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Tree-Ring Laboratory
University of Arizona
Tucson, Arizona

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All correspondence regarding subscriptions should be addressed to Mr. Edmund Schulman, Tree-Ring Laboratory, University of Arizona, Tucson, Arizona.

NOTES ON THE TECHNIQUE OF TREE-RING ANALYSIS. IV: PRACTICAL INSTRUMENTS

A. E. DOUGLASS

Certain practical instruments and techniques of tree-ring analysis have proved their own value since the last general description in 1928*. Frequently, inquiries have come to us in regard to one tool or another and it is hoped that some answers will be found in the present paper.

A. COLLECTING INSTRUMENTS

Small tools. A small hatchet serves to obtain a chip from stump or tree if a preliminary estimate of the ring characters is desired. The saw of moderate size is useful to secure v-cuts from the tops of stumps or from the ends of prehistoric logs. These samples of ring sequences are made by two cuts of the saw across the section, separated by one inch and including the tree center; the cuts slant toward each other and meet about an inch from the surface. Complete ring sequences are thus obtained from center to outside and supplement and often extend the length of records obtained by the increment borer.

Swedish Increment Borer. This is an essential tool for sampling living trees. Such sampling is a necessary part of the collection of prehistoric material also. This instrument, of Swedish manufacture, has been obtained from Keuffel and Esser. The K & E No. 5½, a borer giving up to an 11¾-inch core, is light and suitable for most trees. On large trees the K & E No. 7½ (15¾-inch) borer is much better**. The fragile cores are about 1/5 inch in diameter. The cutting edge of the borer can be chipped easily and the operator must have a delicate touch and take warning if resistance is encountered. Water soaked wood is to be avoided. It is well to have a small drill welded to a steel wire which can be used to drill through a mass of wood that by chance gets plugged in the borer. It is dangerous to try this extraction from the outer or cutting end of the borer since the sharp edge chips easily.

Tubular Borer. The tubular borer is an instrument for securing ring records from weathered logs or from trees that are too tough for the in-

*Climatic cycles and tree growth, vol. 2, Carnegie Inst. Washington Pub. 289, pp. 34-50. Many of the suggestions in this and the following paper (Part V) are by Mr. Edmund Schulman, either in conversation or from his publications.

**Their numbers in the K. & E. catalogue are respectively N 4335 and N 4337½.

crement borer. Prehistoric logs still in place in ancient ruins should be bored at some point that does not weaken the log. The borer has saw teeth at one end and tail piece at the other end which can be held in an ordinary brace. In an upward sampling the sawdust is easily removed. Working downward becomes very difficult; it is possible that such a hole could be filled with water and the sawdust floated out.

The usual borer is a steel tube one inch in diameter with thin walls not over 1/16 of an inch thick. The sawteeth on one end may be made 3/16″or so high if the borer is to be used in living wood, but ⅛″ or less if the borer is to be used in prehistoric logs which have been weathered through many years and are exceedingly hard. This sawtooth end needs to be tempered and the collector should carry a three-cornered file with him to sharpen the teeth if necessary and a pair of pliers to set the slope of the teeth. These teeth must cut a circular ring wide enough for the free rotation of the borer.

Borers for work in prehistoric logs have sometimes been made as short as six inches. An average length is eight inches. We have some ten inches and some of two feet.

Three accessories are commonly necessary. First, a starting plate is important at the beginning of any boring to prevent the borer from catching on one side and sweeping across the precious outside rings of the log with the other teeth. This injures the latest rings which are the rings we depend on for assigning a date to the log. The starting plate may be made of wood or of thin metal. It is perhaps 4″ square and has a hole in the center large enough for the borer to pass through; it has small holes at opposite ends for light nails to be driven into the log and hold it in place. The boring is started through this large central hole and this plate is retained in place until enough depth has been given to the cutting to hold the borer securely in its proper place.

The second important accessory is the extractor, which is simply a quarter-inch iron rod, an inch or so greater in length than the length of the borer. It has a wedge on one end for breaking off the core if necessary and a small screw on the other end to screw into the core and pull it out in case it does not come out readily.

The third accessory is a drill not over ⅛″ in diameter that is used in getting out cores that become jammed in the borer. One drills a series of holes into the core from the outside placing these holes close to each other for a little more than half way around the margin close to the metal and the core is released without injury except deep scoring about the outside. This has sometimes been done by boring a single hole as described and then using a "jig-saw" blade, with the end broken off, to cut around the outside of the core till it comes out.

For use in especially valuable specimens these borers can be made as little as ½″ in diameter. In such cases they should be handled with the fingers and not with any high-powered mechanism from which some injury is likely to occur.

B. FIELD PRACTICE

Paraffine-Gasoline. The paraffine-gasoline treatment with charcoal was used for many years, then various improvements were attempted and later all attemps to preserve charcoal specimens at the time of collection were abandoned. However, recently I have looked over many old collections of charcoal specimens and find that those not treated are falling to pieces. Of course charcoals differ greatly in respect to this danger. Pieces that are already very small are apt to break into still smaller fragments. In attempting to develop the chronology of some prehistoric ruin where ring records are already in small charcoal fragments there is no alternative to a careful soaking of the specimens in some solution so that they may be longer preserved. Perhaps the cheapest and most available is a solution of paraffine in gasoline. It is most convenient to use a can of such size that the specimens may be dropped into the solution and taken out fairly quickly. The preservation of the charcoal is better when the solution is rather thin; a strong solution nearly always produces a bothersome after-effect since the exuding paraffine forms a white coating on the outside and spoils any prepared surface. This clouding can be removed by the free use of gasoline on cotton. For further details see Tree-Ring Bulletin, July, 1940, and October, 1941.

Protection of Increment Cores. Increment cores are very fragile and are easily broken because they cross the grain. On drying they contract very slightly. This has not been considered important because such change is no more than can occur between two radii of the same tree. It is a good policy to mount the cores as early as possible after collection, allowing them to dry first for a day or so, but in the meantime they must be protected as far as possible from breakage. Various methods have been tried: (1) putting each core into an envelope separately, (2) wrapping each core separately in a paper napkin, (3) marking each core with its number every inch or two and putting them together in a paper bag or in a sufficiently long mailing tube conveniently fitted with end flaps; the numbering shows the identity of different parts in case the specimen is broken. After the site is sampled the group of cores is separately wrapped, freeing the field carrying case for further collections. Wooden cases have been tried but the extra weight becomes an unnecessary burden.

Personnel of a Collecting Trip. My colleagues who have had brilliant success in collecting important specimens have preferred to go out in the

Fig. 1. Swedish Increment Borer.

1A. An 11¾-inch increment borer ready for use; the borer tube is horizontal, cutting end to left; the hollow handle is attached at the right; the long slim wedge is horizontal below the borer. Above these are five mounted 10-inch cores (old style of mount) and close below is a 1-foot ruler. (The borer lengths give the *maximum* core lengths).

1B. A 15¾-inch Swedish increment borer, with borer tube and wedge slipped into the hollow handle. Below are six mounted cores (latest style of mount) a mounted razor blade and one increment core mount.

Fig. 2. Radials, and Tubular Borer.

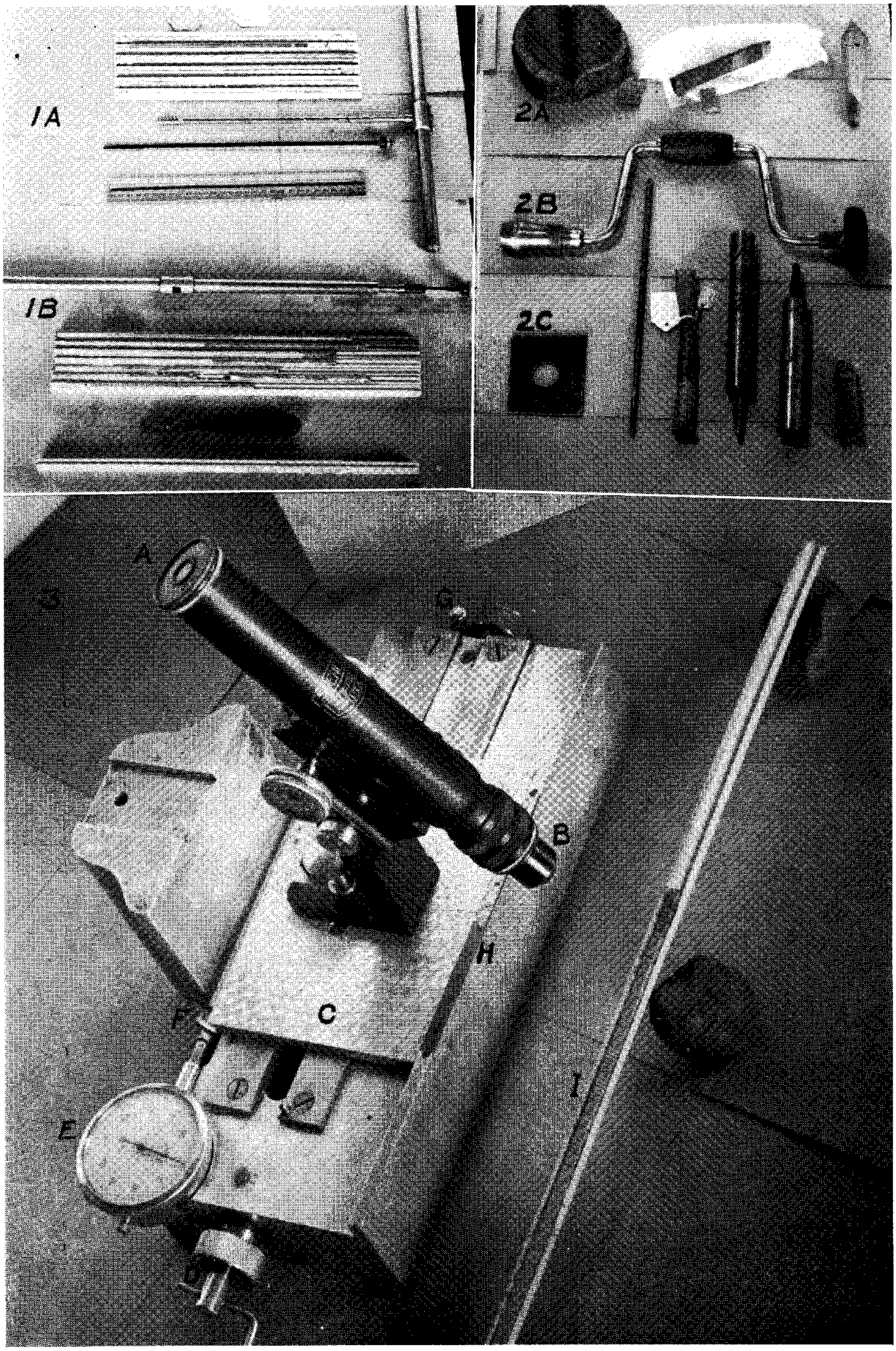
2A. Five-inch section from which standard v-cut has been taken; the v-cut is shown to right of section; further to right is a form of v-cut called "edge-cut."

2B. Brace for the tubular borer.

2C. In order from left to right: (a) starting plate needed to start the borer in the wood without injuring the outer rings; (b) extractor to break off and take out the core; (c) long "tubular" core; (d) 8-inch borer; (e) 6-inch borer reversed to show cutting end; (f) short "tubular" core.

Fig. 3. Two-Scale Measuring Instrument.

Reference letters show its parts: A, eyepiece of the telescope (power x10 with vertical and horizontal threads). B, 2-inch objective of telescope; the telescope is mounted with slide and focusing screw and on a pivot permitting rotation up and down but not sideways. It is mounted on a carriage, C, which in measuring is moved toward the millimeter dial, E, by a long stationary screw underneath the carriage, whose head is at D (the precision of the instrument does not depend on this screw). E is the millimeter dial which shows the width of individual rings as the screw D moves the carriage C and the microscope from left to right in the order of growth as seen by the operator. The mm dial E is actuated by a pin F attached to the carriage. The release pin G detaches the pin F from the carriage and the dial returns to zero. The second scale is at H; estimation of tenths of a millimeter by the eye is usually sufficient. The specimen, I, is mounted for measurement.


1A
1B
2A
2B
2C
3
A
G
B
H
F
C
E
I

field alone or with a guide who knows the region. This search for sites and specimens that give climatic reactions is an intense scientific operation such as usually performed within the protecting walls of a laboratory. The collector in our case is searching for Nature's laboratory where a certain job is done by a climatic reaction in the growth rings of trees. This involves the immediate surroundings of the tree, the characters of the species, the relation to the forest levels, the water in the soil, and many other features. The collector is doing a piece of creative work and must not be interfered with unnecessarily by useless questions from people who do not understand.

C. MOUNTING AND SURFACING

Mounts. Mounts are now made of wood especially cut ⅜″ x ½″—16 inches long with a groove along the length on the narrow top. This groove is about 5/32″ in diameter and made only to half depth. The cores are glued into these mounts with great care to place fragments in the proper order and direction. For that purpose it is necessary first to fit all the pieces of any broken core together and mark them so that they may be properly glued to the mount. The core grain should be made to slope downward some 30° or 40° from the horizontal and thus away from the operator, who holds the core with its early end to his left. This makes possible the proper relation of razor cut to grain in order to get the best surface. After gluing the fragments they are tied tightly to the mount with a string and allowed to set for 24 hours.

Razor Blade and Diagonal Cut. If the core is mounted as above described and if a horizontal cut is made with a sharp razor blade the rings of conifers are displayed to better advantage than in any other way yet known outside of microtome processes. If well done it gives a perfect surface for high microscopic powers, without preventing a survey of the whole foot-long specimen all within a few minutes. In handling the great number of specimens that we use it is very necessary to have rapid and efficient methods.

This particular cut and the illumination appropriate to it constitute our method of preparing the surface so that real decisions can be made as to the annual character of any ring that may be in question. The light in this case should come from a low angle in front of the specimen and the view is nearly vertical downward. This has become standard because it is not only best for visual work but is the necessary position for photographic work.

For actual surfacing, a razor blade with a very sharp edge is necessary. It cannot be used many times without resharpening. It is more easily handled if it is fitted to some form of handle of which there are many. Our best handles have been especially made and are shown in an illustration. The Durham safety razor blade has been found very convenient because it is sufficiently sturdy, long, and flexible, and mounts easily in a position suitable for use. It cuts best with a sliding motion which accentuates the sharpness of the edge. For further notes on cell illumination see Tree-Ring Bulletin, April, 1941.

D. TOOLS IN CROSSDATING

In dendrochronology crossdating is the central part of the process, for similarity of many patterns recognized as occurring in many trees over a considerable area is the criterion by which we separate general climatic effects from the disturbing factors that occur in individual trees. A convincing similarity constitutes evidence of climatic origin and is called crossdatng. To reach a feeling of security in crossdating *there is no substitute* *for minute personal comparisons between actual ring records in different trees.* The only alternatives for this direct comparison on the wood are a series of photographs that show all the rings, or a keen memory of the average ring series so deeply impressed that it can be held as a standard with which to compare every individual record. *There is no mechanical process, no rule-of-thumb, no formula, no correlation coefficient, to take the place of this personal comparison between different ring records; the operator does not dare to seek relief from his responsibility.*

Lenses and Microscopes. Our investigators who have done the greater part of the study of individual rings use almost entirely a magnifying glass with power x10. The triple aplanat type of lens is preferred as it gives a flat field and less distortion and is less of a strain on the eye if properly used. When the power has to be increased we use x20 of the same type of lens, or if more is needed a microscope must be used. In a microscope the field is so small it is only suitable for special investigations. We have used hand microscopes up to power of 60, but that is not high enough to differentiate between the cells of Douglas fir and pine. That requires 80 at least and preferably 100. We have many times tried to use other aids in ring vision; for example, there are a few cases in which the binocular microscope is an important aid. We have tried prism-lenses over the eyes by which both eyes take part in looking at the ring. But those various aids seem to slow down the actual work of crossdating. The x10 hand lens, which has a wide field and is quickly changed from one point to another, has no satisfactory substitute.

E. THE CRAIGHEAD-DOUGLASS MEASURING INSTRUMENT

This instrument was originally constructed by Dr. F. C. Craighead, of the United States Department of Agriculture, who found it well adapted to the measurement of seeds. However, much experience with student work in measuring rings had shown the necessity of having a checking device whose immediate indications could not be overlooked in the process. This was worked out by the writer about 1916 in measuring the long ring sequences of the giant sequoias by means of a horizontal cathetometer which had the telescope and millimeter scale along the horizontal measuring bar. We added to this telescope a thread micrometer which measures the rings in millimeters and hundredths. That micrometer has stationary and movable threads whose separation can be read off from a screw head as is common in astronomical micrometers. By placing the specimen at a measured distance the readings of the ½ mm screw gave values directly in mm.

In operating this device, which we used in some 50,000 measures, the reading of the general mm scale on the horizontal cathetometer bar was entered on an adding machine after the stationary thread was set on a definite outside edge of a decade ring. Then each successive ring was measured through the micrometer telescope and added on the adding machine to the cathetometer scale reading. At the end of ten measurements the sum was derived and the adding machine cleared. Next below that was placed the new reading from the cathetometer scale as a beginning of the next set of ten. If this differed by more than one-tenth millimeter from the sum which had just been derived, the set of rings was measured again at once.

This initial individualizing of the actual ring sizes in the record is a fundamental help because it saves a long series of subtractions when readings are made directly from a single scale. Dr. Craighead individualized the rings in a very convenient and effective way with his compact and efficient instrument. As modified to our use the movable stage carries the microscope which is pointed upon a stationary specimen (the movable stage can carry the specimen which is then observed through a stationary microscope); the stage travels in an accurately machined slide by means of a screw rotated by a proper handle on the right of the instrument. A millimeter dial with a push stem is placed in a site convenient for reading. An arm that pushes on this stem comes up from a block moving on a stationary rod below. This block has an extension that passes underneath the movable stage and has a long spring clip that grips that stage by a rod secured to the stage. The clip can be opened and released by an elliptically shaped rod that passes from end to end underneath the mounting and can be given a ¼ turn by a small handle at the left end of the mounting. While the microscope thread moves from the sharp outside of one ring to the sharp outside of the next ring, the spring clip conveys the movement to the millimeter dial which shows at once the amount of this motion (the ring-width), in hundredths of a mm. Then a twist of the handle at the left releases the connection between the dial and the stage, and the arm and dial stem are returned to the zero position by a spring.

In order to introduce a checking device an additional scale was placed on the margin of the movable stage; a reading is first made on the secondary scale and placed on the tape of an adding machine, ten annual rings are measured by readings of the dial, each one entered individually on the adding machine, and the sum struck off, clearing the machine. Then a new reading is made on the secondary or check scale and is placed in the adding machine to start the next decade. The new reading thus comes immediately below the preceding sum and should agree with it within 1/10 mm; if it does not agree that well the 10 rings are remeasured.

The adding machine strips so produced have dates put on them so that every ring is accounted for and they are saved as a permanent record. Before measuring, the dating has been put on the specimen by successful comparisons between this and other specimens subject to the well known control of crossdating.

One sees that the essential feature of this measuring device is the use of two scales which check against each other, in one of which the ring sizes are individualized and in the other summated for ten years. It is evident that many devices could be and have been made that fill this requirement. We consider the check scale of prime importance and an instrument without it should have one put on for practical use.*

F. PHOTOGRAPHY OF RINGS

Our illustrations of rings are made in a large vertical photographic outfit using a 2-inch and 6-inch lens of good quality with other lenses of much shorter focus available. The vertical form gives a much better chance of a good focus in all parts of the picture. Also, specimens of wood or charcoal can be illuminated better if the desired surface is in a horizontal position. Many details and general procedure are contained in the three earlier installments of this series.

In the absence of this large outfit for the formal photography of rings, success has been reached by mounting an ordinary camera over a microscope. This arrangement is described in the third set of notes (Vol. 8, No. 2, October, 1941) in connection with the photography of charcoal. In the photography of wood the arrangement of the illumination is illustrated in the second of the three articles, Vol. 7, No. 4, April, 1941.

*It should be added that our instrument as here described was made about 1930 at a cost of $250.