EXERCISES IN WOOD-WORKING

WITH A SHORT TREATISE ON WOOD

IVIN SICKELS, M.S., M.D.

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WRITTEN FOR MANUAL TRAINING CLASSES
IN SCHOOLS AND COLLEGES

BY

IVIN SICKELS, M. S., M. D.

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PREFACE.

THE exercises in wood-working in this book were prepared by me during the summer of 188 for the students of the College of the City of New York. Subsequent teaching suggested man changes and additions, until the manuscript was scarcely presentable. This manuscript ha been copied for other schools ; and now, in order that those who have recently asked for may receive it in better shape, this little volume is printed.

I am indebted to Mr. Bashford Dean for the part relating to injurious insects, which was writte expressly for this book.

I. S.

NEW YORK, *September, 1889.*

CONTENTS

INTRODUCTION.

THE tendency of modern systems of education is toward a proper distribution of practical wi theoretical training. The mind is to be aided in its development by the action of the eye ar hand ; and, in fact, all the special senses are employed in objective teaching and manu exercises. In school, the eye does more than interpret the printed page: it recognizes the for and color of objects, it must calculate their size, proportion, and distance, by observing ar comparing them ; the hand is required to do more than writing: it is taught to appreciate th weight, hardness, and other properties of objects, by actual contact with them. At first th introduction of drawing, modeling, and the use of tools, into the courses of study wa experimental ; but, having passed beyond that stage, these exercises are now known to b efficient aids to a more natural and rapid as well as stronger mental development.

There are some who, after being educated in the abstract way, can apply their trainir successfully to practical pursuits, who see no necessity for manual or industrial training in th schools, and who claim that superior and sufficient development may be obtained by th study of mercantile methods and the classics. These, however, form a very small percentag of the people, and systems of education must be arranged to stimulate all intellects, and n measured by the accomplishments of a few. Our best educators recognize this fact, and ar modifying old systems by the greater introduction of manual elements. No one doubts th value of practical qualities, not only in ordinary people, but also in prominent leaders, wh must be thoroughly practical — a fact so aptly illustrated by prosperous manufacturers ar merchants, successful engineers, great generals, and eminent statesmen.

Manual training for the early cultivation of these practical qualities in students takes a place the regular courses of study: by means of it the reasoning power is more easily awakened knowledge of objects and the facts connected with them are more readily understood ar remembered ; and, above all, the accuracy and precision demanded by the practical studie lead to closer observation and exactness in others. This training begins in the lowest grade and continues in its various applications through all the classes, until in the higher grades w find sufficient physical strength to handle the ordinary wood-working tools.

The prime object of all manual training, especially in this country, is to aid ment development, and while this fact must not be lost sight of, the training should be in som useful art, or in some exercises which are introductory to the useful arts.

Perhaps the most valuable of these studies is industrial drawing, which is in itself a sort universal language, a medium between thought and execution. Its study cultivates precisio and is well calculated to develop sound and accurate ideas. Drawing naturally precede construction, it prepares the way for the work of the engineer, manufacturer, or builder. Eve the ideas of the inventor are jotted down in a chance sketch, which is added to and modifie at leisure, leading to the finished sketch, from which the skilled draughtsman produces th designs for the execution of the work.

The studies of drawing and wood-working are closely connected, and may be taught togeth with great advantage to both. A simple object is roughly sketched on paper, its measurement accurately made and marked on the sketch ; from this a drawing is made with instrument either full size or to a scale, which is used in the workshop as a guide to the construction the object. Skill in sketching is a valuable acquirement, and should be taught early in th course of industrial drawing. These sketches should, if possible, be made from real object instead of charts, and should always be accompanied by measurements. In sketching it well, first, to determine the number of diagrams necessary to show the form or structure the object, and allot for each a certain space on the paper ; second, to place each sketch the middle of its space, of which it should occupy about one half, thus leaving a margin f notes, measurements, and small details ; third, to draw the relative proportions of the obje as accurately as possible ; fourth, to mark on the sketch the measurements of each part.

Wood-working from the simple constructions of earliest times has advanced with th necessities and customs of nations, until at present it includes the complicated structures modern requirements. Throughout all wood-working trades we find certain general principle regarding the cutting action of tools on wood, and the joining of different pieces ; and, sinc those principles are more easily taught by carpentry and joinery, these branches have bee generally adopted as educational aids.

The very extensive use of wood for building has given rise in this country to a craft carpenters whose improved tools and methods of work are superior in many respects to thos of European workmen. Based upon these methods, workshop practice in schools and college as applied to wood-work does not stop with carpentry: its design is to prepare the way for th entire field of mechanical arts ; so that carpentry and joinery are followed by turnery, carving and possibly a few lessons in pattern-making. These should be followed by metal-work, suc as forging, chipping, filing, and, finally, with the elements of machine-work. The study mechanics as thus taught in the educational workshop should be applied correctly, b methods which are the actual but intelligent practice of the operating mechanic. As to the tim required, it can not be expected that the three to five hours per week spent in the worksho are going to make mechanics ; far from it: several years of labor and experience a necessary to produce skilled workmen in any of the arts.

This book deals with carpentry and joinery, and is divided into two parts:

The First Part treats of the structure, properties, and kinds of wood ; its manufactures ar economic relations to other substances, parasitic plants and insects ; and means preserving wood.

The Second Part contains the exercises, preceded by a description of tools, and the mann of drawing used to illustrate the exercises.

These exercises are based upon American methods of work and have been taught as follow Each exercise was explained, illustrated by sketches on the blackboard, and then executed b the students. As the exercises advanced, the blackboard sketches were prepared with mor detail, each being shown with its measurements designated. The students copied thes

sketches and noted down such of the verbal directions as they could. With the high
exercises it was found necessary to issue duplicate copies, describing and illustrating eac
step in construction, and also to exemplify by models made by the instructor.

Exercises 1 to 8 introduce the chief wood-working tools and methods of marking. Thes
exercises should be executed with much care and patience, and if necessary repeated,
insure better results in subsequent work.

Following exercise 8 are directions for sharpening tools. But students should not attempt
sharpen tools until they have had considerable practice in the use of them ; especially sav
filing, which requires remarkably good judgment, keen eye-sight, and a steady hand.

Exercises 9 to 20 give instructions for marking out and shaping simple joints.

Exercises 21 to 27 instruct in the methods employed in uniting several pieces to make
complete structure.

Exercises 28 to 35 give the details of ordinary house-carpentry, from which the student ma
obtain particulars for the construction of models, and the apprentice the actual building of th
various parts making up a wooden dwelling.

Exercise 36 shows the use of the frame-saw, and methods of bending wood.

Exercise 37 gives an example of pattern-work, and illustrates the manner of uniting pieces f
economy of labor.

Exercise 38 instructs in shaping by the use of templets.

Exercise 39 treats of veneering, followed by directions for painting and polishing.

PART FIRST.

STRUCTURE OF WOOD.

IF we examine the stem of a young plant, we find three distinct tissues composing it: On th outside is the bark or protecting tissue (*a*, Fig. 3); inside there is a soft material, made up many-sided, thin-walled cells, which constitute the living portion (*b*, Fig. 3); and arranged in circle in this soft tissue are several fibrous bundles (*c*, Fig. 3), giving to the stem its streng to support the branches and leaves. Because of differences in the character of these bundle we separate stems into three classes; and the pine, palm, and oak may be taken as types each.

In the pine and oak the bundles are similarly arranged, and consist of an outer portion calle **bast** (*d*, Fig. 3), and an inner portion called **wood** (*e*, Fig. 3); between these is a thin layer active cells, which multiply by division to form the bast and wood ; this layer is calle **cambium** (*f*, Fig. 3), and adds each year to the size of the bundle. In the palm the bundle arise from active cells at the growing point of the stem, and continue down the sten sometimes becoming smaller, but retaining a rounded form.

As the stems grow older and larger, we find, in the pine, that new and branching bundle appear between the first ones, forming, during the season, a circle of bundles, whic constitutes the first **annual ring**. This ring is interrupted by plates of tissue communicatir between the pith, on the inside of the ring, and the soft tissue on the outside. In a cros section of the stem these plates are seen as lines, called **medullary rays**, radiating from th center toward the bark. At the end of the season growth stops, to be resumed again in th spring. The slow and condensed growth of summer, and the rapid, open growth of sprin give rise to a peculiar mark in the bundles which indicates each year's increase, so that b counting these marks or the annual rings we may ascertain the age of a tree.

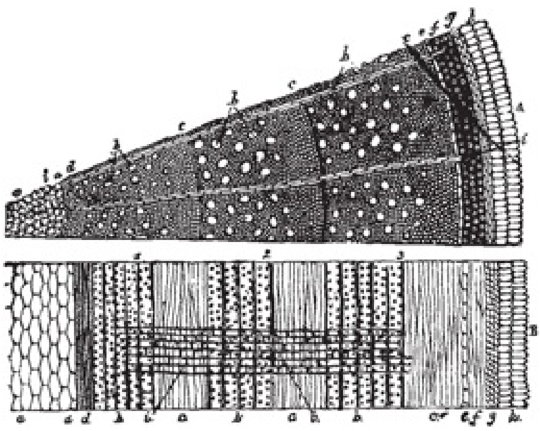

FIG. 1. — Diagram of a stem with a cambium layer. A, section cut across the bundles ; B, section in the direction of the bundles 1, 2, 3, first, second, and third annual rings ; *a, a,* pith ; *b, b,* pitted vessels ; *c, c,* wood-cells ; *d*, spiral vessels, found only in th first annual ring ; *e*, cambium-cells ; *f, g, h,* layers of bark ; *i, i,* medullary ray. (After Carpenter.)

The last few rings formed are engaged in transporting or storing up nourishment, and give ris to what is called the **sap-wood**. The rings inside of the sap-wood serve only for support, ar make up the **heart-wood** of the tree.

In the palm, new bundles arise, placed irregularly in the soft tissue or **pith**, and by tracin these bundles throughout the plant we see that they extend, usually without branching, fro the apex of the leaf to the small ends of the roots, so that for each new leaf there will be the stem new bundles.

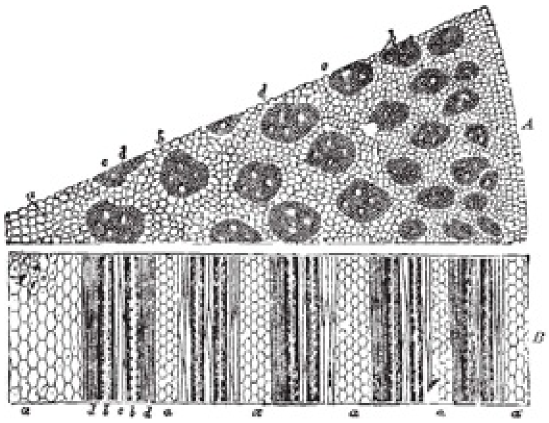

FIG. 2. — Diagram of a palm-stem. *A*, cross-section ; *B*, longitudinal section ; *a, a,* soft tissue ; *b, b,* vessels or tubes with pitte sides: *c, c,* wood-cells or fibers ; *d, d,* vessels with spiral markings. (After Carpenter.)

In the oak we have the same appearance regarding the annual rings and medullary rays as the pine:

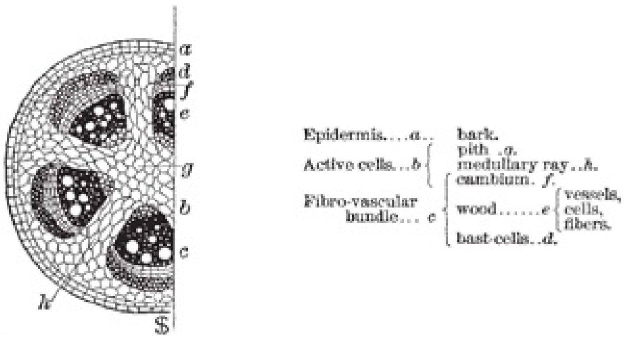

FIG. 3. — Section of stem.

Examining more closely these wood-forming bundles, we find them composed of cells with variety of forms and walls of varying thickness and peculiar markings. In the pine group th cells are long, with pointed ends, and walls marked by characteristic elevations calle **bordered pits** (Fig. 4). These pits arise during the thickening of the cell-wall, which can n take place on the thin circular membranes (Fig. 10, *c*), through which the sap passes, b forms arches with open tops over them, and thus gives the bordered appearance. In th heart-wood these thin membranes have broken down, allowing a free passage of air or wat through the cells. In spaces between the wood-cells there are, in most of the pines, cana containing resin dissolved in turpentine. The thin plates of tissue forming the medullary ray are composed of small cells, with thin walls in the outer annual rings, but in the heart-woo with walls very much thickened.

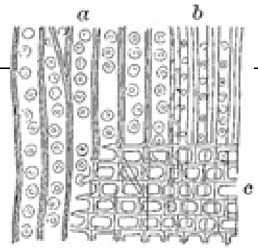

FIG. 4.

FIG. 4. — Section of pine-wood cut parallel with the medullary plates. *a*, spring growth, with large bordered pits ; *b*, summer growth, with smaller bordered pits ; *c*, medullary tissue.

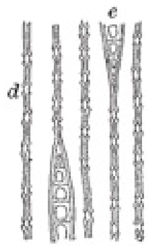

FIG. 5.

FIG. 5. — Section at right angles with the medullary plates. *d*, bordered pits ; *e*, medullary tissue.

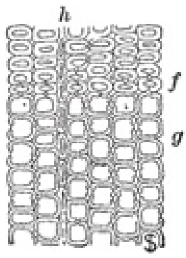

FIG. 6.

FIG. 6. — Cross-section of the same. *f*, summer growth ; *g*, spring growth ; *h*, medullary ray.

The isolated bundles of the palm are composed of various elements, some of which simp support, as the bast and wood fibers ; others support and conduct, as the vessels and woo cells ; these latter convey air, and water charged with mineral matters absorbed by the roots

The bast-fibers are on the outside, surrounding the bundle, and are very long, narrow, man sided cells, with pointed ends, the walls very much thickened and marked with oblique pore The wood-fibers are on the inside of the bundle, similar to the bast-cells in every respec except that they are shorter, and occasionally used for conducting and storing u nourishment. The vessels or tubes are large and few, and present varied markings ; the larg are pitted, the smaller either ringed, spiral, netted, or ladder-form. The wood-cells are lik those of the pine group, but with simple in place of bordered pits. There are present, als sieve-tubes with clusters of small perforations in sides and ends, and a group of long, thi walled cells similar to the cambium-cells of the pine and oak. Frequently in the vicinity of th vessels are found thin-walled cells with blunt ends, separated from the vessels ar surrounding cells by membranous pores ; these cells, which are somewhat similar cambium-cells, serve the purpose of conducting and storing up the organic materials forme in the leaves.

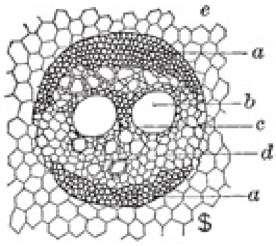

FIG. 7. — Palm-bundle, *a, a,* bast ; *b*, pitted vessel ; *c*, wood-cells ; *d*, smaller vessels ; *e*, soft tissue.

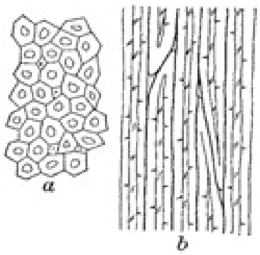

FIG. 8. — Bast-fibers.

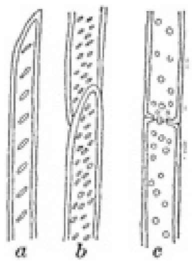

FIG. 9. — Pitted vessels.

In the oak group the wood is composed of compact bundles made up of the same fiber cells, and vessels found in the palm, with the exception of the bast-fibers, which are forme outside of the cambium zone and constitute the inner bark. In the spring growth the vesse are large and numerous; in the autumn they are much smaller, and in some cases may b absent. By this variation in the size and position of the bundles the annual rings becom distinctly marked. The medullary rays in the heart-wood vary in thickness, and in many of th woods the cells composing them become solid.

COMPOSITION OF WOOD.

Newly formed cells have the wall composed of **cellulose**, a substance similar to starch composition. The contents of the cell are made up of a number of substances, the chief which are albuminoids, starchy matters, oils, and water with dissolved sugars, gums, ar acids.

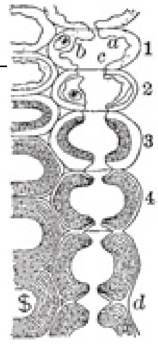

FIG. 10. — Diagram showing growth of the cell-wall.

1. Cambium-cell: *a*, protoplasm or living contents of the cell ; *b*, nucleus in the proto-plasm ; *c*
   thin membrane through which the sap passes. In the heart-wood this membrane has broken down, as at *d*.
2. Protoplasm forming a wall of cellulose.
3. Protoplasm has disappeared. Cellulose changing into lignin.
4. Cell-wall composed of lignin and thin membrane.

In the heart-wood the contents have disappeared, air taking their place, and the cell-wall ha become very much thickened by a deposit within the cellulose of a dense substance calle **lignin**, which gives to wood its elasticity and hardness.

In the living tree, air and water are present in varying quantities, depending on the season ar kind of wood. The amount of water is frequently as much as fifty per cent. During th seasoning of pine, about twenty per cent of water is removed from the wood. This may b called **free water**, because it exists in the plant with all the ordinary properties of water. B there is also in pine-wood about the same amount of water, which is chemically combined wi carbon to form cellulose and lignin. The presence of this **modified water** may b demonstrated by placing the wood in a partially closed iron vessel, and heating it red hot ; th wood is reduced to charcoal, while water is given off, together with a small quantity of gase oils, and other matters.

The elementary composition of wood varies according to the kind, the soluble matters in th soil, and the amount of moisture absorbed by the tree. Generally wood contains larg quantities in proportion of carbon, hydrogen, and oxygen ; less of nitrogen, sulphur, ar potassium ; and small quantities of iron, phosphorus, calcium, sodium, and silicon, with trace of many other elements.

If wood is burned in the open air, the carbon, hydrogen, nitrogen, sulphur, and part of th oxygen are driven off in gaseous form ; the other elements remain, and constitute the **ash**, which the principal ingredient is potassium.

The amount of ash is greater in the palms and least in the pines. The percentage of a few a as follows :

Oregon pine 0.08

Red cedar 0.13

Redwood 0.14

Chestnut 0.18

White pine 0.19

Whitewood 0.23

White oak 0.41

Hickory 0.73

Black walnut 0.79

Palmetto 7.66

Black iron-wood 8.31

Spanish-bayonet 8.94

BRANCHING OF STEMS.

In the middle of a forest, trees grow straight, tall, and slender, as in Fig. 12, because it necessary for them to push up the tops in order that they may receive sufficient sunlight, enable the leaves to digest the plant-food and increase the diameter and height of the ster Lower branches last only a few years, then die, and are broken off (*b*, Fig. 12). On th margins of the forest and in open places, trees send out numerous branches, and stem become large in diameter, but remain short (Fig. 11). The bordering trees, while they serve a a protection from the wind for those inside, furnish knotty and cross-grained lumber ; thos inside produce the straight-grained and valuable wood (Fig. 13). Members of the palm grou rarely have branching stems. In growth, the stems remain long and slender, but frequent larger at the top than at the base.

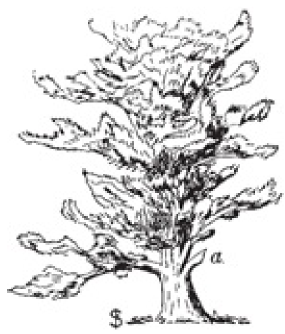

FIG. 11.

FIG. 11. — Shape of a tree on the border of a forest. *a*, broken branch exposing surfaces for boring insects or fungus spores.

FIG. 12.

FIG. 12. — Young forest tree, *b, b,* branches die for want of sunlight.

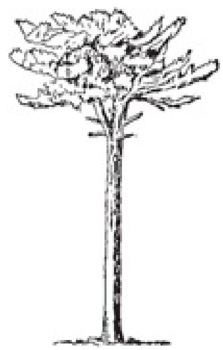

FIG. 13.

FIG. 13. — Shape of forest tree with straight stem and crown of small branches and leaves.

AGE OF TREES.

Like animals, in growth and development plants are subject to influences of climate ar nourishment. In its proper latitude, and with an abundance of water and food in the soil, a tre adds to its annual growth and lives to a great age. But when the soil becomes exhausted the necessary elements, or a more robust species crowds roots and leaves, then a tre begins to show signs of decay. It is difficult to establish rules regarding the proper age fo cutting. For timber, most trees are considered fit at about one hundred years, although oa may furnish excellent timber at two hundred years. The purpose for which the wood is to b cut determines the proper age. Young trees show a closer grain and give a more elastic woo than old ones. Very old trees, although apparently sound, are found to be partially decayed the middle of the trunk, so that the elasticity and hardness of the wood are replaced by characteristic brittleness.

DECAY OF TREES.

As long as a tree is in a healthy condition, its top or crown retains its small branches, b when these refuse to send forth leaves, and break off, it is a sign of decay, and the tre should be cut down and put to some use ; for, if allowed to stand, its decay, aided by parasit insects, will proceed rapidly until there remains nothing but a shell, composed of the growin ~~zone and a few of the last annual rings, and its value for any purpose will become very~~ muc lessened or entirely lost.

Breaking or sawing off a branch and leaving the wound exposed will furnish an opportunity fo fungus spores or boring insects to begin the destruction of the wood.

Cutting down trees on the border of a forest, or clearing a large space within it, is destructiv to the tall trees remaining exposed to the winds and elements. The swaying of the stems in storm causes the tender root-hairs to be broken off, thus preventing absorption of sufficie nourishment by the root, and shortening the life of the tree.

SEASON FOR CUTTING.

The proper time of the year for cutting down trees is an important matter. In the spring an late summer the outer portion of the wood is charged with elements which tend to hasten i decay. In the drier summer months and in winter the growing and conducting cells are les active or altogether dormant, and better wood may be secured if cut during those times of th year. Oak is said to be more durable if cut just after the leaves have fallen.

The trees are cut with axe or saw, and skill is required to fell a tree so that it will come safe to the ground, and not hang suspended to neighboring branches or crush young trees in i fall. An experienced woodman will direct the falling tree exactly where he wishes. He cuts o the side and about at a right angle to the direction in which he wishes the tree to fall ; next h cuts on the opposite side, and, if necessary, a few inches higher.

The tree, after falling, is cleared of its branches and sawed into lengths, according to th future use of the wood.

MILLING.

If near a stream, the logs are rolled or drawn to the water and floated to the mill, where the are examined and grouped according to fitness for special uses. A long immersion of the log in water removes soluble substances in the sapwood, but is said to injure the heart-wood b rendering it less elastic. **Water**, however, is the easiest and cheapest means of transportin logs. In the absence of an available stream, the logs are carried on wagons or sleds to railway or directly to the mill.

The old-time mill, with its single upright saw and ancient water-wheel, is seldom see nowadays ; it has given way to gang and circular saws, and even to giant band-saws, run b turbine or steam. Frequently portable engines and saws are employed on the ground wher the trees are cut, thus saving the transportation of the waste portions of the logs.

Logs are sawed into either **timber**, **planks**, or **boards**, and these constitute **lumber**. Timbe includes all of the largest sizes, such as beams and joists. Planks are wide, of varying length and over one inch in thickness. Boards are one inch or less in thickness, and of varyin

lengths and widths. Lumber may be **resawed** into the many smaller sizes which are to b
found in the seasoning and storing yards.

The rough-sawed lumber may be planed at a mill, and is then called **dressed** lumber, of whic
there is a great variety, adapted to almost every purpose for which wood is used. Dresse
planks and boards when free of all defects are called **clear**, and their regular sizes are $\frac{5}{8}$, $\frac{7}{8}$
1 $\frac{1}{8}$, 1 $\frac{3}{8}$, and 1 $\frac{7}{8}$ inches, which are one eighth of an inch less in thickness than sawe
lumber. One-half-inch dressed is made by resawing one-and-a-quarter-inch lumber.

DRYING OF WOOD.

In the preparation of lumber for use, it is necessary to remove its moisture, after which th
wood is **seasoned**. The planks and boards after sawing are placed in large square piles in th
open air, each layer separated by three or four narrow strips or boards laid in the opposit
direction. By this means a free circulation of air takes place throughout the pile ; the drying
gradual and thorough, if allowed sufficient time. For ordinary carpentry, two years
considered enough, but for joinery at least four years should be allotted to the seasonin
Many processes have been devised to hasten the evaporation — such as kiln-drying, in whic
the wood is placed in chambers heated by steam or hot air, or by the employment of vacuum
pumps together with heat. All are inferior, however, to the open-air seasoning, in that the
cause a rapid drying of the surface and ends, with a slow or imperfect drying of the interio
thus impairing both the strength and elasticity of the wood.

It is difficult to give rules for testing wood to determine whether it has been properly seasone
or not. One way is to push a knife-blade into the wood, and note how much it sticks whe
withdrawn. Another is to cut a shaving from the board, and note its elasticity, brittleness, o
strength. Experienced workmen crush shavings in their hands to determine the character
the wood.

As the wood loses its water it shrinks perceptibly, much more in the direction of the annu
rings than in the direction of the medullary rays, and very little, if at all, in the direction of th
fibers. If we examine the end of a log which has been exposed to the weather, we will fin
cracks extending from the center toward the circumference, and which penetrate from a fe
inches to a foot or more into the log (Fig. 14). These cracks, called **wind-checks**, are seen
planks and boards, and cause the ends to become waste wood. To prevent this rapid drying
the ends of the logs are tarred or painted. If the lumber is piled soon after sawing, these win
checks are smaller, and the waste portion is consequently less.

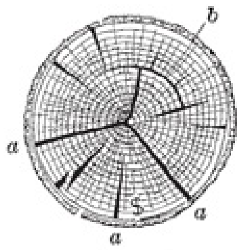

FIG. 14. — End of oak-log exposed to the weather. *a*, wind-check ; *b*, shake.