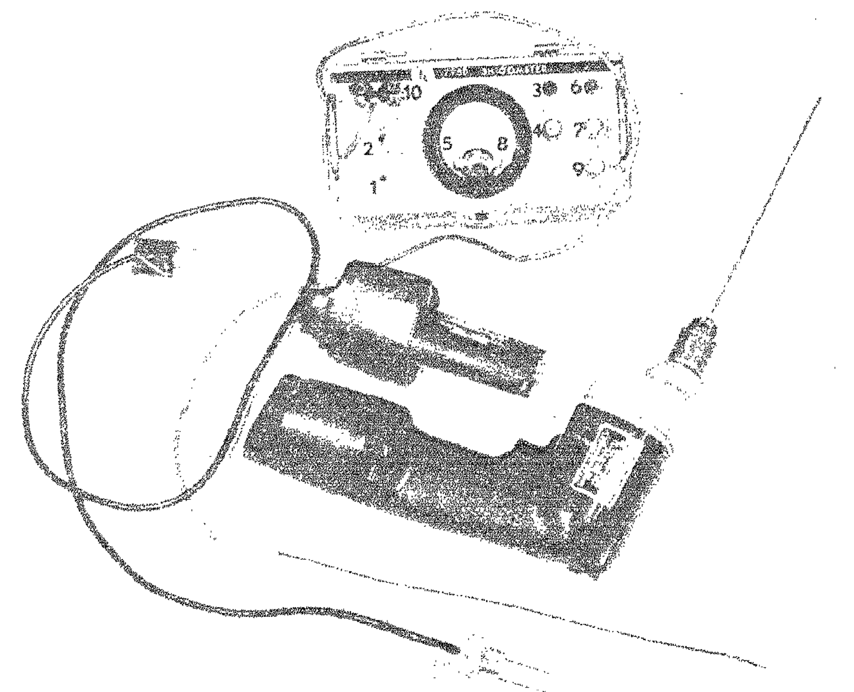
Detection of Active Decay at Groundline in Utility Poles



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ABSTRACT

Active wood decay at groundline in in-service utility poles can be detected by a skilled inspector using:

1. A knowledge of basic patterns of decay.
2. Recognition of obvious signs of decay.
3. Proper interpretation of information obtained from a pulsed-current meter—Shigometer®—used with various probes and probing techniques.

WOOD DECAY is a major cause of damage throughout the world to in-service utility poles. Despite preservative treatment, some poles in service, especially the older ones, develop decay. Poles weakened by decay can fall during storms or while being climbed.

Decay is a condition of the wood. It is the final stage of a long, complex deterioration process that includes the activities of many species of microorganisms. These microorganisms digest the walls of the wood cells; but they do this only when temperatures are above freezing, under favorable conditions of moisture and air, and when preservatives are either lacking or beginning to lose their protective properties.

Prevention is the best answer to the decay problem. Prevention starts with the selection of high-quality, defect-free poles, followed by the proper treatment with preservatives. After poles are placed in service, routine periodic inspection is necessary to ensure that utility poles are in serviceable condition. The earlier decay is detected, the better the chances are for refurbishing the pole, stalling decay, or minimizing the damage that could occur. Timely detection of decay, coupled with on-site supplementary preservative treatment of infected poles, can arrest further deterioration and contribute to the safety, economy, and longevity of the pole.

Active decay at groundline in poles can be detected accurately and rapidly during an inspection with these basic skills:

1. A knowledge of decay and common decay patterns in poles.
2. Recognition of common signs of decay; tools such as a Phillips screwdriver or hammer may aid in this operation.
3. Proper interpretation of information obtained from a pulsed-current meter—Shigometer®[1]—used with various probes and probing techniques.

[1]The Shigometer® is a registered trademark for a pulsed-current meter manufactured by Northeast Electronics Corporation at Concord, New Hampshire. The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader; such use does not constitute endorsement or approval by the U. S. Department of Agriculture, the Forest Service, or Western Electric of any product or service to the exclusion of others that may be suitable.

The purpose of this paper is to give the pole inspector the information he needs to detect decay in utility poles. Emphasis is placed on proper use of the Shigometer, and on photographs that can be used for easy reference in the field.

COMMON DECAY AND DECAY PATTERNS IN POLES

Types of wood alteration in poles

Types of wood alteration in poles

White rot.—White rot results from infection by certain fungi that digest the lignin and cellulose in the cell walls of the wood at an equal rate. This is the most common type of decay in poles. As the decay develops, the strength of the wood is reduced greatly.

Brown rot.—Brown rot results from infection by fungi that digest the cellulose of cell walls preferentially, and alter the lignin only slightly. Wood is weakened greatly by brown rot, even in the early stages of the process. Infected wood often is brown and cube-shaped; the decay columns usually end abruptly.

Soft rot.—Soft rot results from the infection of the middle layer of the cell walls by microorganisms different from those that cause white rot and brown rot. Cavities may form, or the middle layer may be partially digested; wood altered by soft rot may have a charred appearance.

Stain.—The cell contents of the wood are altered, usually by microorganisms. A common term for this is "bluestain". Stain usually develops soon after trees are cut, and it appears as wedge-shaped blue or black areas on the exposed ends of logs. The microorganisms associated with stain grow rapidly into the ray cells, where there is an abundance of materials needed to support their life. Stain at the outer surface of fresh poles may be caused by nonliving agents as a result of oxidation. Stain does not reduce the strength of wood, but may affect the penetration of preservatives, which could affect the development of decay.

Bacterial alteration.—Bacteria may attack the pits of cells and weaken them. This condition can occur in logs placed in ponds for long periods. The altered pits may affect the penetration of preservatives.

THE LIVING TREE

The condition of the wood in the living tree at the time it was cut for a pole is extremely important in determining whether decay will develop rapidly in the pole. The wood in the tree may already be in an early stage of decay, or it may already be altered so that preservatives will not penetrate some portions of the wood. Or, it may be altered so that moisture concentrates rapidly in some portions of the pole. The condition of the wood in the tree also has a strong effect on the patterns or configurations of the decay that may develop in the pole. It is important to remember that the pole was first a living tree.

Development of decay

An understanding of decay development in living trees is absolutely necessary if one hopes to understand decay development in dead poles.

In trees, wounds start the processes that can lead to decay. A wound is any break in the bark that exposes injured xylem, or wood, to the air, which is full of fungus spores and bacteria. Many agents wound trees; insects, birds, animals, storms, fire, and, most important, man. But the most common and often the most serious wounds on trees may go unnoticed. These are the wounds that are caused by branch death.

All trees have branches, and all trees lose some branches during their lifetime. When a branch dies, or is torn off, or is cut off, an opening into the tree results. When the tree is vigorous, and responds strongly to the wound, the wood-inhabiting microorganisms may not invade. But when the wound response is weak, the microorganisms may invade rapidly.

The tree has a unique system for interacting with invading microorganisms. Trees do not "heal" wounded tissues. *Heal* means to restore to a previous healthy state. Once wood tissues are injured, they are never repaired, replaced, or restored to their previous healthy state. Trees wall off, confine, or *compartmentalize* injured and invaded tissues.

A highly compartmented multiple perennial plant, a tree is constructed like a battleship. When a battleship is hit, the damaged area is sealed off by closing doors—and the ship keeps going. A tree has a similar defense system; but a tree forms a new set of compartments every year in the new growth ring. This would be similar to a battleship being enveloped by a new ship every year; and each new ship would have its own compartments. When a tree is wounded, the "doors" start closing around the injured areas. This defense system minimizes the number of compartments that are invaded. And like the ship, the tree keeps going.

When a tree is wounded, it reacts. A chemical barrier is formed around the injured tissues. The tissue systems near the wound that transport liquids are often sealed off or plugged. In some trees such as the conifers that are used for poles, resin floods and plugs the injured areas.

But one of the most spectacular events takes place in the cambium around the wound. The injury triggers mechanisms in the cambium that produce altered cell types and arrangements. In a sense, the cambium begins to form a barrier wall. If the microorganisms have been able to get into the tree and to invade the wounded tissues, they are confined by the barrier wall—the "doors" start closing. The new wood that continues to form after the tree was wounded is not infected by the invading microorganisms; they are confined to the tissues present at the time of wounding, which are walled off or compartmentalized.

Whenever a branch dies, or is cut, there is a wound response. Even in winter, the chemical events take place; when the cambium begins to produce new cells again in the spring, the barrier wall will be formed.

From trees to poles

Why is the knowledge of decay development in trees necessary for an understanding of decay in poles? Because the barriers of chemically altered wood and the barriers of anatomically altered tissues set up compartments in the tree. And the tree will later become a pole. The injured wood in some compartments in the tree may already be infected by microorganisms. The wood in some compartments may be so flooded with resin that preservatives will not penetrate it. Tissues that have been walled off by the barrier zone and are now harboring organisms attacking the living tree will later harbor new wood rotters in the dead pole. Some organisms may survive the best preservative treatments and continue to degrade the tissues walled off by the barrier zones.

In trees that will be used for poles, branch stubs will be the most common type of wound. Some trees will also have wounds inflicted by small animals, or wounds caused by fires.

The extent of the barrier wall and its position play an extremely important part in the patterns of defect that may develop in poles.

The barrier zone in living trees has great survival value for the trees. But the barrier zones, and the altered tissues within them, can be the cause of some serious problems when trees become poles and are used for long periods.

The barrier zone is usually where wood tissues will pull apart when stresses occur. The partition that forms between growth rings is called ring shake; most ring shakes develop along barrier zones. Radial checks may form from ring shakes. Large radial checks in poles often start from the inside and develop outward. Checks give spores, bacteria, and insects easy access to the interior of the pole.

The microorganisms that attack wood in living trees usually die after the tree is cut. Other microorganisms cause the decay that may develop later in the poles.

BASIC PATTERNS OF DECAY IN POLES

Internal decay

Central.—The decay is in the central core, and sound wood surrounds it; the decay may be associated with a hollow inner core.

Shell (subsurface).—Decay develops immediately under the surface of the pole. The surface will be sound, and the wood deeper in from the ring of subsurface decay will be sound. Shell rot is prevalent in cedar poles.

In-between.—Decay is between the sound central core—usually the core of sound heartwood—and the sound outer periphery of the pole. It could occur in isolated pockets, or the entire circumferential zone could be decayed.

Wedge.—Decay is wedge-shaped. The wedges could be few in number to many, and range from slight decays to hollows.

Complete.—The entire cross section of wood is decayed. The patterns of internal decay in poles usually depend on the species of tree used. They are typically different in species with thick or thin sapwood. Patterns typical of species with thick sapwood, such as southern pine, ponderosa pine, and red pine are illustrated in Figure 1. Patterns typical of species with thin sapwood, such as Douglas-fir, western redcedar, lodgepole pine, jack pine, and western larch are illustrated in Figure 2.

External decay

Surface rot.—The outer layers of wood in the pole are obviously decayed, may be spotty, and generally are associated with checks.

Soft rot.—The surface and outer layers of wood are decayed at groundline and below; the wood has a charred appearance. The external decay in general occurs in three basic forms as illustrated in Figure 3. They are general circumferential decay, decay in checks, and decay pockets.

There are many causes of the different patterns of decay—poor preservative treatment, depletion of preservative, mechanical damage, alterations in the wood when it was in the living tree, etc.

COMMON SIGNS OF DECAY

With a keen eye, hammer sounding, probing with a blunt screwdriver, checking if the wood splinters (sound) or breaks across (decay, brashiness), and a little practice, it is easy to recognize many signs of decay. Here are some of the most common ones.

Deep checks.—Deep open checks, especially those greater than 0.5-inch wide, signal possible trouble. Determine whether the check is associated with an old, large, branch stub. The checks usually form to the sides of the stubs. The in-between decay pattern should be suspect here. The checks may also serve as entry ports for insects.

Mechanical damage.—Wood damaged by vehicles serve as entrance points for insects and microorganisms.

Woodpecker holes.—Although woodpecker holes are usually high in the pole, some are near the base. There may be ants in some of the

Figure 1.—Patterns of decay typical in species with thick sapwood.

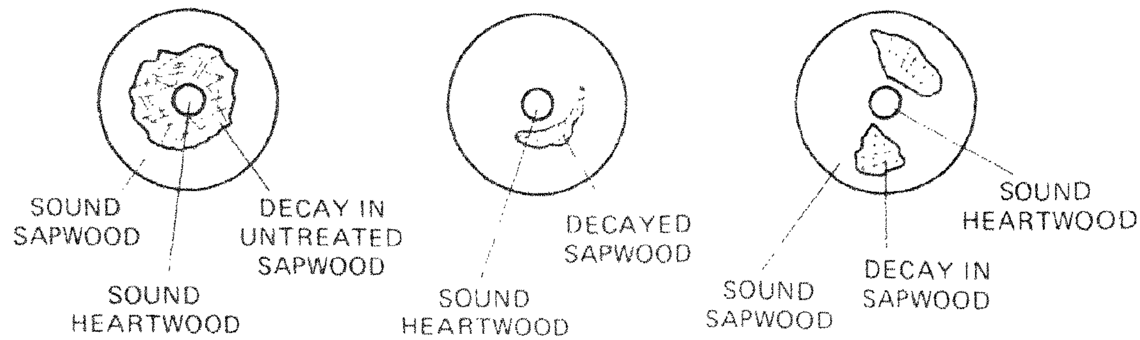


Figure 2.—Patterns of decay typical in species with thin sapwood.

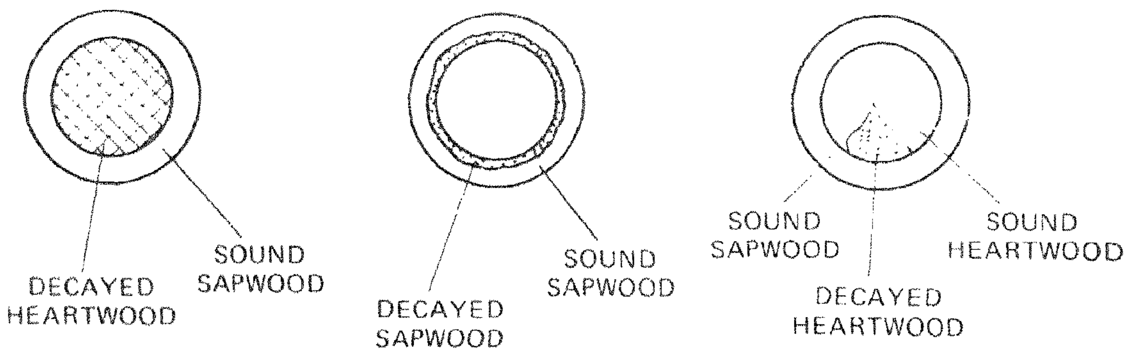
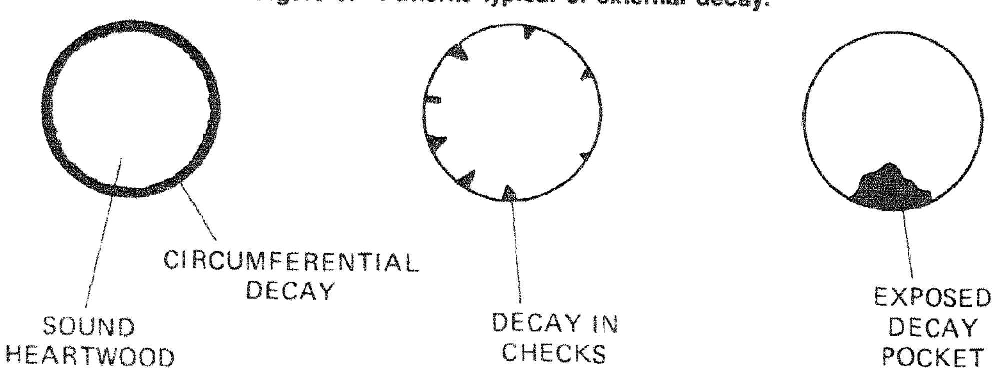


Figure 3.—Patterns typical of external decay.



holes; and birds may peck holes later to get at the ants. Ants also may be in pockets of decay.

Knots.—Be on the alert for large knots, especially those with long associated checks. The knot was once a branch stub, and branch stubs are common infection courts for microorganisms in trees.

Fragile, soft outer surface.—The wood at groundline may be so altered that it can be pushed in with a finger or with a metal rod. The surface will collapse under the impact of hammering to sound a pole.

Insect holes.—Ants and termites move in and out of poles through large checks or small holes. The edges of the holes will be smooth. The ants use the pole for a homesite, not food; termites use wood for food. Often, insect damage is associated with decay.

Large holes and hollows.—Often, large holes are associated with decay and large hollows. A blow with a hammer can be helpful in locating large hollows. Upon impact, a hollow pole will sound dull, producing a low pitched sound; a sound pole will produce a higher pitched sound.

Loose spongy fiber; charred appearance.—These fibers may indicate any type of external decay that is obvious to an unaided eye.

Additional tests for obvious decay

One of the first tests an inspector must make is an exploratory probe around the base of the pole with a Phillips screwdriver or similar tool. This probe will yield valuable information about the depths of checks, and the presence of shell rot or soft rot. If the tool goes deep into the pole with relative ease at several places, the pole is obviously decayed.

A shallow hole made by a screwdriver could also be used as the starting point for the long drill bit mounted in the battery-powered drill. The hole could set the proper angle of the drill bit. The screwdriver could also be pushed into holes that are suspected entrances for ants or termites.

THE SHIGOMETER

The Shigometer is an electronic device that delivers a pulsed electric current and measures electrical resistance to it up to 500kΩ (Fig. 4). When used properly with a variety of probes and probing methods, it will provide valuable information on patterns of resistance that are associated with changes in wood tissues. The Shigometer can be calibrated in a few minutes (Fig. 4).

Principles of operation (Why does it work?)

Many changes take place in wood as it progresses from sound to infected, to invaded, to early decay, and finally to advanced decay. In the early stage of infection and invasion, there is very little weakening of the wood. As the decay progresses, the moisture content of the wood may increase, and microelements may concentrate in the invaded tissues. The wood then begins to lose some of its weight—the specific gravity decreases. At this point we say that decay has set in.

When a pulsed current is passed through wood in progressive stages of decay, the current encounters decreasing resistance. The exact reason for this is not known, but it is probably because of the effect of several factors leading to higher concentrations of microelements in the wood, and decreased specific gravity.

The Shigometer functions *only* above the fiber-saturation point of wood tissues, the point at which the walls of the wood cells are saturated with moisture. The fiber-saturation point is approximately 27 percent (weight/weight). It has usually been found that, at groundline, the moisture content of poles in the ground is above the fiber-saturation point, and that when microorganisms are active in wood, the moisture content will usually be above the fiber-saturation point (there are a few rare exceptions).

Procedures for the twisted-wire probe

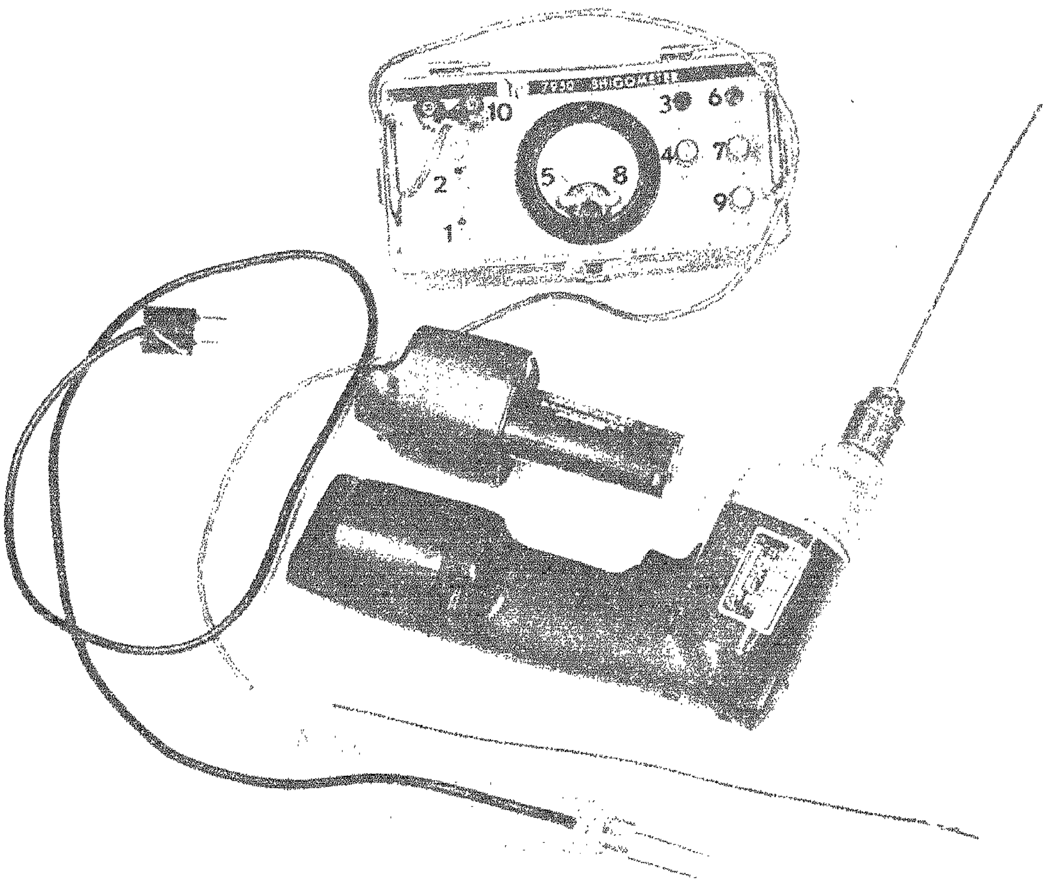
Measurements for internal decay are made with a special twisted-wire probe; an abrupt drop in electrical resistance indicates decay. A hole 3/32 inches in diameter is drilled into the pole horizontally, or at a downward angle of 45° at groundline. In the latter case, when determining position of probe tip to establish a respective point at the horizontal level, an adjustment must be made for the slope—that is, the measurement at an angle is to be reduced by 0.15 inch for every 0.5 inch.

The hole is made with an 8- or 12-inch drill bit mounted in a lightweight battery-powered drill.

Figure 4.—Shigometer and accessories: battery-powered pulsed-current meter with 50 kΩ and 500 kΩ scales; battery-powered drill with extra battery pack, 3/32-inch diameter, 8-inch drill bit in chuck, twisted-wire pole probe (tree probe is slightly smaller in diameter), and needle probes.

To calibrate meter:

a. Turn on (1).
b. Pull switch (2) upward to 50 kΩ (now dial reads from 0 to 50 kΩ).
c. Press zero button (3).
d. Turn adjust knob (4) until needle is exactly on 0 line (5).
e. Press calibration button (6).
f. Turn 50 K knob (7) until needle is exactly on 50 line (8).
g. Push switch (2) downward to 500 kΩ (now dial reads from 0 to 500 kΩ).
h. Press calibration button (6).
i. Turn 500 K knob (9) until needle is exactly on 50 line (8).
j. Insert plug (10) for either twisted-wire probe or needle probes (the plug can be inserted in either direction).



The time it takes to drill the hole depends on the skill of the operator; usually it is 5 to 10 seconds. No excavation is necessary, but excavation may be necessary when standard increment borers are used.

1. The drill bit must be secured firmly in the drill chuck. Only sharp drill bits should be used.
2. The hole should be drilled with a constant in-and-out motion, and changes in torque should be noted. A sudden release in torque indicates that the bit is passing through soft, damaged wood, or through a hollow. The drill should not be stopped while the hole is being drilled. After the hole is drilled, the drill should be run in and out of the hole to clean out any bits of wood.

If a sudden release in torque is felt during drilling, drill a second hole to the depth where the release occurred, stop the drill, and advance the bit to determine the diameter of the hollow in the pole.

3. Attach the twisted-wire probe to the meter. Make certain that the meter is properly calibrated. Set the scale for 500 kΩ. Make certain that the probe tips are clean and spread apart slightly; push the tips apart with your fingernails before starting to probe. A clean probe will register above 500 kΩ on the meter.

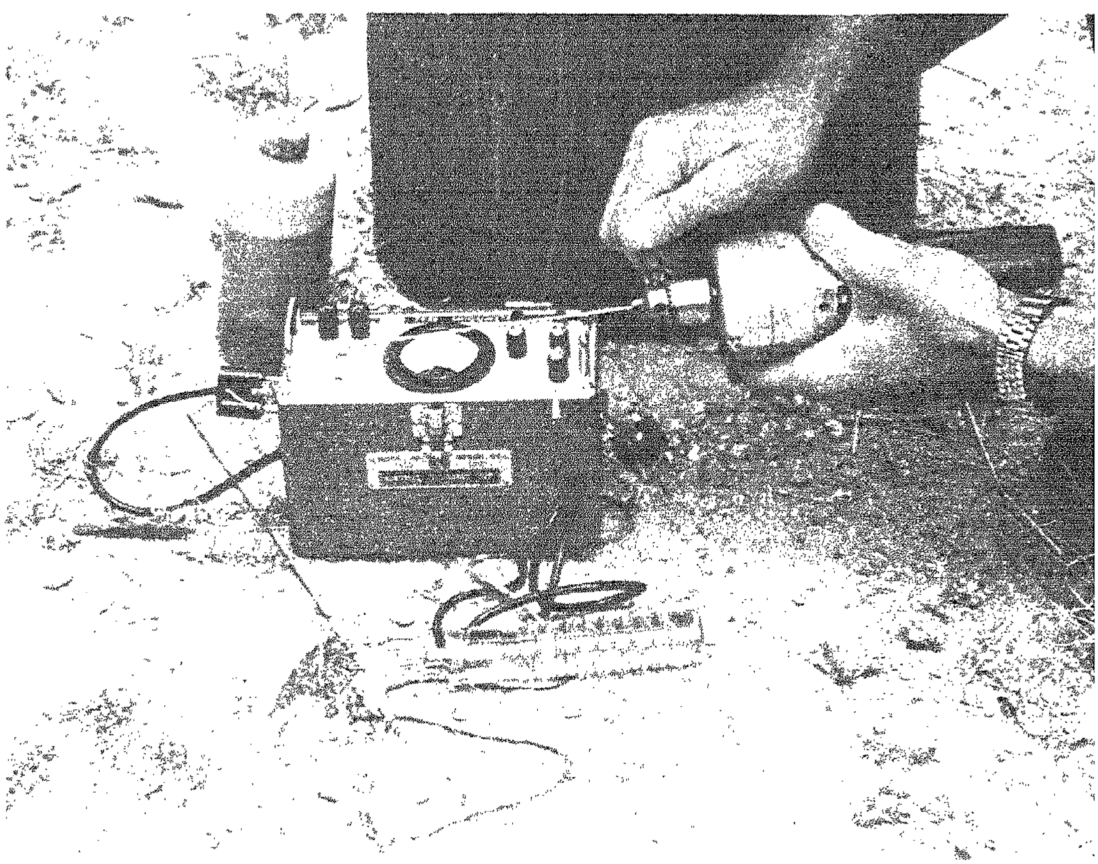
4. Insert the probe slowly with an even motion. While inserting, hold the probe with your fingers as close to the pole as possible to keep the probe from bending. Read the resistance on the meter frequently while the probe is being pushed in, noting the highest and lowest resistance readings. When an abrupt decrease occurs, the probe may be pulled out slightly, a pushed in again very slowly to determine the (act depth at which the decrease occurred.

For very accurate measurements to det(mine the exact position of the decay, che where the needle begins to drop abruptly. H(the probe at that position and pull it out. T depth of the rear knuckle on the probe tip w indicate the position of the outer rim of deca The inner rim of the decayed section will be i dicated by an abrupt increase in resistan when the probe is pushed further inward.

5. When the inspection is completed, a drilled holes are to be filled with a liquid pres(vative from a plastic squeeze bottle or syring

Figures 4 through 6 show some of the poir discussed.

Figure 5A.—Place drill bit firmly in the chuck of drill. If a 12-inch deep hole is desired, make the hole as deep as you can with the 8-inch drill; then complete the job with the 12-inch drill.



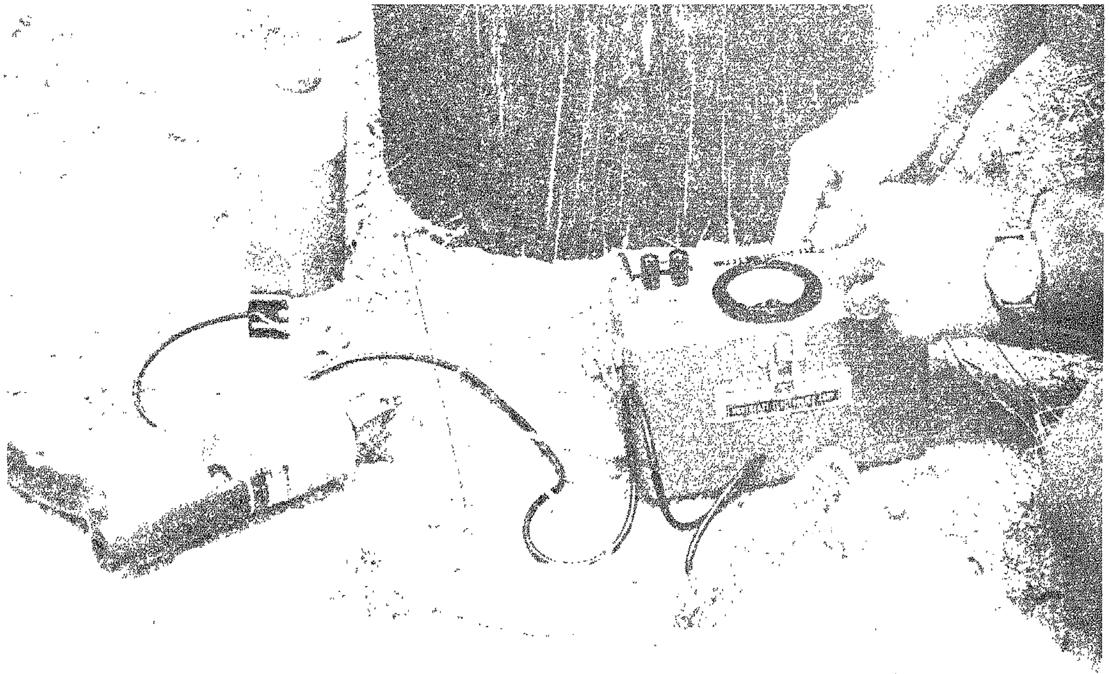
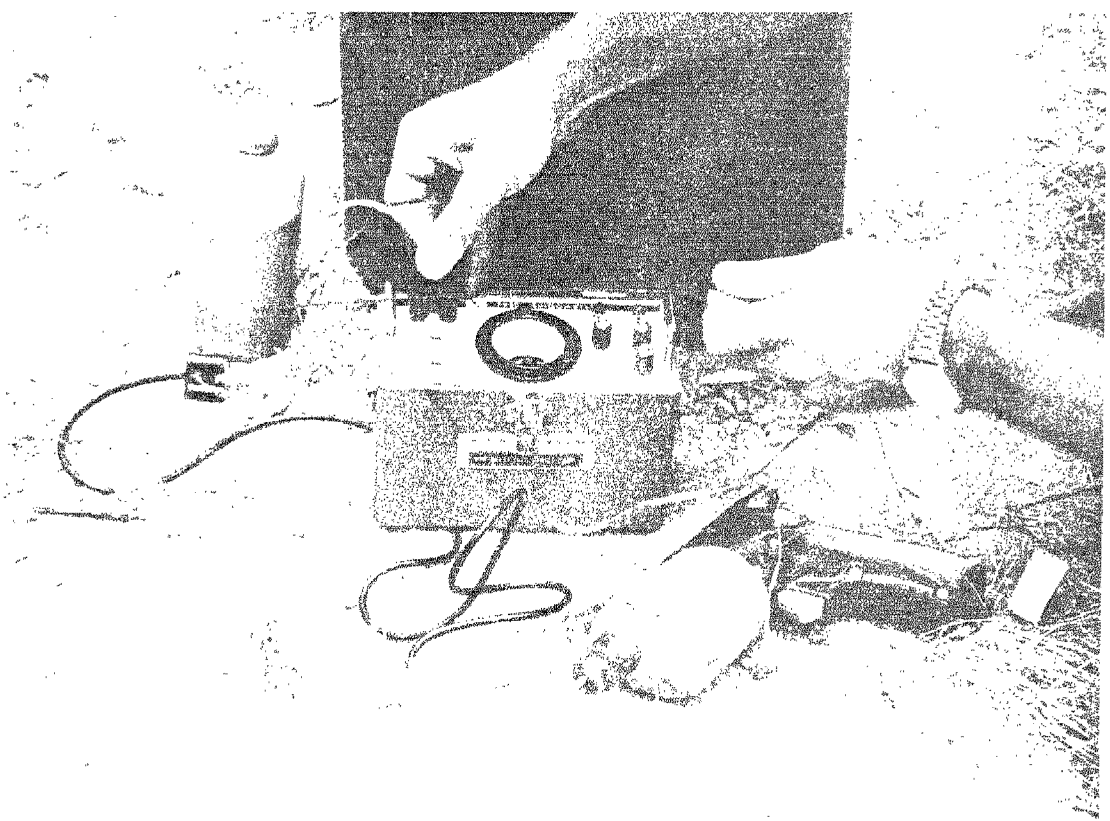


Figure 5B.—Calibrate meter (See Fig. 4). If meter cannot be calibrated, the batteries may be low; put meter on 500 kΩ scale.

Figure 5C.—Plug in twisted-wire probe. Needle on dial of meter should be above 500 kΩ. If the needle is not beyond 500 kΩ, clear the tips of the probe of foreign materials. Any erratic movement of the needle signals a loose connection. Check to be certain that the plug is all the way in, or check for worn or exposed wires near the plug.



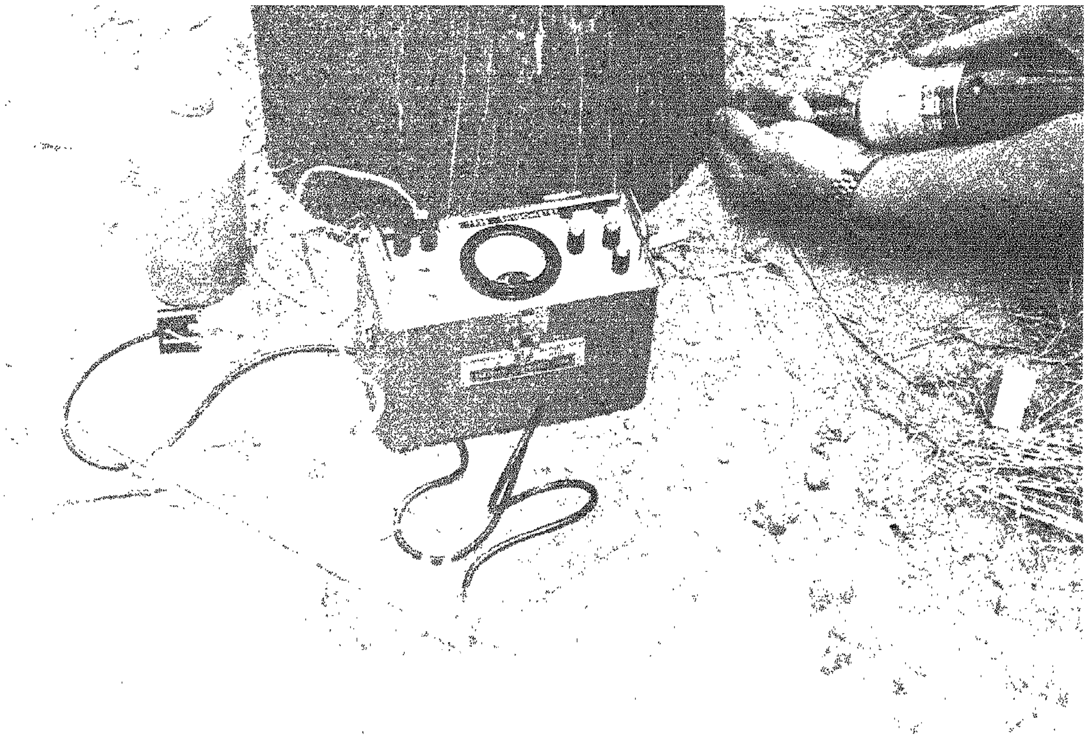
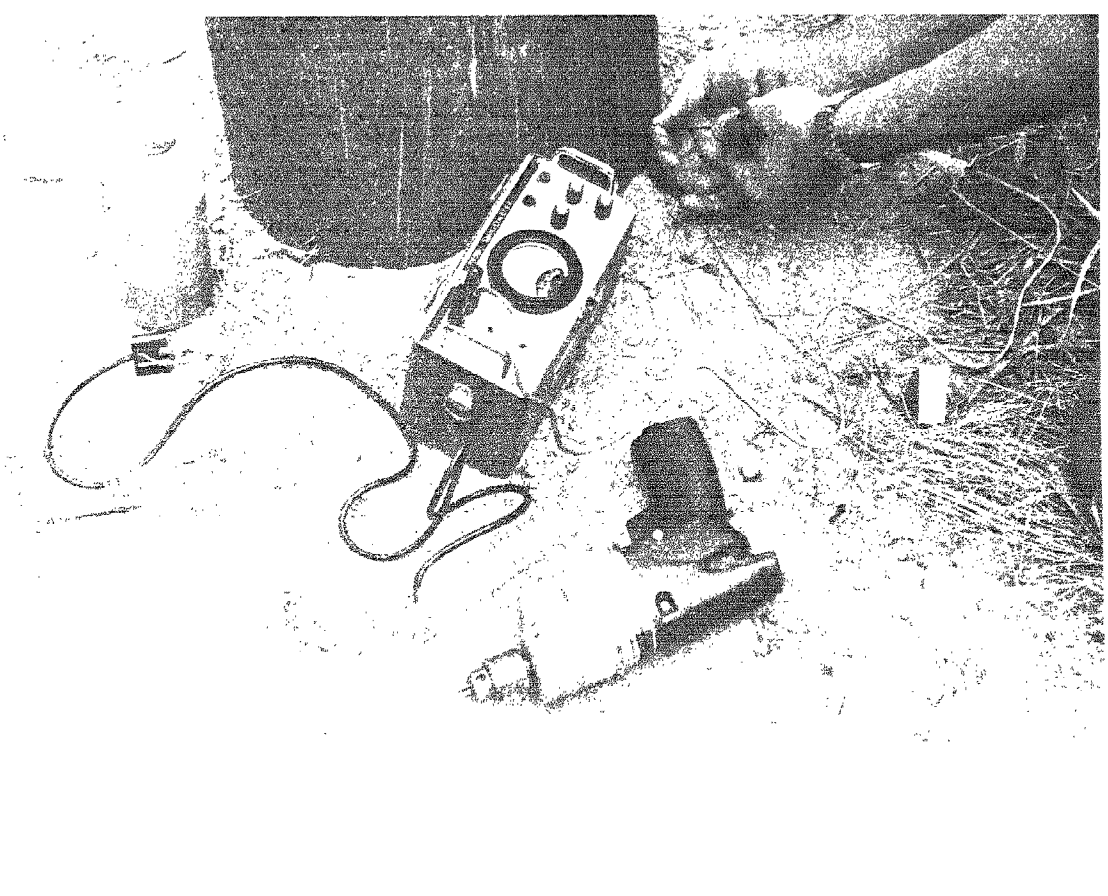


Figure 5D.—Cup hand around drill bit and guide it to the proper position and angle. If drilling is difficult and the bit gets hot, let the hole cool for a few minutes before inserting the twisted-wire probe.

Figure 5E.—Insert twisted-wire probe slowly, and watch the dial on the meter as you momentarily release your fingers from the probe. Make certain that the probe is pushed in only a quarter of an inch at a time. Hold finger on probe close to the pole; this will prevent the probe from bending.



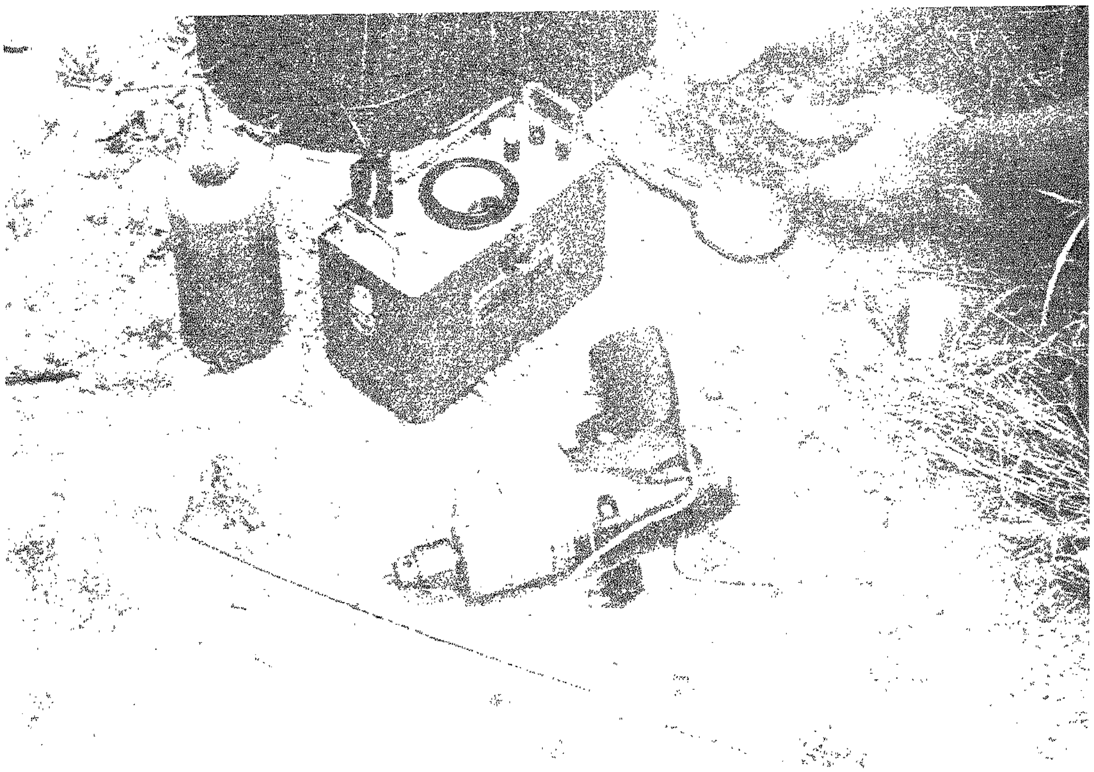
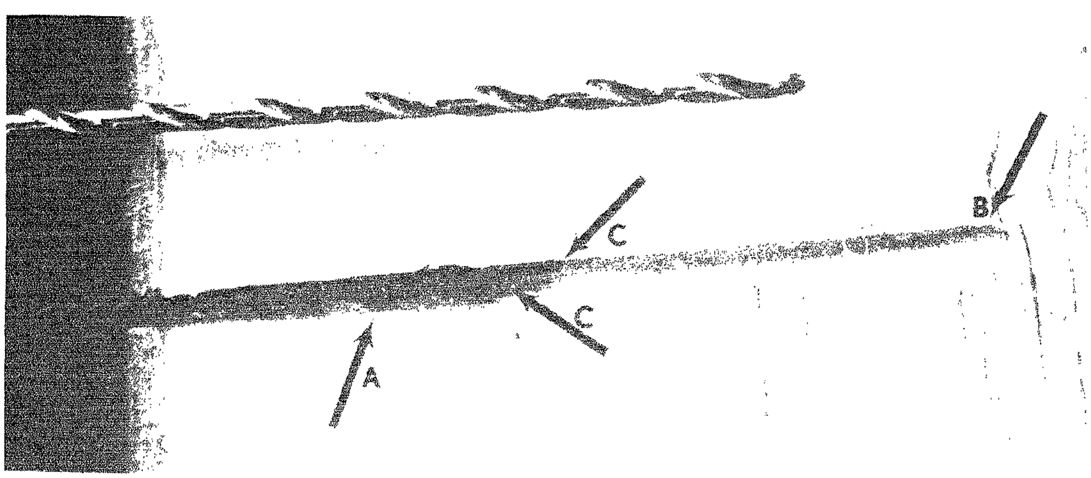


Figure 5F.—Probe around the base of the pole with the needle probes. When the probes go easily into the wood decay is suspect. Probe only with the needles alined vertically as shown. Probe into checks also.

Figure 6.—Closeup of the 3/32-inch diameter drill bit, a hole made by the bit, and the twisted-wire probe in the hole. The arrow (A) points to the back bowed area of the probe tip. The exact depth of a decrease is measured from the surface of the pole to the back bowed area of the tip. Do not record the readings obtained when the probe tip goes to the end of the hole (B). This reading will usually be lower than the others because the open noninsulated tips (C) of the wire make contact with the wood at the end of the hole (B).



PATTERNS OF RESISTANCE READINGS

Sound wood

The following patterns of resistance readings indicate the presence of sound wood:

1. All readings above 500 kΩ.
2. Some readings above 500 kΩ, with some as low as 250 kΩ, and none below 250 kΩ. (The high reading of 500 kΩ or above could be at any point in the pole, in the outer sapwood, or deep in the heartwood).
3. All readings below 500 kΩ, provided that the lowest readings are not 75 percent below the highest reading.

Table 2.—Examples of patterns of resistance readings (kΩ) that indicate sound or decayed wood in poles

Condition of wood	Depth in poles [a] (inches)							
	1	2	3	4	5	6	7	8
Sound	>500	>500	>500	>500	>500	>500	>500	>500
Sound	500	500	450	475	500	450	430	500
Sound	450	400	425	450	500	500	450	430
Sound	350	300	325	350	400	325	350	400
Sound	200	250	230	225	200	270	225	200
Sound	150	125	175	125	150	140	200	150
Decayed [b]	>500	500	100	50	75	475	500	500
Decayed [b]	350	300	50	40	45	350	375	350
Decayed [b]	200	250	30	45	50	250	200	250
Decayed [b]	150	175	25	35	10	175	150	125
Decayed [c]	>500	500	400	125	90	80	75	100
Decayed [c]	400	350	375	100	85	100	90	30
Decayed [c]	200	175	175	40	35	40	45	40
Decayed [c]	150	140	120	25	30	20	30	25

[a] Each horizontal row of readings is at 1-inch intervals into a pole.
[b] In-between pattern.
[c] Central pattern.

Decayed wood

The following patterns of resistance readings indicate the presence of decay:

1. Some readings above 500 kΩ and some below 250 kΩ, with the highest readings on a particular pole above 500 kΩ. The position of the probe tip when the needle drops below 250 kΩ indicates the position where the decayed wood begins. Determine the exact position and extent of the decayed wood by taking readings at other points around the periphery of the pole.
2. All readings below 500 kΩ, but where the low readings are less than 25 percent of the highest reading (Table 1). The position of the probe tip when the 75 percent drop from the highest reading occurs is the exact position of the start of the decay. Again, determine the exact position and extent of the decay by probing at other points around the periphery of the pole. (The 75 percent drop in resistance was chosen on the basis of 174 sound and decayed poles that were examined in New Jersey and Florida). Examples of patterns of resistance readings that indicate sound or decayed wood in poles are shown in Table 2.

Table 1.—One pattern that indicates decay is when the highest readings are 500 kΩ or less and the lowest readings are less than 25 percent of the highest ones.[a]

If highest measurement (in kΩ) is:	Decay begins where measurement drops below:
500	125
475	119
450	113
425	106
400	100
375	94
350	88
325	81
300	75
275	69
250	63
225	56
200	50
175	44
150	38
125	31
100	25
75	19
50	13
25	6

[a] Earlier stages of decay may be indicated by decreases of 50 percent.

Hollow wood

An experienced inspector can detect hollows, decay pockets, and ant and termite galleries while drilling. There will be a release of torque when such defects are penetrated. A hollow will have an abrupt release; it takes practice to recognize this type of defect. The ant and termite galleries will have a repeated release pattern as the drill tip goes from sound to hollow several times. When inserting a probe into the hollow pole, an abrupt deflection of the meter to the right and above 500 kΩ will indicate the outer rim of a hollow, for example, the reading will be the same as that observed when the probe is held in the open air. The depth of the hollow cannot be measured with a probe in all instances because it might be impossible to hit and enter the hole on the other side of a hollow with a probe (the probe is flexible) to obtain positive contact with the wood. The extent of a hollow is best determined by using both drill and probe.

If a hollow is suspected, first drill to the point of torque release. If the probe or drill goes 8 inches into hole drilled only 4 inches, there is no doubt about the hollow.

Small hollows can be detected easily with the twisted-wire probe. Move the probe very slowly into the hole. The resistance will drop abruptly at the edge of the decay column; as the probe tip enters the hollow, the resistance will abruptly increase to infinity. When several small hollows are present, the needle will swing abruptly from left to extreme right on the dial. Hollows directly under the surfaces of the pole can be detected with the needle probes.

One has to proceed cautiously when determining the extent of hollows. The rim of wood around some old hollows is hard and dry. In such cases, the drill technique may be the method to use. Or, if such a hollow is suspected, drill at a slightly higher or lower position, and then use the twisted wire probe.

Some decay columns will contain loose bits of wood with advanced decay. When the probe tip passes through such decay, the needle on the dial may swing back and forth as the tip moves from decayed wood to air pockets. But, here again, this condition should be suspected after drilling.

Ant and termite galleries may cause some problems because the rims of the hollow will be hard and dry. Signs of ant exits and the typical drill pattern will alert an inspector for ant galleries. The dry galleries will be aboveground. to verify ant galleries, it may be necessary to drill at an acute angle downward into the pole at groundline. The rims of the galleries will be more moist at this position.

Some points of caution

1. Do not insert probe rapidly or with a jerking movement. Move the probe with an even movement

2. Read the meter only when your fingers are not touching the probe.

3. When decay is suspected, move the probe in very slowly and evenly.

4. Keep the probe tips clean; spread them apart slightly with your fingernails.

5. Don't bump the calibration knobs when moving from pole to pole.

6. Learn how to get the most out of your drill. Make certain that it is put on full charge overnight. Read the instructions of the drill manufacturer carefully.

Subsurface decay and the use of the needle probes

Subsurface decay may be detected with the long needle probes attached to the Shigometer. Two long needles are attached to a plastic handle similar to the one used for moisture readings. If the probes can be pushed easily into the wood, subsurface decay is obviously present. If the probes can be pushed about 1 cm (3/8 inch) into the wood, and the electrical resistance readings are below 50 kΩ, then decay is suspected. When this happens, probe other areas of the pole at groundline. If it is difficult to insert the probes beyond a centimeter, and some other readings are far above 50 kΩ, then the suspect areas are probably decayed or are altered by soft rot.

SUMMARY

The advanced decay columns in poles often end abruptly. But the slightly altered wood around the advanced decay and the slightly altered wood above and below the decay often appear sound. This is when the Shigometer reading can provide valuable information that is not available with any other decay detection device.

The meter will measure abrupt decreases of resistance in wood that is in the early stages of decay. For example, a central column of decay at one position of the pole may be surrounded by 4 inches of sound wood. A meter reading at a depth of 4 inches will show an abrupt decrease in resistance. At a point only a few inches above that column, the wood may appear sound when sampled with an increment borer. When a meter reading is made at such a point, an abrupt decrease will still occur at the 4-inch depth, indicating extension of the decay column.

Understanding the patterns of decay in poles should alert an inspector to watch for such readings.

Detection of internal decay in poles by visual means alone is not dependable. When an increment core is taken and visually examined, the wood may look sound; but it may be in the early stage of decay that can be detected only by laboratory methods.

In using the Shigometer when inspecting utility poles, it is important to remember that:

1. It is the PATTERN of readings that indicates decay, not absolute readings.

2. There is no substitute for practice. An operator should first practice with freshly pulled sections of poles that are sound and unsound.

3. Most poles will be obviously sound. Some poles will be obviously decayed. But decay will be suspected in other poles. It is the suspect poles that require the time and the skill of the inspector.

CHECKLIST FOR DETECTION OF DECAY AT GROUNDLINE IN POLES

1. Calibrate Shigometer, set for 500 kΩ, attach twisted-wire probe.
2. Check for obvious decay - use Phillips screwdrivers, hammer, etc.
3. Be alert for possible internal decay - know patterns.
4. Place drill bit in chuck very firmly!
5. Drill hole — in and out — do not stop.
6. Be on the alert for hollows - release in torque.
7. Insert probe slowly and evenly.
8. Check resistance patterns:
   - Sound wood - a. All above 500 kΩ.
     - b. Some above 500 kΩ; none below 250 kΩ.
     - c. All below 500 kΩ; lowest not 75 percent below highest.
   - Decayed wood - a. Some above 500 kΩ; some below 250 kΩ.
     - b. All below 500 kΩ; lowest less than 25 percent of highest.
9. Check base with needle probes for surface decay and soft rot.
10. Fill drill holes with preservative.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the help of many people in the many phases of this work: Harold Wochholz, Thomas Dors, Raymond McOrmond, Theresa Taylor, Dr. Robert Zabel, G. E. Bruderman, Kenneth Knox, Michael Simmons, Doyle Weller, Harry Fry, Jonathan Carter, Janice Huss, and James Abusamara.

PHOTO GUIDE TO DECAY IN UTILITY POLES

It is extremely important for the pole inspector to study the dissected samples shown in this section. The inspector should have in his mind's eye the typical types of decay patterns in poles. As the tests are being made in the field, the inspector should review the possible types of decay he may encounter. This will also help to determine where additional probes should be made.

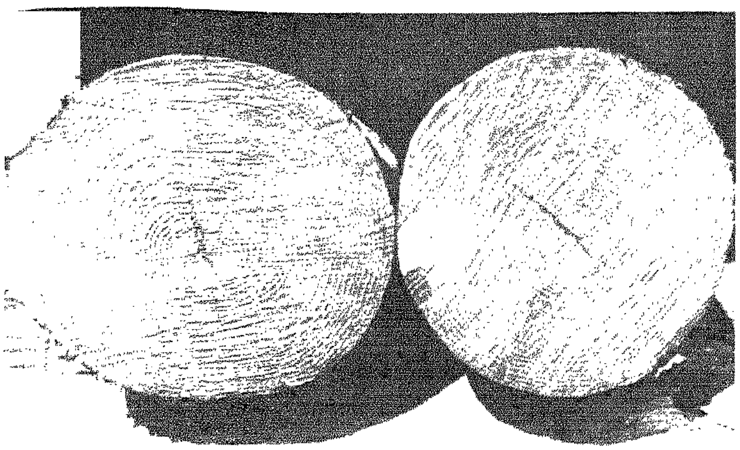


Figure 7A.—Cross section of sound well-treated poles of southern pine.

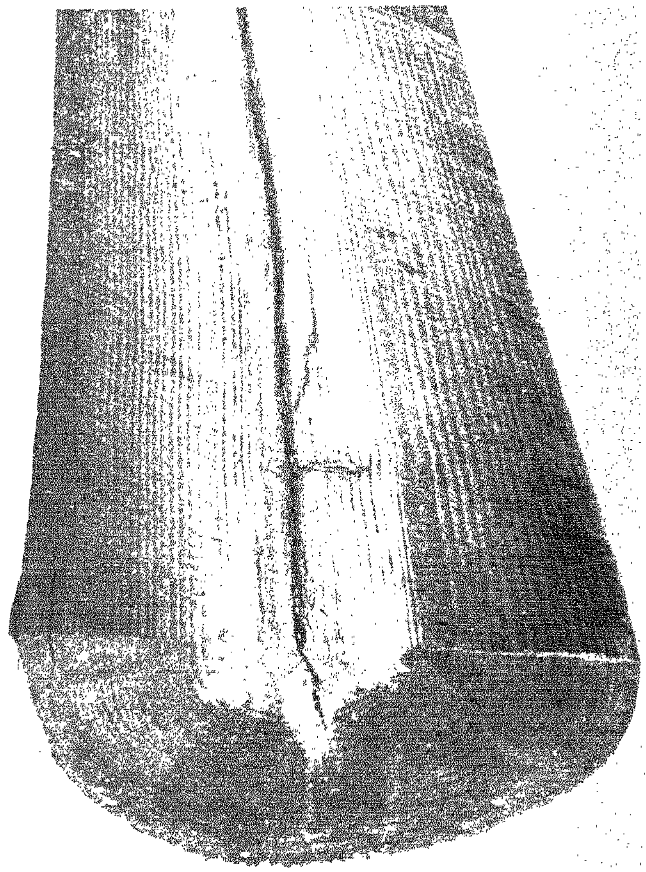


Figure 7B.—Radial section of sound well-treated poles of southern pine.

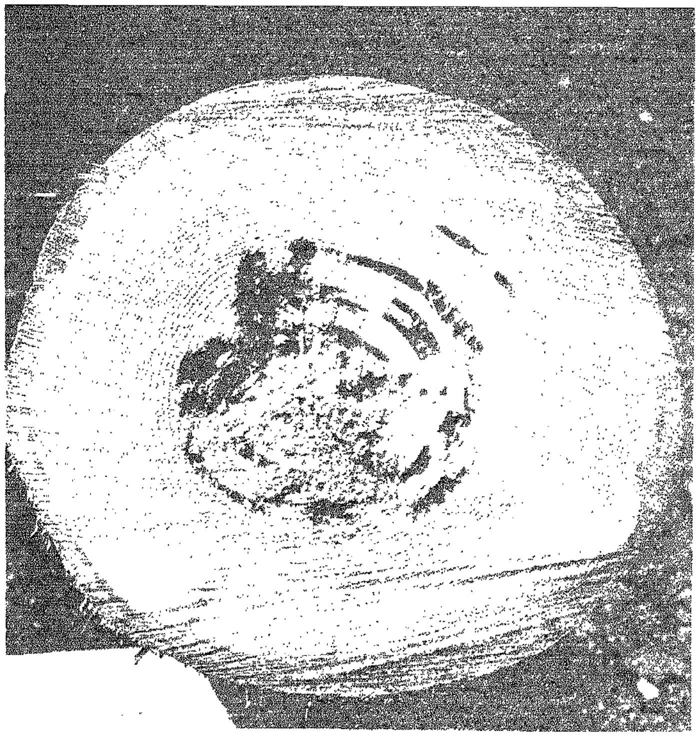


Figure 8A.—Cross section of central decay in cedar.

Figure 8B.—Radial section of central decay in cedar.

Figure 9.—Subsurface decay and hollows (cedar).

Figure 10A.—Cross section of in-between pattern of decay.

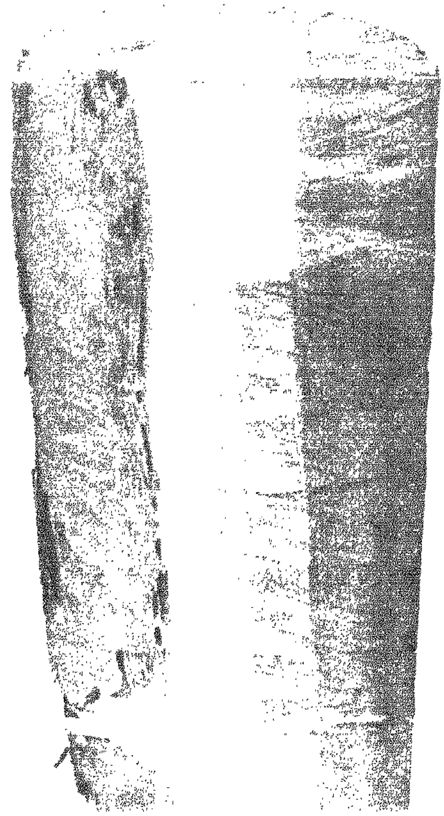


Figure 10B.—Radial section of in-between pattern of decay.

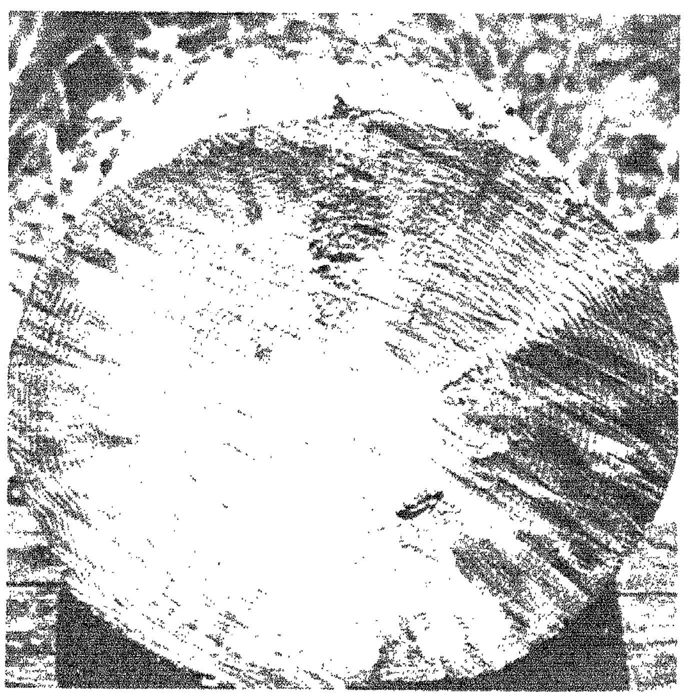


Figure 11.—Wedge pattern of decay.

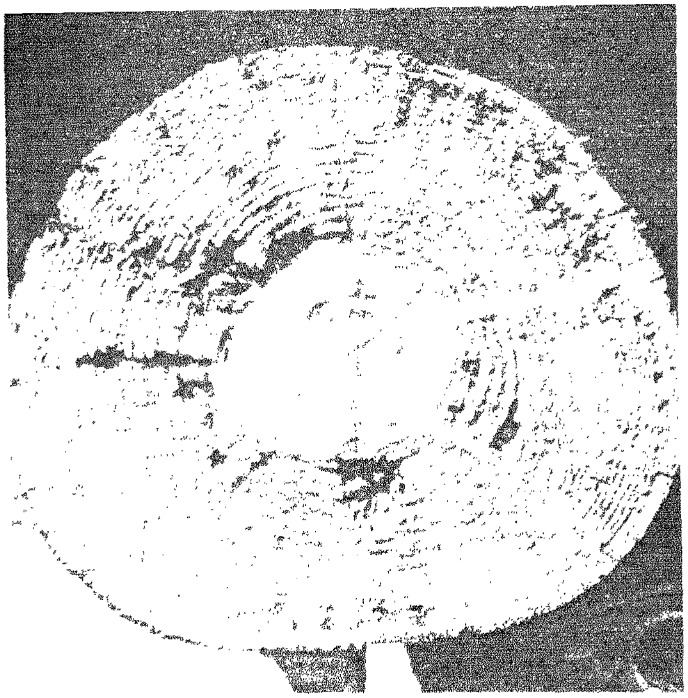


Figure 12A.—Cross section of complete decay.

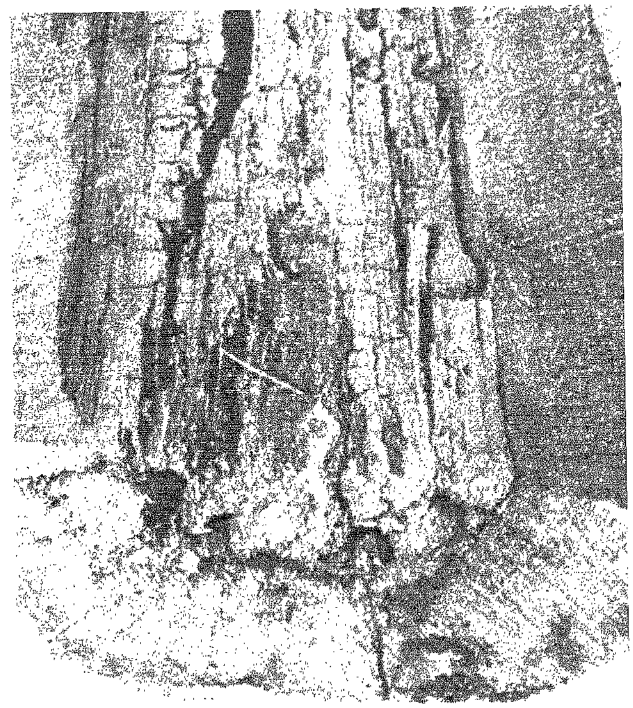


Figure 12B.—Radial section of complete decay.

Figure 13.—Shell rot (external decay).

Figure 14.—Soft rot (external decay).

Figure 15.—Central hollow.

Figure 16A.—Cross section of in-between hollow.

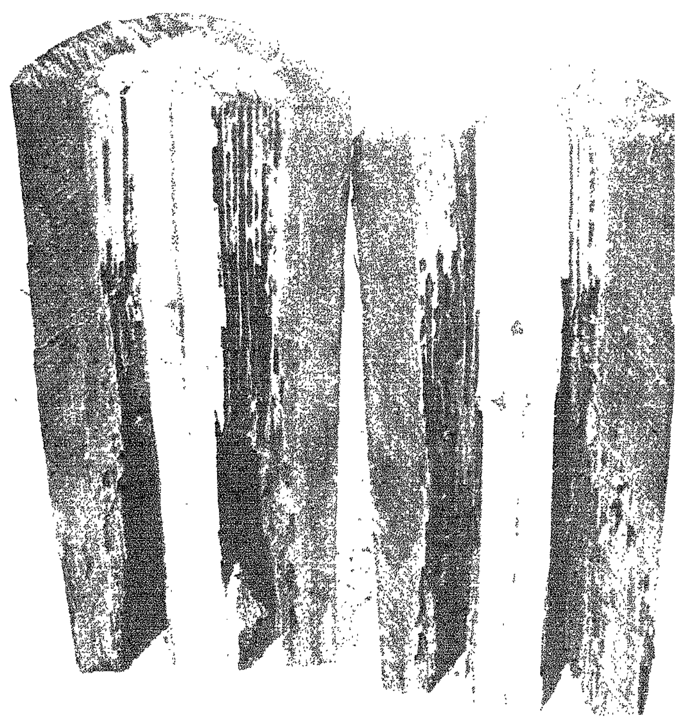


Figure 16B.—Radial section of in-between hollow.

Figure 17A.—Cross section of wedge-shaped hollow.

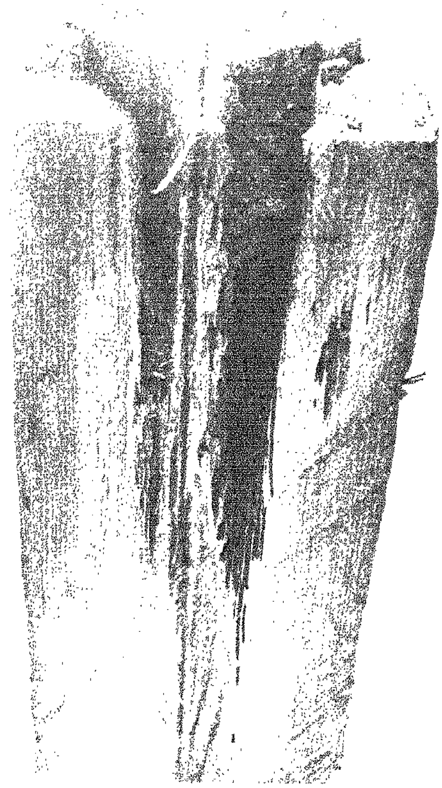


Figure 17B.—Radial section of wedge-shaped hollow.

Figure 18.—Beginning stage of in-between pattern of decay. (When used properly the Shigometer will detect this).

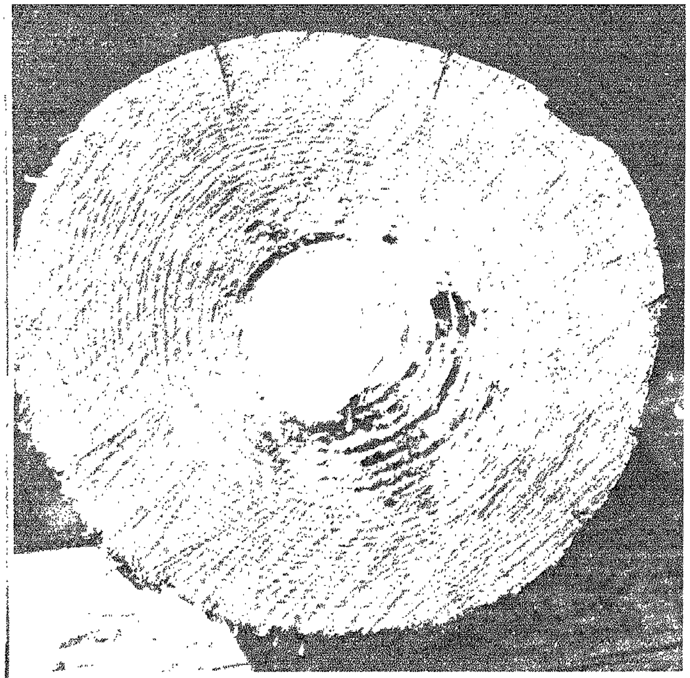


Figure 19.—Early decay (in-between pattern), mostly in spring wood or early wood.

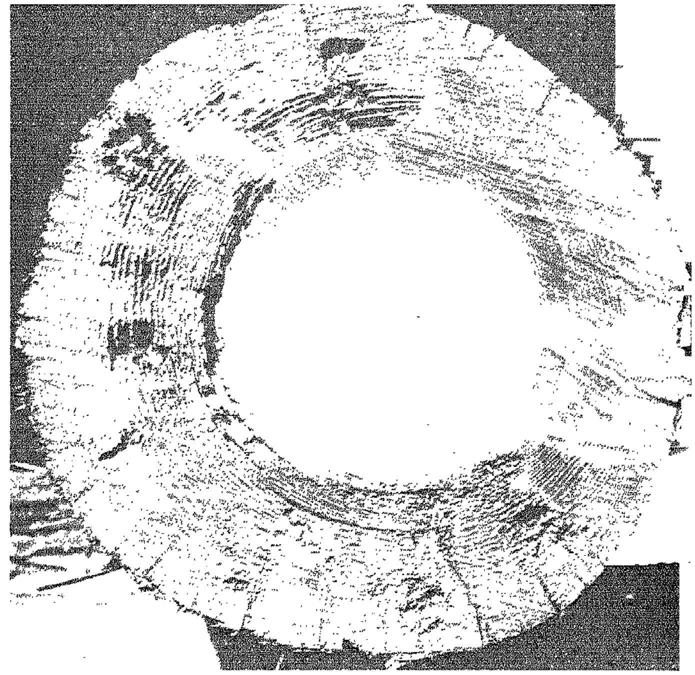


Figure 20.—Moderate decay (in-between pattern), hollows beginning to form.

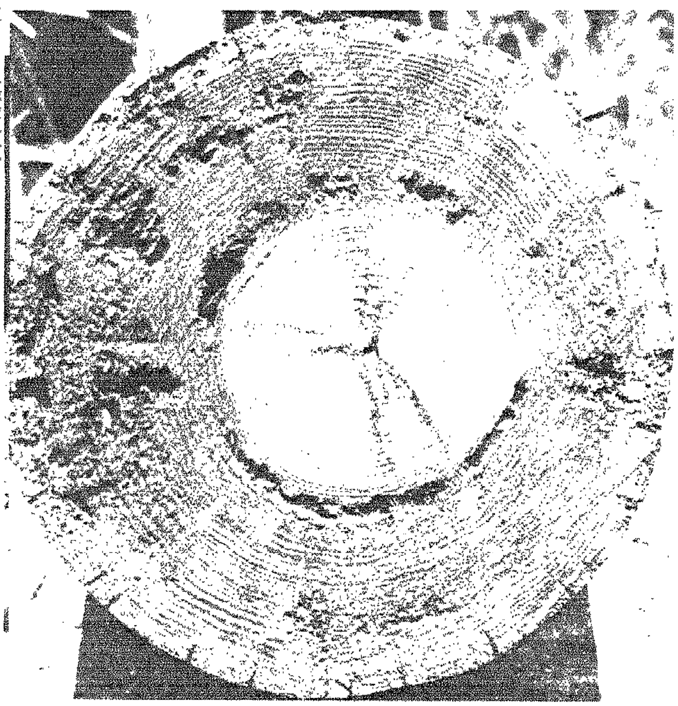


Figure 21.—Advanced decay (in-between pattern), only the central heartwood is sound. (The highest electrical resistance measurements will be in the central heartwood).

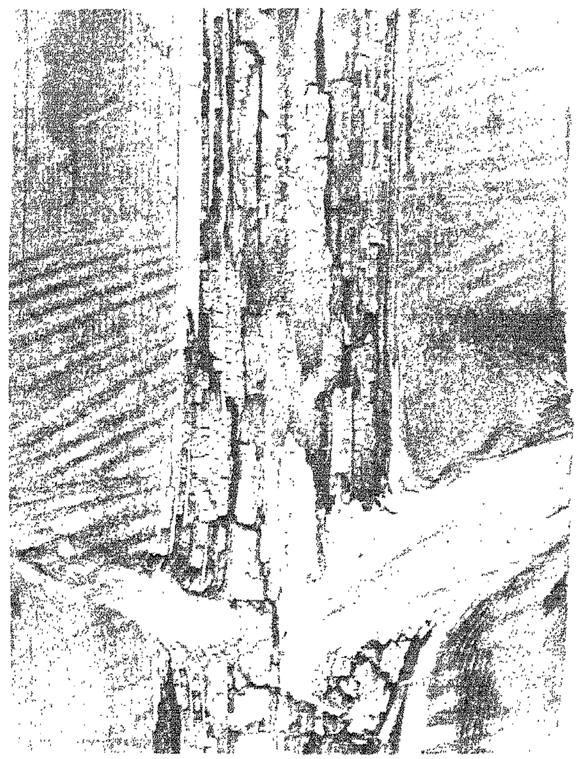


Figure 22.—Central brown rot associated with two large branch stubs.

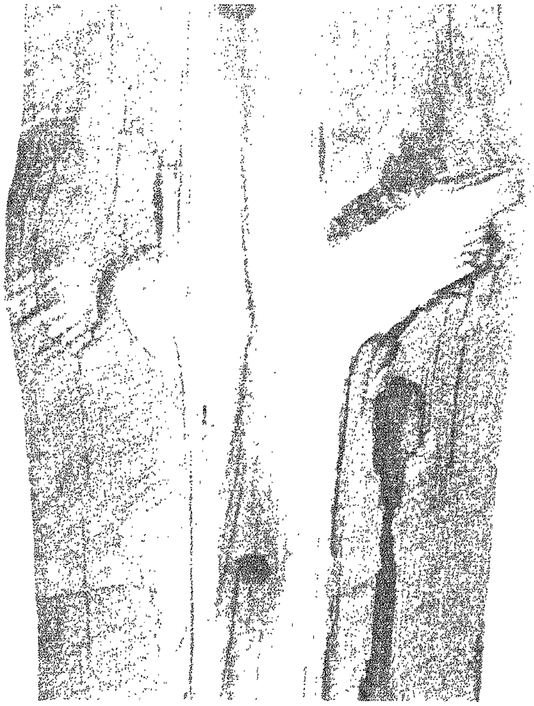


Figure 23.—In-between pattern of decay (brown rot) associated with a large branch stub.

Figure 24.—Large holes are obvious signs of internal decay and hollows.

Figure 25.—Wood at groundline that is charred in appearance often indicates soft rot.

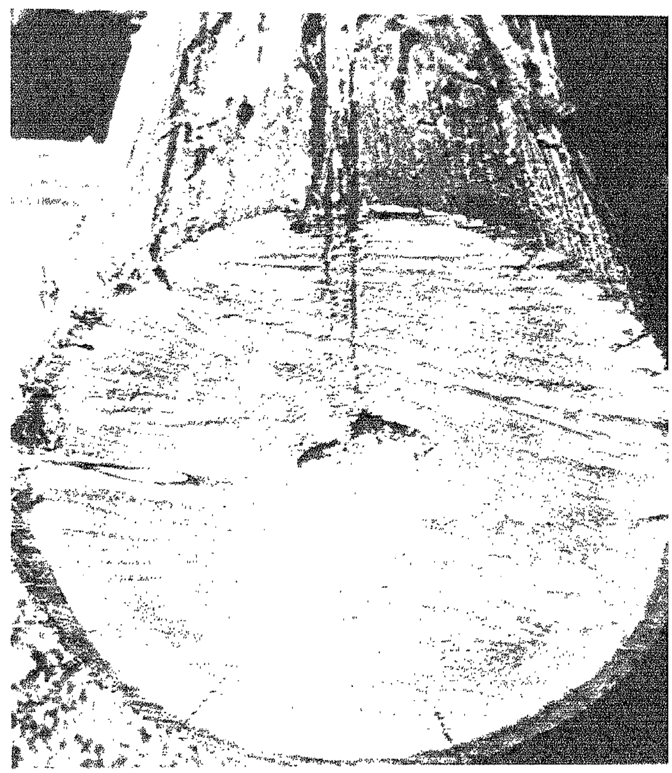


Figure 26.—Deep checks as entrance holes for ants that were in the central hollow.

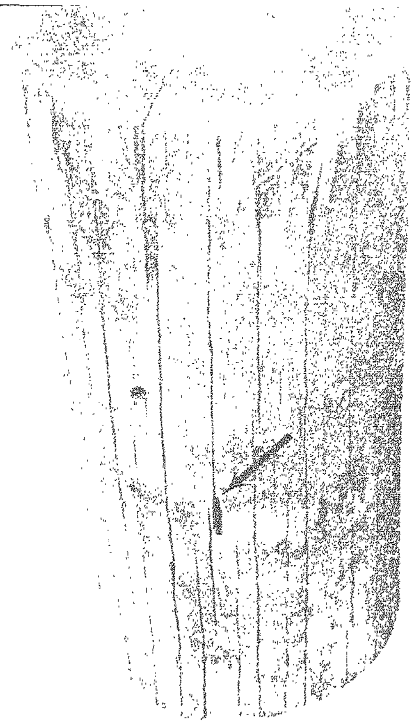


Figure 27.—Holes with smooth margins (arrow) often indicate entrance ports for ants.

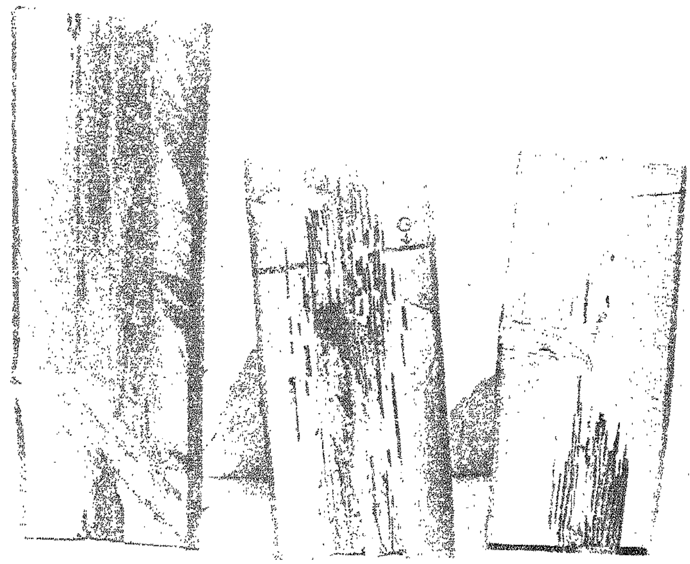


Figure 28.—Ant galleries in a cedar. The "G" and line indicates the groundline. The section on the left was belowground, the section on the right aboveground.

Figure 29.—The ant galleries in this pole were in the heartwood as well as the other tissues.

Figure 30.—Decay associated with deep checks initiated by increment borer holes plugged with wood dowels.

Figure 31.—Closeup of decay associated with increment borer holes.

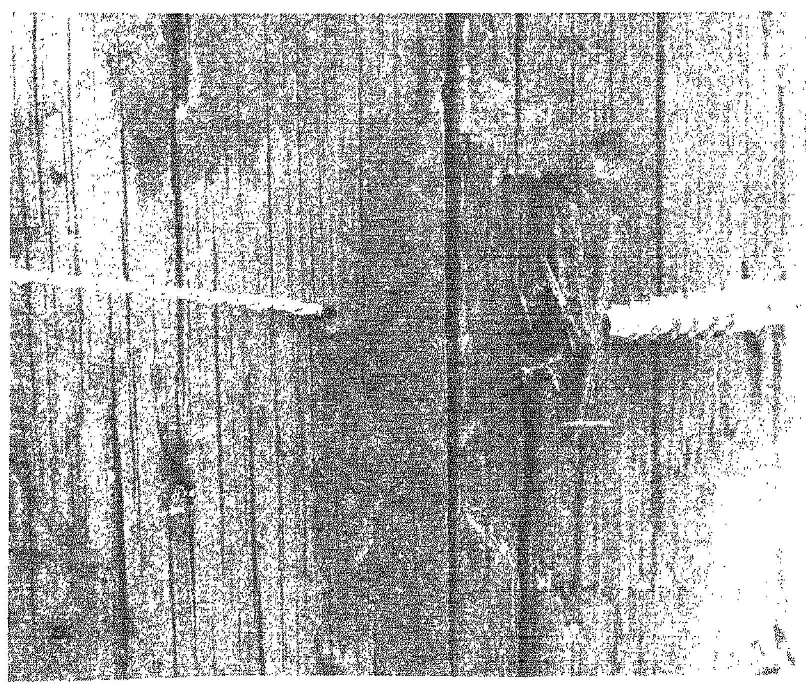
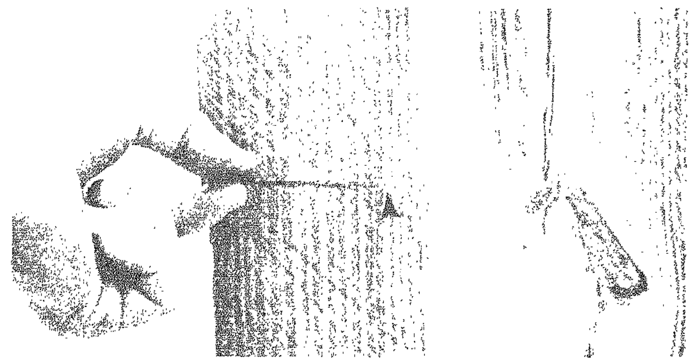


Figure 32.—Holes made by increment borer and drill bit.

Figure 33.—Core from an increment borer at the exact position as shown. The wood at the inner portion of the core would appear sound to the eye. The Shigometer would indicate that the wood was beginning to decay. The core was taken only a few inches beyond the margin of the obvious column of decay. With the Shigometer it is not necessary to drill exactly into the column of obvious decay in order to detect it.



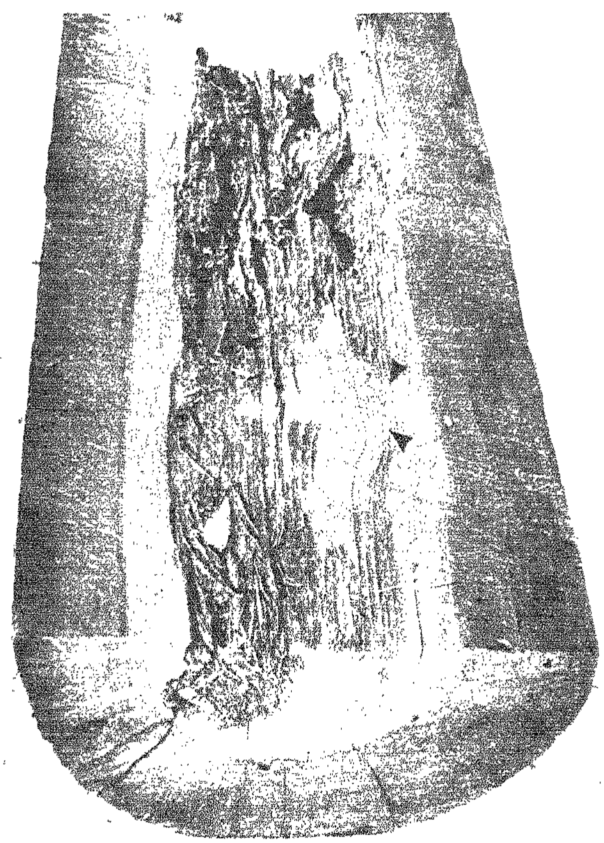


Figure 34.—An increment core at the position marked by the arrow would indicate sound wood. The Shigometer would indicate decay.

Figure 35.—Large branch stub and associated decay. Note abrupt end to decay column on left. The Shigometer would show an abrupt decrease far beyond the obvious end of the decay column.

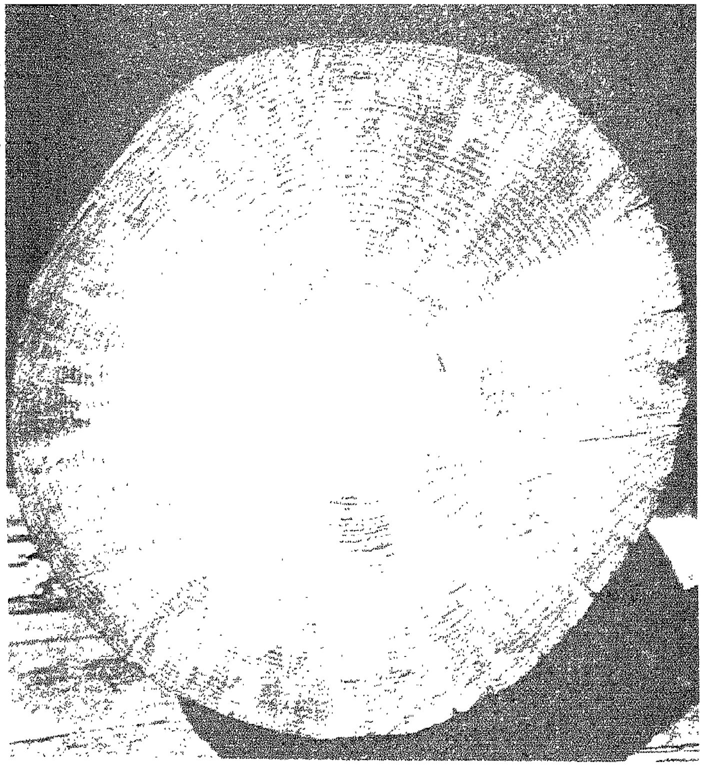


Figure 36.—Bluestain in a pole. The stain pattern can occur rapidly on the cut ends of freshly cut tree trunks. The stain may block the penetration of preservatives.

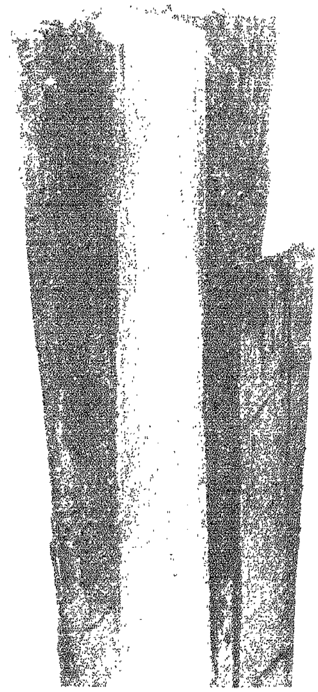
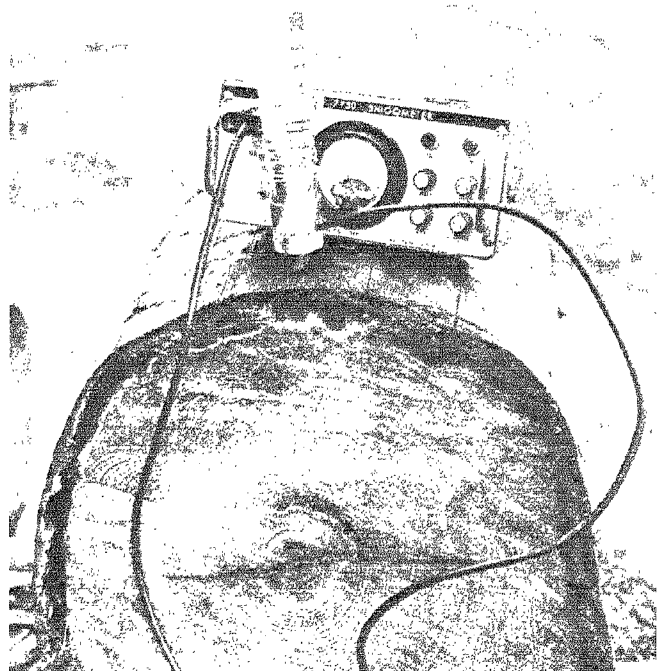


Figure 37.—The heartwood core is often very resistant to decay.

Figure 38.—The arrow shows the groundline. Note the sound heartwood core and the abrupt end to the decay. The section on the left was below the other, deep in the ground.

Figure 39.—Easy penetration of the needle probes deep into the pole indicates hollows or decay beneath the surface. Resistance readings below 50 kΩ also indicate decay.



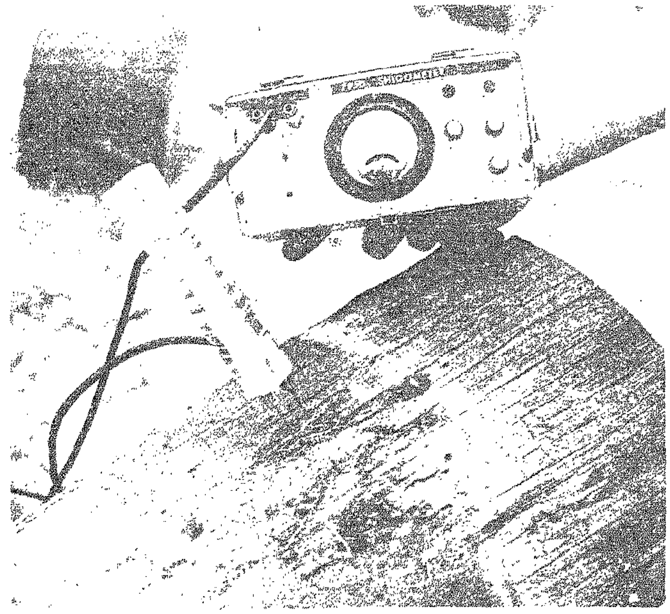


Figure 40.—Needle probes can be used at groundline to detect soft rot. Easy penetration of the wood surface; resistance readings below 50 kΩ indicates decay.

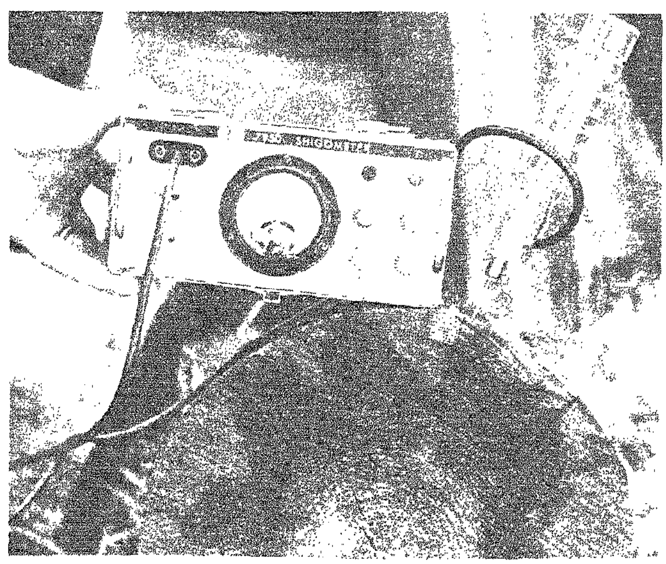


Figure 41.—When it is difficult to push the needle probes into the pole, but very low readings still occur, early deterioration of wood is suspected. When additional probes around such a pole have very high readings, the areas that gave the low readings are all the more suspect. The needle probes shown here are in wood that is beginning to deteriorate; sound zones are also visible on this cross section.

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- Berea, Kentucky, in cooperation with Berea College.
- Burlington, Vermont, in cooperation with the University of Vermont.
- Delaware, Ohio.
- Durham, New Hampshire, in cooperation with the University of New Hampshire.
- Hamden, Connecticut, in cooperation with Yale University.
- Kingston, Pennsylvania.
- Morgantown, West Virginia, in cooperation with West Virginia University, Morgantown.
- Orono, Maine, in cooperation with the University of Maine, Orono.
- Parsons, West Virginia.
- Pennington, New Jersey.
- Princeton, West Virginia.
- Syracuse, New York, in cooperation with the State University of New York College of Environmental Sciences and Forestry at Syracuse University, Syracuse.
- Warren, Pennsylvania.