{7}{8}$″	×	$1\frac{1}{2}$″
C.	1 top rail . . .	2′ $10\frac{1}{2}$″	×	4″	×	$\frac{7}{8}$″
D.	1 top mirror rail .	2′ $10\frac{1}{2}$″	×	2″	×	$\frac{7}{8}$″
E.	1 panel	6″	×	$4\frac{1}{2}$″	×	$\frac{5}{8}$″
F.	1 cap	7″	×	$1\frac{3}{8}$″	×	$\frac{7}{8}$″
G.	1 bottom mirror rail	2′ $10\frac{1}{2}$″	×	4″	×	$\frac{7}{8}$″
H.	1 shaping . . .	2′ 9″	×	4″	×	$\frac{5}{8}$″
	1 shelf	1′ 2″	×	5″	×	$\frac{7}{8}$″ or $\frac{5}{8}$″
	3 brackets . . .	$3\frac{1}{2}$″	×	$2\frac{1}{2}$″	×	$\frac{7}{8}$″
	1 back	2′ 10″	×	1′ 5″	×	$\frac{1}{4}$″

1 mirror 2′ 7″ × 1′ $2\frac{1}{2}$″ sight, 7 hooks, 4 glass plates.

In Fig. 38 there is given a practical little suggestion for a boot-rack and tidy—a really useful addition to any boy's or girl's bedroom. It combines a rack for boots and shoes, a shelf for slippers, and a convenient receptacle for handkerchiefs, collars, ties, and the various etceteras of toilet that are often carelessly left about. With regard to dimensions a minimum size will probably suit most requirements, say, 2 ft. 3 in. wide by 2 ft. 9 in. high, the length being increased to 3 ft. where more accommodation is desirable. The method of putting together is given at Fig. 39. In getting out the stuff two pieces A (Fig. 39), 2 ft. 9 in. long, should be nicely cleaned up to finish 8 in. to 9 in. wide by $\frac{7}{8}$ in. thick. A simple shaping is introduced at the top to relieve the general outline somewhat, and, as shown, mortises must be cut to receive the tenons on box, sides, shelf, and rails. Tenons are also cut on these ends to enter the shoes at I, and the heart-shaped openings seen

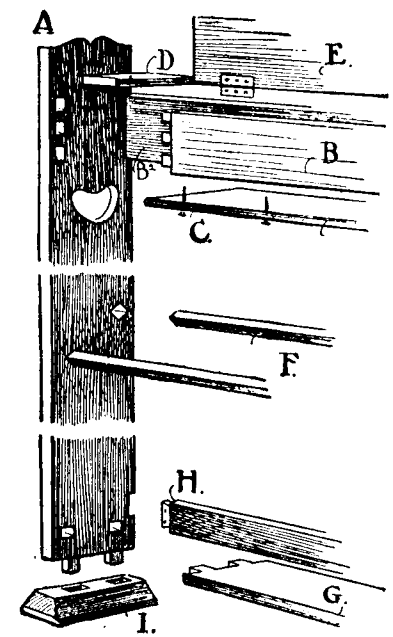


FIG. 39.—Details of Boot-Rack.

will be useful as hand-holes when the whole thing has to be lifted. The back edge can be dovetail-halved for lower rail (H), as also for back of box, both dovetails being screwed into position. The pieces between which the lid is hinged can be blocked and screwed into position, a couple of 2½ in. brass butt-hinges being used to hinge the lid to the back. The shoes can be cut from pieces 11 in. by 3 in. by 1½ in. with the top edges bevelled away, the mortises being right through to receive the tenons on the ends, which should be wedged to secure them. The tenons on the shelf should fit nicely, and may have small screws entered through them from the under side as a further hold. The bottom of the box of ¼ in. stuff can be screwed up into position, the inner angles being neatly blocked to stiffen them and help to keep out the dust, to which end a bead may be glued to the front edge of the lid, with a strip of baize along it to shut on to the edge of the side. This will likewise deaden the sound should the lid slip from the hand when up. A list of parts is given to assist the worker in setting out his working-drawing :—

	L.		W.		T.
A. 2 ends . . .	2′ 9″	×	9″	×	⅞″
B. 2 box sides . .	2′ 3″	×	5″	×	⅝″ or ½″
C. 1 bottom . . .	2′ 1½″	×	9″	×	¼″
D. 2 slips . . .	9″	×	2½″	×	⅝″ or ½″
E. 1 lid	1′ 9″	×	9½″	×	⅝″ or ½″
F. 2 rails . . .	2′ 2½″	×	1″	×	1″
G. 1 shelf . . .	2′ 2½″	×	9″	×	½″
H. 1 rail	2′ 2¾″	×	3″	×	⅝″
I. 2 shoes . . .	11″	×	3″	×	1½″

A bay-window is an attractive position to secure for a successful piece of one's own handiwork, and therefore the flower-stand seen in Fig. 40 should prove a tempting subject for any young craftsman's best efforts at the bench. It is designed as a centre piece, and must be cleanly finished on all sides. The dimensions might be made to finish 3 ft. 6 in. high by 1 ft. 10 in. by 10 in. over the lower shelf with the uprights to show a full 1 in. square. There is little in the construction to offer difficulties to the beginner, and tackled with care the result should be both pleasing and useful. The uprights must be shouldered at the upper ends to give a short stout tenon to enter the top, which will overhang about 1½ in. The two rails under the top shelf are tenoned into uprights, the shelf immediately below being notched at the corners to enter them also, and being screwed through from the underside. The lower shelf is also notched to fit round uprights, and has a couple of wide rails

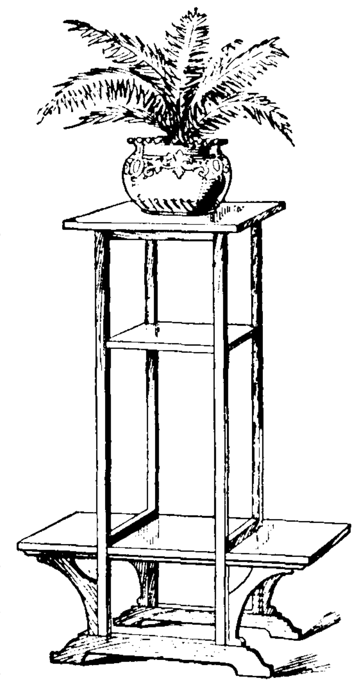


Fig. 40.—Flower-Stand.

under each side as stiffeners, a pair of rails being tenoned in position at the sides above and below the shelf. Shaped supporting brackets are grooved and screwed under the shelf, and the uprights terminate into the two base struts with a couple of wedged tenons. Crossed stretchers may be fitted under the centre and smaller shelf if desired, these being halved together in the centre and tenoned into uprights on the angle ; or dowels may take the place of tenons all through. The following detailed dimensions will doubtless make all clear :—

A.	1 top	1′ 2″ × 12″ × ½″
B.	4 uprights . . .	3′ 4″ × 1″ × 1″
C.	2 rails	10″ × 1¼″ × 1″
D.	1 shelf	10″ × 10″ × ½″
E.	2 rails	10″ × 1¼″ × ⅞″
F.	1 shelf	1′ 10″ × 10″ × ½″
G.	2 stiffeners . . .	1′ 9″ × 2½″ × ½″
H.	2 base struts . . .	1′ 4″ × 2¼″ × 1¼″
I.	4 base brackets out of .	9″ × 4″ × ¾″

Among the various things that the worker who has gained a little facility with his tools may try his hand at, none, perhaps, will win a readier welcome from the home circle than a bedside table. The suggestion at Fig. 45, it will be seen, is of pleasing proportions, and is fitted with a fall-down flap to the cupboard, to be supported by chains fastened by screw-eyes to the inner sides of legs and flap so that all closes up neatly. Suitable dimensions would be 16 ins. to 18 ins. square for top with a height of 2 ft. 8 ins., to which the shaped back rails would add

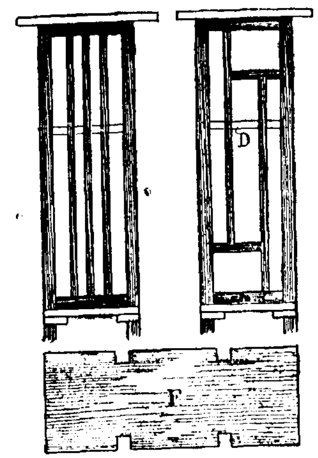


Fig. 41.—Front and Side Views.

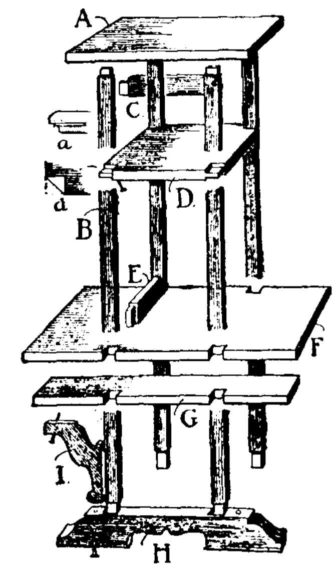


Fig. 42.—The Principal Parts.

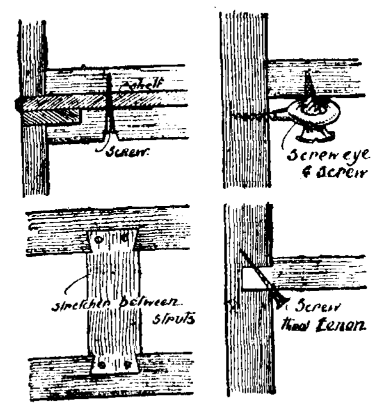


Fig. 43.—Details.

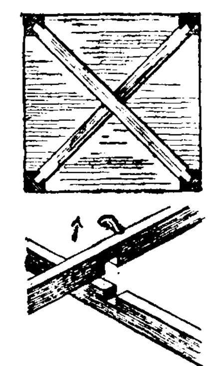


Fig. 44.—Cross-Stretchers to brace up Shelf from underneath.

Details of Flower-Stand.

another three inches. There is nothing in the construction that a careful boy could not easily master. The uprights are connected at the top by dovetailed rails front and back, and tenoned rails below this, or dowelling may be preferred instead as being quicker and less troublesome to fit. The sides are tenoned into position and the back may be screwed on. The stile of the flap should be mortised right through to receive the tenons on the rails, and the panel should be rebated in flush on the inner side. The bottom can rest on and be screwed to the rails front and back, and the lower shelf screwed up to under side of side rails. The upper back and return rails are screwed together and dowelled into the top, the small shaped shelf and bracket under being both screwed into position from the back. Made in mahogany, stained to a dark plum colour and wax polished, the careful worker should find himself in possession of a piece of furniture that will win him praise from all.

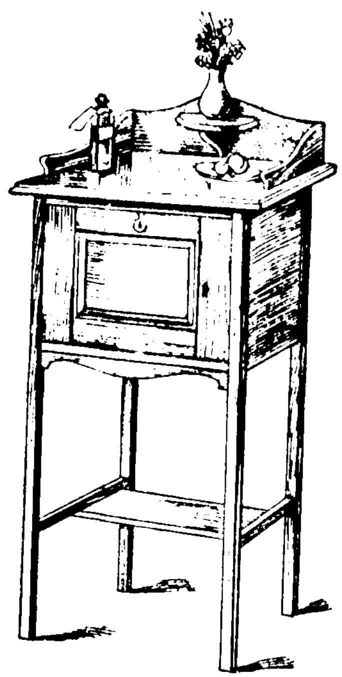


FIG. 45.—Bedside Table.

The delights of cabinet-making are probably tasted in the most convincing manner when the young craftsman has made something that ministers directly to his own particular needs and comfort. The boy is rare who does not value the possession of a desk that he can claim as his very own, and the craftsman will probably

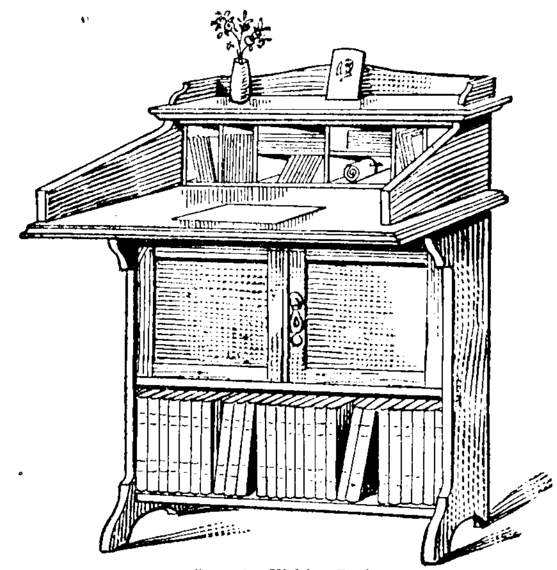


FIG. 46.—Writing-Desk.

cast a favourable eye on the simply constructed writing-desk, bookshelf, and cupboard combined shown in Fig. 46. A useful proportion for this would be 2 ft. 6 in. wide by 1 ft. 10 ins. deep over all for the table top, which will finish at a height of 2 ft. 6 ins. from the ground. The ends below the top are planed up and finished to a length of 2 ft. $5\frac{7}{8}$ ins. by

12 ins., the projections top and bottom at front being 4 in. wide, separately dowelled and glued on. The upper edges of the ends are connected by a false top dovetailed on and screwed, the table top proper being afterwards screwed down on to this. The ends are also carefully mortised to receive the three tenons on each shelf, which may have a fine screw entered aslant from the underside. The doors are mortised and tenoned together, and the panels beaded into the rebate from the back. The upper part has the back screwed to the wings, or these may be dovetailed together at the angles, and the whole dowelled into the table top. The stationery case can be dovetailed together of ¼ in. stuff with partitions of ⅛ in. thickness V-grooved in, this part being separately made to fit the recess under top shelf.

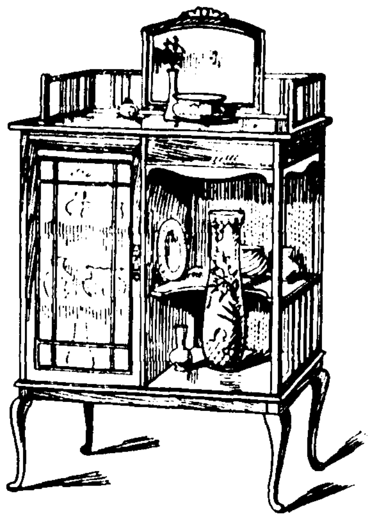


Fig. 47.—Drawing-Room Cabinet.

At a little later stage, with skill increasing, something of a more ambitious nature will be sought and attempted. Casting about for a suitable subject for the next venture the young craftsman might do worse than decide upon the making of a cabinet for the drawing-

room, as suggested in Fig. 47. A recess and shelves are shown for the placing of china, photographs, and bric-à-brac, a cupboard with glazed doors for curios, and an upper gallery with shaped mirror of simple but pleasing proportion. There is little involved in the construction of such a cabinet that he will not already be familiar with from the examples previously given.

CHAPTER IX

Lesser Woodcraft; An endless Scope for Talent

FRETWORK is a minor branch of woodcraft that may afford endless pleasure to the youth of a mechanical turn of mind. It is a handicraft which, within the last fifteen or twenty years, has made remarkable strides, and which is probably now more popular than any other. The extraordinary hold that fretwork has over the British boy and young man is not, however, surprising if the causes are traced. In the first place it is not difficult to learn. Some practice is required in guiding the delicate saw-blade accurately on the pattern line, but the actual cutting is easy and the joints used in fixing together are simple. Then the tools are inexpensive. A few shillings will enable one to make a fair start, and at no time is any heavy outlay really necessary. At the present day, moreover, the needs of fret-cutters are well looked after by tool manufacturers. In our fathers' time it was different. Tools then were only procurable at a few of the larger shops, and were often of an inferior quality. Now the very best tools of all kinds may be had at a small cost, and as for suitable designs there is an

A SPLENDID FRETWORK EXHIBIT

endless variety. Magazines, too, deal with fretwork in a practical manner, and in this way the cutter is kept in touch with all that is being done in this branch of woodwork.

But perhaps the chief reason why fretwork is such a favourite pastime is that in hardly any other way can handsome and useful articles for the home be so quickly made. To the young boy who has never seen a fret saw a fretted ornament seems a marvellous piece of work. When he learns that such work can be turned out by himself, he is eager to attempt it. He finds that what would involve weeks of labour with the knife and chisel can be produced in a few hours, and far better, with the ordinary fret saw ; and this is why so many, to whom other woodcrafts have never appealed, have made a life-hobby of fretwork. There are thousands in this country—middle-aged men as well as lads—who devote every spare minute to fretwork, and who have not only decorated their homes with their own work, but are also adding to their incomes by selling what they can turn out in the free hours of the evening.

There can be little doubt that what has done more than anything else to establish fretwork so firmly is the publication of so many beautiful designs. These may be had from the most delicate miniature ornaments to large pieces of furniture. A fretwork design for almost every conceivable household ornament is now procurable. Many of these are exceedingly beautiful, and some of the large models of buildings or other structures are wonderfully fine.

Of course fretwork as a handicraft must not be compared with carpentry or cabinet-work on the one hand, or wood-carving or inlaying on the other. In strength and general household usefulness the purely fretted article is not in the same class as the cabinet-made table or bookcase. Nor from the purely artistic point of view can it rank with wood-carving and inlaying. Wood-carving is wood-sculpture—modelling in relief. Inlaying combines with fret-sawing the skilful and artistic arrangement of coloured veneers. Fretwork, while certainly an art craft, is in the nature of flat decoration, although, as will be seen later, in its more advanced branches relief may be added to it by means of overlays.

Fretwork means the cutting out in thin wood of some ornamental design. For this a very fine saw is required, a tool that usually goes by the name of saw-blade. The word 'blade,' indeed, is used as frequently as 'saw.' Saw-blades are about 5 in. long, and are as fine and flexible as wire. They are made in eight or more degrees of fineness, but even the coarsest are very much finer than any saw used by a cabinet-maker. The finest ones are so delicate that the teeth are almost invisible. The cost of saws is about threepence a dozen. At first the beginner will break a good many, but after some practice it will be found that, fragile though they appear, they are remarkably tough and durable.

To hold the saws a hand-frame is required. The saw is gripped in the clamps of this at each end, the teeth facing downwards. Hand-frames cost from a shilling up to about 3s., according to size and quality, and vary in length from 12 in. to 20 in. The advantage of a short frame is that it is more rigid and more easily held; that of a long frame being that it will take in a larger piece of wood between the saw and the back of the arm. A 14-in. or a 16-in. frame is the most generally useful.

A luxury which experienced workers allow themselves is a treadle fret saw. The great advantage of this is that, as the saw is worked by the feet, both hands are free to control and guide the work. A greater speed, too, can be reached, although this may sometimes result in less accurate cutting. Strong and reliable treadle fret saws may be had for as little as fourteen or fifteen shillings. Larger ones, with extra accessories, such as drilling attachments, cost from thirty shillings upwards. Some fret saws are combined with lathes. While, however, a treadle fret saw has certain obvious advantages, it ought to be said that some of the finest work in the country is turned out with the hand-frame.

Assuming that the hand-frame is used for holding the saw-blade, a cutting-board for the work is required. This is a beech board (held to the table or bench by means of either one or two iron cramps) with a V-shaped opening at the front end. The work lies on this table, the saw-blade working vertically within the V opening. The object of such a table is that a delicate fret is supported when held over the narrow neck of the V; were no such cutting-board used the friction of the saw might break some delicate point of the wood ornament. Cutting-boards with cramps cost only 6d. or 8d.

The only other tool that need be specially mentioned is the drill for boring holes in the interior portions of the fret, in order to secure access for the saw-blade. A good drill of the Archimedean type may be had for 1s. One or two small fretwork files are useful, and the worker must have a sheet or two of fine sand-paper and glass-paper.

No fretwork can be done without wood, and here again the fret-cutter is well cared for. He need never trouble to plane down his own wood, as planed fretwood of the best quality may now be bought in all thicknesses. The favourite and most suitable varieties are these:—white woods—holly, sycamore, white chestnut, and maple; yellow woods—satinwood, canary and figured oaks; light brown or red woods—birch, cherry, and lacewood; darker woods—satin walnut, cedar, mahogany, amaranth, padouk, dark walnut, rosewood, and ebonia (black-wood). The stained grey wood, known as silverwood, is useful for light work, and occasionally other fancy woods with fine figuring may be had. Of the white woods holly is the purest, but maple is the most generally useful. Satin walnut is one of the most serviceable of all woods, having a nice colour, an even grain, and being easily

cut. Ebonia is a beautiful black wood, but is costly.

The usual thicknesses for ordinary frets are $\frac{3}{16}$ in. and $\frac{1}{4}$ in. For very large work $\frac{3}{8}$ in. is used, while for small ornaments $\frac{1}{8}$ in. is sometimes required. Overlays—that is, thin frets which are mounted on solid backgrounds—are cut from wood only $\frac{1}{16}$ in. thick. Prices are reckoned by the square foot, according to kind, thickness, and width. Threepence or fourpence per square foot is a fair average price, but some of the finer woods run up to 6d. or even 1s. As wood grows, and is not manufactured, boards vary in width. Thus, a square foot need not necessarily be 12 in. by 12 in. If the board is only 8 in. long, an 18-in. length will be given for a square foot, each foot requiring to contain 144 sq. in. Similarly, a board 24 in. by 6 in. or a board 16 in. by 9 in. makes a square foot.

Three-ply wood is made up of three thin layers, the grain of the inner board running at right angles to that of the two outer ones. In this way a delicate fret is protected to some extent. Three-ply wood, however, should be eyed with caution, as the gluing of the boards is not always satisfactory, and as the middle layer is sometimes of a different colour the cut edges have an ugly appearance.

Just as the fret-cutter cannot do without wood, designs to him are also indispensable. As already mentioned, there are many hundreds—indeed thousands—of printed designs available. Sheets of fine designs may be had for 1d. each, while larger ones of furniture, models, etc., are priced at 6d. or 1s.

The usual way of getting the design on the wood is by pasting down the paper diagrams. This means that the pattern can only be used once; but designs are very cheap, and pasting down saves the laborious task of tracing. Flour paste is used, and it is customary to apply this to the wood and not to the paper. Great care must be taken not to stretch or twist the diagrams when they are damp; this would throw the fixing parts out of position, and there is less risk in doing this when the paste is applied to the wood.

The other way of transferring the pattern is by means of black or blue carbon paper. A sheet of this is placed between the design and the wood, and the outline traced with a sharp-pointed pencil. In this way the design is preserved, and tracing is useful when two or more parts have to be cut from a single diagram.

When the pattern is satisfactorily transferred to the wood, care having been taken that the grain runs lengthways with the design, holes are bored with the drill in all the interior parts of the fret. Unless the outline happens to be almost plain, it is usual to cut out these inside parts first. One end of the saw-blade is released from its clamp, passed through the drilled hole, re-thread, and tightened with the tension screw at the top of the hand-frame.

Cutting begins at a corner, if there is one, and the saw guided slowly along the line. The frame must

be so held that the saw is absolutely vertical, otherwise the cut edge will be bevelled—that is, it will be slantwise, not square with the surface. This is a most important point in fretwork, as bevelled edges mean that the reverse side of the fret will be irregular. Whether in treadle-cutting or in hand-frame work, the greatest care should be taken to see that the saw-blade is working with a vertical stroke. The stroke should be smooth and regular; jerks and plunges should be avoided, and in hand-sawing it will be found that a series of short even strokes will give a better result than long pulls. The latter tear the grain and are apt to cause breakages.

Saw-blades are so thin that it is easy to guide them round the sharpest curves. When an acute angle is approached, however, the blade must not be turned abruptly. If this is done it will get locked in the wood and will break when an attempt is made to move it. What has to be done at a corner is to keep the saw moving up and down, *without cutting*, till it eases itself in the waste wood. It is meanwhile gradually turned, so that, when it faces the new direction, it is free. At projecting points it is a good plan to run the saw right out into the waste wood, turn it in a circle, and let it strike the point from the other side. In this way the risk of breaking a blade is avoided, while at the same time a sharper point is secured. Inside corners can often be cut sharp and clean by approaching the angle from different directions.

There are many hints on matters of detail in cutting which it is hardly necessary to give here. Two features of fret sawing may, however, be mentioned.

The first of these is 'plural cutting.' When fairly thin wood is being used, and when two similar pieces have to be cut, it is customary to nail two pieces of wood together and saw both at once. The cutting is a little heavier, but duplicate work in other ways is saved. Plural cutting is particularly useful when only one diagram of some small part is shown on the design sheet, and when two pieces have to be cut from it.

The second matter is just to remind aspiring fret-cutters that, for a board of wood 16 in. or 18 in. long, it is not really necessary to have a hand-frame of that length. An 18-in. fret can be cut with a 12-in. hand-frame. The only difficulty is with the openings at each end. The saw cannot completely circumscribe those, as the back arm of the frame will butt against the far end of the wood. What has to be done is simply to cut as far as the saw will go in one direction, then draw it back to the starting-point and proceed in the other direction.

When all cutting is finished the paper pattern has to be removed, this being done by sand-papering. The edges have then to be examined and all threads of grain taken off with the file. Both surfaces are finally glass-papered till they are perfectly clean and smooth. A fret should never be looked upon as finished until every loose thread of grain has been removed.

Fretwork joints are of a simple character. Firstly, there is the tenon and mortise—or, as it is usually called, tenon and slot. The slot must be cut to fit the tenon exactly, the joint afterwards being secured with glue or with a fine screw passed in from below. Then there is the half-cut joint, used when two parts cross each other at right angles. In one piece a long slot is cut in the upper half; in the other piece a corresponding slot is sawn in the lower half. In width each slot is exactly equal to the thickness of wood used; thus, when the parts are fitted into each other, they are both held tightly. Another joint sometimes used is the simple dovetail. This must not be confused with the cabinet-maker's dovetail joint. A fretwork dovetail is used when a large piece of wood has to be divided at the middle for convenience in cutting. The division line is sawn in dovetail fashion, so that the two sections may not afterwards pull apart. On designs it is usually arranged that such joints are hidden by some other piece.

For gluing, it will be found that the liquid glue in small collapsible tubes is most useful. Only a small touch is required, and care must always be taken not to allow any surplus glue to remain on the surface of the wood. Screws used are the very fine brass ones, the most suitable lengths being $\frac{3}{8}$ in. and $\frac{1}{2}$ in.

Fretwork ornaments are, as a rule, left plain.

They are never varnished; at least, they never ought to be varnished, as varnish gives a greasy, sticky finish quite unsuitable for small fretted ornaments. Some woods, such as maple, oak, and satin walnut, can receive a firm rub up with beeswax and turpentine, which gives them a dull but rich gloss. Dark walnut is sometimes given a coat of boiled linseed oil, being afterwards rubbed to a dull finish with a piece of leather or a nail-brush. Of course any article may be French polished, but this should only be attempted by those who have had some experience in this work.

Overlaying is a branch of fretwork for which some very fine designs are now published. An overlay is a thin fretted ornament, usually cut from sixteenth-inch wood, which is mounted on a solid or fretted background. The overlay itself may be exceedingly delicate, but when glued in position it is quite strong. For many small articles the overlays are cut in xylonite or in metals such as brass or aluminium. These are used thinner, about $\frac{1}{16}$ in. for xylonite and $\frac{1}{32}$ in. for metal.

One of the most common uses to which an overlay is put is to provide for the framing of a photograph or mirror. In a fretwork frame, for example, the opening for the glass and picture is cut in the back. Over this is placed a thin fretwork rim which partly overlaps the back opening, and thus leaves a rebate for the glass and picture. Apart from this, overlays are introduced in many other ways. A wood lighter in colour from that used for the background is taken

in order to emphasise the relief. Sometimes more than one wood is used, and variety of colour is thus obtained.

The cutting of overlays is similar to that of the ordinary fret, except that a very thin piece of wood is rarely sawn alone. To give it protection a board of waste wood is fixed on below. Xylonite and metals are placed between two boards of wood (all being tightly fixed) for cutting, and with thin white woods the same plan is frequently adopted. The detail on overlays is usually finer and smaller than that on larger frets; consequently finer saw-blades are required, and greater care has to be taken in glass-papering. It is of special importance, too, that overlays are glued exactly in their correct positions, and that they are fixed firmly without any trace of the glue being visible.

Closely associated with overlay work is the art of miniature fret-sawing. This is so called because, while just ordinary fretwork or overlaying, it means the cutting of the tiniest ornaments of only two or three inches in size. Some of the designs for miniature work are most elaborate, and when cut in white xylonite they are almost equal to the finest Indian ivory carving. Miniature cutting is chiefly carried out in xylonite, but where the material can be as stout as one-sixteenth inch, wood may be employed.

Underlaying is frequently introduced in conjunction with overlaying. An underlay is not a fret, but is a plain panel of coloured wood or xylonite which is sunk behind an overlay to form an extra background. Very fine effects may be had in this way. A simpler method of underlaying is to line the back of an overlay with thin veneer or with silk, and then glue the whole to its wood ground.

Inlaying differs from carving and fretwork, inasmuch as the finished ornamented surface is flat and smooth. Colour, too, is an essential element. Decorative ornament is cut with the fret saw from one or more coloured woods, and let into a solid background. Thus the decorative effect is obtained not only by the design, but by the artistic arrangement of the woods used in making up the design.

Inlaying is done in several different ways, but these may be divided into two general classes: (1) solid inlaying, and (2) marquetry, or inlaying by means of very thin veneers. The former method is the favourite with amateurs; the latter is the professional or trade method.

In solid inlaying saw-cut wood is used—that is, wood that has been cut with the circular saw or band saw, and which is necessarily thicker than veneer sheets cut off the log by means of a knife. Some beautiful solid inlaying is done by fret-workers in woods of $\frac{1}{8}$-in., $\frac{3}{16}$-in., and even $\frac{1}{4}$-in. thickness. Much is also done with the thinner $\frac{1}{16}$-in. boards, but these latter usually require to be mounted on a solid background.

We may suppose that the lid of a box is to be inlaid with a comparatively simple floral ornament. The

box is in, say, $\frac{3}{16}$ in. dark walnut, and maple is to be used for the inlay. As hardly even the most expert cutter could first saw the maple ornament, and then saw a hole in the walnut to hold it exactly, the plan adopted is to nail the two woods together and cut both at once. In this way the ornament and hole are absolutely alike, and the fit must be accurate at every point. Work of the sort may be done by any fretwork amateur, and with either the treadle fret saw or the hand-frame.

Of course any one will see that, although the fit is correct, it cannot be very tight, for the simple reason that the saw has removed a certain quantity of sawdust. The finest blades are used for inlaying, but there must always be the width of this fine saw between the inlaid ornament and its background. To overcome this little difficulty, and to ensure a perfectly tight fit, we have resort to a simple expedient. The cutting-tables of treadle fret saws can be tilted to any angle, and by moving the table very slightly to one side the saw cuts on the bevel. Thus, when two pieces of wood are cut together, and the saw is sent round in the right direction, the piece which comes out of the upper board will be just a shade larger than the opening in the lower board, and will fit into it like a wedge. Of course, if the saw is sent round the wrong way the hole below will be larger than the inlay which it is to receive, and great care has always to be observed in determining the direction the blade is to take. All practised inlayers adopt this method, as a tight fit means that there is no ugly black line between ornament and ground, and there is also little fear of the ornament springing out of its bed.

When several different woods are being used it is not necessary to nail all together. This would mean needless labour, besides wasting good wood. Each colour is dealt with separately; thus, if walnut is the background wood, and holly, satinwood, and ebonia are being inlaid into it, the walnut and holly are cut together, then the walnut and satin, and then the walnut and ebonia. As the pattern has to be on the top, the walnut is in such cases kept uppermost, and the inlaid ornaments cut to come into it from below.

Marquetry is an art which dates back many centuries, and one which, in the time of Louis XIV. of France, reached a state of wonderful perfection. Beautiful examples of inlaying, in which woods of choice grain and colour, metals, tortoiseshell, pearl, ivory, etc., are employed, are still produced, and at our great museums it is worth while making a close examination of these.

Veneers are of two kinds: the knife-cut ones, which are less than $\frac{1}{32}$ in. in thickness, and the saw-cut ones, which are nearer $\frac{1}{16}$ in. Many fine varieties of woods are obtainable, and white woods, such as maple and sycamore, may be had in stained colours—reds, blues, greens, greys, etc. Veneering means the covering of a plain surface with a sheet of figured veneer. Pattern veneering is the arrangement of

veneers in some geometrical or other design, the effect being obtained by so laying the pieces that the pattern is indicated by the direction of the grain. Marquetry is the inlaying of some more or less elaborate design, either with a plain or patterned background.

To give adequate instructions here for veneering would be impossible, but the work may be briefly described. Perhaps the wood which best takes veneer is Honduras mahogany. Oak and walnut are also good, and American whitewood is used for cheaper work. Hard veneers are never laid on a soft wood, as the latter would absorb most of the glue. The surface of the ground is made quite flat, and then roughened with a toothing plane. The veneer is cut to size with a veneer saw, and some Scotch cake glue is boiled and prepared. The glue (while hot, of course) is spread well over the ground and the veneer laid down. A sponge is wet with hot water and passed over the surface; then with the veneering hammer the sheet is pressed down. All air between the veneer and the ground must be pressed out, and the hammer is kept working with a slow zigzag motion, first at the centre and then towards the edges, till the whole is flat. The object at first is to squeeze all surplus glue out at the edges, and it is usual again slightly to damp the veneer, pass a hot flat-iron over it, and repeat the hammer movement. It must be seen that all edges are properly laid. The glue is then washed off, and to prevent warping the board is held between two pairs of stout wood strips and tightly cramped.

Stouter veneers require more care, and are laid by means of pressure. They are held between two sheets of zinc, called 'cauls,' which are brought close either by hand-screws or in a special press. The cauls are heated before receiving the work. Wood cauls are often used for small work, but zinc ones do not adhere to any glue which oozes out. Newspaper is invariably placed between the work and the caul to catch any escaping glue. When whitewood or other light-coloured veneers are used some flake white is mixed with the glue to prevent any discoloration.

With pattern veneering the different parts are cut out, carefully arranged, and a piece of thin paper glued over the surface. In this way they are glued and laid down on the ground in the way just described.

Table tops, drawer fronts, etc., are frequently inlaid with strings of satinwood or boxwood, or with broader fancy bandings made up of different woods. These may be purchased in lengths from any veneer merchant. They are inlaid in the following way. A cutting gauge is set, and a shallow groove run in the wood. This groove is then glued, and the stringing let in. In the case of the wider bands two grooves are run, and the space between them routed out. Into this the band is laid.

Professional marquetry—that is, ornamental inlaying with veneers—is done on a stool called a "donkey." This is a long stool, astride which the

cutter sits. At one end is an upright clamp, which holds the work. Attached to clamp and to the cutter's foot is a strap, by means of which the work can at any moment be released for turning. The saw-frame usually works along a rod, and is held in the right hand. The different veneers are cut together, and when the pattern is arranged a sheet of paper is glued over it. This sheet, representing an elaborate inlay, is passed on to the cabinet-maker, who makes use of it on furniture. Any fret-cutter can do these fine inlays, and it is only in the after-work of gluing that he will find himself handicapped through the want of proper appliances, such as cauls.

Parts of veneers, before being pieced together, are sometimes shaded. Some sand is put in a dish and heated in an oven. The veneers are then placed in this till they are partially shaded or darkened all over as required. Care has to be taken that no part is scorched.

Pictorial marquetry, such as landscapes, seascapes, architectural features, etc., is sometimes called intarsia work. Its feature lies less in the design or the choice of colours than in the skilful arrangement of woods according to the direction of the grain. Remarkable effects in light and shade, and in conveying the idea of perspective, can be obtained by a clever placing of the grain. In speaking of 'intarsia,' it ought to be mentioned that the word is commonly applied to mediæval inlay work in wood and stone.

Of all woodcrafts relief-carving is the most artistic, the one in which the highest artistic spirit and feeling may be shown. This is due to the fact that relief-carving is modelling, and that therefore form as well as design has to be reproduced. Excellent effects can be had by surface-carving, such as chip or incised cutting, and no boy need hesitate to attempt the more elementary work; but to become an expert carver needs practice and study, and requires also a fair knowledge of drawing.

To describe carving is unnecessary. In the case of wood-carving proper, known as relief-carving, the ornament stands out from its background. The background is sunk (or cut down) to give this ornament its required relief, and the form is modelled to carry out the designer's idea. In the case of chip and incised carving the general surface is left flat, the design being indicated by the removal of little chips of wood or by incised lines. It will then be understood that, although beautiful and elaborate effects may be had by chip and surface carving, relief-carving is a more advanced art craft.

Of carving tools there is a great variety. They are cutting tools of the chisel type, and include square-pointed chisels, angle or skew chisels, gouges of all shapes, curved chisels and gouges, fluters, veiners (which are exceedingly fine gouges), V-parting tools, and others. Cramps or bench-screws are required for holding the work, and a wood mallet and one or two background punches are sometimes found useful. Sharpening hones are essential.

It is unwise for the beginner to buy a large stock of tools, even if he can afford them. It is far better to choose only a few of the necessary ones, and then get others as they are found to be needed. It is only as experience is gained that the carver really learns to know the particular tools he requires.

The wood used for carving depends largely on the character of the design, but it should be of an even and uniform grain. Dark walnut and oak are always popular, but the latter should never be used by a beginner owing to its hardness and peculiar grain. English and Austrian oak are better than American or wainscot for carving. Satin walnut is now used a lot for carving, and is easy to cut. Kauri pine, sycamore, basswood, and lime are the whitewoods generally used. Good yellow pine is excellent for preliminary exercises; it is soft, and as clean cuts can only be made with the sharpest tools it teaches the beginner how to keep these tools sharp.

The pattern is traced to the wood by means of carbon paper, and the work held firmly to the bench either with hand-cramps or with a regular carver's bench-screw. Before any serious design is attempted, however, the beginner will be wise if he practises a few exercises on some soft wood. Two essentials in carving are: control of one's tools, and mastery over the grain. The uses, the possibilities, and the limitations of all tools must be understood before the best work can be done. Similarly with the wood. No one fully realises the peculiarities of grain fibres until he has tried wood-carving, and it is by exercises that the grains of different woods and the differences in cutting with and against the grain are understood. Take, for example, a V-tool and cut a straight groove across the grain. Watch that the cut is straight, that the depth is uniform, and that the tool is not allowed to lean to one side. Next try a similar cut, but this time with the grain. Then try one diagonally across the grain, and afterwards cut some simple curves in different directions. Other tools may be tried in the same way—chisels, gouges, fluters, veiners, etc. The difficulties in working each will soon be appreciated, but the first thing necessary is to understand what they do and how they do it. Some practice in exercises, too, will guide the carver as to the designs he may be able to tackle.

If the reader is so situated that he is unable to take a few lessons, he should buy one of the excellent sixpenny or shilling handbooks on wood-carving which give a course of study, and from which an intelligent boy can teach himself.

When a regular design is attempted, the pattern is first outlined; that is, the V-tool is taken and a trench cut all round the design, about an eighth of an inch from the line, and to about the depth of the ground. This is called 'outlining,' the object being to free the design portion from the background, and thus minimise the risk of splitting any part of the wood. The work is then 'set in' by taking tools which fit as well as possible the form of the curve,

holding them perpendicularly, and driving them down into the wood as far as the background. The tool should not be placed quite up to the pencil-mark of the design. All cuts must meet, and care should be taken to have them deep enough. The background is then cut away, this work being called 'grounding,' and the modelling of the design is taken in hand. Here the worker must try to understand the form of what he is about to carve. If, for instance, it is an ivy leaf, he should get hold of a real leaf and note which parts are sunk and which are raised. It is of the greatest importance to understand the 'section' of whatever is being carved, and whenever a model can be procured it should be studied. Skill with the tools will come with practice, but no amount of skill can ever remedy a faulty form.

Carving rarely looks well when highly polished. On furniture the plain parts are usually polished, and the carved panels left dull. Walnut is sometimes given a coat or two of raw linseed oil, followed by a brisk rubbing. Oak is waxed with beeswax and turpentine; or, if a darker tone is wanted, it is first fumed with ammonia. Satin walnut may be oiled and then waxed.

In Chip Carving there is no actual relief. The general surface is left flat, and the design is formed by the small chips which are cut away. It is a class of decoration that is thus suitable for flat surfaces, especially horizontal ones, and even table-tops and trays may be chip-carved without interfering with their general usefulness. A great deal of chip-carving may be done with the carving-knife alone, and in any case only a few other tools (spade tool, veiner, one or two small gouges, and a V-tool) are required.

The great majority of designs for chip-carving are geometrical, triangles being the most common of detail forms. Designs based on natural floral forms are also to be had, but such designs are necessarily conventionalised in order to suit the work. On many patterns there is a good deal of simple work with the veiner and V-tool to do, but the rest of the design will be found to be made up of a series of pockets, like inverted triangular pyramids, which are chipped out by means of slanting cuts. A little practice with the various tools soon shows how these pockets are cut. Deep cuts are rarely required; indeed, the feature of a chip-carved surface is the lightness of its shadows, these being just sufficient to give a proper representation of the design. On very large work a deeper cut is permissible.

Somewhat similar to chip-carving is the flat relief carving practised so much in the Scandinavian countries. The ornamental design is formed by simply cutting away the background, the relief being very low. On the design itself there is little or no modelling, although a few incised lines are sometimes introduced to indicate details. The work is comparatively easy, but if good patterns are secured it is very effective. Incised work is merely the outlining of some design with the veiner or V-tool.

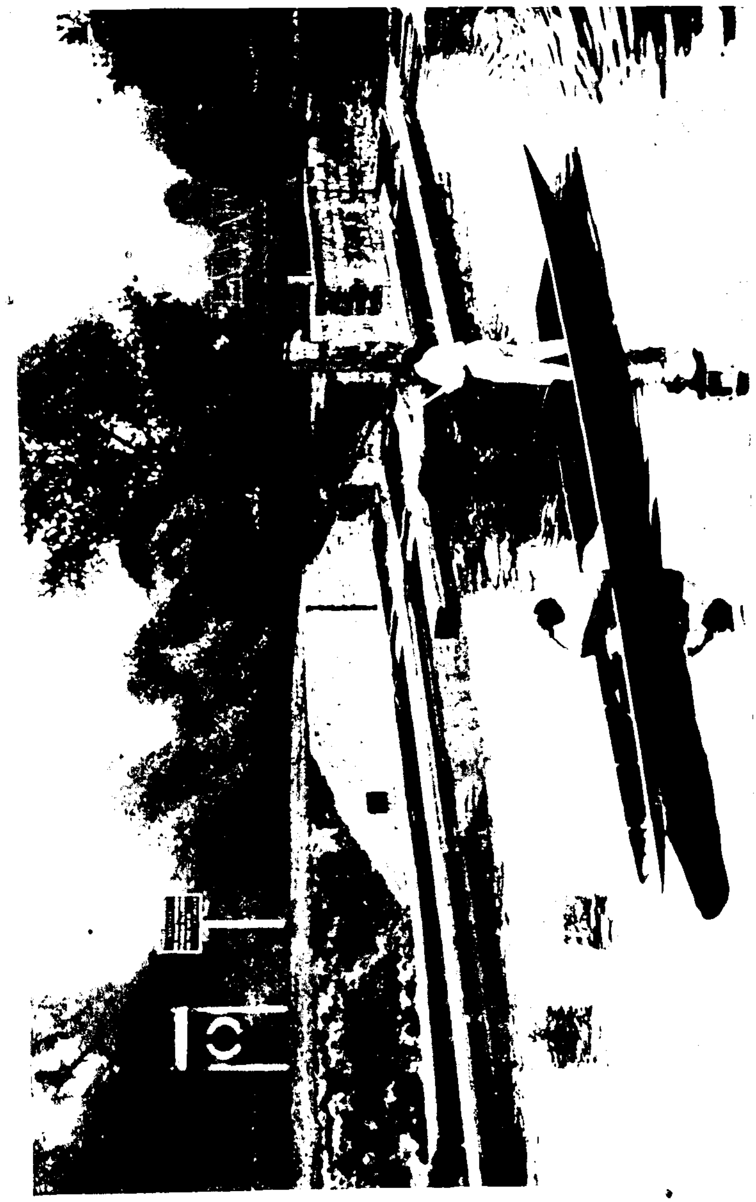
Wood-carving is among the finest of all art crafts, and one that is well worth the study it requires. In its advanced branches, such as the carving of figures or other objects in the round, it calls for great skill and artistic feeling, but even in its more elementary stages it is a medium by which some beautiful work may be produced.

CHAPTER X

How to Build a Punt.

OF all kinds of constructive woodwork the building of a real boat offers to many minds the strongest attraction. Its characteristic difficulties lie in the cutting and bending and coaxing of tough timber into nice adjustment with curved surfaces—a task demanding not only skill in the use of tools and a great deal of patience, but a knowledge of the methods which experience has proved to be the best for solving the multitude of problems peculiar to the work. In the building of a punt, however, these difficulties do not present themselves since the sides and bottom of the vessel are either flat, or are curved so slightly as to be easily fitted without the use of a steaming trunk. Any amateur carpenter who can use a saw and hammer, and will follow carefully the directions I am about to give, will be able to build a punt which, if heavier and less ornate than the gilded constructions of mahogany turned out from the boat-yards of the Upper Thames, will be not less safe and sound.

The first question to be considered by the prospective punt-builder is that of the principal dimensions of his vessel; the next is the site of the building stocks. A



A THAMES PUNT

useful length for a fishing punt is from 16 to 18 ft., and the extreme breadth or beam should be not more than a fourth nor less than a fifth of the length. Let us split the differences and make our punt 17 ft. long and 3 ft. 10 in. wide. As to the place of building, a roof of some sort is, of course, desirable, if only for the reason that it enables work to be carried on in all weathers and at all hours. Building in the dwelling-house must not be contemplated, even if no difficulties in the shape of narrow stairs and crooked passages present themselves to the removal of the finished punt. The builder must bear in mind that his work will necessitate the driving and clenching of about 300 nails, and a noise intolerable to any one less keenly interested than himself in its cause. Failing the command of a disused coach-house or suitable shed, he must build out of doors, selecting a corner of the garden or the yard as far as possible from the house.

Whether the building is done indoors or outdoors, some support will be necessary to raise the work high enough for the workman to sit or kneel underneath it at times, and not too high to prevent him when standing beside it to reach well over its upper surfaces. The punt is to be built bottom upwards, and the bottom must be low enough to allow holes to be bored and nails to be driven downwards from the outside. The simplest supports for use on a hard floor are a couple of trestles, which can be put together from any old pieces of wood. For outdoor use firm and efficient supports may be made by driving two pairs of stakes well into the ground, and nailing a cross-piece at the top of each pair. The two trestles or pairs of stakes should be exactly parallel and exactly the same height — about the height of the workman's hip-bone, so as to bring the top of the work up to the level of his chest. For a 17-ft. punt they should be set up about 5 ft. apart, and the top of each trestle at the cross-piece of each pair of stakes must be not less than 4 ft. long.

At this point of the proceedings, if the builder has not already done so, he must make a plan and sheer plan of the proposed punt in order that he may clearly understand every detail of the work he is about to undertake. The drawing should be on a generous scale, say half or a quarter full size, and may be made on the boards of a floor or on continuous brown paper, or on sheets of white paper pasted together to the required size. It will be seen from the sketch that the bottom of the punt is curved both in the plan and the sheer plan. These curves should be drawn in with the help of a batten or thin strip of wood held in place upon the drawing by weights or pins.

The plans finished, we proceed to assemble our materials. The planks of our punt will be of larch, spruce, or red pine. For durability and ease of working there is little to choose between these three, but probably the amateur will find spruce or red

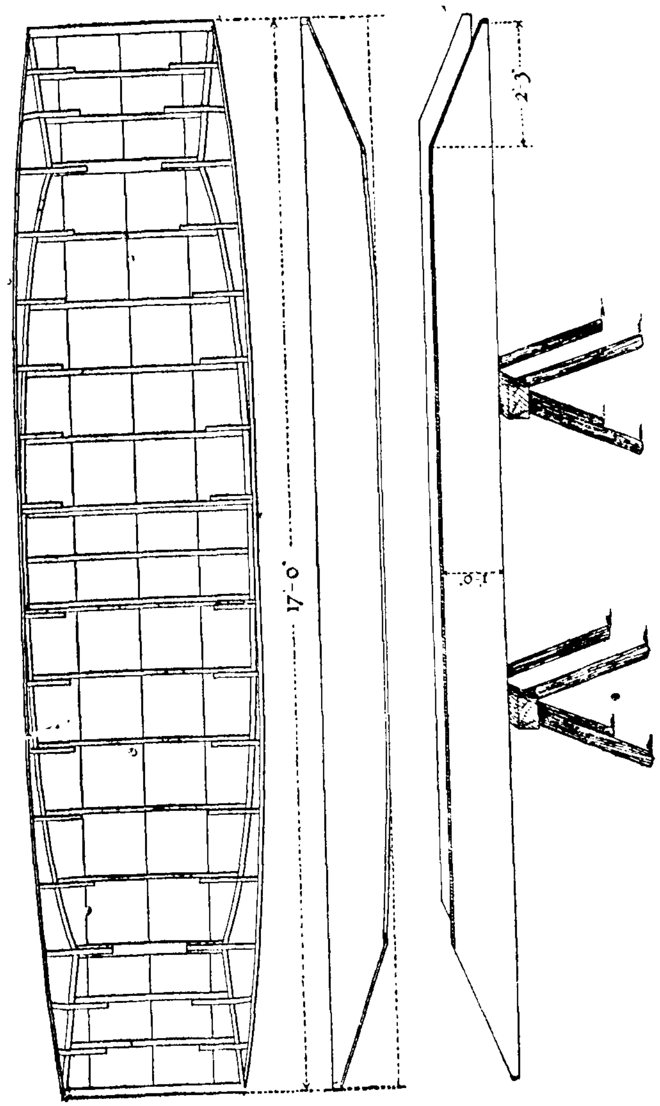


FIG. 48.—Plan and Sheer Plan of Punt, with Side Planks on Trestles.

pine the easiest to obtain in the sizes he wants, namely :—

For the sides : two planks 17 ft. long.

For the bottom : four planks 14 ft. long, and two 10 ft. long.

The planks for the sides and bottom must be of selected wood, free from knots. They must be 12 in. wide and ¾ in. thick when planed. The six planks for the bottom should be tongued and grooved.

For the locker : one plank 18 ft. by 9 in. by ¾ in.

For stringers and floors : 70 or 80 ft. run of 1 in. by 1 in. These may be sawn from a 14-ft. plank.

For knees and timbers : about 18 ft., not necessarily in one piece, of 1-in. oak plank with a curved grain.

We now come to the important question of nails. About two gross of these will be required 2¼ in. long. Copper nails are the best, but they are expensive. The copper nails most frequently used by boat-builders are of two kinds, the boat nail and the clout nail. In both cases, after a hole has been bored, the nail is driven through from the outside of the work. In the case of the boat nail a 'roove,' or thin disc with a hole in its centre, is slipped over the projecting end of the nail. All but a sixteenth of an inch or so of this end is then nipped off with a pair of cutting pliers and the remainder hammered on to the roove so as to form a rivet. Rooving makes a neat and tight fastening, but requires a little skill. The clout nail needs no roove. Its projecting point is nipped

down to about a quarter of an inch and then simply 'clouted' or hammered over into the grain of the wood. In punt-building it is not absolutely necessary that copper nails should be used. If on the ground of cheapness iron nails are preferred, they should be galvanised or tinned. I have seen a punt quite neatly fastened with common wire nails clouted over. I should add that whatever nails are used must be rather thin, so as to minimise the risk of splitting our pine planks.

Now we are ready to build, and we must begin with the two side planks. Mark off a point on the edge of one of the planks 2 ft. 3 in. from the nearest corner, and another point on the end of the plank 1 in. from the corner above. Join these points with a line and cut off the triangle with a fine saw. Treat both ends of both planks in the same way and set them up edgeways on the building stocks with the sawn edges uppermost. They must be perfectly perpendicular and parallel, 3 ft. 10 in. from outside to outside, and the ends must be in a line at right angles with the length of both planks. If the planks will not stand perpendicularly upon their edges, they may be supported in position by one or two temporary stays fixed into the ground and lightly nailed to the planks. Indeed, in any case it is worth while to take this precaution in order to avoid the risk of knocking over a plank and being compelled to repeat the labour of ranging and gauging it into accurate position. The next thing to be done is to cut and fit the sides of the locker or well, the prime function of which is to serve as the midship frame or principal cross-girder of the punt. These sides are to be sawn from your 9-in. plank. They will be 3 ft. 8½ in. long, and at each of the corners that will be uppermost in building you must cut out a rectangular piece 1 in. long and ⅛ in. deep. Make a pencil-line across the edges of the side planks in the middle of their length—that is, at 6 ft. 3 in. from the angles of the bevels—and other pencil-marks at 10 in. on either side of the central line.

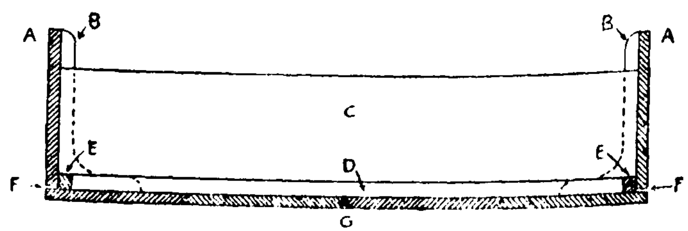


FIG. 49.—Midship Section of Punt.

A, Side Planks, 12″ × 3¼″; B, Oak Frame; C, Locker; D, Floor Timber; E, Stringers, 1″ × 1″ section; F, ¼″ Crevice for Caulking; G, Bottom Planking, ¾″ thick, 12″ wide, tongued and grooved.

The latter show the positions of the outer edges of the locker, which will be 1 ft. 8 in. apart. Take one of the two pieces you have just sawn and insert in between the side planks at these marks, adjusting it carefully so that its upper edge—the edge with the cut corners—is exactly in line with the upper edges of the side planks, and fix it firmly in position with three brass 2¼-in. screws on each side. The screws should be spaced 2¼ in. from centre to centre and from the edges of the side plank. Their shanks should be at least ¾ in. long, so as to go past the junction of the

planks, and the holes for them must be bored the full length of the screws. The second frame must be inserted in the same way.

Now bend the side planks together until the outside edges are exactly 3 ft. apart at the ends, and fix them so with temporary ties—any odd pieces of wood, lightly nailed to the lower edges in such a way as to prevent movement inwards or outwards. The effect is, of course, to give a lateral curve to the sides of the punt. Another curve is shown in our plans. This is effected by bringing the upper edges of the planks closer together than the lower edges. You will probably experience some difficulty in doing this without mechanical aid. The simplest method is to drive a couple of nails half-way into the outside of each plank, two or three inches apart and near the upper edge at the angle of the bevel, and putting a loop of cord across to twist it with a stick until the angles are a few inches nearer to one another. Care, of course, must be taken that the nails do not split the planks. If there is any danger of this happening it is best to cut a pair of forks or nippers out of hard wood, with an opening just large enough to grasp the edges of the plank, and to put the string round these. When the edges have been drawn together to the right distance they must be fixed in position, like the lower edges, with temporary binders. This second curve is not absolutely necessary and it increases the difficulty of fitting the frames and bottom planking, but it makes a great difference to the appearance of the punt, which without it would be a wall-sided affair with an absolutely flat bottom.

The next step is to saw a pliant stringer of 1 in. square section and the length of the upper edge of the side planks. Rest this in the recesses cut in the midship frames, where it will project $\frac{1}{8}$ in. above the side plank, and proceed to nail it along the plank from end to end at this level. Holes for the nails must be bored six inches apart with a bradawl, and the nails driven in from the outside and rooved or clouted. A second stringer must be cut and fastened on the opposite side. Now we are ready to turn our attention to the floor timbers and frames. Let us take the drawing in hand and accurately mark with a pencil their positions between the stringers. There are two of these frames along each side of the locker and five on either side beyond, spaced 12 in. apart. The bottom frames are strips of pine 1 in. square, cut from the same plank as the stringers, between which they are to be closely fitted. The side frames are to be sawn from the curly-grained oak mentioned in the list of materials. These are obtuse-angled, elbow-shaped pieces one foot long in one direction and six

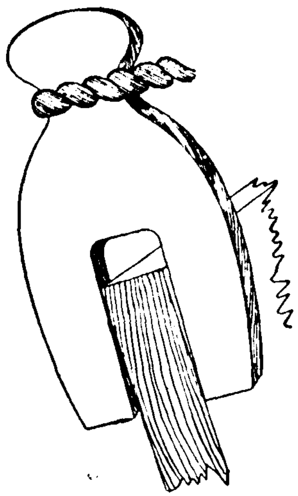


FIG. 50.—End of Plank, being bent by Nipper.

inches in the other. They are to be 1 in. thick at the extremities, but curved on the inside of the elbow, the curve following, as far as possible, the grain of the wood. The angles of the elbows will vary, of course, with the slope of the side planks, and in the case of those near the ends of the punt it may be necessary slightly to bevel the edges next the side planks in order that the frames may fit firmly and squarely. If the lines of the punt are perfectly symmetrical, every pair of frames at one end of the structure will have its exact counterpart in a pair at the other end. In that case the workman might prefer to saw four frames in one piece out of 4-in. stuff, and divide them longitudinally. It is safer, however, and in the end not more laborious, to cut and fit one frame at a time. A pattern or template of each frame should be made of thin wood or even strong cardboard, a recess being cut in the corner to make room for the longitudinal stringer. The template must be held against the inner side of the plank in the position marked out for the frame and tried against a straight-edge set across the stringers. Before this is done it is well to slide the straight-edge from one end of the stringers to the other, and to bevel them where necessary to make close contact, being careful, however, not to make the curve unfair. It is not necessary that the straight-edge should make contact with the inner edges of the side planks; indeed it ought not to do so, as in that case there would be no crevice for the oakum which is to come in later on between those edges and the bottom of the punt. When a template has been carefully shaped to fit, it may be laid upon the 1-in. oak and its outline traced round with pencil. It is best to fit each frame before making the template for another.

The frames first to be put into position will be those against the outer walls of the locker. Having prepared a frame for this position, hold it firmly against the locker-wall and the side plank, and adjust it so that the edge of the short arm of the frame is on a level with the stringer and the locker-wall. Your straight-edge will help you with this adjustment. When the frame is exactly in the proper place, fix it there with three nails, 3 in. apart, through the side plank. The holes for these nails should be bored from outside, and the nails driven through but not clouted for the present. Now adjust and fix the opposite frame in the same way, and fasten both to the locker-wall by a couple of nails through each arm. These nails will be best driven from inside the locker, and may be clouted or rooved as soon as they are in. Fix the second pair of frames in the same way on the outside of the other locker-wall, and then cut from one of your 1-in. by 1-in. stuff two pieces to fit across the bottom of the punt between the stringers and on the inside of each locker-wall. These must be placed as carefully as the side frames, on a level with them and with the locker-wall and the stringers, and fastened to the locker-wall with six or eight nails, one of which, at

each end of the floor timber, should pass through the partition into the short arm of the side frame beyond.

The other frames and floors—five on each side of the locker—are fixed in a similar way, except that the floors are fastened at each end by two nails driven through the foot of the side frame and rooved or clouted. The builder should not be in a hurry to clout his nails until he is quite satisfied that frame and floor are accurately placed. The fixing of the frames will be greatly facilitated by the use of a pliant batten of the same length as the bottom of the punt, namely, 12 ft. 6 in. This should be lightly nailed to the two frames first fixed amidships. When bent down along the centre-line of the punt, level with the edges of the stringers, it will show the curve which the bottom planks will follow, and the exact height at which the floor timbers should be fixed.

The fifth of those timbers, counting from either side of the locker, is double the width of the others, since it has to support the sloping end of the punt as well as the nearly flat bottom. In this case, instead of placing the side frame beside the floor-piece, the latter must rest upon it and be through-nailed. The floor-piece will be bevelled for half its width to the angle of the ends. Cut two pieces of your 1-in. by 1-in. pine for stringers for each end of the punt and nail them down the sloping edges of the side planks—protruding $\frac{1}{8}$ in. above—just as you nailed the long stringers for the bottom. Partly as a strengthening piece and partly as a finish to the punt, you will want a strip of solid wood at each end. This should be of oak or elm, worked outside on its lower edge to a nice curve. Its length will be the full width of the end of the punt, that is 3 ft. It must be deep enough to be flush with the bottom planking, that is about 2¼ in. at 1 in. from the end of the side frames, and 2 in. thick. Its ends will be recessed for half the thickness to take the ends of the side planks and stringers which are to be fastened to it with brass screws, and a recess ¾ in. by 1 in. must be cut throughout its length for the ends of the bottom planks.

The space along the end stringer, between the oak end-piece and the 2-in. floor, will be about 2 ft. 3½ in. We must put two more frames in this length, so they will have to be spaced 8½ in. instead of 12 in. like those on the bottom. The side frames will be fastened exactly as before; but, being on the slope, their longer arms will not be at right angles with the edge of the side planks. Obviously, too, they will be shorter than the others, the pairs at the extreme ends being only about 4½ in. long in the upright.

Having fastened the end stringers and frames, and screwed the stringers and side planks to the solid end-pieces, we are ready to plank the bottom. First mark very carefully the centre-line of the punt along the floors and ends. Take one of your 14-ft. planks and

range its grooved edge exactly on these marks. Put a nail through the middle of it into each of the two mid-ship floors and bend it down over the framework of the boat. If it makes a fair curve, and fits closely against every floor, you may put a nail through its middle at every frame, but do not roove or clout any of the nails until all the planking is on. If the frames have been put in carefully with the aid of a batten, as already described, the plank should fit without difficulty, but if there is any unevenness anywhere it must be remedied before proceeding further. It is less troublesome in the end to take out and put right an ill-fitting frame or two than to attempt to scamp the work at this stage.

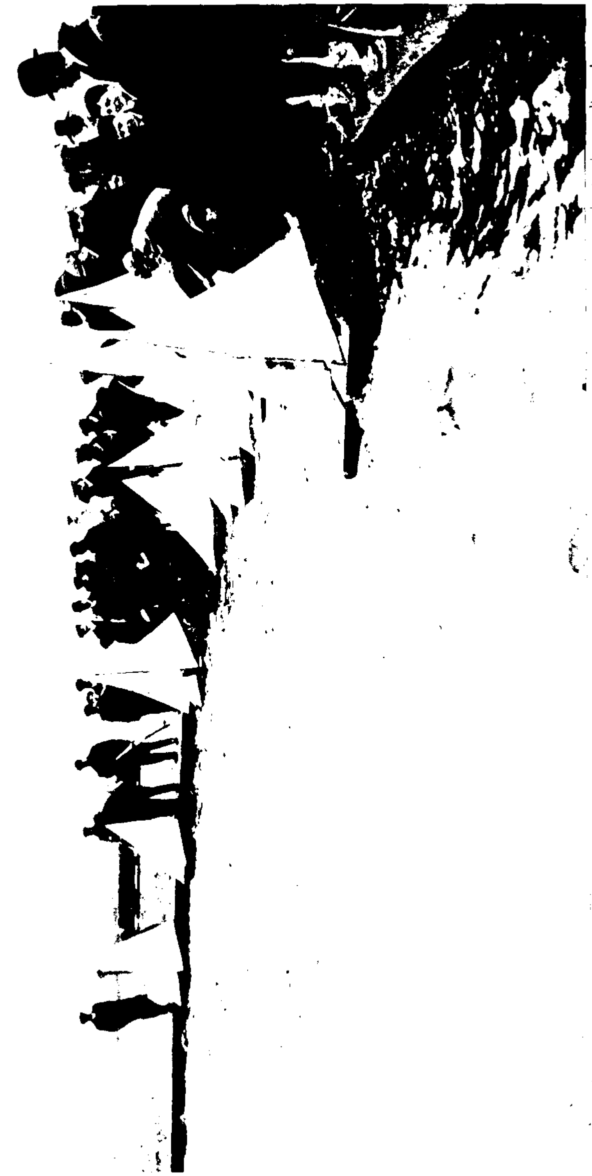
We will suppose, however, that the plank lies nicely upon its framework at the first trial. Now take the plank that is to lie upon the other side of the centre-line and see if, when its tongue is inserted into the groove of the plank first fitted, it also will lie properly. If it does so, give the tongue a thin 'lick' of red or white lead paint before inserting it permanently, and nail it lightly to the floors as before. The nails are to be driven in from the outside, and as a guide for those and others it is well to draw a line across every plank, as fitted, over the centre of each floor. The points of importance in using the bradawl and driving the nails are to see that they go perpendicularly through the middle of each floor, and to avoid splitting the wood. The latter point will become more urgent when the tapering ends of the two outside planks are to be fastened. For the present these planks are untapered. Take one of them, and having tried it, as you tried the planks now in place, fit it and fix it as before. It will of course project beyond the side planks, but it is best to defer the sawing off of this projection until all the bottom planks have been nailed and rooved. When the fourth and last plank has been fitted, two more nails must be put into each plank at each floor, 1½ in. from the edges of the plank. All the nails may now be rooved or clouted. In the former case a special tool, called a rooving or roving iron, will be required. This has a hole drilled in one end and a flat surface at the other. The roove is placed over the nail, and driven home with the hollow end of the iron. The point of the nail is cut off and an assistant holds the flat end of another rooving iron, or the head of a hammer, firmly against the head of the nail while the rooved end is riveted down.

Now saw off the superfluous portions of the bottom planks, where they project beyond the sides and go over the edges, with a rasp and some sand-paper. Saw off also the ends of the planks to the angle of the sloping ends. These ends can now be planked. The work is similar to that already done, but simpler because the surface is flat. The ends must be fastened to the solid end-piece, each with two brass screws, and two nails will probably be as many as can safely be used to fasten the tapering planks to the floor timbers. The fastenings completed, the edges of these may be

sawn away and smoothed. The structure of the punt is now nearly complete. All that remains is to make it water-tight, and to put in a locker-lid and any other fittings for which the owner has a fancy, and to paint.

Caulking is the operation of closing up seams with oakum saturated or 'paid' with pitch. To practise it we shall want three or four pounds of pitch, a pot in which to melt it, some tallow to soften it, a quantity of oakum, a small box or saucer full of cotton waste soaked in oil, and a caulking-iron and a mallet. The caulking-iron is a blunt broad chisel of soft iron, and the mallet is similar to a carpenter's mallet, except that the handle is thinned away under the head so as to make it springy. Put a little tallow in the pot with the pitch and melt it slowly, stirring the tallow well in. Remember that pitch and tallow are inflammable substances, and do not carry out your melting operations amid a heap of shavings and saw-dust. When the pitch is thoroughly melted and mixed, take out a drop on the end of a stick and dip it into cold water. The consistency of the cooled drop will show whether the proportions of pitch and tallow are correct. The drop should be neither brittle nor sticky; it should be elastic but not soft, and if at the first attempt this happy mean is not attained, pitch or tallow must be added to the pot, to harden or soften the mixture as may be necessary.

The most important of the seams to be caulked are those between the side and bottom planking. The pitch being melted, twist some oakum into a loose thread of sufficient thickness to fill the seam, and dip it in the pitch. When it is well covered, gather it up on the end of the caulking-iron and drive it into the crevice with sharp but not heavy blows of the mallet. One of the chief difficulties of the operation to the learner is that the oakum is apt to stick more tightly to the chisel than to the seam. This difficulty is overcome by frequently dipping the chisel in the box of oiled waste. The amateur will find it of great assistance to watch a practical boat-builder at work, and note how he handles his oakum and tools. Some judgment is required in picking up enough oakum to fill the seam completely. If this is not done at the first attempt, a second string of pitched oakum must be put in, care being taken not to drive it so heavily as to crack the pitch already inserted. When the bottom seams have been caulked, the builder should turn his attention to the seams between the end and the bottom planks, and the joints between the floors and frames and planks, and any other crevices in which water can enter or lie, remembering that the object is not only to make sides and bottom water-tight, but also to protect the wood from rotting. In some of the crevices inside the punt it may be found more convenient to insert dry oakum and pour in a thin streak of pitch from a small ladle; in others it will be sufficient to paint the pitch on thinly with a stiff brush. When it has hardened, all superfluous pitch must be trimmed off with a carpenter's chisel frequently



MODEL YACHT RACING AT WANSTEAD FLATS

oiled. A coat of white paint should now be given in the inside of the punt and locker, and when this is dry the builder may proceed to put a lid on the locker and any other fittings that he may desire. Short decks fore and aft will add to the strength of the structure, but they are not necessary, and they are in the way when poling. Moreover, the sloping ends if undecked make comfortable lounges for idle passengers. Decks, if fitted, must rest on a stringer at each side, the full length of the deck, and one or two cross-beams supported by short oak knees securely fastened to the side planks. Tongued and grooved $\frac{3}{4}$-in. planks may be used for the decks, which should be neatly covered with canvas and painted.

Punts are sometimes fitted with rowlocks and sometimes with a step for a short mast, but these are superfluities, necessitating the fitting of a thwart which is in the way when poling. The punt is intended for use in shallow water, and the pole in skilful hands is the best instrument of propulsion. If an alternative method is desired the short paddle will be found most efficient; its use requires no rowlocks and no thwart, since the paddler sits on the floor of the punt. The only additions to the punt to be recommended are a half-round $\frac{3}{4}$-in. strip along the upper edge of the side planks, and a similar but wider strip fastened as a rubbing strake round the outside about 3 in. below the edge. The strips should be of oak or ash. They will improve the appearance of the punt, and prevent the sides' from roughing, but they are not necessary. These details having been attended to, all that remains to be done is to give the punt another coat of paint inside and three coats outside. As soon as the paint is dry the vessel is ready for launching.

CHAPTER XI

Model-Boat Building

NOT very many years ago the making and testing of model boats and ships was regarded merely as a pastime for boys. Now it is, in one of its aspects at all events, a serious branch of industrial science. The investigations of Froude and other naval architects of renown have shown that the behaviour of the model in water bears a definite relation to that of the full-sized ship, and to-day no vessel of any importance, whether racing yacht, ocean liner, or war-ship, is laid down until a miniature hull has been cut out to her proposed lines and tested in water. The scientific value of such experiments has been officially recognised in England by the establishment at the National Physical Laboratory at Teddington of the William Froude Tank, in which any one can have a model tested on payment of a small fee. Within a few months of its opening the tank proved its usefulness in a direction probably not contemplated by its designers, for it was visited by the judge, assessors, and counsel engaged in an important collision case, who witnessed a demonstration, with scale models of the vessels concerned, in which the circumstances of the accident were reproduced as closely as possible.

A testing tank like that at Teddington, and like those in the great naval yards, is an expensive structure, costing, with its electrically driven tractors, some thousands of pounds. Interesting, though of course less exact, comparisons of models may be made in a much simpler and smaller tank—even in a wooden trough 10 or 20 ft. long, the tractive force being supplied by weights and pulleys; but few model yachtsmen have at their disposal both the means and the space for the apparatus, and even those who have will prefer to test their vessels under their own sail or steam in lake, river, or pond. Even if the amateur cannot join a model-yacht club and thus compare his skill with that of other designers, he may reap knowledge and entertainment by building, so to speak, against himself, and endeavouring to make each new model faster and more seaworthy than the last.

There are at least half a dozen ways of making a model boat, but in most of them it is desirable, in some it is essential, to begin with a design. The professional maker of model sailing yachts, who is often also a builder of real boats, seldom uses a design. He works by eye alone. You must remember, however, that his eye and his hand are highly skilled, so highly that I have seen him carve a model of a real boat without taking a single measurement, and gouge out the hull until the top-sides were no thicker than cardboard. Also, he makes only three or four

varieties of model, turning these out by the hundred for the toyshops. On the other hand, the man who makes a model for the guidance of the builder of a real yacht or ship works carefully from design, the value of the model in this case resting entirely on its accuracy as an embodiment in miniature of the architect's idea.

Before going further, I should explain that the models I have in mind throughout this chapter are models intended for the water. The amateur model maker, if he lives in or near London, should make a point of visiting the Science Museum at South Kensington, where a big department is devoted to naval models and objects illustrating the design, construction, and methods of propulsion of ships. Here he will find a large number of models of war-ships, ocean liners, and other vessels, perfect to the minutest detail, and admirable as illustrative exhibits, but designed and constructed for that purpose only, and as ill adapted for the ponds of Hampstead or Kensington Gardens as a pair of dancing shoes for a country lane. They are capable of suggesting to the intelligent amateur many useful wrinkles as to detail and design, but on the latter subject the half-models of famous clippers which hang upon the walls of the museum will afford more valuable information, and these should be closely studied and compared.

The design of a model yacht is drawn out in exactly the same way as that of a real vessel, the only difference being that the model-yacht designer is able to draw his paper plans to the full size of his work. He will want a drawing-board, paper, pins, and pencil, a T-square, one or two set-squares, a rule marked in inches and twelfths of an inch, some French curves and one or two splines. The last-mentioned tools are thin strips of pliant wood for drawing long curves. They are readily bent to any desired curve, and are held in place by weights or pins on either side while it is being drawn with the pencil. They are necessary for drawing the half-breadth and body plans to be described later. The French curves will be handier for the curve of the forefoot, counter, and rudder. The size of drawing-board, paper, and T-square will, of course, be ruled by the length of the proposed vessel. The model-yacht clubs favour two length-classes, of 24 and 30 in. respectively. A cheap drawing-board 28 in. by 19 in. may be bought for 3s. 3d. The next size, 31 in. by 23 in., costs only ninepence more. A pearwood T-square, 30 in. long, costs 1s. 2d.; if of mahogany it will cost more than twice as much. Pearwood set-squares are threepence or fourpence each; they should have two angles of 45 degrees, and their sides should be 6 in. long. French curves are about the same price as set-squares. Splines or ships' curves in pearwood cost about 5s. 6d. for set of nine, but the model yachtsman needs only two or three, of lengths ranging from 6 in. to 32 in. There is a handy curve called Brooks's patent, which is held in place by the fingers, but its greatest length is limited, I believe,

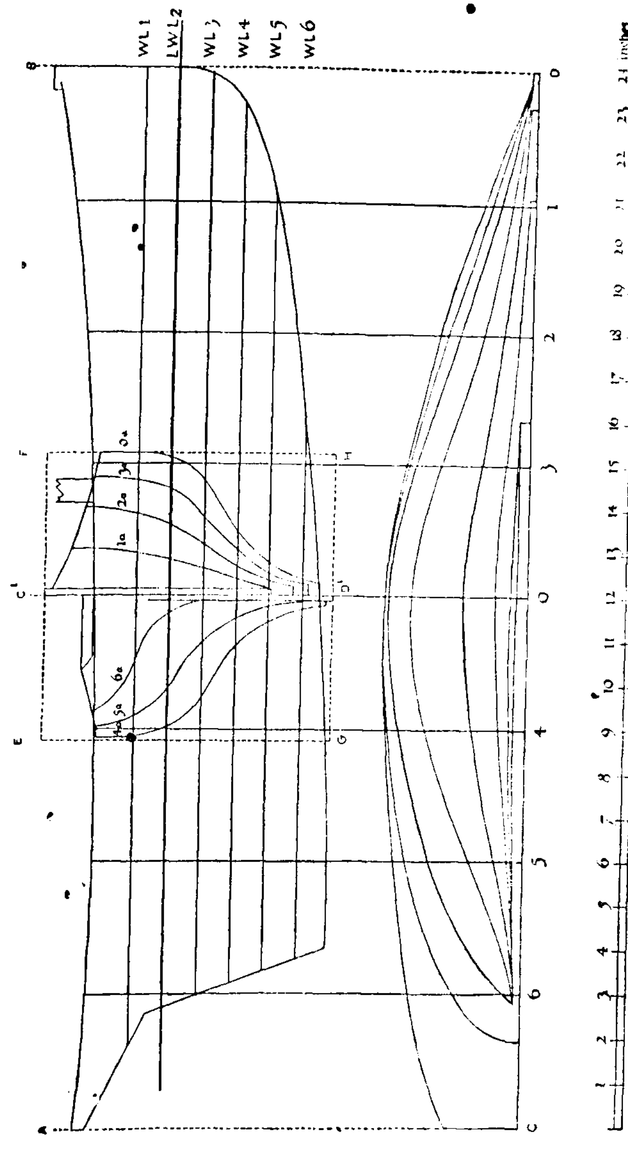


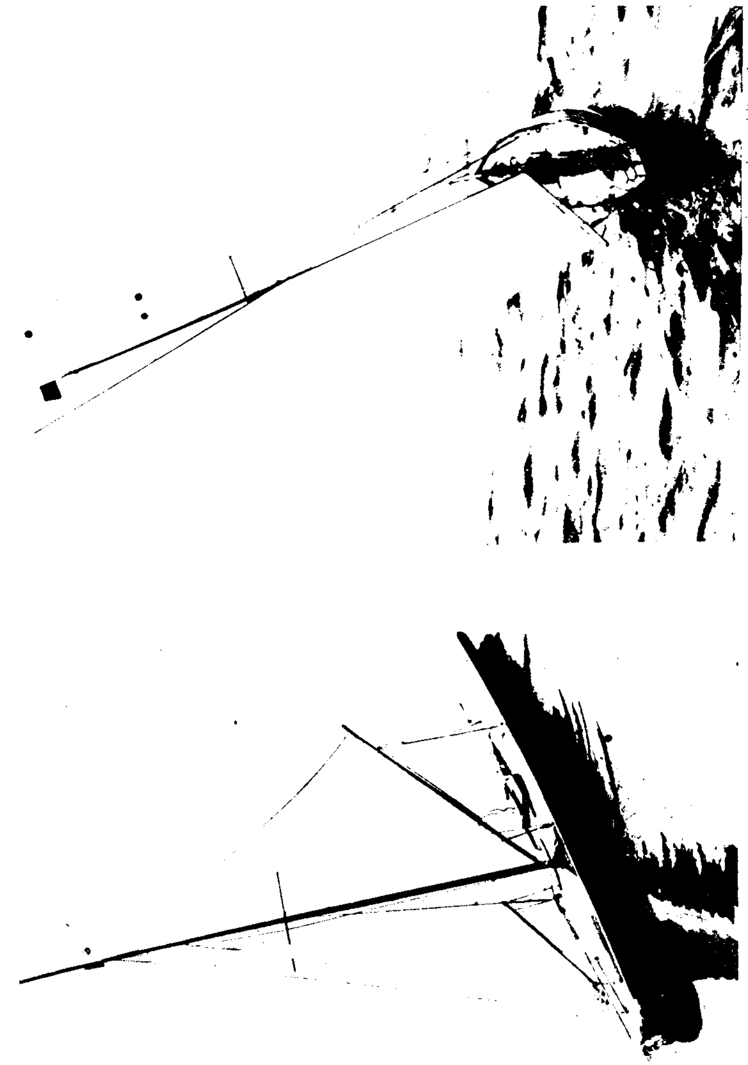
Fig. 51.—Design for a Model Yacht.

to 18 in., and this is obviously not enough for the water-lines of a 24-in. model. Drawing-paper is expensive in large sizes and unnecessary for our purpose. White or coloured wrapping paper is quite good enough. Even brown paper may be used, but it should be rather thin, as it is sometimes convenient to trace or paste the design upon the block from which the model is to be carved.

We will suppose that the model is to be 24 in. long, over all, and of cutter rig. The amateur architect must not expect to produce a successful design 'out of his own head' until he has mastered the principles upon which the form of a vessel is based. To begin with he must be content to copy the design given on page 269, or to adapt to his purpose one of the designs of real yachts which are published from time to time in the yachting papers. It will be seen that the design consists of three parts, known respectively as sheer plan, half-breadth plan, and body plan. The sheer plan is traversed by a number of horizontal lines which are represented in the half-breadth plan by longitudinal curves showing the horizontal outlines of the vessel at their respective levels. Both sheer plan and half-breadth plan are cross-sectioned by lines which again are translated in the body plan into the upward and downward curves on the outside of the boat at the respective sections. To copy the design, take your T-square and rule the line L.W.L. (load-water-line) across the paper, seven or eight inches from its upper edge. Then draw the

parallel line CD about ten inches below L.W.L., and at 14 or 15 in. from the left-hand edge of the paper draw the perpendicular O, which marks the midship section, or section of greatest beam. Measure along the L.W.L., from the point of its intersection by the line O, the distances to the stem of the boat on the one hand, and on the other to a perpendicular dropped from A, the extremity of the counter. These measurements and all subsequent measurements must of course be converted to the scale of your full-sized drawing. Having converted them and transferred them to your paper, draw through the point thus marked the perpendicular AC and BD.

The sheer plan and half-breadth plan of your vessel will be within the parallelogram ACDB. For economy of space I have drawn within it the body plan also, but for reasons which will presently appear it must be placed elsewhere in the working drawing. Its proper place is alongside the sheer plan so that the same water-lines serve for both. Set off on the L.W.L. the greatest beam of the boat, and mark above and below it the extreme height of the stem and depth of the keel. The points thus obtained will give you the angles of the rectangular frame EFGH which is to contain the body plan. Bisect this figure with the perpendicular C′D′, which is the centre-line of the vessel as shown at CD on the half-breadth plan. Now put in the sheer and body plans the water-lines 1, 2, 3, 4, and 5, and in the sheer and half-breadth plans the sectional lines 1, 2, 3, 4, 5, and 6. Measurements on these lines will enable you to draw in the sheer plan, or longitudinal outline, of the boat. Show the width or 'siding' of the stem on the half-breadth plan and half its thickness; rule off half its thickness also on the left-hand side of the central line of the body plan, carrying it down to the level of the end of the first sectional line of the sheer plan. On the other side of the central line you must show half the thickness of the stern post. Now put in the outermost or deck curve on the half-breadth plan. Having marked off carefully the points at which it intersects the vertical lines, adjust your spline so that it touches all these points and rule in the curve. This done, draw the deck line in the body plan. Your T-square ranged successively with the tops of the perpendiculars on the sheer plan will enable you to line upon the body plan the height of the deck at each of these points, the horizontal distance of each point from the central line C′D′ being measured from the line CD to the deck curve on the half-breadth plan. Now draw in the water-line curves on the half-breadth plan and then the curves on the body plan, taking the measurements for the latter from your own curves on the half-breadth plan. All the curves must be perfectly 'fair,' that is to say, they must run smoothly and gracefully. If you find that the spline will not embrace every point you have marked for any particular curve, you must slightly shift one or more of the points until it will do so, but in that case



MODEL YACHTS AFLOAT

A strange craft that skims along the water you must shift to the same extent the corresponding points upon the half-breadth plan and redraw the curve which passes through them. In enlarging a plan from a small drawing there is often a little difficulty in 'fairing' the curves, but it is easily overcome with patience and care. It will be noticed, of course, that the left half of the body plan shows the curves forward of the midship section and *vice versa.* The midship section, however, should be drawn on both sides if the boat is to be cut out of a solid block.

Cutting out from the solid block, though perhaps not the easiest, is the simplest and most straightforward method of model-boat building. Wood for the purpose, ready planed and 'trued,' can be obtained from the model shops and from most of the large stores, and the amateur will save himself a great deal of planing and squaring if he buys it prepared and of the exact size required. Pine and white fir are the most suitable kinds of wood. The dimensions required are, for length, the extreme length of the vessel; for breadth, the extreme beam; for depth—in the case of the design before us—the distance from the top of the stem to the lowest W.L. It will be seen from the body plan that the portion of the boat below the last W.L. is nearly all keel. It will be convenient to cut this out separately and to use it as a mould for a lead casting.

Having obtained a piece of wood planed to the required size and squared with perfect accuracy, mark the L.W.L. round its sides and its after end. This line, of course, will be the same height from the bottom edges of the block as the L.W.L. in the sheer plan is from the lowest water-line. On the upper, or deck, surface of the block draw a central line—the CD of the half-breadth plan—and carry this right round the block. On either side of this line draw lines marking (1) on the under-surface the greatest width of the curve of the lowest water-line, or—what is the same thing—the width of the midship section of the body plan on that line; and (2) at the forward end the

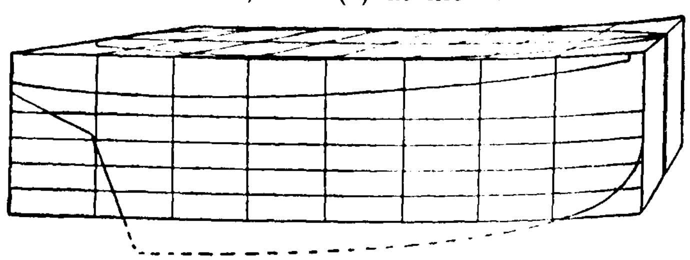


FIG. 52.—Block marked out for Carving.

width of the stem. On the after end draw a line marking the depth of the taffrail. Now lay your sheer and half-breadth plans upon another sheet of paper and cut out their outlines in duplicate. Draw on the duplicate sheer plan, but on the opposite side, the water-lines and perpendiculars of the original, and number them in the same way. The two sheer plans are then to be stuck to the sides of the block, their load-water-lines coinciding with the line on the wood, stem level with stem, and taffrail with taffrail. The two half-breadth plans must be stuck upon the upper surface of the block, on either side of the

central line. A spirit gum or thin varnish is the best adhesive to use, as water causes the paper to swell and is apt to create difficulty in fitting. If no spirit adhesive is available, starch jelly is perhaps the best substitute, or the paper may be attached with drawing-pins.

Now take a marking bradawl, or, if you do not possess this tool, an ordinary bradawl and a piece of chalk, and mark on the awl the horizontal distance from the line EG to the curve 1^a at the deck-line, as shown by the body plan, and make a hole to that depth on each side of the block, at the point marked by the intersection of the perpendicular line 1 with the deck-line on the sheer plan. Then mark the awl to the distance from EG to 1^a along W.L. 1, and make a hole in the block at the intersection of the same perpendicular with the first W.L. Deal in the same way with every intersection of every curve, being careful to keep the awl square with the sides. The result will be a series of perforations on each side of the block, showing by their depth the contour of the wood to be cut away. A glance at the upper surface of the block will show you that the chiselling may be lightened by first sawing off the superfluous wedges on either side of bow and stern. Having taken off these, turn the block on its side and saw off to the line of the counter and sternpost. You may saw off also a small piece under the forefoot. These cuts will remove the pencilled lines marking the breadth of the sternpost and forefoot, which must be redrawn upon the new surfaces. On the under-side of the block, where two parallel lines mark the extreme breadth of the sections on the lowest water-line, draw the curve of that water-line as shown by the half-breadth plan. The block is now ready for the chisel and gouge. Fix it, bottom upwards, in the bench-screw and chip away the wood to within the sixteenth of an inch of the bottoms of the holes made by the bradawl. Work from amidships towards either end, keeping the body plan before you as a guide to the flow of the curves. On the lower water-lines you will be able to take off some big chips with the aid of the mallet, but most of the driving must be done with the hands alone, one hand thrusting and the other pressing and guiding the tool. Be careful to leave a trace of every bradawl mark.

Finally, go over the surface with a rasp, and with sand-paper of increasing degrees of fineness, until you have removed the traces of the bradawl and made both sides of the boat perfectly smooth and symmetrical. If you wish to be very faithful to the design you must cut out of cardboard or veneer a mould of each of the curves shown in the body plan, and use the moulds as gauges for the accuracy of your carving. When you are satisfied with your work on bottom and sides, you may turn your attention to the deck-line. Most, if not all, of this line, as shown by the sheer plan, will have been obliterated by your chisel and rasp. Strike it in again on both sides, and make a number of transverse cuts nearly down to it from the top-side of the block. The pieces between the saw-cuts

can be chipped out with the chisel and the deck smoothed down.

Proceed to hollow out the model. But first run a line round the deck, about $\frac{1}{4}$ in. from the edge, to mark the thickness of the rail or bulwark. Then, with bits of suitable sizes, bore three or four holes in the deck surface to facilitate gouging. The size and depth of these holes will vary according to their position, which should first be marked upon all three plans in order to make sure that they will not approach within $\frac{3}{8}$ or $\frac{1}{4}$ of an inch of the sides or bottom of the model. The wood between the holes must be cut out with gouges of convenient sizes. The work will be best performed with the model held between the knees, and here, again, the hand and arm are safer than the mallet as the driving force. Be careful to make the hollow as symmetrical as possible, so that the model will float upon an even keel. Some provision must be made for supporting the deck. Most models made for sailing, rather than for sale, have flush decks. If you prefer a sunk deck, you must either leave a ledge $\frac{1}{4}$ in. wide and about $\frac{1}{4}$ in. below the deck curve, or you must pin round the inside of the boat a thin spline or batten to serve as a stringer. In the case of a flush deck, two slots or recesses must be cut out of the inside edge of the deck-line, on each side of the boat, to the depth of half its thickness, to take the ends of two deck beams. These beams will be of wood $\frac{1}{4}$ in. by $\frac{1}{4}$ in., and cut a little longer than the horizontal distance between the opposite recesses, so that when their ends are fitted into the recesses the beams are slightly arched. The beams should be about 3½ in. on either side of the midship section, and must be secured in the recesses with marine glue. When they are in place, give the boat a coat of white paint inside and out.

The deck must be cut out of very thin wood; that used for picture-backing is suitable if free from knots and cracks. Sand-paper one side until it is quite smooth. Take a sheet of paper rather longer and wider than your model, and adapting it to the curves of deck-line and supporting beams, run your finger round it so as to take an impression of the outer edge of the boat. Cut out the paper to this outline and use it as a pattern for cutting out the deck. With a very fine bradawl bore holes about an inch apart round the edge of the deck, and having smeared the edge of boat with some rather moist putty, fasten down the deck with fine brass pins. The superfluous putty may then be wiped off and the edges of the deck trimmed with a chisel. A hole is then bored for the mast, and another hole, ¼ in. deep, exactly below the first, is cut in the bottom of the boat for the mast heel.

The mould for the lead keel may be made of fine sand or, better still, of plaster of paris. In the latter case, smear the pattern with oil and lay it upside down upon a sheet of oiled glass. Make a card-board frame, about three times the height of the

MODEL YACHT MAKING

Photos, Ancell, Sandown, I.W.

Nine stages in the transformation of the block to the finished model

Hollowing out

pattern, to surround the glass closely, and then pour in the plaster mixed with water to the consistency of cream. When it has set you can remove the pattern, and when the plaster is quite dry it is smeared with oil and melted lead poured in. The keel should be fastened on to the model with thin brass screws, which, if desired, may be placed in the mould before casting. Having screwed the keel in place, and made a hole through the counter and deck for the rudder-post, it only remains to paint the hull and varnish the deck.

If it is desired to imitate the planking of a real deck, the lines should be drawn with a hard pencil before varnishing. The hull may be painted black all over, or the top-sides black and the bottom red or bronze, in imitation of anti-fouling composition or copper. The black generally used by model-makers is made by dissolving 1 part of shellac in 10 parts of naphtha and stirring in lampblack to the desired consistency. A simpler method is to black-lead the hull and coat it with copal varnish. If the bottom is to be coloured differently from the top-sides the dividing-line between the colours should follow the L.W.L., and must be drawn with a thin spline or batten bent along the side of the boat. A very narrow gold riband is sometimes painted round the boat just below the deck-line, but a neater effect is produced by a riband or rubbing strake of varnished wood, about $\frac{1}{8}$ in. wide and $\frac{1}{8}$ in. deep, nailed neatly round the sides and across the transom. I should add that the photographs illustrating the block method were taken at the factory of Mr. Boyce, of Sandown, Isle of Wight, where some thousands of model boats are turned out every year.

A method of building preferred by some amateurs is that of cutting out a number of horizontal sections or planes, which are afterwards screwed together. This method involves more trouble in preparing the design, but demands rather less skill in the moulding and hollowing stages. It throws less work upon the

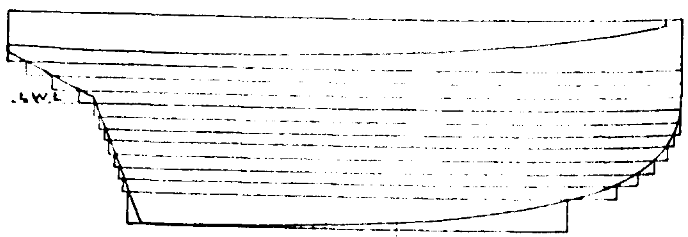


FIG. 53.—Sheer Plan for Building in Layers.

chisel and gouge and more upon the saw. In building by this method from an ordinary design, the plans are drawn out as already described, but all the water-lines, except the load-water-line, are then removed from the sheer and body plans, and all the curves, except the deck and load-water-line curves, from the half-breadth plan. The vertical lines on sheer and half-breadth plans and the curves on the body plan must remain. Now rule in on sheer and body plans new horizontal lines, half an inch above and half an inch below the L.W.L., and other lines parallel with them, and half an inch apart down to or

below the heel and up to or above the highest part of the deck-lines. The lines mark the sections in which the boat is to be built. If the deck has much sheer it will probably be necessary to make the uppermost section three or four times as thick as the others, in order to get the curve into it, and it may be convenient also to make the lowest or keel section thicker than $\frac{1}{2}$ in.

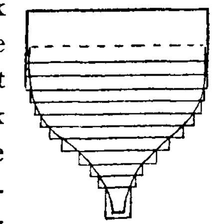


FIG. 54.—Midship Section of Body Plan.

Measure the offsets of the body-plan curves along the new lines and, transferring the offsets to the half-breadth plan, rule in the new water-line curves. These will give you the outline of the edges of each of the sections.

Now get some sound plank, planed to the thickness of the sections. Cut out in paper a full-breadth pattern of each curve in the half-breadth plan and trace it on the plank. The plank is then to be carefully sawn round the outline, but not so closely as to remove it. A centre-line and the line of the midship section are to be pencilled on the sides and edges of each piece.

Putting the keel-piece aside for the present, range the next two or three lowest pieces together, centre line to centre line and midship line to midship line, and join them with two fine screws inserted on the centre-line, and as near the ends as is possible without splitting the wood. Then impose and join on to these in the same way one, two, or three more sections.

The number of sections which can be added at a time will depend upon the length of the screws which can be most advantageously used, and this again will be regulated by the profile of the model. In a 2-ft. model with a fairly straight stem, four screws, ranging from 3 to $1\frac{1}{2}$ in., will probably suffice to hold all the sections together at the bow end. Shorter screws, and consequently more of them, will be required at the stern, especially if there is a large counter.

The sections having been joined up, cut out the keel-piece and fasten it in place with screws from the outside. Strike the deck-line on the sides of the uppermost section, and mark the transom and the breadth of sternpost and stem on the ends of the block. Mark on the sides, also, the profile of stem and stern. Now take the block, keel uppermost, between your knees, and with chisel and gouge work off the corners of the sections, keeping the body plan before you and rendering its curves as gracefully and symmetrically as you can. This done, unscrew the sections and mark a line round the under-side of each, $\frac{1}{4}$ in. from the edge, to show the thickness to be left after the interior has been hollowed out. The section to which the keel is attached will be best left solid. The parts through which the screw-holes pass, at the ends of the sections, must not, of course, be cut away. Cut out the inside of each section with a fret saw or keyhole saw, and cut the uppermost section down to the deck-line marked on its sides. Then screw the parts

MODEL YACHT MAKING: SHAPING THE HULL.

together again and smooth out the inside with a gouge, taking care to avoid the screws. Again unscrew the sections. Place them in order before the fire to warm, laying the screws and screw-driver at hand. Prepare some marine glue, and when it is ready smear it with a piece of stick or a knife upon the upper side of the lowest section; put the next section on top of it and quickly and firmly screw it down. Put on section after section in the same way until the model is complete, and lay it aside for some hours until

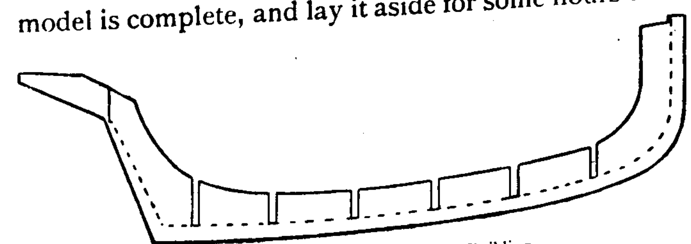


FIG. 55.—Backbone cut out for Carvel Building.

the glue has hardened. The superfluous glue may then be cleaned off with an oiled chisel and the hull rubbed down with sand-paper until it is perfectly smooth.

The last method of boat-building which I propose to describe is the most difficult of all, but it produces the lightest model. It is, in fact, an adaptation of the methods of the builder of full-sized yachts and ships to the small dimensions and light scantlings of the model. A frame or skeleton of the boat is constructed and the sides are planked up in the same way as those of a carvel-built vessel.

The backbone of the skeleton is a piece of plank, preferably yellow pine, planed to the thickness of the greatest breadth of the keel. Cut out on this the profile of the sheer plan and transfer to it the vertical lines marking the sections of the body plan. These lines must be ruled on both sides of the wood. Draw in, also on both sides, the rabbet line, that is, the line on which the curves of the half-breadth plan merge into stem and sternpost, and on which the curves of the body plan merge into the keel. Draw another line, parallel to the rabbet, and an inch inside it, and cut away the wood to this line. What remains is the sheerboard or backbone of the mould to be built upon. Mark upon its outer edge the shape of stem, keel, and sternpost, and with a sharp knife or chisel shape these properly from the rabbet line outwards. Each section of the body plan, as far as the rabbet line, must now be transferred, full breadth, to a $\frac{1}{4}$-in. plank, sawn out, and the edges sand-papered down smoothly and accurately. On the fore and aft sides of each section draw vertical centre lines and parallel lines marking the breadth of the upper edge of the sheer frame. In this frame a slot must be cut down to the rabbet line at each of the vertical lines marked upon it. The slots must be cut exactly at right angles to the frame, and they should be a shade less than $\frac{1}{4}$ in. wide in order that the sections may fit into them tightly. Having ascertained that they will all fit down to the rabbet line, fix them accurately in place with marine glue, and when the glue is dry, temporarily fasten, with nails or screws, two or three thin longitudinal battens to the upper edges of the sections

and the stem and stern of the frame in order to keep all rigid during the planking operations.

The next proceeding is to cut out the rabbet. This is an L-shaped recess running down stem and sternpost and along the keel to receive at the ends of the boat the ends of the planks, and at the keel the lower edge of the garboard or lowest strake. The planks will be $\frac{1}{8}$ in. thick, so the lower arm of the L will be that thickness throughout; but its angle with the keel will vary. It will always be at a right angle with the plank, the slope of which along the keel follows the lines of the boat. The slope of the garboard strake at each body mould will, of course, be that at which the mould strikes the rabbet line, and as a guide for the chisel it is well to tack a thin batten along the moulds, about half the chisel's breadth above the rabbet line. A small and very sharp chisel will be found the handiest for the work. The rabbet in stem and sternpost had best be worked as each plank is fitted, the planks themselves being the best guide to its angles.

The planks will be $\frac{1}{8}$ in. thick and $\frac{1}{2}$ in. wide. Having rabbeted the keel on each side, take a piece of cardboard as long as the rabbet and $\frac{1}{2}$ in. wide and 'try' it round the moulds with one edge in the rabbet. The real boat-builder, who uses a piece of thin plank for this purpose, calls it a 'spiling' batten, and an ingenious friend of mine concluded in haste that the name was connected with the fact that the batten was 'spoiled' in the process. Truly a shocking example of the pitfalls of nautical etymology! A 'spile' is a short spike or pin, and a 'spiling batten' is one that is lightly pinned in place for trial. That it is spoilt for any other purpose is, however, true enough, as you will find when you have cut your cardboard to fit into the rabbet. You will probably be surprised at its shape, and later on the shape of some of the planks above it will surprise you still more. When you have the pattern perfect lay it on a piece of wood ⅛ in. thick and cut out two planks, one for each side of the boat. Smear some putty on the lower edge of the plank, place it in position, and nail it to the rabbet and the frames with the small black pins used by upholsterers for putting fringes on furniture. Holes for the nails must be bored with the finest of bradawls. They should be spaced about half an inch apart along the rabbet, and two nails should be put into each frame.

Having fastened the garboard strakes on both sides of the boat, make a spiling batten for the next plank and proceed as before, smearing the lower edge of the plank with putty before fastening it above the garboard. The upper strakes will be fastened only to the frames and to the rabbet at the ends. If any of them prove intractable to the curves of the boat, they may be reduced to docility by holding them for a few minutes in the steam of a kettle. The top strake should be thicker than the rest, as it will have to hold the deck-fastenings. When the planking is finished and the putty has hardened, the outside is smoothed

down with sand-paper and the boat painted inside and outside. The inside should have two coats of white lead paint, or, better still, a coat of tar, well brushed into every crevice.

The rigging and deck-fittings of a model boat, being mainly cotton and wire, scarcely come within the scope of a book on wood-working. I may say, however, that the guiding principle in these matters should be the adaptation of every part to its immediate purpose. Do not hamper your boat with a top-mast and cross-trees, if a pole-mast will better carry all the sail she wants, nor cumber your deck with sham skylights and windlasses. The aim of every intelligent shipmaster is simplicity of working, and this should be the aim, too, of the model yachtsman.