CIRCULAR No. 16.

United States Department of Agriculture,

DIVISION OF FORESTRY.

AGE OF TREES AND TIME OF BLAZING DETERMINED BY ANNUAL RINGS.

THE ANNUAL RING.

In all the timber trees of the temperate portion of our country the wood of the stem is laid on in sheets or layers which, on any cross section, appear as so many concentric rings. Generally these rings are sufficiently well defined to be readily counted, and since only one is formed each growing season they furnish a very convenient record of the age of the particular cross section and, if properly chosen, of the age of the tree.

Viewing a cross section of the stem of a pine, fir, cedar, etc., these concentric yearly rings appear as alternate narrow bands or lines of lighter and darker color, the dark line, or "summer wood," occupying

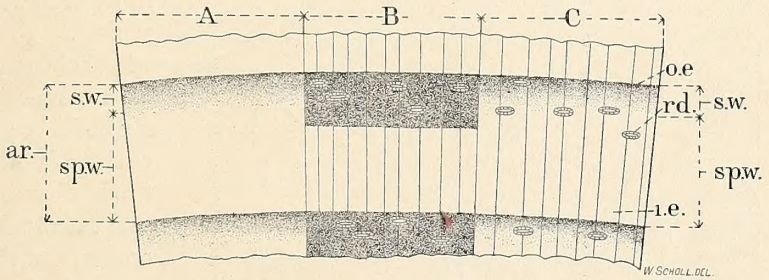

FIG. 1.—"Nonporous" woods: *A*, fir; *B*, "hard" pine; *C*, soft pine; *a. r.*, annual ring; *o. e.*, outer edge of ring; *i. e.*, inner edge of ring; *s. w.*, summer wood; *sp. w.*, spring wood; *r. d.*, resin ducts.

the outer portion of any one ring and being sharply contrasted against the lightest portion of the inner, lighter, or "spring wood," part of the next ring. (See fig. 1, especially B, and also fig. 2.)

In oak, ash, elm, hickory, locust, and other "ring-porous woods" (see fig. 3), these rings are conspicuous through rows of pores, each row occupying the inner, or spring wood, part of a ring and being separated from the row of pores of the next ring by wood practically devoid of large pores. (See fig. 2.)

In the "diffuse porous" woods (see figs. 4 and 5) like birch, poplar, gum, tulip, willow, etc., the rings are generally less conspicuous, being defined by a mere line, often scarcely perceptible in the fresh wood, and due to the fact that the outermost cells of the summer wood are always small, flattened in form, and usually have thick walls, while the adjoining innermost cells of the spring wood of the neighboring ring are much larger, not flattened, and always have thin walls, the effect being much increased by the regularity of the line along which these two forms of elements meet or touch each other.

The annual rings in a tree grown in a park or under generally favorable conditions are widest near the base, and become narrower upward in the stem; and they are also widest near the pith, growing more and more narrow toward the bark. The same is true generally, but is often somewhat reversed, especially in trees like the balsam, spruce, and oak, if the trees are shaded or otherwise hampered when young.

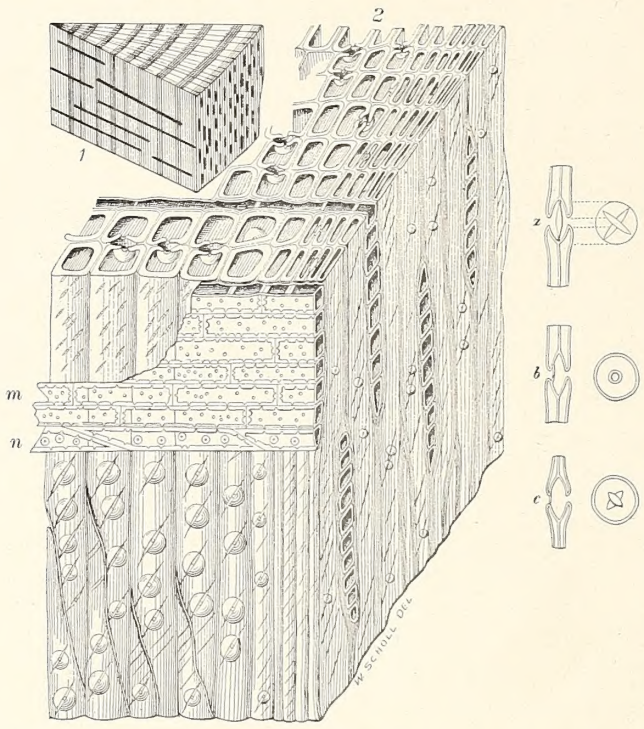

FIG. 2—Wood of spruce: 1, natural size; 2, small part of one ring magnified 100 times (the vertical tubes are wood fibers, in this case all "tracheids"); *m*, medullary or pith rays; *n*, transverse tracheids of pith rays; *a*, *b*, and *c*, bordered pits of the tracheids, enlarged.

In their width, the annual rings differ; occasionally they are half an inch and more wide; commonly they average from one-eighth inch to three-eighths inch in hardwoods, and from one-twentieth inch to one-eighth inch in conifers, and cases are not rare where a whole century's growth of a spruce or balsam amounts to but two to three inches on the radius of the stem.

In all young, sound, and thrifty timber the rings are laid on with the utmost regularity and a cross section of a stem furnishes, therefore, not only information as to the age of the given section, but is a

fair indicator of the life history of the tree, periods of suppression and thrift being indicated, respectively, by zones of correspondingly narrow or broad rings. In such timber the countings along different radii always give the same results.

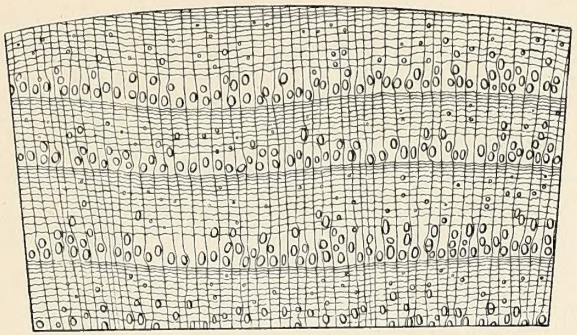

FIG. 3.—Wood of hickory (ring porous).

If, on the other hand, the rings of very old, especially slow-grown, stems are counted, it happens not infrequently that counting along one radius gives one to five rings more than the counting along some other radius. The reason for this is not always apparent; in some cases, such a difference in results is due merely to the inability of the eye to detect an extremely narrow but otherwise well-defined ring, and the error may be corrected by microscopical examination. In other cases, however, the difference is based on the actual absence of one or more rings along a given radius, extremely unfavorable circumstances having led to a failure of the regular, continuous development of these

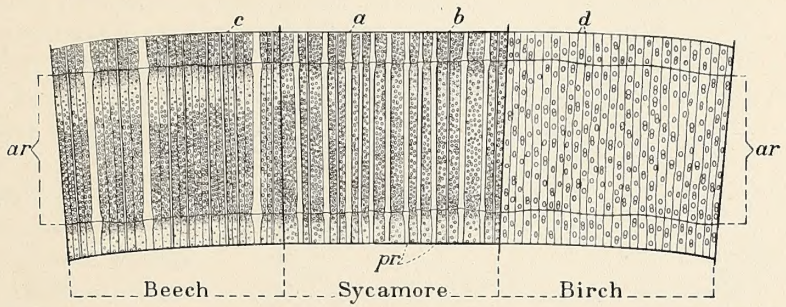

FIG. 4.—"Diffuse-porous" woods: *ar*, annual ring; *pr*, pith rays which are "broad" at *a*, "fine" at *b*, "indistinct" at *c* and *d*.

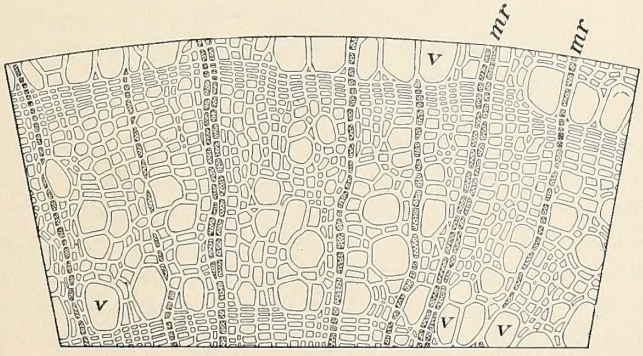

FIG. 5.—Cross section of basswood (magnified): *v*, vessel; *mr*, pith rays.

rings. In densely shaded or otherwise stunted timber, also in timber injured by coal smoke, a similar irregularity has been observed as regards the number of rings in different sections, so that a given ring, or year's growth, was found developed 20 feet from the ground but entirely absent near the stump of the same stem, thus misleading in a consideration either of age or rate of growth.

At times, especially in extremely stunted timber, it is difficult to decide whether a given ring is really a year's growth or not. The difficulty in such cases is sometimes due to a formation of "false" summer wood, a dark band passing through the light-colored part of the ring, resembling the true summer wood, but being separated from this by a lighter colored band. This leads to a "false" ring quite frequently occurring, even in thrifty timber, and always subject to being detected by sufficient magnification. In other cases it is the imperfect development of the rings carried to such an extreme that the entire ring is only one to three cells wide. This case, which occurs only in extremely stunted growth, is practically beyond remedy, the rings furnishing here only an approximate instead of an exact record of age. A much less common case still is a regular duplication of the rings in woods like oak, ash, etc., due to a defoliation in midsummer. It has long been shown that such a duplication is possible, but cases where such rings possess the normal appearance, even in the stem, are so rare that they require no special mention in this connection.

In the determination of the age of a tree, or of a particular section, it is desirable to make a clean, smooth cut; and in trees like poplar and willow, and even in birch, it is most convenient to cut out the particular cross section and allow it to dry before the counting is attempted. In many woods, if of thrifty growth, a clean saw cut is sufficient, and the aid of the knife may be dispensed with. Generally a magnifying glass of some kind is helpful, and in many cases indispensable, while with extraordinary specimens even a compound microscope will be needed. The counting is best done along the greatest radius, since the rings are plainest along this line; all covered wounds or other obstacles should be avoided. It will also be found helpful to mark every tenth or twentieth ring with pencil to avoid repetition in case of interruption; and zones of very narrow rings, such as occur in the outermost portions of old stems, will usually require repeated counting.

Since a seedling of White Pine, for instance, is only about 1 foot high when five years old, and since the parts of this five-year-old seedling are never raised upward by growth, all growth being by addition of new parts, a cross section 2½ feet from ground does not include this five-year-old tree at all. If the number of rings on the stump section is 100, the real age of the tree is not 100 years, but 100 plus about 6, or 106 years.

For most purposes it is sufficiently near the truth to make this allowance, but where greater accuracy is desired the cut must be made level with the ground, so as to include the seedling stem as well. Here, however, the lesser distinctness of the rings in the seedling and its slow upward growth will always leave an uncertainty, which for old or large trees readily amounts to two to five rings, varying with species and nature of origin, that is, whether from seed, or sprout, etc.

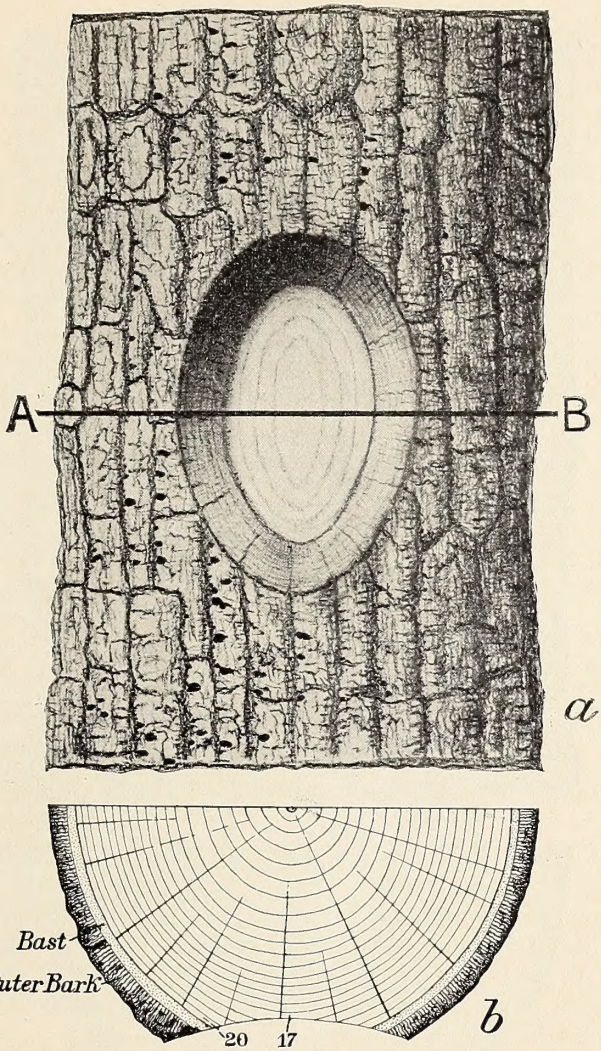

FIG. 6.—Blaze in tree trunk: *a*, front view; *b*, cross section on line *A*. *B*. in *a*.

From what has been said, it is clear that for an ordinary tree 100 years old, the record for the total age is exact within about three to five years; for a very old tree, 200 years and over, it is accurate within about six to ten, or within 3 to 5 per cent, if the growth is fairly normal, but may be amiss by as many as twenty years and more, if stunted at any time. Where, as is common, it is not so much the total age, but a certain portion of this age which is desired, as for instance, if we wish to know how old the tree was when 12 inches in diameter or when 60 feet high, the per cent of accuracy is correspondingly increased. The same is

true where the age, not of a given tree, but of a grove of old timber is wanted, and there exists a choice of trees so that the most regularly grown specimens may be selected.

Since the reliability of the annual ring as a measure of age or time, that is, its essential character as annual ring, has so often been a subject of controversy in this country, a few words by way of evidence in favor of the commonly accepted position may prove acceptable. The correctness of the rings as record forms a fundamental tenet in the science of forestry as practiced abroad, and has within the last half century been verified by tens of thousands of countings made on trees of all European forest species in almost all parts of Europe, and on trees where time of seeding, planting, age of plant stock, etc., were accurately known from permanent records. Generally these countings were made for purposes other than the mere determination of age, but nevertheless serve to-day as incontrovertible, accurate evidence at least for Europe and its species. But there are also in the same

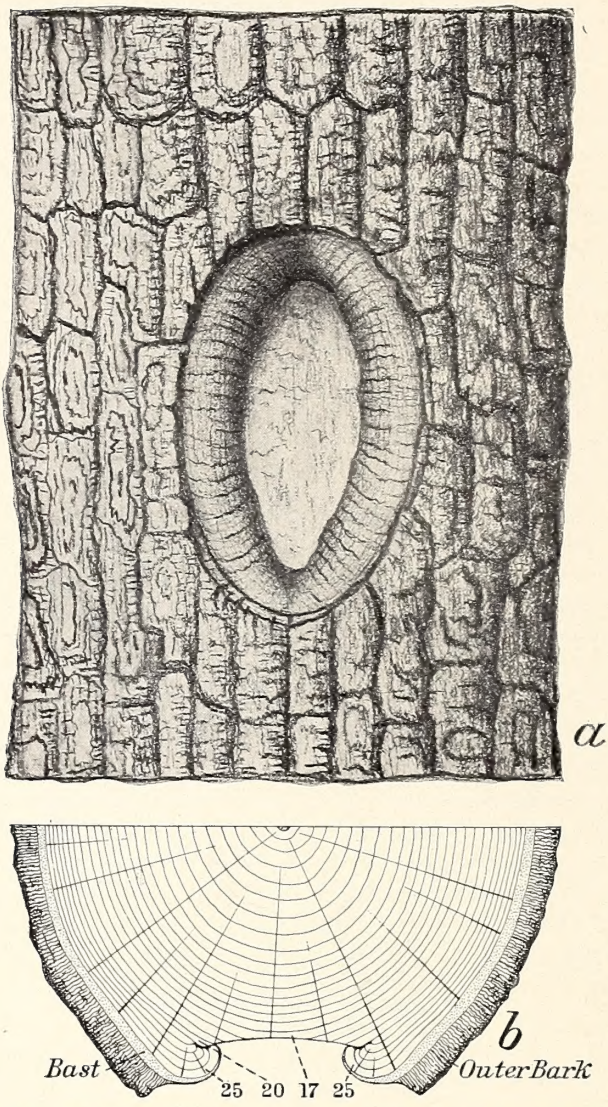

FIG. 7.—Blaze five years after cut was made: *a*, front view showing rim of callus; *b*, cross section.

countries, especially France and Germany, thousands of similar records for American species, White Pine, Red Oak, etc., which in all cases bear out exactly the same results. In addition, we have in our own country many hundred countings on record and thousands more not permanently recorded, proving the same for the forest species of the temperate zone in the United States.

Should any one doubt, let him but test the matter on a young tree, such as the Red Pine or White Pine, where the part grown during the

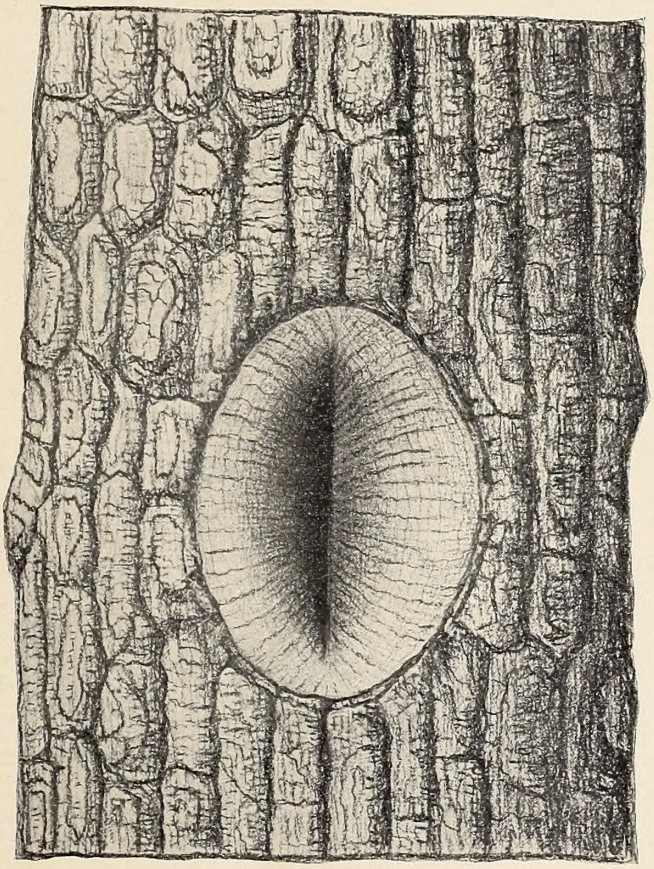

FIG. 8.—Blaze twelve years after cut was made, the callus having completely grown over the cut: front view.

last ten or twenty years is represented by so many internodes; or go to the many groves of poplar and other trees sprung up on clearings, or in windfall of known age; or still further, examine the trees of the now quite numerous tracts artificially stocked by individuals and companies, whether in parks or otherwise. The most striking contradictions ever printed were due to the mistaking of well-known features of wood structure, as for instance, the wavy markings on

elm, for annual rings; and all so-called investigations of this subject leading to contradictions were performed, not on forest trees, but in apple and peach orchards, and by men who failed in their attempt to count what actually existed. A few of the most striking cases of this kind came to this Division from Kansas and Nebraska, which, when the actual specimens were sent, proved not the fallacy of the ring record, but the utter ignorance on the part of the men attempting to disprove a theory which has for more than a century been a help to the practical forester of Europe—as important as his ax and saw.

COVERING OF BLAZES, WOUNDS, AND KNOTS.

When a slight blaze is cut, as in the running of survey lines, the wound involves not only the bark but also commonly passes into the wood, cutting through several, often many, annual rings, as is shown

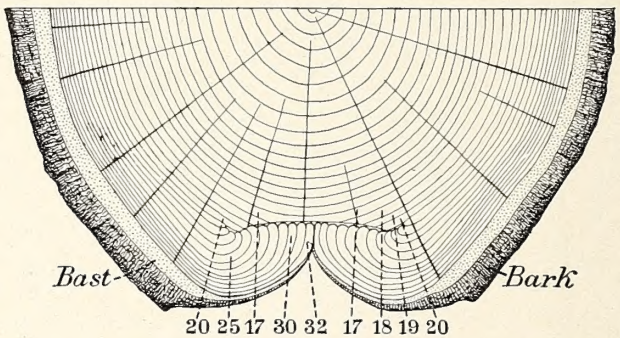

FIG. 9.—Blaze twelve years after cut was made, the callus having completely grown over the cut: cross section.

in fig. 6, *a* and *b*. The cambium being removed, and also part of the outer wood, there is no growth on the wood surface of the blaze, and this surface soon dries and takes on the dingy brownish-gray appearance characteristic of the "spot."

On each side of the blaze the cambium is killed for but a very short distance, and growth not only continues in the uninjured part, but is commonly even stimulated by the process of wounding, so that the cambial growth, together with the growth of the uninjured part of the live bark, soon form a rampart-like thickening, the "callus," around the blaze. This callus is thickest on the two sides,[1] least so on the lower point, and thickens and encroaches more and more on the wood surface. (See fig. 7, *a* and *b*, where, after five years, the callus has begun to reduce the width of the original blaze.) In time this growth covers the entire blaze, the callus from one side

[1] Supposed to be due to the normal tendency in cambium of the stem to divide in planes parallel to the long axis of the stem.

meeting that from the other. (See figs. 8 and 9.) Usually the bark is pressed out so that a perfect union forms between these two, and in almost all cases the wood grows firmly along the dead wood of the blaze, filling out all its depressions and producing an exact matrix of the old blaze, so that any inscriptions are faithfully recorded in this cover as well as the old wood. After the covering is complete the blaze ceases, of course, to be visible, and its position is merely

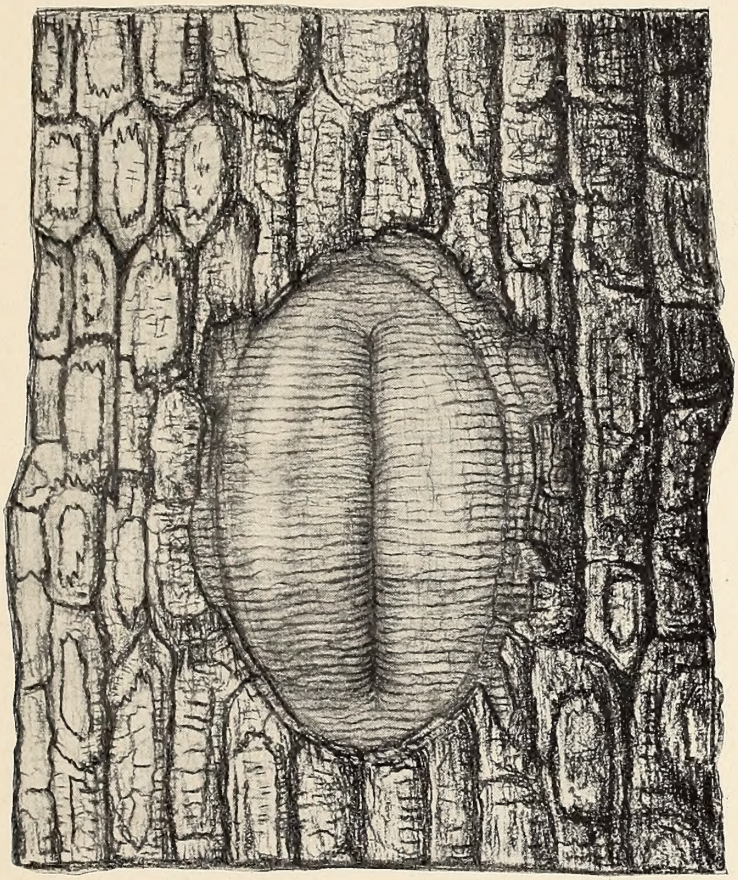

FIG. 10.—Blaze twenty-three years after cut was made, the later annual rings having assumed the normal growth over the wound: front view.

indicated by a depression corresponding to the thinner and smoother bark on the old blaze and the thickened remains of the old rampart-like callus. (See figs. 8, 9, 10, and 11.)

In some cases even the large blazes of "witness" trees have been covered entirely in twenty-five and even fewer years, while in many cases the slow growth of the old trees never entirely obliterates the marks.

The process of covering a knot or the stub of a broken or sawed-off limb is similar in every particular to that just described. Here, too, a callus, most extensive on the sides and least on the lower side of the knot, covers the stub and, as in the blaze, enters faithfully

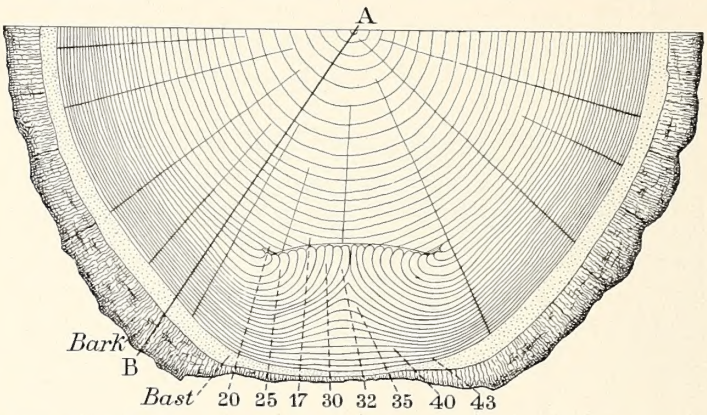

FIG. 11.—Blaze twenty-three years after cut was made, the later annual rings having assumed the normal growth over the wound: cross section.

into all depressions. Where the knot decays a cavity, of course, is formed behind the callus (see fig. 12), though such a cavity may not exist when the wound first covered.

It is evident from what has been said, that the chip covering the blaze itself does not furnish information as to what time a blaze was made in a given tree, since here all rings are not necessarily represented. To find how many years ago the cut was made, it is necessary to have a cross section of the stem, or at least a part of a cross section lying on both sides of the line A B, fig. 11. Then the number of rings may be counted from bark to pith and the particular ring leading to the edge of the wound (ring No. 20 in figs. 6, 7, 9, and 11) may be traced from the wound to the radius along which the counting is done.

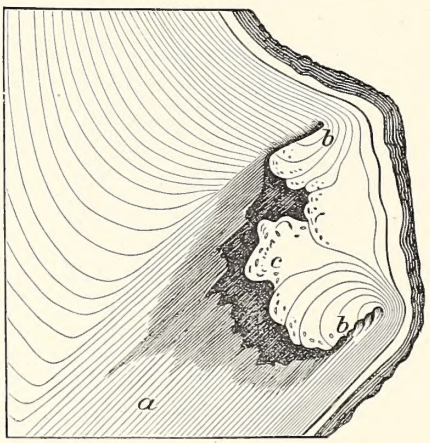

FIG. 12.—Section through a partly decayed knot in oak wood: *a*, wood of the knot; *b* and *c*, wood callus of the stem covering the wound; shaded portion, decayed wood; black part, a cavity remaining.

Where the wood is decayed below the covering callus, this latter is commonly intact, and the innermost ring of the callus becomes the starting point. If the cut is made in winter, this innermost ring is

the ring of the summer following the time of blazing. If the cut is made in summer (June to July), the ring of the particular season may still form a partial beginning of a callus, but would be incomplete at the point where the wound destroyed the cambium. If the cut is made in August or later the likelihood of any ring formation is generally excluded.

From these considerations, it appears that generally this record is accurate to about half a year, but may at times through mistake fail by one whole year. In cases where decay has encroached both callus and old wood it may be wrong by several years. But even in this latter case the reckoning is not so hopeless as would appear, since there are usually a number of cuts from different trees. By a careful study of the entire cross section the time may usually be approximated to within a very few years. Such a study, however, will require proper equipment, time, and preparatory training.

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Approved:
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Washington, D. C., *August 18, 1897.*