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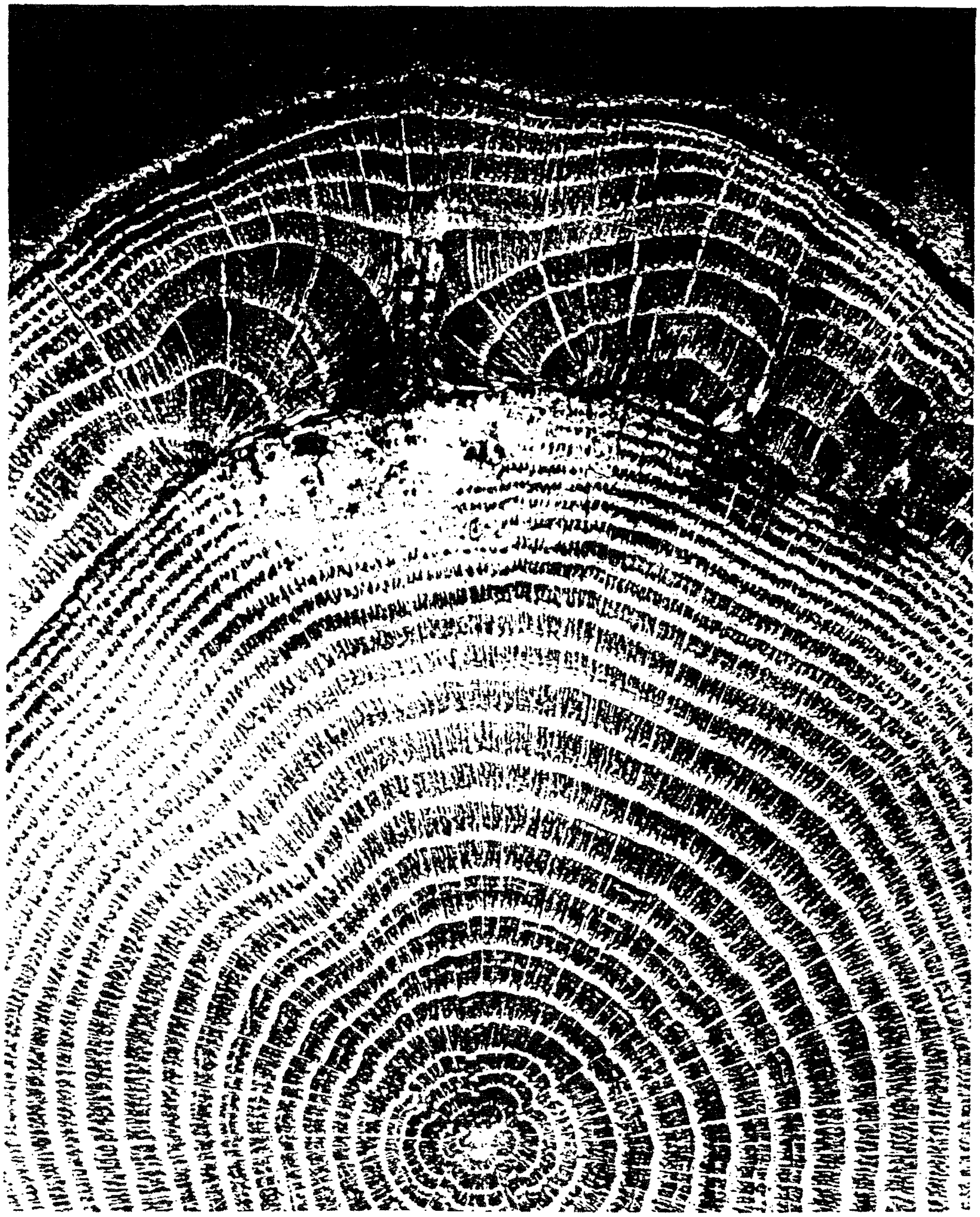
Tree Defects: A Photo Guide

Alex L. Shigo



The Author

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Dr. Shigo has used a chainsaw to make longitudinal dissections of thousands of trees. He has studied trees throughout the United States, and in Canada, Australia, Europe, and Asia in his research on the response of trees to injury and infection. He has packaged parts of his research findings to reach many audiences worldwide.

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Abstract

Dissections and wounding studies on thousands of trees since 1959 have resulted in an expanded concept of tree decay. A long gradation of events begins after wounding as tree and microorganisms interact. The highly compartmented tree forms boundaries to resist the spread of microorganisms. This defense process is compartmentalization, and CODIT is a model of the process.

The expanded concept of decay and CODIT are used to reexamine many tree problems. Discolored and decayed wood are major tree problems that cause low quality in trees. A better understanding of these defects makes it possible to begin growing healthier and higher quality trees in our forests and cities.

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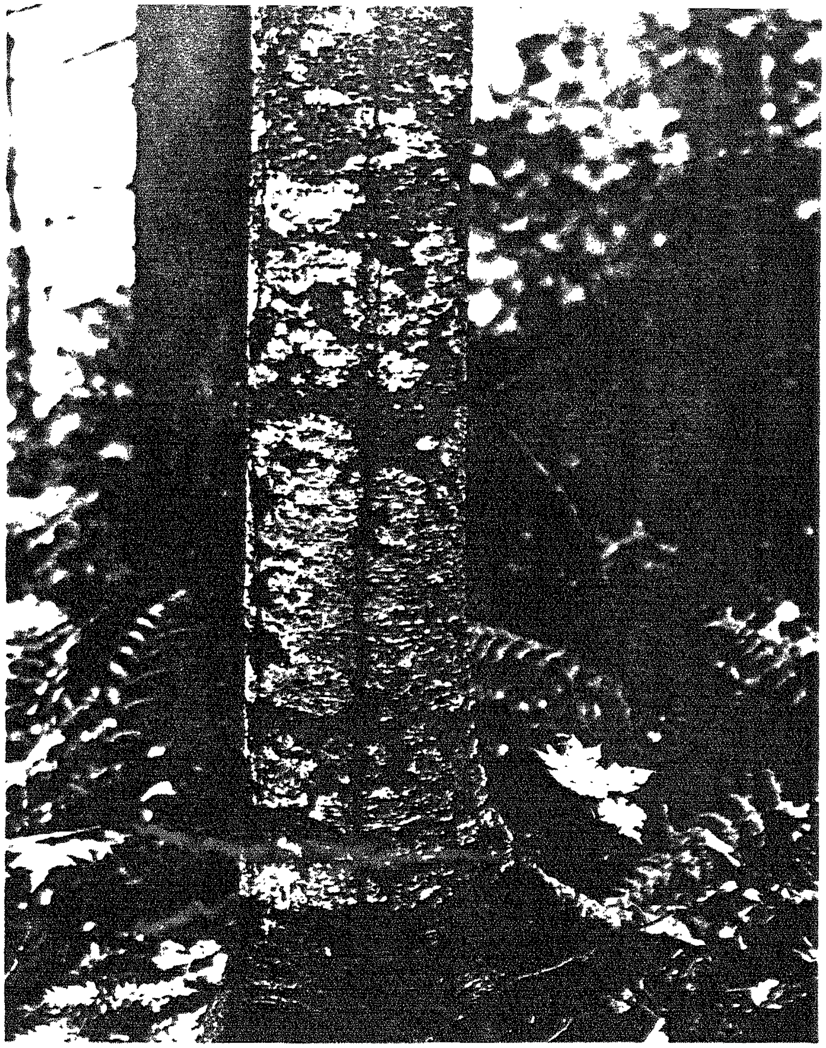
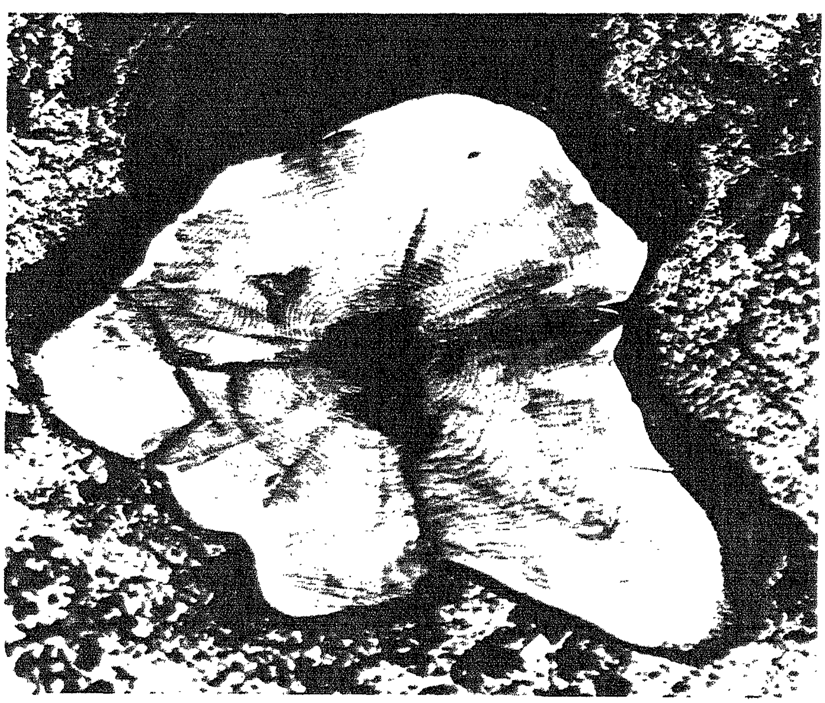
80. Multiple cracks on balsam fir indicate serious internal decay and internal cracking. Cracks at the base of balsam fir usually indicate root and butt rot. *A. mellea* is usually, but not always, the fungus involved. Resin often flows from old branch core sockets on trees infected with root rot. Trees with basal cracks should be cut as soon as possible. Some forest areas are root-rot areas because the fungus is kept vigorous on dead roots of cut trees. When balsam fir is cut, more balsam fir grows again. Root rots are common in many fir areas.

81. The basal section of the tree shown in the previous photo shows the central hollow and the radial cracks splitting out from the hollow. A great amount of wetwood is associated with the roots and the butt. Trees with root and butt rot often break near the base. Such trees in an area indicate a root rot zone.





82. Large collar cracks form on root-rotted birch. Trees with such collar cracks should be cut as soon as possible.

Collar cracks start when support roots are rotted. Cracks that start at the butt spread upward.

Armillaria mellea and its related species infect many species of trees worldwide.

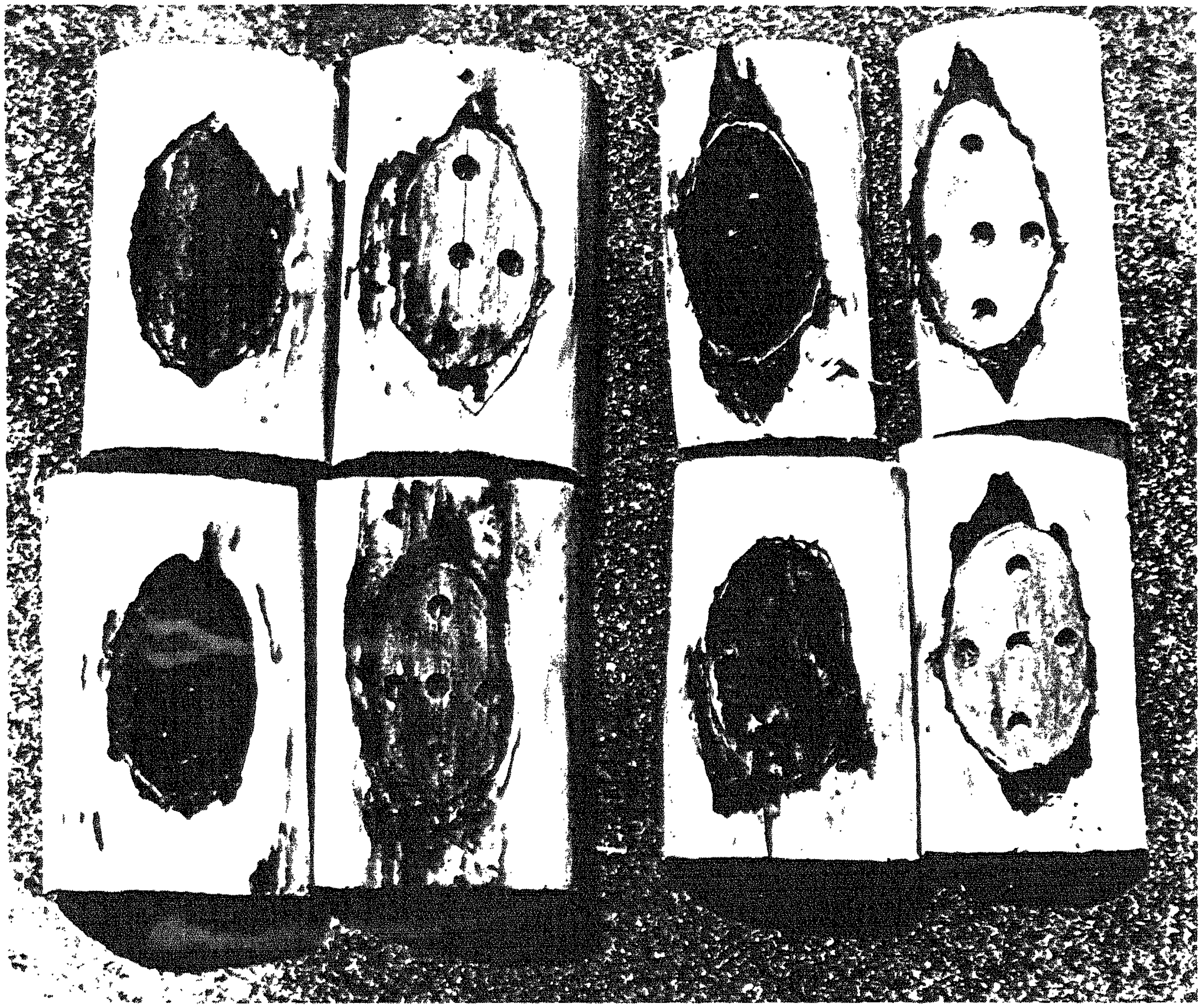
Pause

CODIT is a model of compartmentalization. Compartmentalization is a highly ordered boundary-setting process to resist the spread of infection. The process is not absolute. It does not function perfectly all the time. When it does not function effectively, some part of the tree, or the entire tree, may die. Our responsibility is to understand the natural processes of buildup and breakdown well enough to be able to prevent, detect, or regulate them. And when this cannot be done, then predict their movement over time accurately. In forestry, the group of trees must be considered. In urban forestry or horticulture, or in orchards, the single tree must be considered. Treatment of trees to prevent and "cure" diseases has been a personal art form. Many treatments arose from practices used in human medicine. It is time to reexamine many tree care practices on the basis of new information and of new pressures inflicted on trees. Science is a constant reexamination process in search of, and in documentation of the truth. Truth is order.

The more we understand the order of natural systems, the more we will be able to make the best decisions, most of the time. Some common tree treatments have been reexamined:

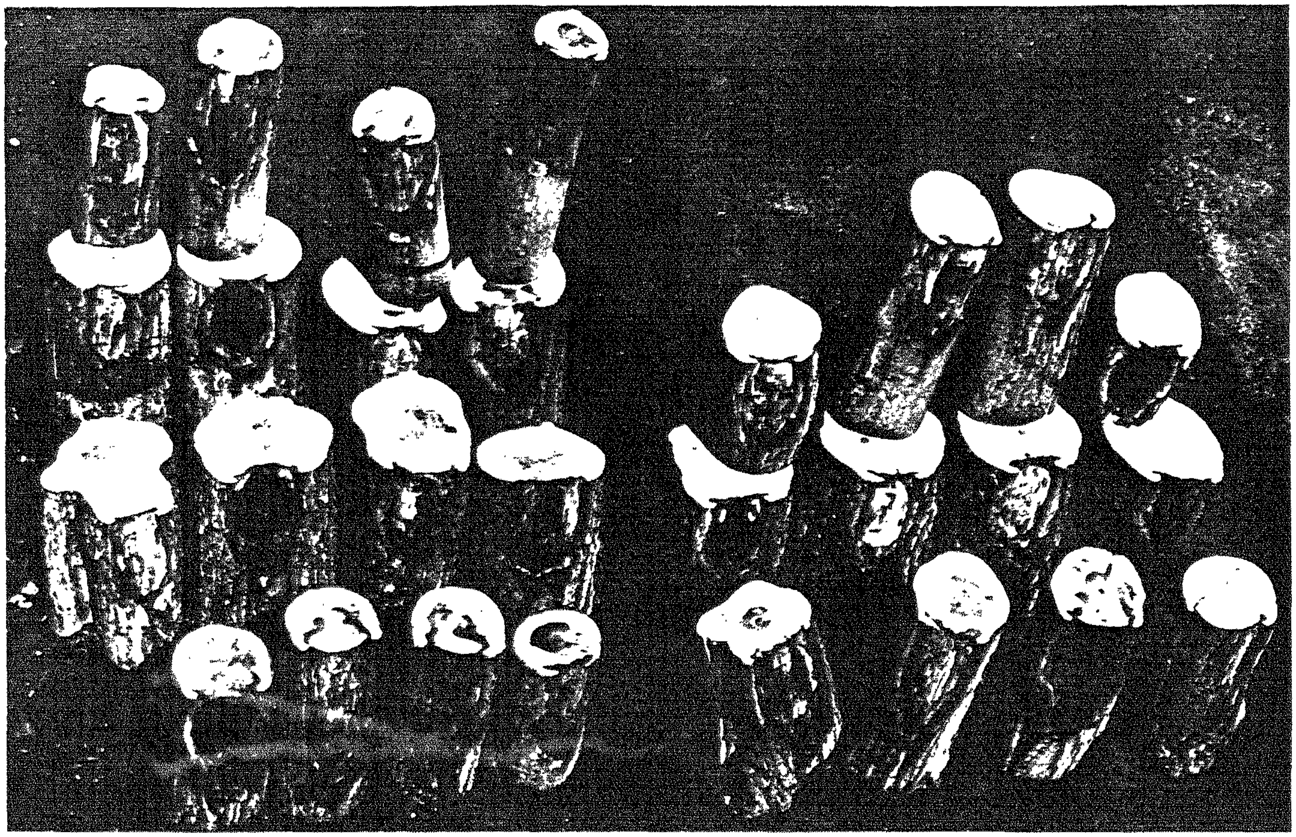
wound dressings, cavity filling, wound scribing or tracing, cabling and bracing, injections and implants, and most important, pruning. For the good of our trees, some adjustments must be made.

83. Wound dressing has been the hallmark of the arborist. Wound dressings were used to prevent or stop decay, but there are no data to show that any wound dressing prevents or stops decay. Studies that included dissections and isolations showed that trees with wound dressings were no better off than the untreated controls. The four wounds on the left were on one red maple tree, and the four wounds on the right were on another red maple tree. The dark-faced wounds were coated with a common wound dressing. Note the dieback associated with the wounds. Dissections showed no difference between the two trees in the amount of discolored and decayed wood. This photo was taken 1 year after treatment. Bark was removed to show the dieback.



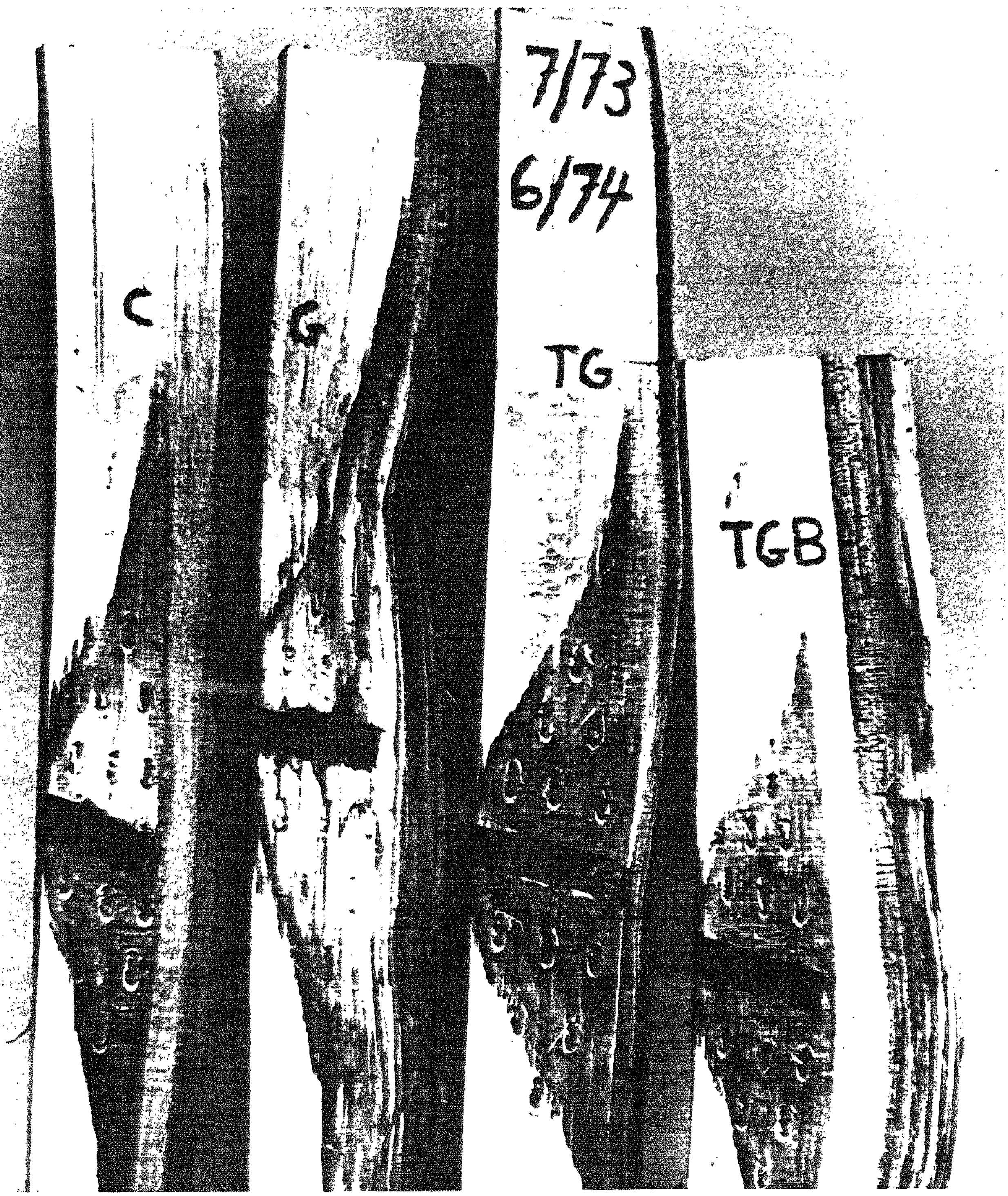
84. Seven-year old treated and control wounds on seven red maple trees. Each tree received four wounds, three of them treated and one control. The treatments were a very common black asphalt-based dressing, orange shellac, and a rubber-type material, plus the untreated controls. Note similarities in callus formation and dieback pattern on the four wounds from each tree—four per horizontal row. Note also that some dressed wounds have no decay associated with them while others do. Why? A closer look will explain why. When the experimentally inflicted wounds injured wood very close to inner defects, decay developed. When there was a wide band of healthy wood separating the inner defect from the experimentally inflicted wounds, no decay developed. These results show again the importance of wounds that decrease the volume of healthy wood in a tree.

Seven red oak trees wounded and treated the same as the red maples were also cut and dissected after 7 years. The strong effect of individual genetic traits was shown with the oaks. Some trees closed all wounds, regardless of treatment. No wood decayed, and there was only a small column of discolored wood.

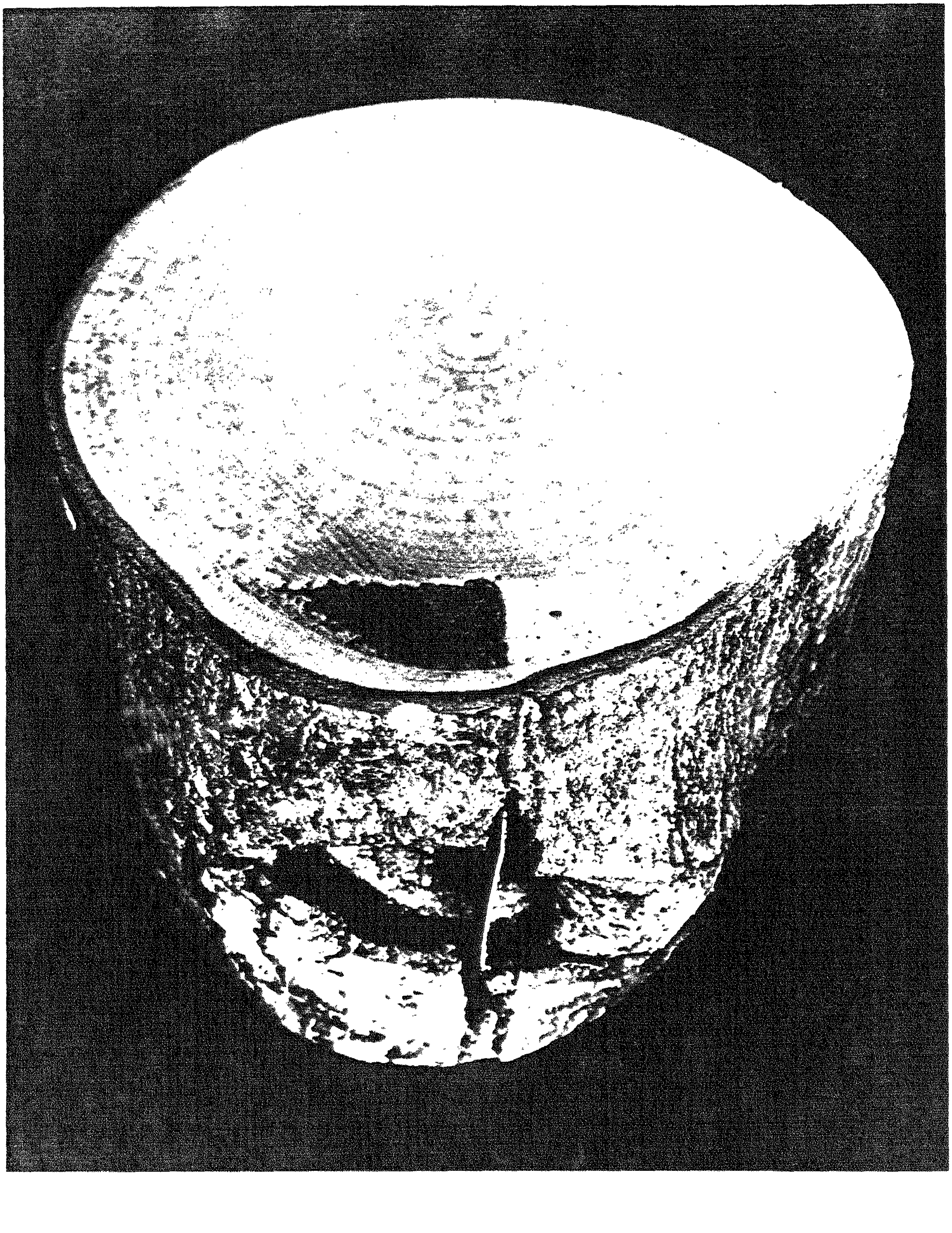


85. Agents of biological control were also tried in wounding experiments. Results of studies showed that when a non-decay-causing fungus *Trichoderma harzianum* was introduced into fresh wounds, along with glycerol, decay was stalled for at least 2 years.

Sections from one tree are shown here. C = Control; G = glycerol; TG = *Trichoderma harzianum* mycelial and spore culture with 5 ml of glycerol; TGB = as preceding, plus a culture of bacteria commonly isolated from discolored wood. Note decayed wood in sections C and G. The small holes show where wood chips were taken for isolation of microorganisms. The treatment with the fungus isolate used was not as effective when temperatures were low.

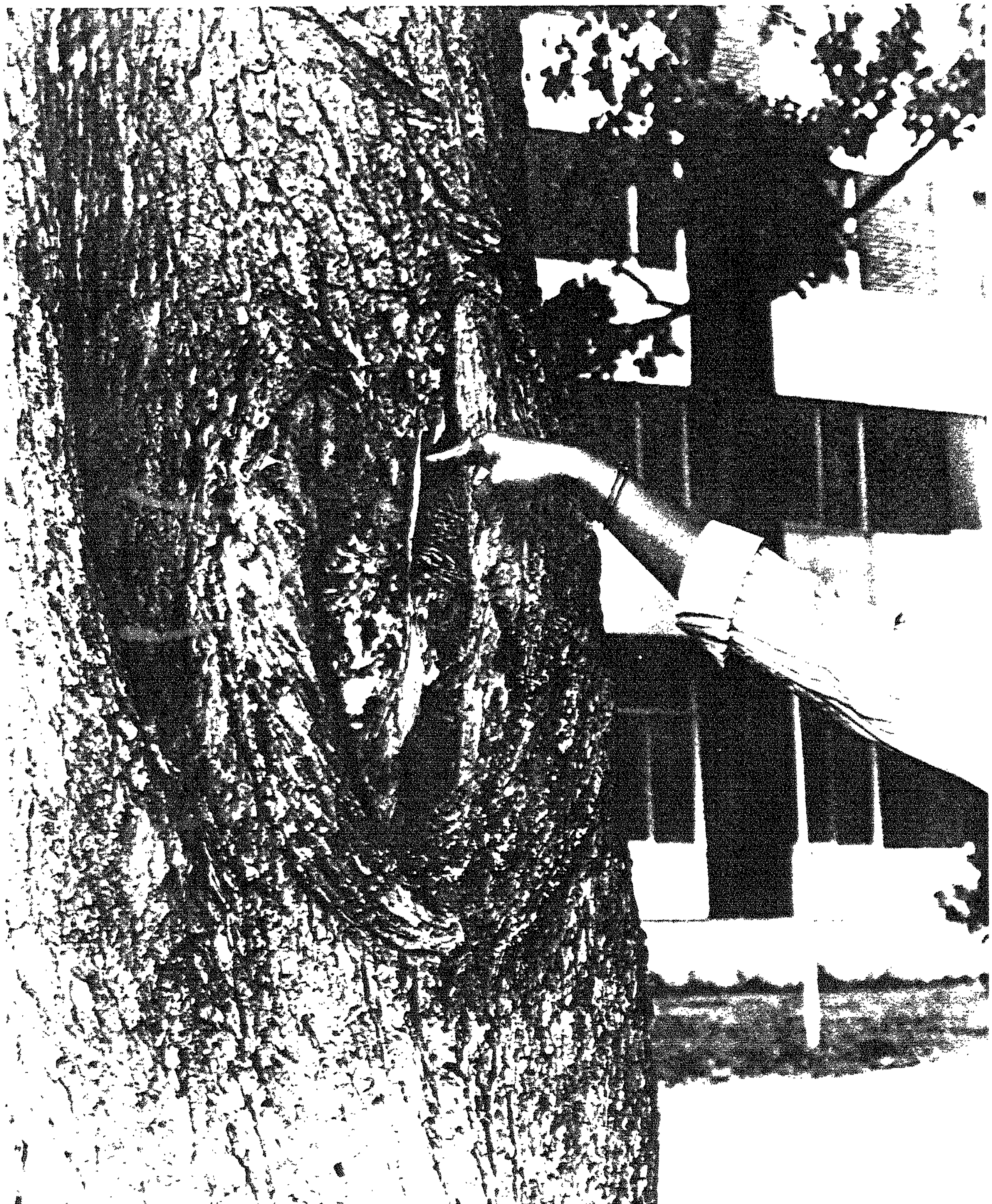

7/73
6/74
C
G
TG
TGB

86. A section from a red maple showing a method used to test the effects of biological agents on the wound response. A wound was inflicted with a chainsaw. Then a metal plate was forced into the center of the wound. The wound on one side of the plate was treated; the other side was left as a control. Because of the way trees compartmentalize wounds, the method is highly applicable.

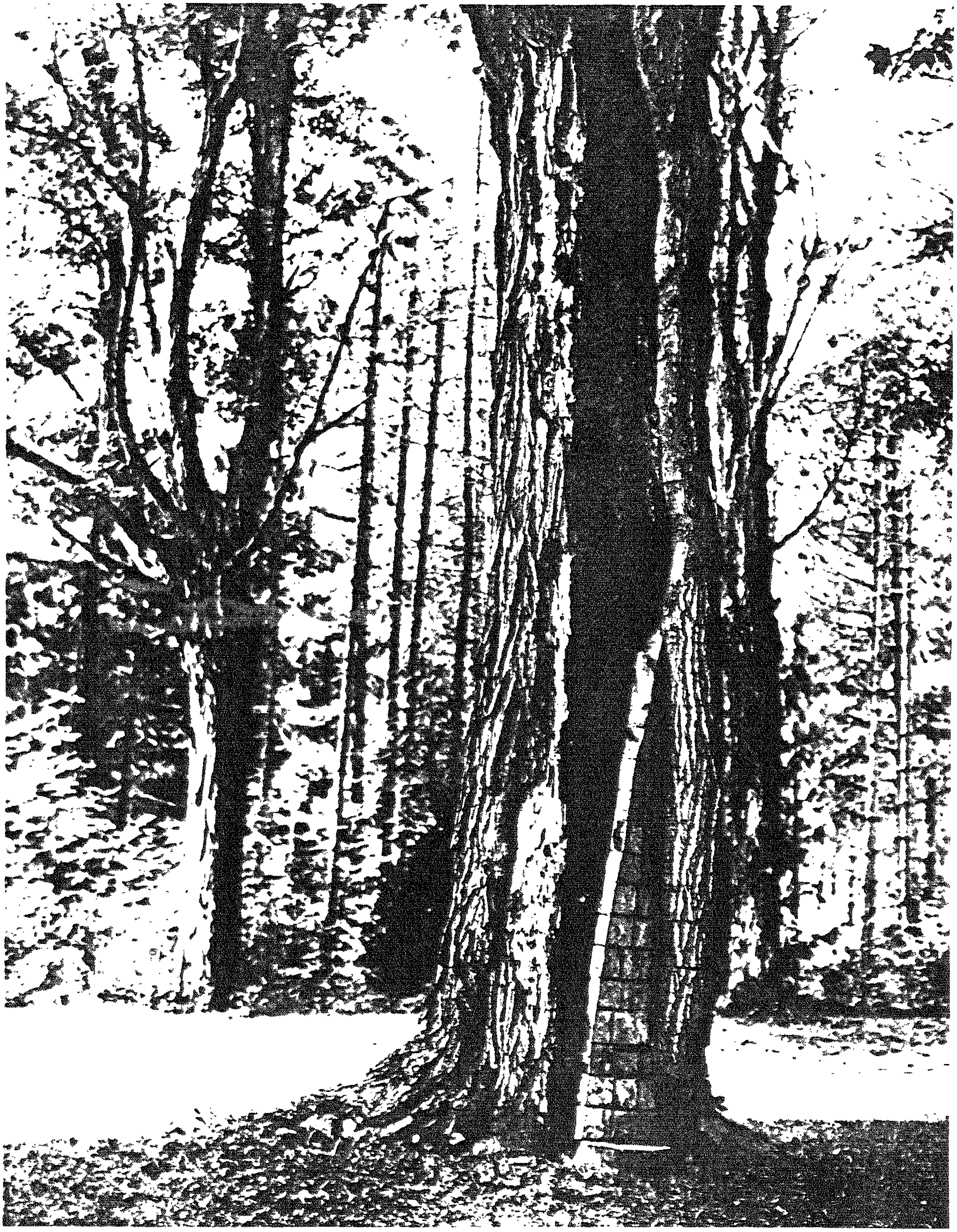


87. Trees with decayed wood are potential hazards. Trees usually fall as decayed roots break, or trees break at the 2-3-meter trunk level. More dangerous than decayed wood are the vertical cracks. When decayed wood also is associated with cracks on the opposite side of the tree, the tree is a high potential hazard.

88. Hollows in trees are often associated with old, large branch bases. Flush cutting of branches, especially large branches, is a major starting point for large hollows. A flush cut wounds the trunk. Rapid formation of callus follows. The large callus ribs form an oval around the hollows. The U-shaped callus on this tree indicates that the branch was cut too close to the trunk on the upper side.



89. Along with wound dressings, the filling of cavities was considered the mark of a professional tree expert or tree surgeon. The recommendation has been to clean cavities thoroughly before they are filled. "Thoroughly" meant to chip into the healthy wood behind the decayed wood. We now know that the only reason there is a cavity is that after wounding the tree formed strong boundaries about the injured and infected wood. If a cavity is to be filled, the natural boundary should not be broken. Cavities can be filled for aesthetic reasons, but materials that are coarse or abrasive should be avoided. And above all, clean out only the decayed wood that comes out easily. Do not break the boundaries. Boundaries were broken in this large sugar maple. The concrete shows the edge of the original filling, yet dieback extended far beyond it because of the thorough cleaning. Some practices die slowly. Not only are some trees injured severely by extensive internal cleaning beyond the boundary, but in some trees the protective callus is also destroyed. In attempts to help, man has often caused trees many problems. Much of this results from the desire to "play doctor" or "play dentist". Trees are not animals, and should not be treated like animals.



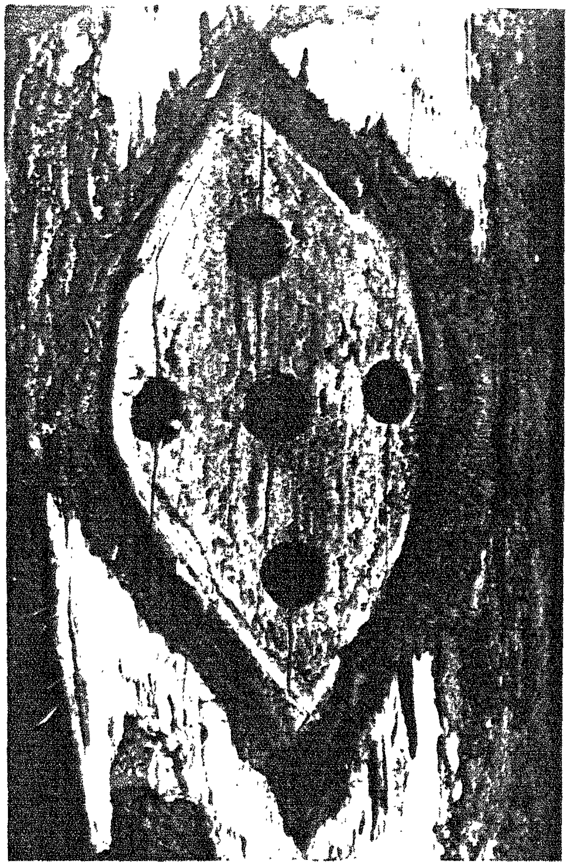
90. Removing dead and dying bark from the margins of fresh wounds can be beneficial to the tree. There is no need to scribe in the form of a vertical ellipse. It is important to cut as shallowly as possible and to round off the margins, especially the top and bottom. More dieback and cracks occur when the top and bottom are strongly pointed.

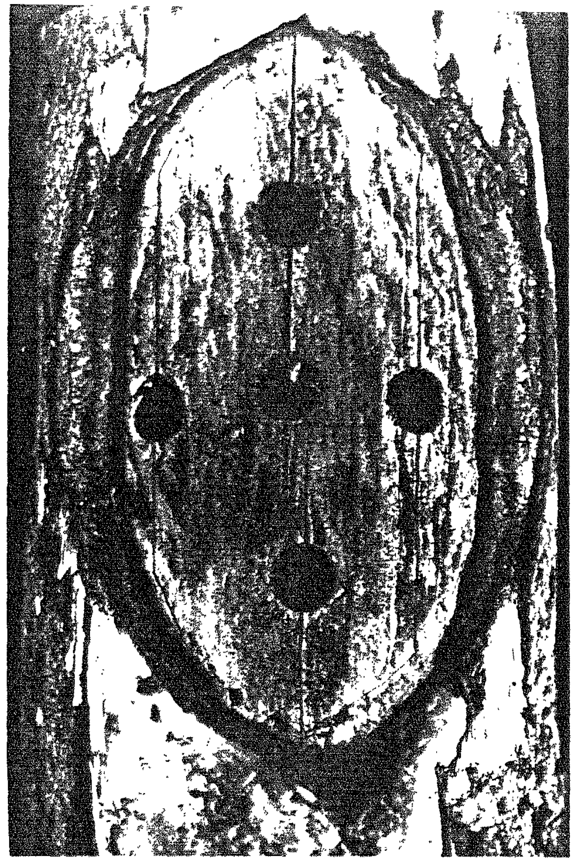
91. Hardware can be placed into trees to help maintain strength. Tubes can be used to drain wetwood fluids, but tubes or holes should not be used to drain water from a cavity. Why the difference? Wetwood is sound wood infected by bacteria. Decayed wood in a cavity is unsound wood. A hole into wetwood will extend the wetwood to the bark. A hole into decayed wood will extend decayed wood to the bark.

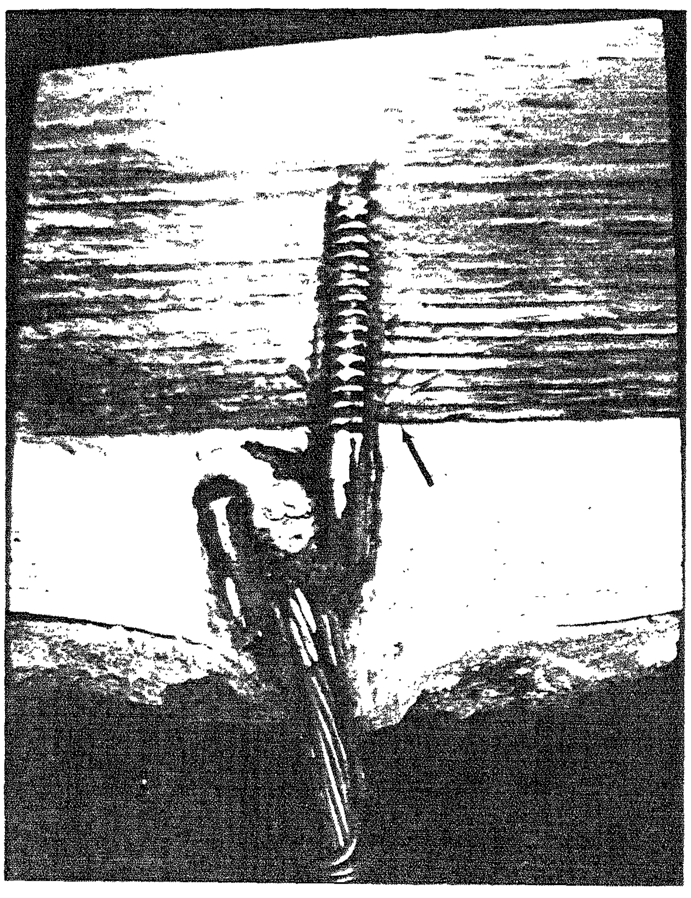
Avoid diamond-shaped washers. They cut into the cambium and retard closure, and may increase cambial dieback. Never dead-end hardware into decayed wood. The wood that forms after hardware is inserted does most of the long-term holding. Proper use of hardware can extend greatly the safe and attractive time of a tree.

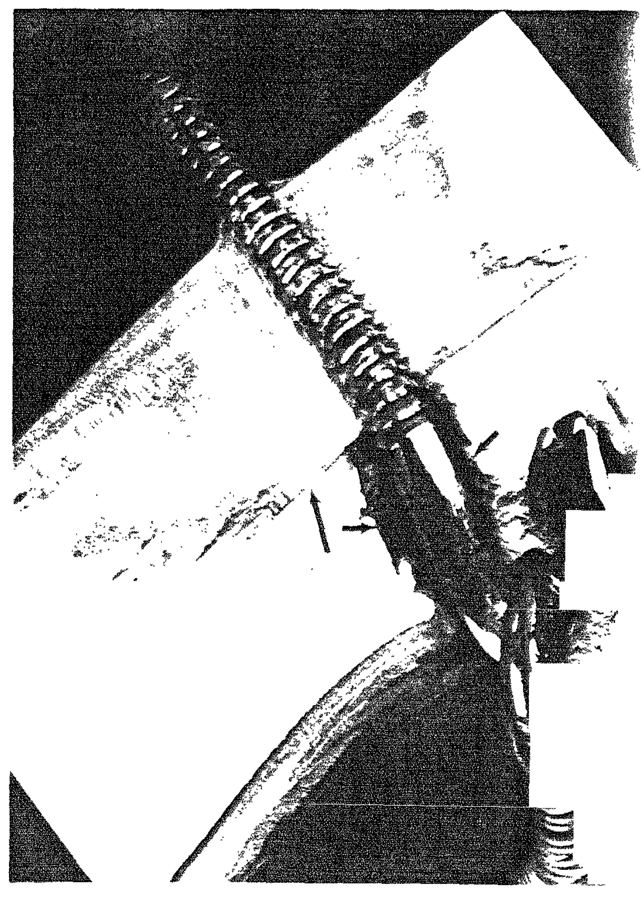
Discolored wood is on the inner side of this open screw lag in a red oak. The arrow shows the crack that usually forms after insertion of hardware. The open end of the lag is properly set. The new wood will hold for a long time.

92. Screw lag in a maple. Large arrow shows barrier zone that formed after the screw lag was inserted. The top of the lag went into decayed wood, and it fell away in sample preparation. The small arrow shows the cavity that formed as a result of movement of the lag. This type of lag will have a short life, because the new wood that formed after insertion will not hold it.



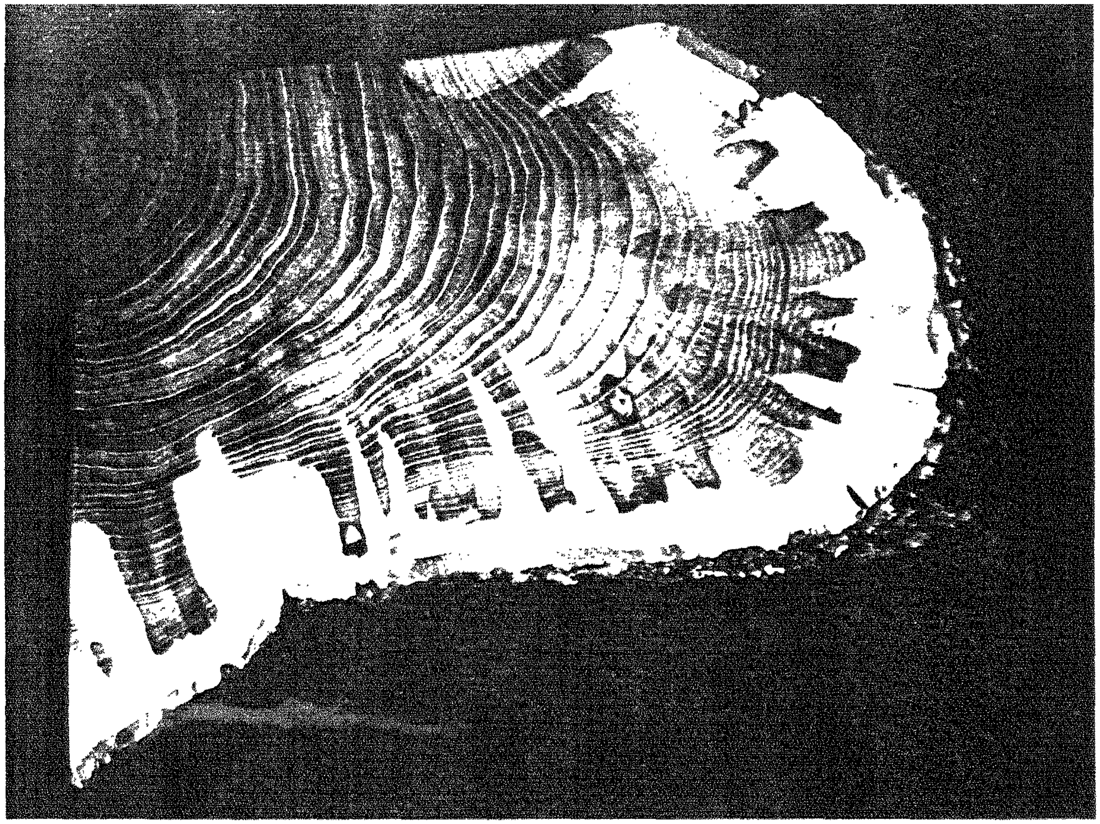






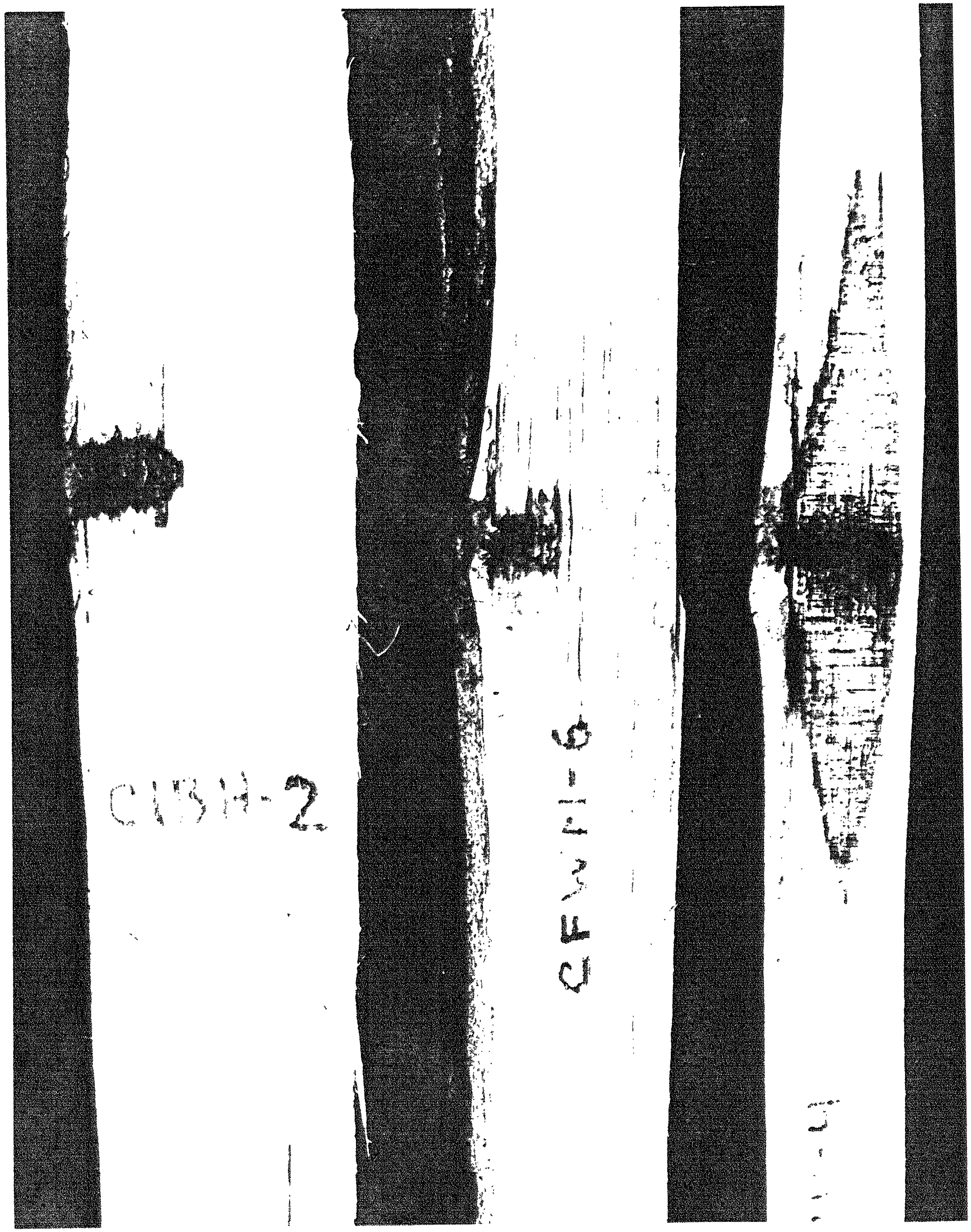
93. Injections and implants are being used for a great number of reasons, from supplying essential elements to adding many types of chemicals to combat insects and fungi. Care must be taken in the treatment so as not to cause more injury to the tree than it had originally. Injections properly done may be beneficial. Proper injections and implants should be as shallow and as small as possible, and at the base of the tree, not into the roots. The root flare was injected repeatedly on this American elm. American elms usually have 12 to 18 clear, healthy growth rings that store energy reserves. The injections and the associated discolored wood have reduced the energy-holding rings to only a few. Discolored wood is dead wood. It is highly doubtful that injections alone could kill a tree, but the combination of repeated wounds and chemicals that cause long columns of discolored wood could weaken a tree and make it an easy target for other invaders.

94. The many experiments conducted with drill holes give information applicable to injection wounds. In elm 132, the injection holes that touched the internal column of discolored wood spread to form large columns. The injection holes that were surrounded by clear healthy wood were walled off to small columns. Also, note the decayed wood in the columns that joined with the already present central column. Injections properly spaced in position on the tree butt, and spaced over time, will not cause serious internal injury. When trees are injected repeatedly over time, the discolored columns associated with the injection wounds begin to coalesce. The volume of wood that would normally hold energy reserves is reduced.



95. Most of the transport in a tree occurs in the current growth ring. There is no need to inject beyond this wood. In many cases it is not the wound, but what is put in the wound that causes injury. Several injection methods are now using very small holes—microinjections. These samples show small control holes, in which no materials were injected, in three tree species after 1 year; left to right: shagbark hickory, white oak, and red maple.

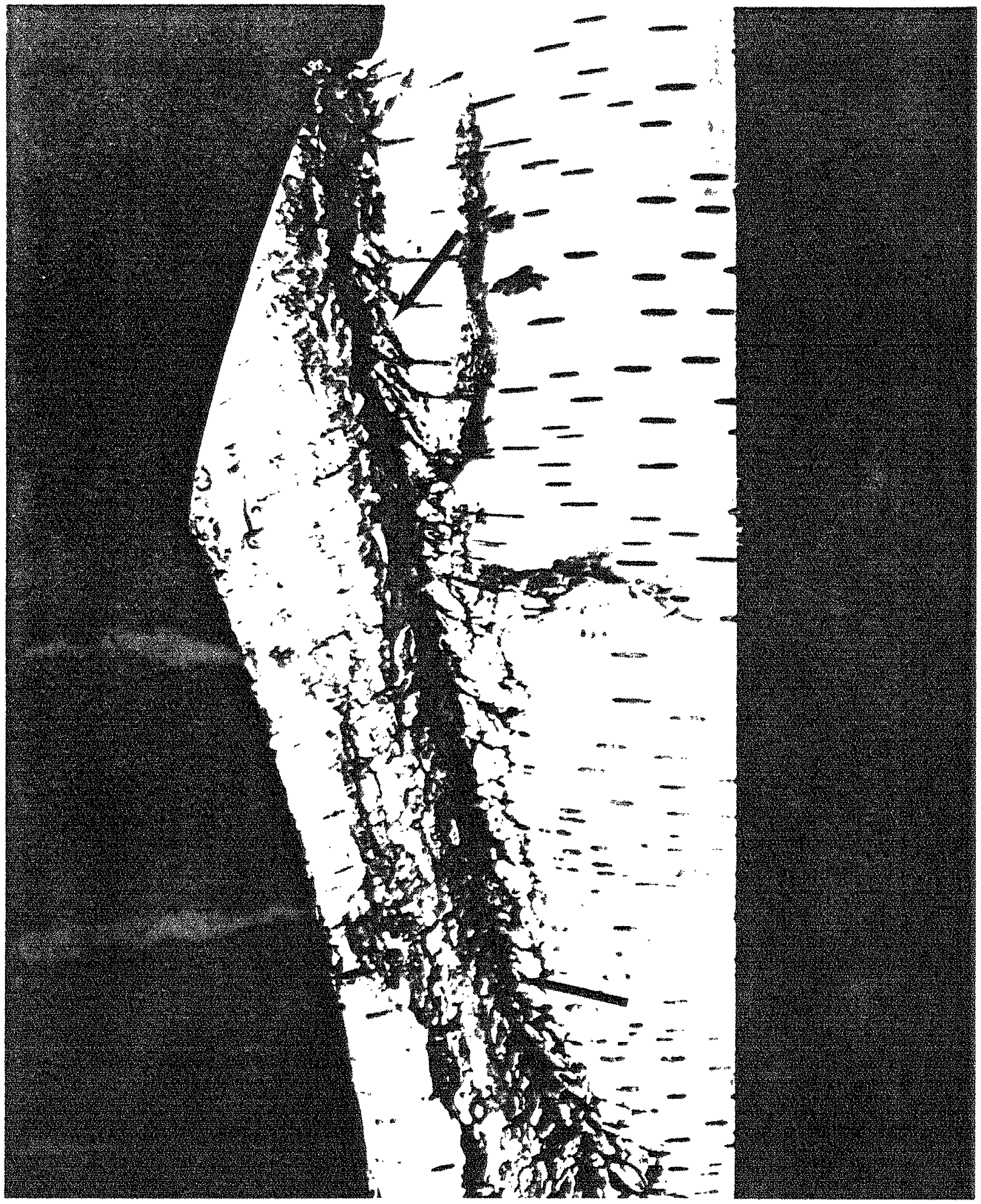
Injections in young, smooth-barked trees may result in cracks and blemishes that are considered unattractive. Indeed, attractive bark is a major reason for having ornamental trees. Injection holes, or any type of wound, should never be directly above or below other wounds. Proper injections require a high degree of skill.


CIBH-2
CFWH-6

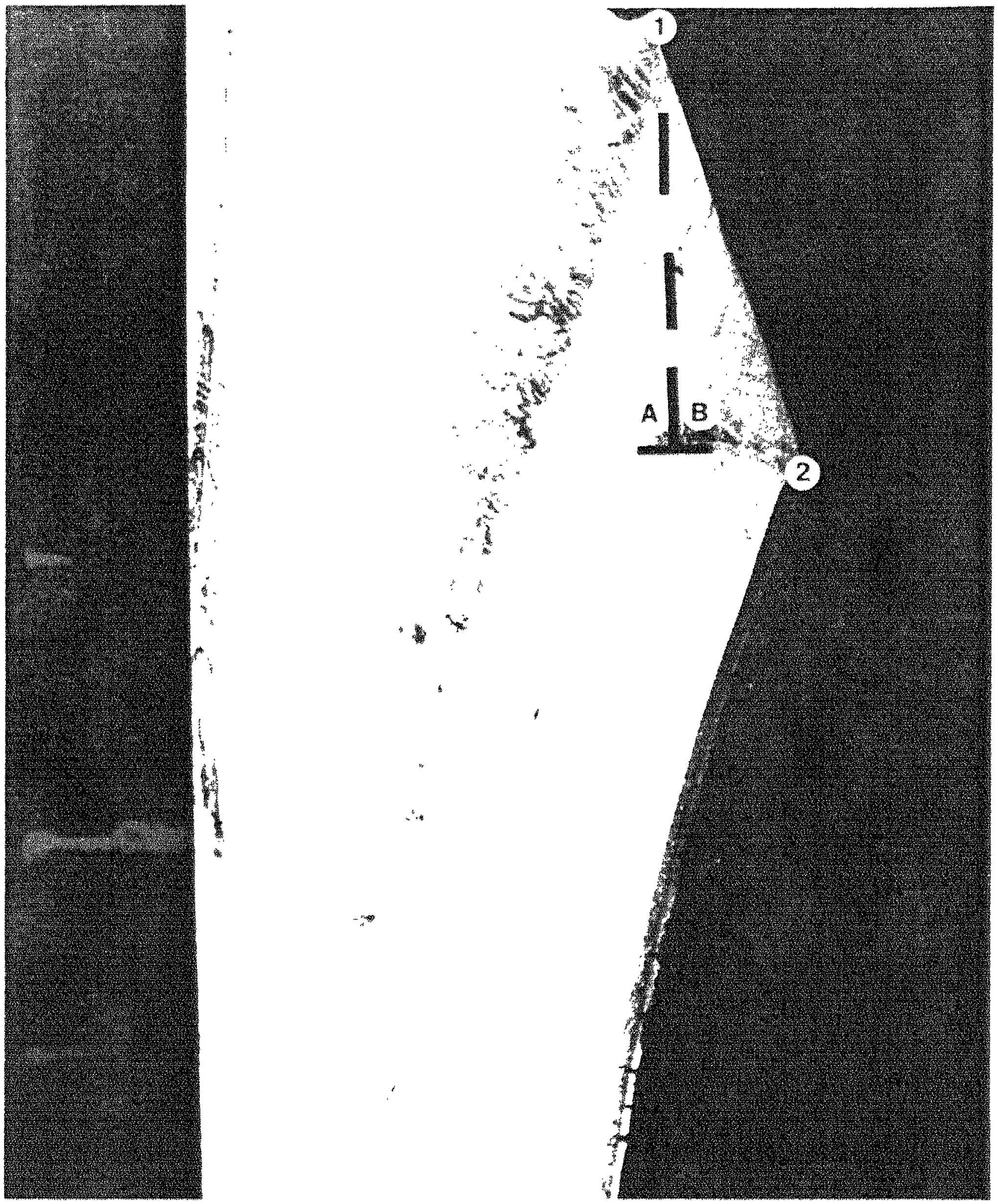
Pruning

Pruning properly done is the best treatment for trees. Pruning improperly done is the worst injury that can be found on trees worldwide. Branches are either cut leaving a long stub, or cut so close to the trunk that a trunk wound results. The close cut, or cut that is flush to the trunk or larger supporting branch, is called a flush cut. Such cuts have been recommended for hundreds of years. Why flush cuts? A flush cut injures the larger supporting branch or trunk. When the larger stem is injured, it begins to form a callus. The formation of callus has been considered a sign of "healing". Therefore, the idea was, to promote healing, cut branches flush. The more flush, the larger the callus, therefore the better the "healing". We now know that trees do not replace injured wood; callus is formed by the new growth rings that continue to grow after the pruning cut. Large branches cut flush will form large oval callus rings. When the center decays away, a cavity is formed. Large flush cuts are major causes of cavities. Here are some photos that show proper and improper pruning, and the internal results.

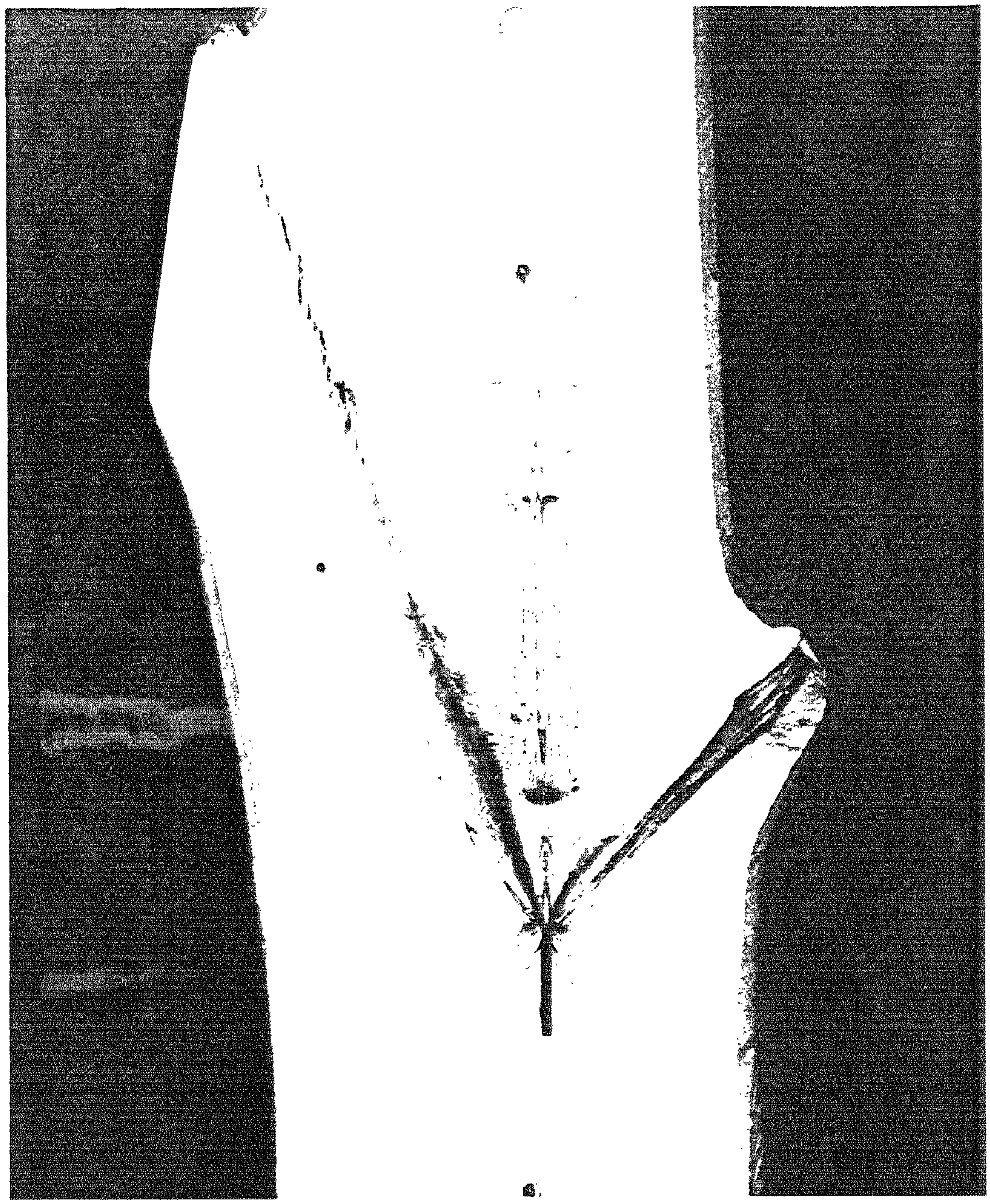
96. The branch bark ridge (BBR) (arrows) is very pronounced on this paper birch sample. The cut is at the proper angle. The BBR forms as the enlarging branch pushes against the enlarging stem. The branch enlarges as an expanding cylinder, and so does the stem. But, the two expanding cylinders are at an angle, and the meeting of the two constantly expanding cylinders produces the BBR at the crotch of the branch. The raised bark is carried on the bark as a ridge. The lowest point of the BBR shows where the branch started as a bud.



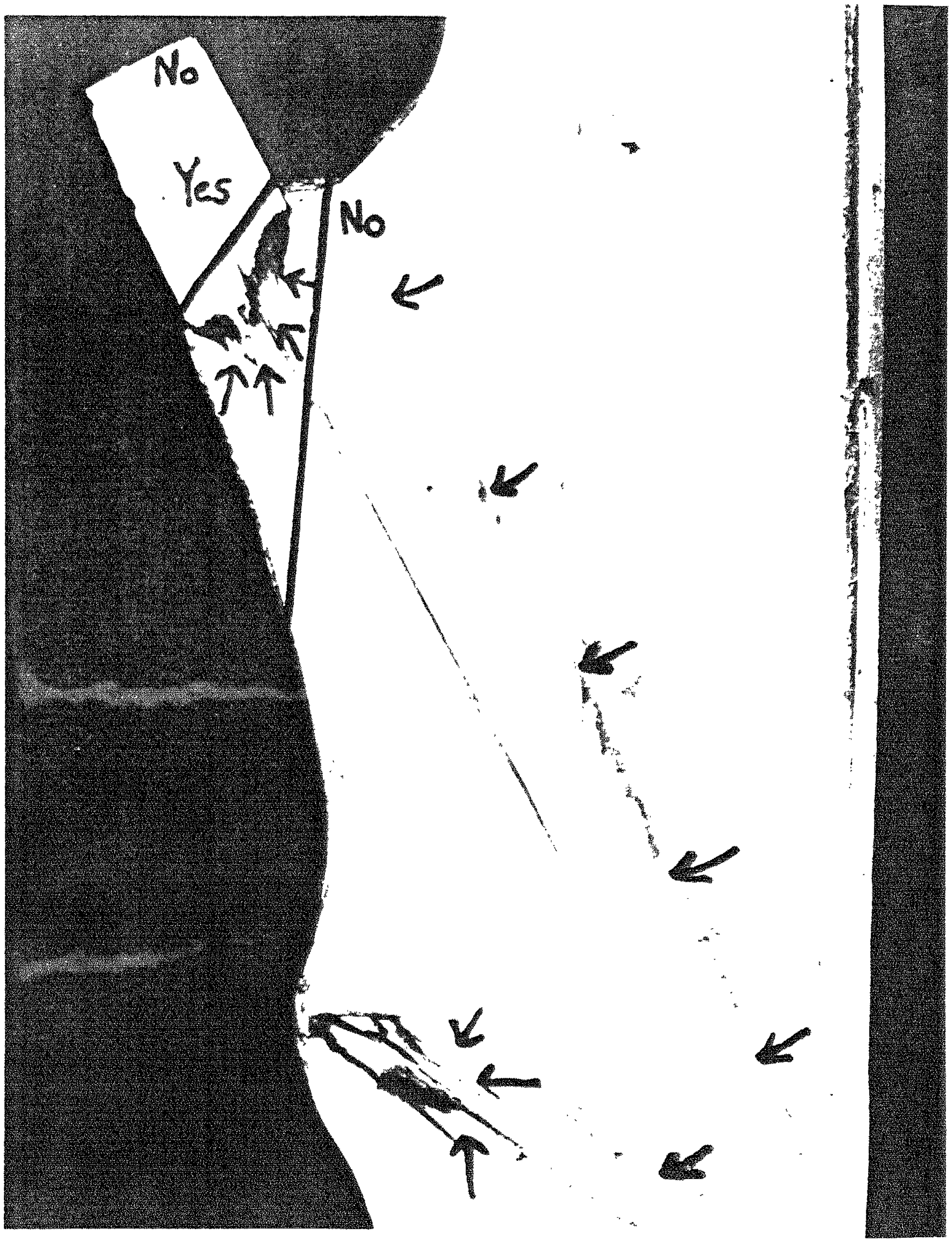
97. Dissection of the birch sample shown in the previous figure shows the inner hard tissues that separated the developing branch from the expanding stem. Target 1 shows that the trunk has not been wounded. Target 2 is the part where the expanding circle of the trunk meets the expanding circle of the branch. Tissues below target 2 are trunk tissues. If a straight line were drawn as shown, from target 1 downward, Angle A to the BBR equals Angle B to the proper angle of cut. When in doubt about target 2, the straight line can be "drawn" in your mind on the outside of the stem, and the proper angle of cut determined very easily.


1
A
B
2

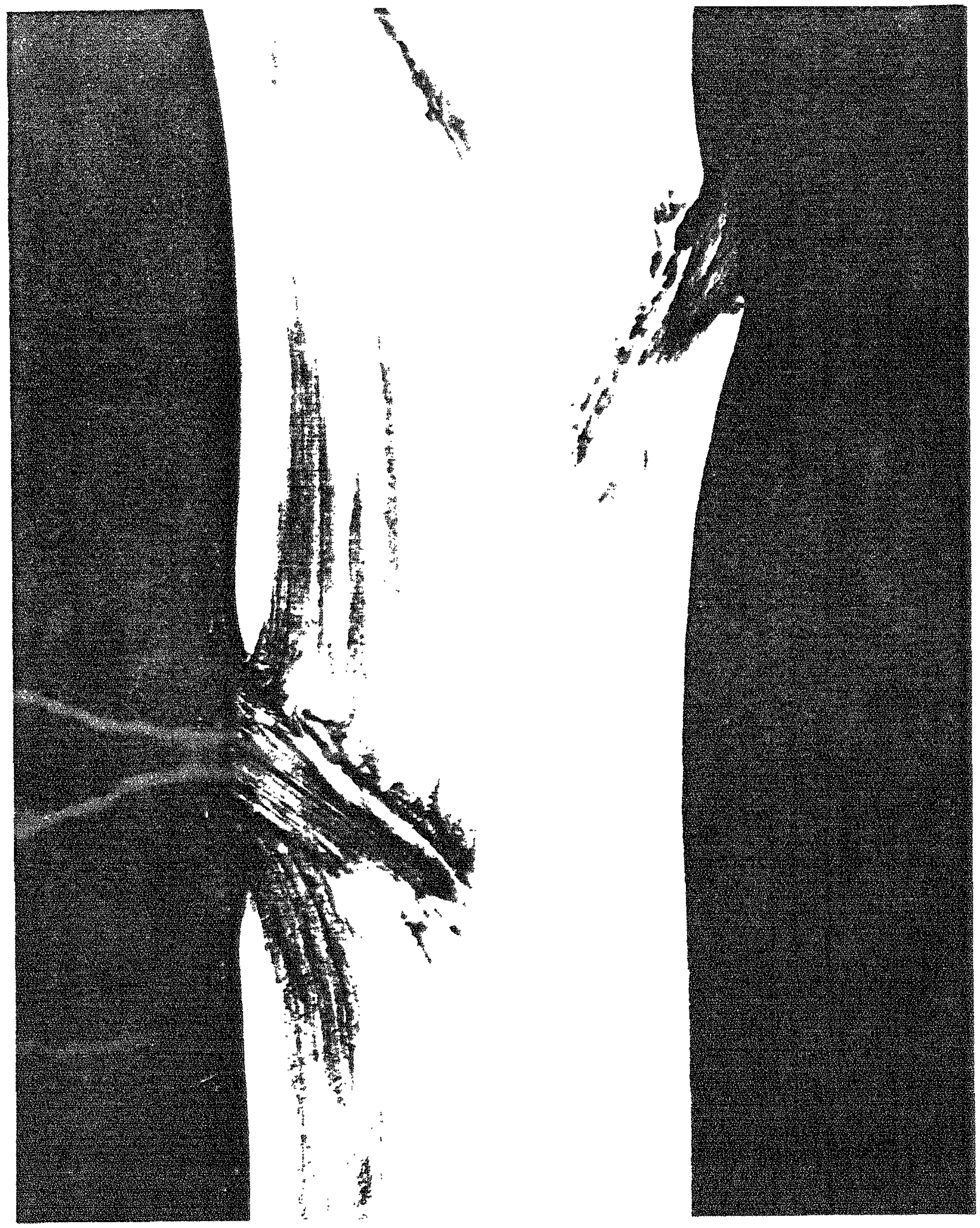
98. Properly cut living branch on a red maple. Note that the hard inner tissues that separate the branches from the stem start at the point where the buds were set on the end of the twig (arrow). The hard inner tissues that are shown as the BBR on the outside separate the two branches from the trunk. The small branch on the right died, and it was shed. Trees do not cast off branches; the trees wall off the branch, decay spreads downward to the branch base, and the weakened branch falls away. All properly shed branches will have a small pocket of walled-off decayed wood at the branch base. The decay seldom spreads; it is walled off in the branch compartment.



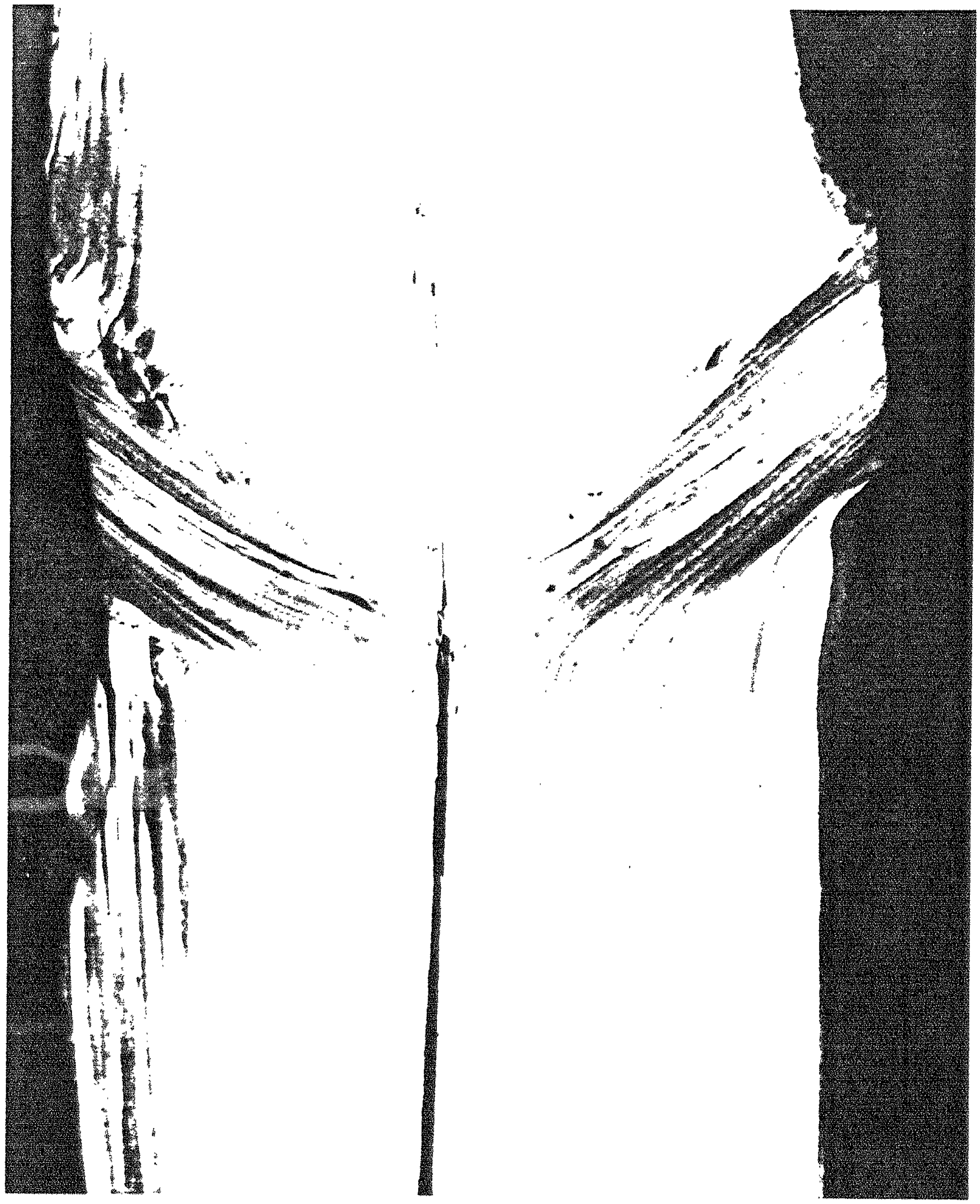
99. Dissections of a red maple stem showing a dead branch and its union with the living trunk. As branches wane and die, many microorganisms begin to infect the dying and dead tissues. Decay-causing fungi usually infect and begin to spread downward to the branch base, or the branch collar. The branch collar is the swollen basal tissue—trunk tissue. As the branch dies and as microorganisms spread downward, the tree begins to form a boundary of chemicals at the position where the last area of branch tissue is enveloped by trunk tissue. In hardwoods, the boundary contains a high concentration of phenol-based materials, many of which have been oxidized, and thus act to inhibit the spread of many microorganisms, especially the decay-causing fungi. When pruning dead and dying branches, great care must be taken not to remove the protective boundary zone. Do not leave a stub. Do not flush cut. Cut as shown in the figure. Do not remove the living ring of wood that surrounds dead branches. Note the well-compartmentalized pocket of decayed wood associated with the small lower dead branch core wood. The inner BBR is also shown.


No
Yes
No

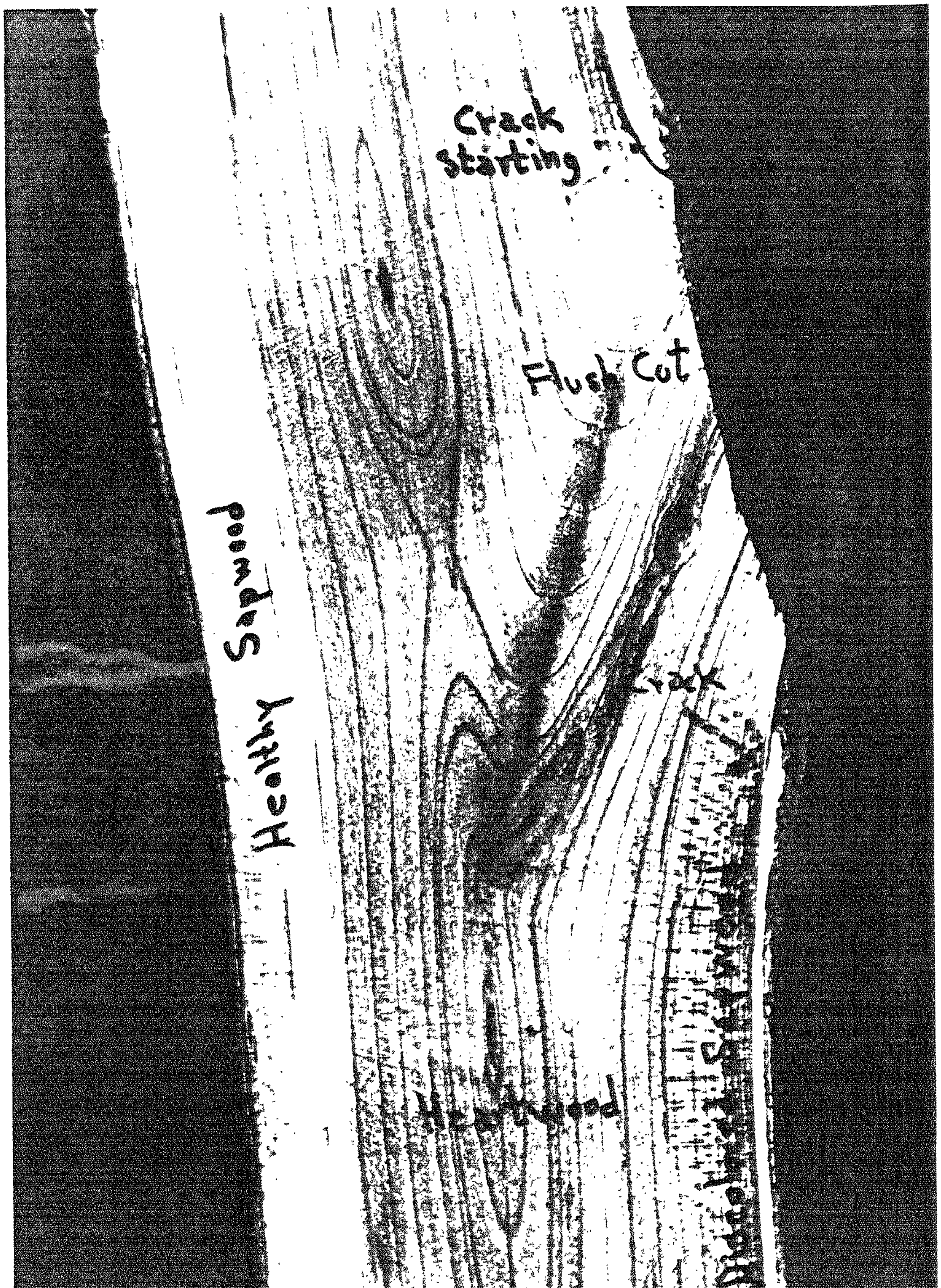
100. A yellow birch pruned in January, 1981, and dissected in July, 1981. Upper branch properly pruned, lower branch improperly pruned.



101. Improper cut on left, and proper cut on right, of a white pine after 1 year.

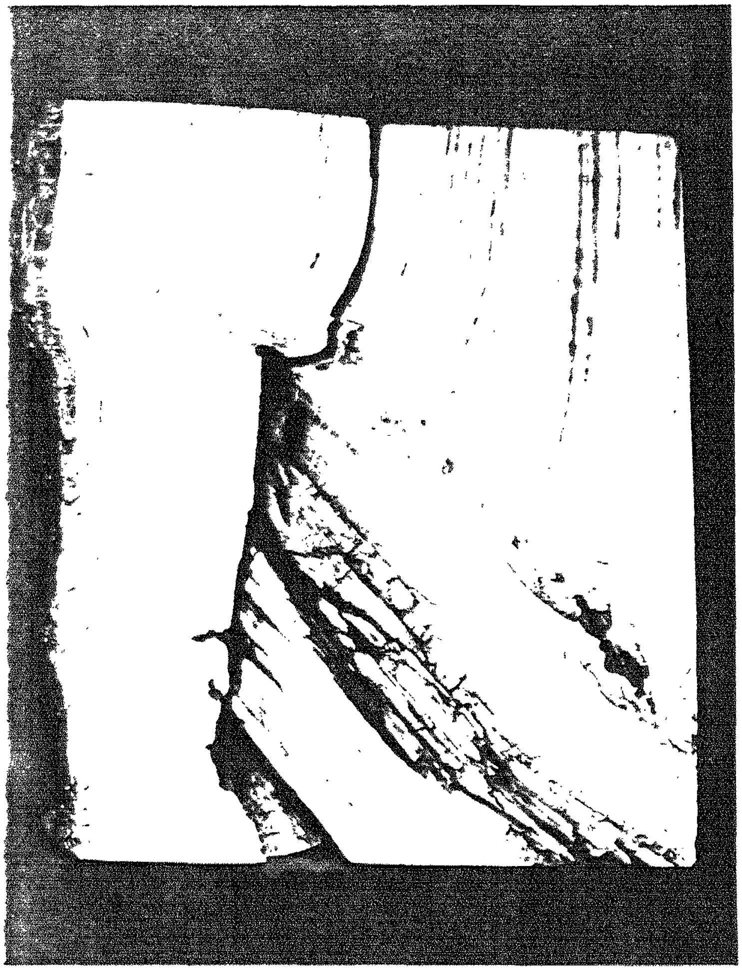


102. One growing season after improper cutting of a living branch on a black cherry. Note discolored band of sapwood on flush cut side. Only a thin band of sapwood is above and below the cut. The discolored sapwood reduces the volume of wood that stores energy reserves. The single growth ring of sound sapwood may easily crack or split from sudden cold or sudden heat—"frost cracks" or "sunscald". Insects often infest the thin band of tissue. Canker-causing fungi often infect the weakened tissues around such cuts. Cracks may also form as Wall 4 forms. All because of a flush cut!

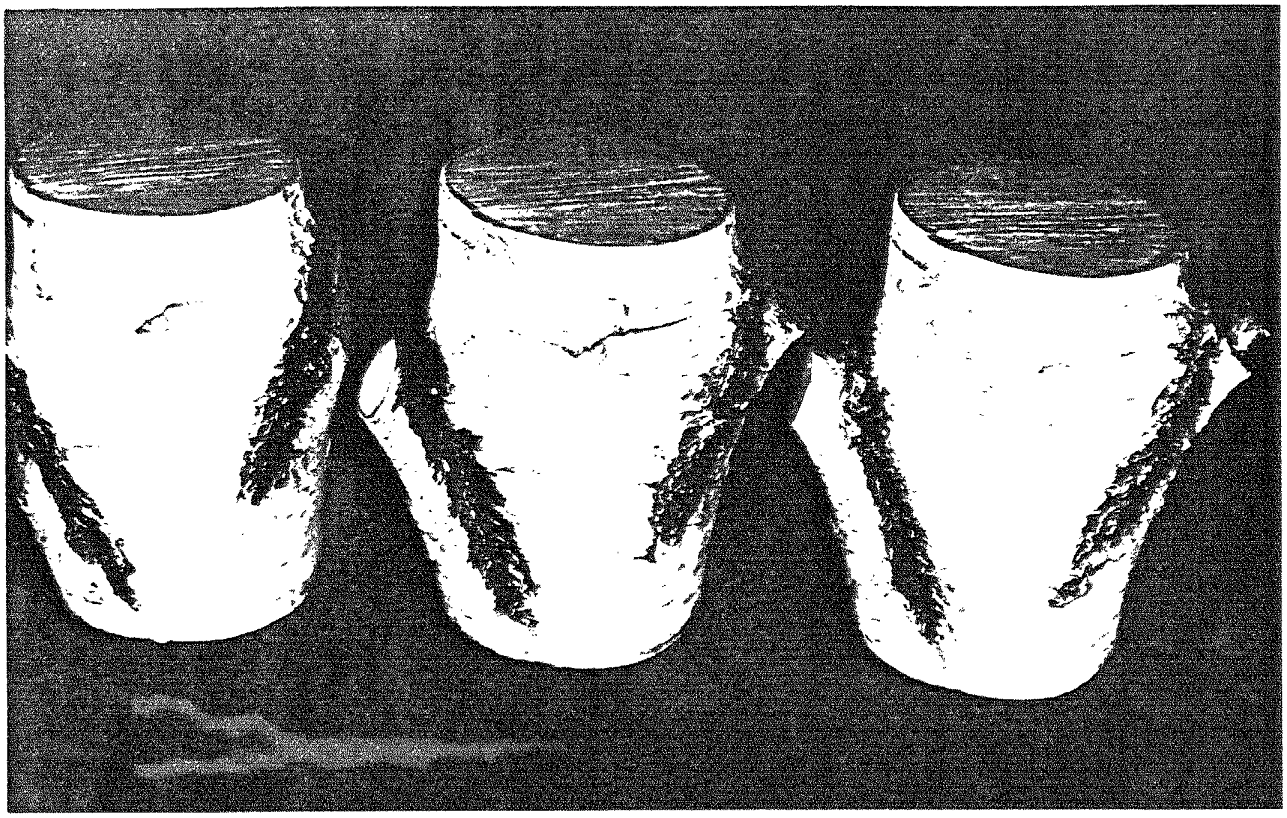

Crack
Starting
Flush Cut
Healthy Sapwood
Crack
Heartwood

103. Proper cut of a red oak branch after 50 years. Closure was complete. The brown rot that was in the branch at the time of pruning was still walled off within the branch.

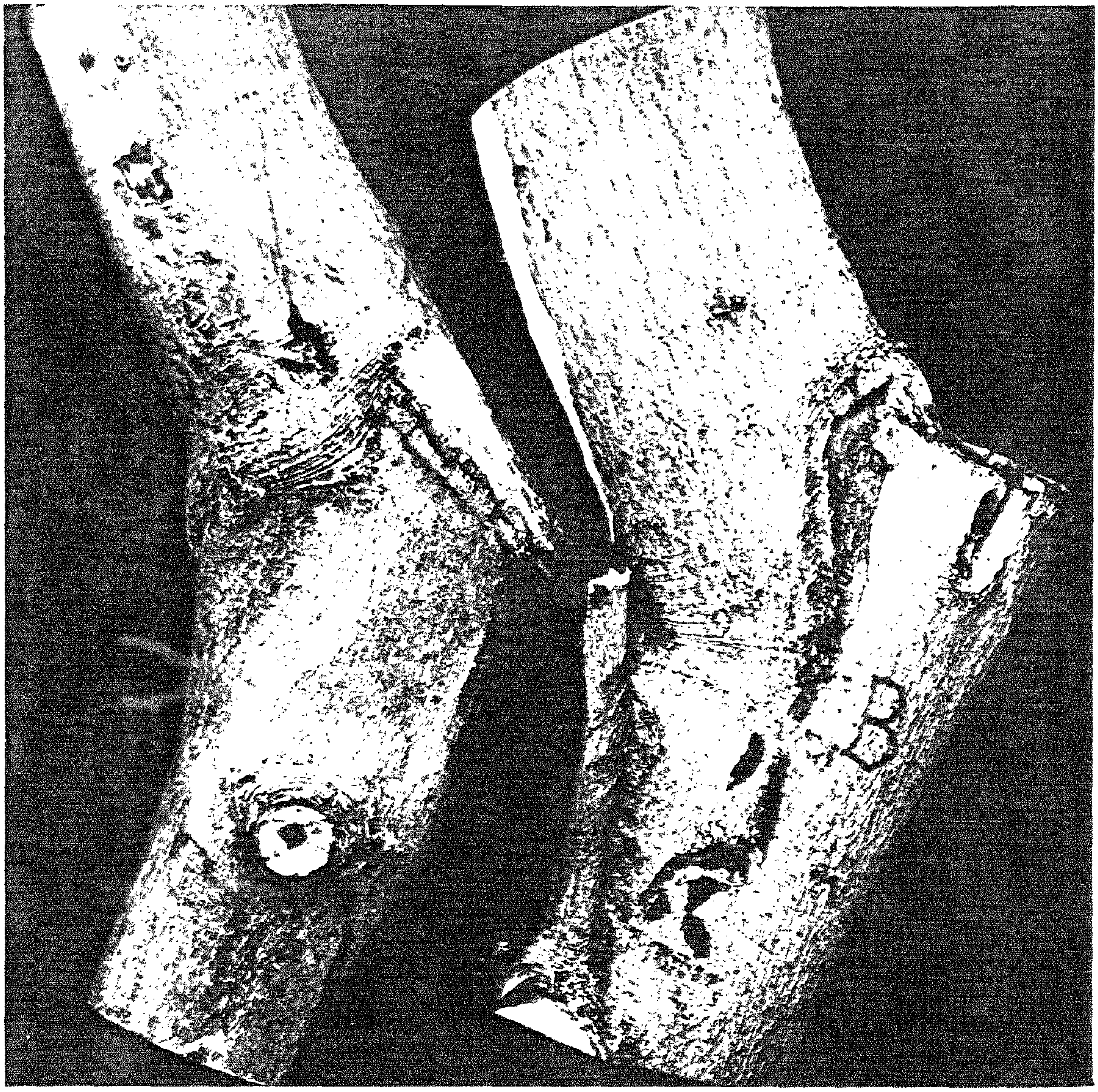
104. Improper cut of a red oak branch after 30 years. Closure looked complete, but the crack was still open, and made conditions perfect for the decay-causing fungi. Decay was advanced in the wood present at the time of the harsh flush cut. Insects infested the dying tissues surrounding the cut, in spite of the coating of wound dressing on the surface of the cut. Such cuts cause serious injury.



105. Summary of proper and improper pruning: The three samples are rubber models all made from the same section of paper birch. The model at right shows a living branch cut too long (left), and a dead branch cut too long (right). The center model shows proper pruning of a living and dead branch. The model on the left shows improper (too close) pruning: live branch (left): dead branch (right).



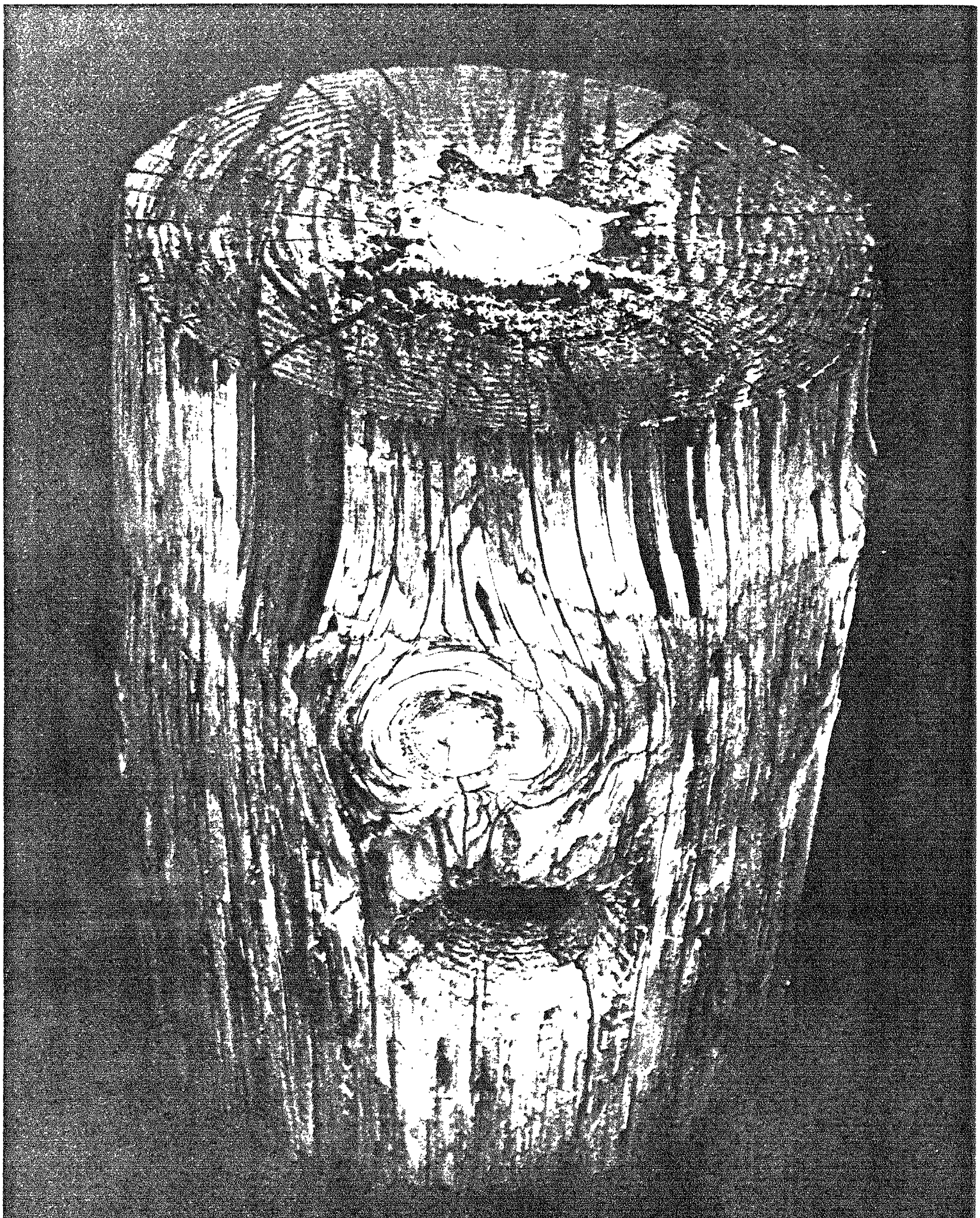
106. When it is necessary to cut off the leader of a tree and have a branch develop as a new leader, the old leader should not be cut flat across the stem. This type of "flat-top" cut will start decay rapidly. The proper cut is on the left; the flat-top cut is on the right. Both red maple trees were the same age. Note the complete ring of callus on the left sample. When a top cut must be made, start on the inner side of the branch bark ridge, opposite where you start when removing a branch. The cut should be slanted at approximately the angle of the branch that will be the new leader, which will also be fairly close to the angle of the branch bark ridge.


B

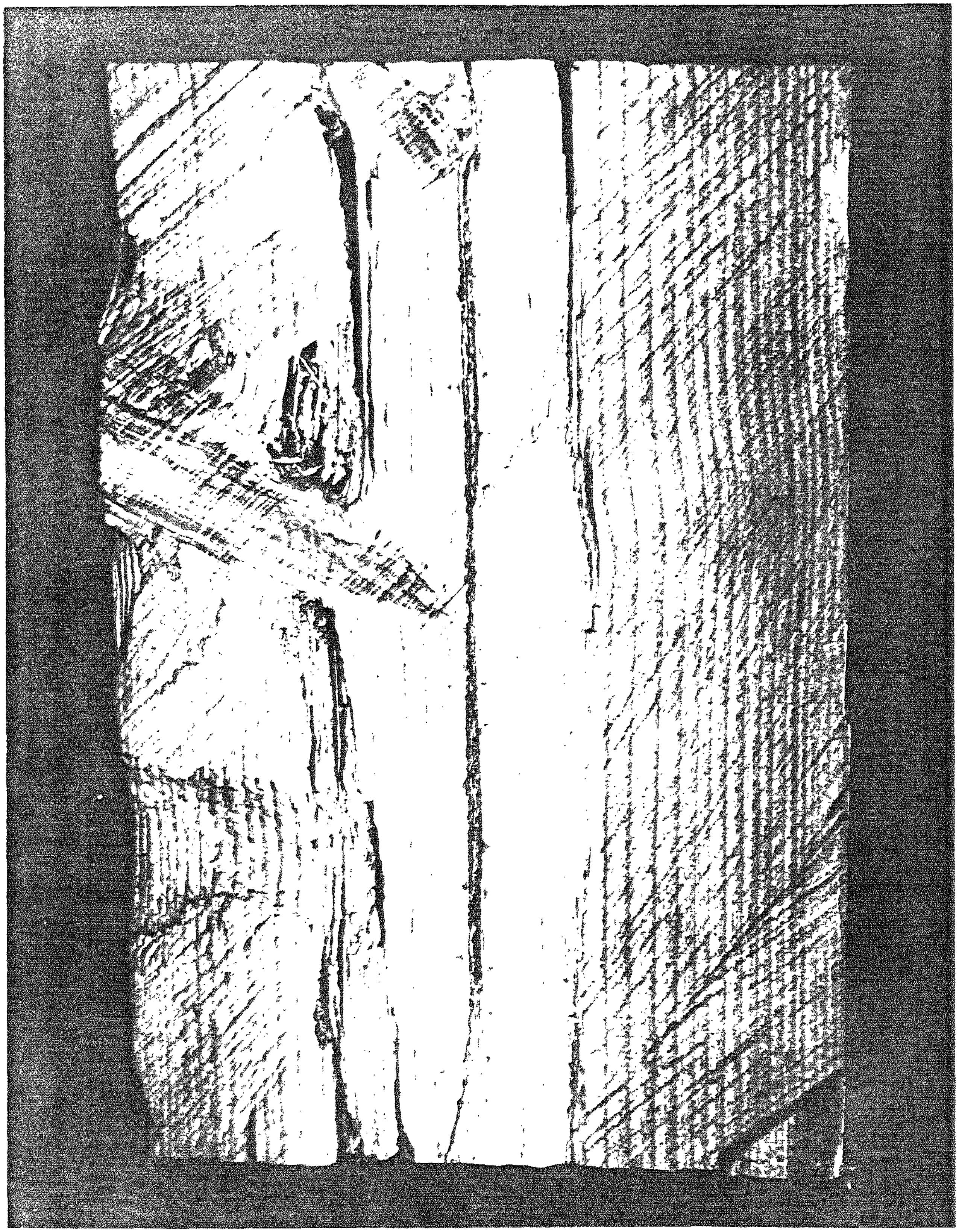
107. Dissection of the red maple samples shown in the previous figure: proper top cut on left, improper cut on right, after 3 years. When a top cut is made, it causes serious injury no matter how it is done. But the degree of injury can be greatly reduced by starting on the inner side of the BBR, and slanting the cut approximately at the angle of the BBR. The word "approximately" is used here because it is difficult to determine the exact angle of cut due to the bends in the branches. But flat-top cuts should never be made. Why? The stub of wood that remains will be dying wood, and microorganisms spread most rapidly in dying wood. The stub will be alive, but defenseless, just like a branch stub. The tree walls off the cut where the end of the original cut should be made. The angle of the proper cut was determined from dissections of flat-top cuts, as shown on the right. Note the large amount of decayed wood in the right sample. Flat-top cuts are causes of serious injury to orchard trees, especially species of *Prunus.* Ornamental cherry varieties are also very sensitive to flat-top cuts.

Topping cuts should not have too steep an angle. A steep angle cut will lead to decay above and below the cut. Improper topping cuts can lead to limb drop, as the new leader grows larger and as the decay in the old trunk develops downward.

108. Many defects in wood products have their origin in the living tree. After a branch or root dies, or the tree is wounded, the tree responds by setting boundaries to resist the spread of infections. The boundaries are often the sites of cracks in wood products. Also, the injury-altered wood within the boundaries is often the first wood to be attacked by other microorganisms when it is made into a product. Insects—ants, termites—also infest first the injury-altered wood. In many cases the wood is really not defective when it goes from the tree to the wood product, but it will not last long. The many large stubs in this pole were the start of problems about 15 years after the pole was set. The wood that was altered when the branch died began to decay. The decay did not spread into the heartwood or outward to the wood *that formed after the branch died.* The pattern of decay was not determined by where the preservative penetrated. Cracks started from the internal decayed wood and spread outward. (Checks start from the outside and move inward.) Ants infested the decayed wood through the cracks. Woodpeckers bored many holes in the pole to eat the ants. The poles had to be replaced.

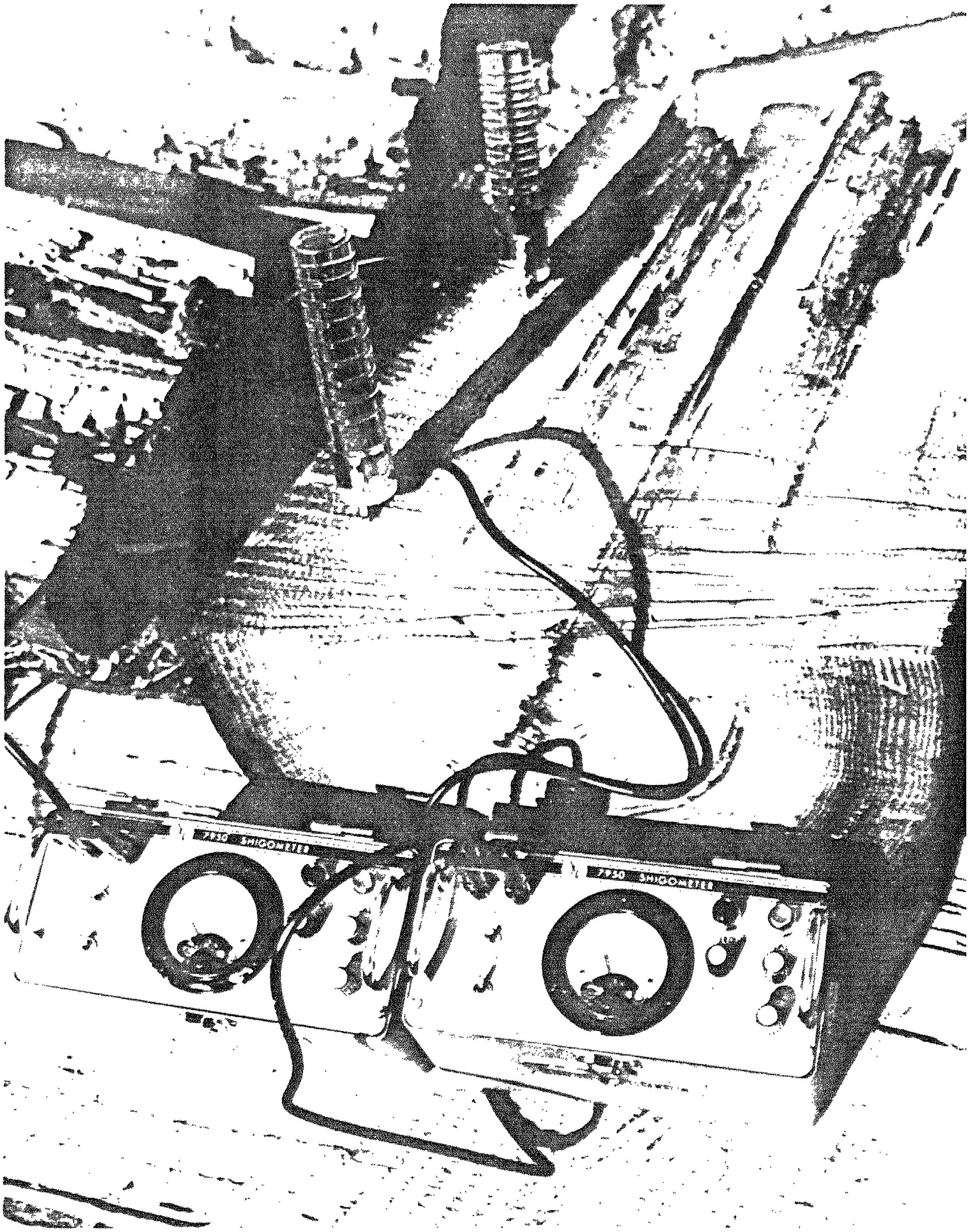


109. Dissected view of pole sample shown in previous figure. Note the column of decayed wood associated with the branch wood.



110. New electrical tools have been developed that now make it possible to detect decayed wood in living trees and in wood products. The meters register, in ohms, the resistance to a pulsed current that is generated by the meter and passed through the wood through a variety of electrodes. A skilled operator who understands wood and trees, and CODIT, can use the pattern of electrical readings to help determine the internal condition of the wood.

For experimental purposes, the meters are being used with double-needle, noninsulated electrodes to measure the resistance of the wood directly below an obvious column of brown rotted wood (above) and wood distant from the brown rotted wood (below). The meter on the left shows 20 Kohm for the upper electrode; the meter on the right shows 140 Kohms for the lower electrode. Note also how abruptly the brown rot ends.


7950 SHIGOMETER
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