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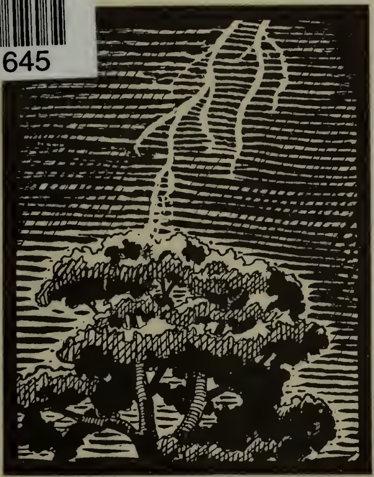
LIGHTNING PROTECTION FOR TREES



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TREE PRESERVATION BULLETIN NO. 5
(REVISED)

LIGHTNING PROTECTION FOR TREES

BY

A. ROBERT THOMPSON, FORESTER

CIVILIAN CONSERVATION CORPS
ROBERT FECHNER, DIRECTOR

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LIGHTNING PROTECTION FOR TREES

By A. Robert Thompson, Forester.

Part F of Chapter III, Standard Practices

Tree Preservation Bulletin Series

Section I

Lightning Protection Installation

Since the time of Benjamin Franklin the value of lightning rods for the protection of buildings has been recognized. There has been a wide variety of practice, however, and many early installations did not fulfill the purpose for which intended, usually because of improper installation. In the last few years electrical engineers have endeavored to formulate certain standards for the protection of property against lightning. These standards have been compiled by the National Bureau of Standards, in the "Code for Protection Against Lightning", revised 1937. 12/

The protection of trees from lightning is comparatively new practice, but it has been done on a slowly increasing scale on valuable trees the last few years. Letters from commercial arborists, etc., indicate that something over 4000 trees have been given lightning protection in the last 20 years. It is now the established policy of the National Park Service that important trees of Type I areas which are especially valuable from an aesthetic or historical viewpoint, shall be given this protection in a manner approved by the Branch of Forestry if such trees are growing in a zone of proven danger from lightning. (See Tree Preservation Bulletin No. 2)

The literature listed in the bibliography found in the last pages of the bulletin has been freely consulted in endeavoring to standardize an efficient protection system as recommended by recognized authorities. The personal criticisms and suggestions offered by Dr. M. G. Lloyd of the National Bureau of Standards, Professor J. B. Whitehead of Johns Hopkins University, Mr. A. W. Dodge, and Mr. Charles Irish, Arborists, have been especially helpful in the presentation of this subject.

In order to ascertain modern common systems of protecting trees from lightning a questionnaire was prepared in 1935 and sent to more than 100 persons engaged either in commercial tree care or in some phase of Governmental tree control. Approximately 70 replies were received from arborists of 14 States, thus giving a fair cross-section of present practices. Acknowledgment is made of the valuable assistance given by these many arborists who responded to the lightning protection questionnaire.

Theories of Protection

The fundamental purpose of lightning protection for trees is to provide a conductor by means of which a discharge may enter or leave the earth without passing through the tree which is relatively a nonconductor.

There appears to be a divergence of opinion as to how a lightning protection system protects a tree. Two of these theories may be stated as follows:

> "The sole purpose of lightning rods....(on trees) is to protect....(the trees) by conducting away the sudden stroke when it occurs, there being no evidence or good reason for believing that any form of protection can prevent a stroke." 12/

> "The protective value of a lightning rod is in its ability to discharge continuously, and so prevent an abnormal rise of potential gradient as related to an overhead cloud." 33/

Although the first theory has the majority of adherents who base their opinions on factual data the second theory is still supported by some. This controversy of long standing has been admirably summed up by Professor John Zeleny who points out that although there are experimental data to demonstrate the continuous discharging action of air terminals, this discharge is in such small quantities as to have little if any real effect on lightning discharge. 38/

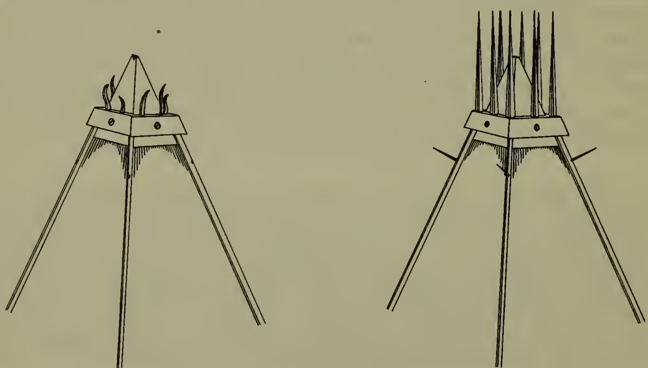

FIG. 1
SKETCHES OF THE TIP OF THE WASHINGTON MONUMENT
SHOWING LIGHTNING AIR TERMINALS BEFORE AND AFTER REPLACEMENT IN 1935

This conclusion is rather well demonstrated on the Washington Monument which, although provided with more than 200 terminal points, has been frequently struck by lightning. The visible evidence of the action of lightning on air terminals was noted by the writer during the recent cleaning of that Monument. The sketches shown in Fig. (1) were made directly from photographs of the Monument apex before and after replacement of the pointed tips which had been badly burned, pitted, and bent by lightning discharges since they were installed in 1885.

It is a well known fact that leaves and twigs on trees and shrubs act as discharge points during the passage of electrified clouds. "Owing to the great number of such natural points in a wooded region, the total upward current flowing from them during a storm is correspondingly large, and yet trees in a forest are frequently struck." 38/ In fact, "lightning storms cause an average of 750 forest fires per year in the national forests of Oregon and Washington alone....; they usually occur in large numbers on a single day." 11/ In addition it must be considered that many discharges occur in forest lands which do not start fires.

Careful study of the literature on lightning can but lead one to the conclusion that in the light of present available data lightning protection of trees serves only to protect the trees in case a stroke occurs.

Nature of Lightning

We know that electricity of opposite polarity (positive and negative) is mutually attractive, and we know further that to cause a lightning discharge the clouds and earth must be charged with electricity of opposite polarity. Experiments have shown 19/, 36/ that thunderclouds are bipolar in nature, the upper part of the cloud usually being positive and the lower part negative. The earth normally carries a negative charge, but the overhead passage of the thundercloud usually induces a positive charge beneath it. The source of these charges is now understood to be largely due to precipitation and air currents. Each time a drop of water breaks, a separation of electricity takes place, the water receiving a positive charge and the air currents a corresponding negative charge. A given mass of water may be broken up many times before it reaches the ground and consequently may obtain a high positive charge. 12/

It has been stated by F. W. Peek, Jr., 15/ that, "It appears that the order of voltage of a severe lightning stroke to ground may be about 100,000,000. The lightning voltage during a storm will, of course, vary over a wide range, sometimes much higher, but generally lower than the value above." The "Code for Protection Against Lightning" states, "....the current of direct strokes may vary from a few thousand to a few hundred thousand amperes." 11/

The atmosphere surrounding the earth normally acts as a retardant to the passage of electricity; but when a sufficient gradient is built up this resistance breaks down and allows an arc between clouds or between clouds and earth, and we have a lightning discharge. This arc will often take place through a high structure or tree standing alone or above other trees, since that structure or tree offers less resistance to the passage of the electricity than the atmosphere; the tip of such a structure or tree is the nearest point of contact.

Cone of Influence

The "Code for Protection Against Lightning" points out, "Experiments have indicated that, under certain assumed test conditions, a vertical conductor will generally divert to itself all direct hits which might otherwise fall within a cone-shaped space, of which the apex is the top of the conductor and the base a circle of radius two to four times the height of the conductor." 11/ Thus, a lightning protected tree will tend to protect nearby structures or trees which are totally within the cone-shaped space

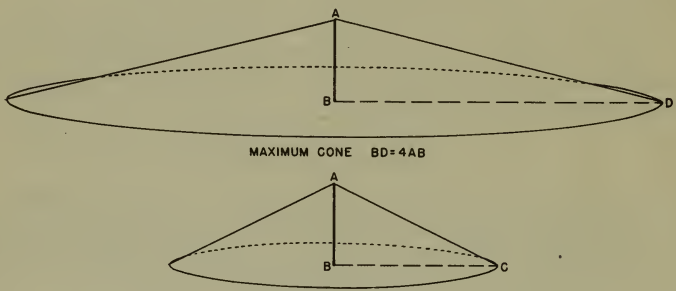

FIG. 2
DIAGRAMATIC SKETCH OF THE THEORETICAL CONE OF INFLUENCE CREATED BY A VERTICAL LIGHTNING CONDUCTOR

as represented in Fig. (2). However, as Dr. M. G. Lloyd has pointed out, the cone of influence is not a zone of complete protection, and lightning occasionally strikes within such a zone. In recent years two such violations have come to the attention of the writer. The article by F. W. Peek, Jr., mentioned in the bibliography, contains the data upon which this theory of influence is based.

Trees Likely to be Struck

Observations by various people have indicated that there is considerable difference in susceptibility to lightning attack among trees of different species and in different environments. It is thought that trees standing alone or above their fellows, and trees along avenues, streams, and lakes are struck more frequently than others. Studies made abroad tend to show that oak, elm, pine, poplar, maple, ash, and spruce are struck frequently, while beech, birch, horsechestnut, and holly appear to be relatively free from lightning attack. Deep-rooted trees are generally believed to be more liable to lightning injury than those with shallow widespreading root systems, and as a general rule decayed or rotten trees are greater sufferers from lightning than sound undecayed specimens. It is also thought that vertical air currents arising from topography changes and the prevalence of underground metallic deposits are important factors in the susceptibility of trees to lightning injury.

So far as can be ascertained, little careful research has been attempted, at least in this country, on the varying phases of lightning injury to trees. In order to advance general knowledge along these lines the National Shade Tree Conference, under the chairmanship of the writer, has initiated a survey of lightning-struck trees. 23/ This survey only started after the September 1936 conference so that detailed results will not be available for some time. It is anticipated, however, that a continuing study of lightning-struck trees will eventually increase general knowledge of the subject to a considerable degree.

Principles of Tree Protection

Before installing a system of lightning protection in a tree the following principles should be understood and considered:

1. Air terminals.--The tree should be examined and the point or points most likely to be struck should be noted with the view to establishing air terminals at these points. It is axiomatic that air terminals should be placed at the highest point or points in a tree. It is unnecessary to place air terminals on lateral branches of trees where such air terminals would fall within the cone of influence shown in Fig. (2).

2. Conductors.--Conductors should follow the most direct path to the ground in order to offer the least possible resistance to the passage of the current. Where bends are unavoidable they should have a radius of at least eight inches and no change of direction greater than ninety degrees.

3. Conductor attachments.--Copper cable may be attached to trees with copper nails, never steel nails, in order to avoid electrolysis. Copper lag screws may be used for this purpose if desired. The use of insulated fasteners is never recommended since the potentials of lightning strokes are so enormous that the small insulators would be unable to withstand them. Then too, it is important that nothing interfere with the free passage of the surface charge on the tree to the conductor.

4. Ground terminal location.--When a stroke is about to take place to earth, the surrounding surface of the ground carries an electric charge for miles around. As the discharge takes place this surface charge moves radially toward the ground end of the air path, forming an electric current in the ground. Near the point where the discharge enters the ground the current density becomes high, and if the flow takes place through a tree and its root system, the damage may be great. Ground terminals should be distributed, therefore, more or less radially about the tree beyond the root system rather than on one side close to the tree.

5. Grounding.--Ground terminals are the most important part of the system; three should be provided for each down conductor.

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Ground terminals should be extended their full length (about 8 feet) into the earth, but if many rocks are encountered or if the soil is dry Dr. Lloyd suggests that a network of wire be spread just under the surface of the ground. The grounding of a lightning protection system may be varied from that of a power installation since the earth's surface charge is the charge which is considered the more important from the standpoint of lightning.

6. Joints and splices.--Joints should be as few in number as possible, mechanically strong, and of good electrical continuity. The contact area of splices should be at least 6 to 12 times the diameter of the cable. Wrapped joints for tree installations as illustrated in Fig. (3) are preferable to clamped sleeve joints by reason of greater strength and electrical continuity. Soldering of joints will also assist.

7. Side flashes.--If the tree has been braced mechanically with steel cables all such cables should be connected with the lightning protection system to prevent side flashes. Protection systems on nearby houses should also be connected to the tree system for the same purpose.

8. Electrolysis.--Metals of different kinds should not be joined if it can be avoided as the electrolytic action will wear out connections. Where such connections are necessary, as in connecting copper lightning cable to galvanized steel strand, the connections should be soldered if possible or painted with waterproof paint. In this connection it should be noted that the common tube liquid or heatless solders, although strong, are not electrical solders, but some of them actually act as insulators.

9. Servicing.--Since a lightning protection system is expected to remain in working condition for a long time the materials used should be strong, and the attachment to the tree firm. Since trees continue to grow above the air terminals and tend to imbed the lightning cable in the trunk it is necessary to service the installation at least every three to five years in order to extend the air terminal upward and to readjust or replace the trunk attachments.

10. Decoration and ornamentation.--The use of fancy ornaments, special air terminals, glass balls, weather vanes, insulators, etc., is unnecessary and undesirable since they serve no useful purpose and only add to the cost. The best protection system is the simplest and least conspicuous.

Lightning Protection Specifications

Lightning has such a wide range of characteristics that it is difficult to provide any practical system which will afford perfect protection under all conditions. However, the degree of protection afforded by the practices described in this bulletin is high if the installation is properly made in accordance with instructions.

Where it appears desirable to install lightning protection in a tree the following rules shall apply for National Park Service installations:

1. Materials

All materials shall conform to the following specifications:

Cable, main.--Bare stranded copper of not less than seven strands of four wires each. The four wires to be not less than No. 16 A.W.G. soft drawn copper conductors, loosely twisted or braided into strands, the strands to be laid up with a spiral twist as in a rope. The approximate overall diameter is to be 7/16 inch, and the entire cable to possess flexibility. Approximate weight per 1000 feet to be 219 pounds.

Cable, miniature.--Bare stranded copper of not less than 10 No. 16 A.W.G. soft copper wires to be laid up in three strands of three wires each, and one single wire, the three strands and the single wire to be loosely twisted or braided into a single strand, and the whole to be laid up with a spiral twist as in a rope. Approximate weight per 1000 feet to be 78 pounds.

Ground rods.--Copper or copper-clad steel. If the latter, the copper sheath to be welded permanently and effectively to the steel core, and the proportion of copper to be such that the conductance is not less than 30 percent of the conductance of an equivalent cross section of solid copper. The rods to be 5/8 inch in diameter by 8 feet in length.

Nails.--Solid copper, broad head, at least 2 inches long.

2. Coursing of conductors

In general a single main cable shall be run from the highest part of the tree along the trunk to the ground, thence to a ground connection. If the tree is forked, branch conductors of heavy cable shall be extended to the highest parts of the principal limbs. If the tree is very large two down conductors may be run on opposite sides of the trunk and interconnected near the top. The coursing shall be in as near a straight line as possible. Branch conductors shall be run to all bracing cables in the tree. To accomplish this, bracing cables may be interconnected with miniature cable and also connected to down conductors at one or more points.

In commenting on the first draft of this bulletin Dr. Lloyd stated, "With respect to the miniature cable referred to, I would recommend that it be used only to connect bracing cables to the down conductors and for similar secondary purposes, but not for branches of the main lightning conductor."

3. Attachment of conductors

Conductors shall be firmly nailed to the tree at intervals of two to four feet with copper nails. Nail heads shall be left protruding 1/2-inch beyond the cable to allow for tree growth. The old belief that copper nails will kill a tree has no basis in fact. The use of materials other than copper for attachment of conductors should never be based on this old fallacy.

4. Air terminals

Air terminals shall consist of conductor cable frayed out about eight inches at the tip so as to form an inverted cone. Air terminals should be attached to the highest point on the tree possible to reach. A new practice being tried out in some areas is to attach the air terminal to a 12- to 20-foot wooden pole which is bolted near the lower end to a high point in the tree. This practice extends the air terminal beyond the branch tips and should require less frequent servicing to compensate for terminal growth of the tree. It also prevents any possible electrical shielding of the air terminal by the foliage and extends the zone of influence upward and outward. The necessity for this extension is undetermined at present.

5. Ground connections

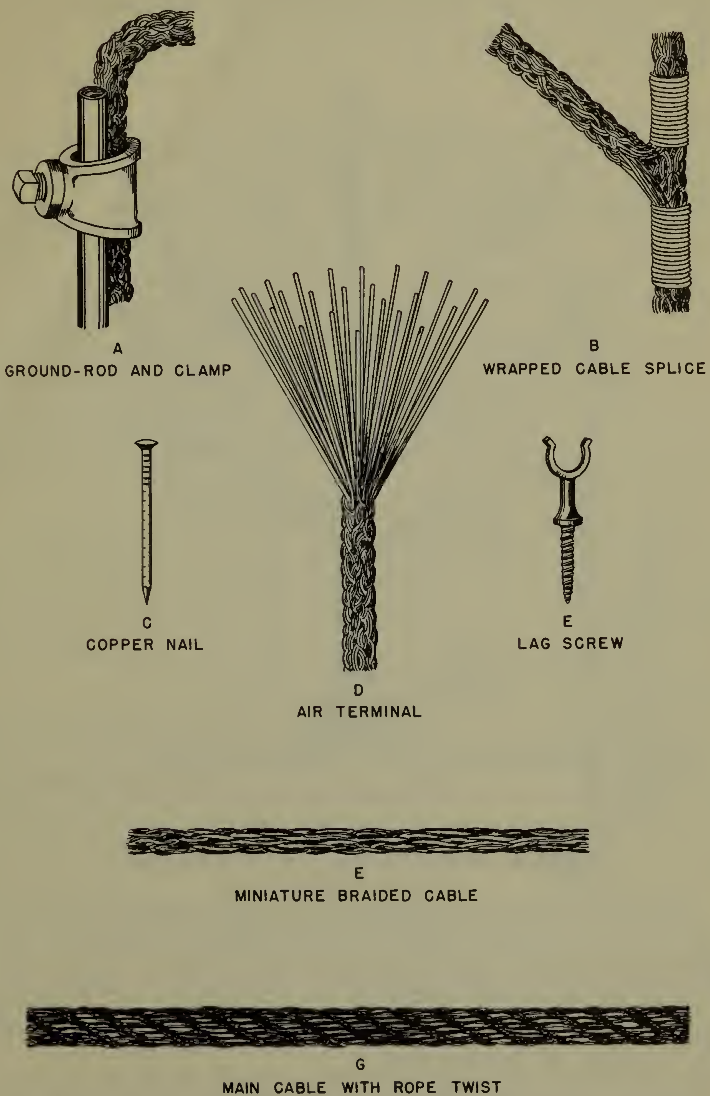
Grounds for the lower ends of conductors shall be made as follows: From each conductor extending to the ground, extend three radial conductors in trenches 12 inches deep to points beyond the drip line of the tree crown. Ground rods are driven eight feet into the earth at these points, and the ground conductors are connected to these by means of special ground rod clamps. Ground rods should be placed in as moist soil as possible and be evenly distributed around the tree. As an economy measure there is no reason why the ends of the radial conductor cables cannot be inserted in small diameter holes eight feet deep instead of using ground rods. If this is done mud should be driven tightly around the cable to assure good electrical continuity with the earth. In very dry soil it may be desirable as a further protective measure to connect the outer ends of the radial conductors with a conductor which encircles the tree at the same depth as the radial conductors.

6. Splicing

If it is necessary to splice cables together the connection should be a tightly wrapped splice at least six times as long as the diameter of the cable (See Fig. 3). All connections of copper cable with steel or iron tree braces should be soldered if possible to avoid electrolysis between the metals. If soldering is impossible painting the splices thoroughly with waterproof paint will retard electrolysis.

FIG. 3

APPROVED LIGHTNING PROTECTION MATERIALS



Protection System--Installation Procedure

Let us suppose that the tree which we are planning to protect from lightning is a mature white oak in good general condition which was struck by lightning years ago but has completely recovered. The tree is growing in a national military park and research has shown that it was associated with an historic event of great importance. Such a tree is certainly worthy of protection.

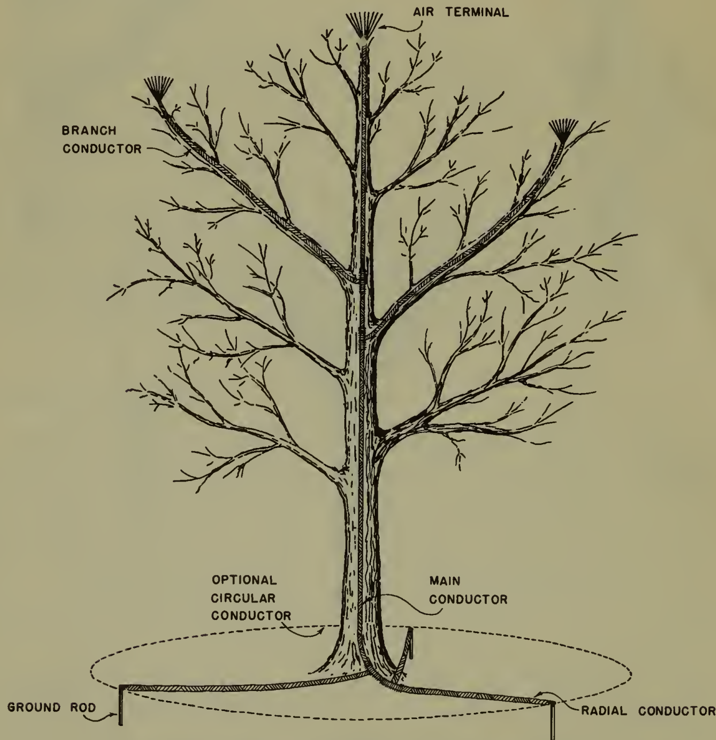


FIG. 4
DIAGRAMATIC SKETCH OF A LIGHTNING PROTECTION SYSTEM

Before any actual work begins the tree should be thoroughly inspected by a representative of the Branch of Forestry to decide upon the number and location of air terminals to be provided, the coursing and branching of conductor or conductors, and the number and position of ground terminals. These points having been decided and the necessary materials procured we are ready to begin the installation.

First of all a rope should be carried into the tree and placed where it is desired to course the main conductor. This location should follow the main trunk and leader and should terminate at the highest central point of the tree. If branch conductors are required their location should be laid out first with ropes in order to avoid future changes. The coursing should be as near a straight line as can be obtained, and it should avoid water pockets and cavities.

Then by connecting the ground end of the rope to an end of the main copper conductor coil, the cable may be drawn up into the tree in its final exact relation to crotches, branch conductors, etc. The main conductor should be a single stretch of cable, not spliced.

The top end of the cable then should be frayed out, and the strands straightened so that the individual strands of the cable form an inverted cone about eight inches high. This is for the purpose of forming a number of points. This air terminal should be nailed with a copper nail to the highest point possible to reach.

If an elevation pole is to be used it is easier to connect the air terminal to the pole before it is hauled up the tree. Then all that has to be done to secure the elevation pole is to run two bolts through the lower end of the elevation pole and attach it to a high branch of the tree as shown in Fig. (5).

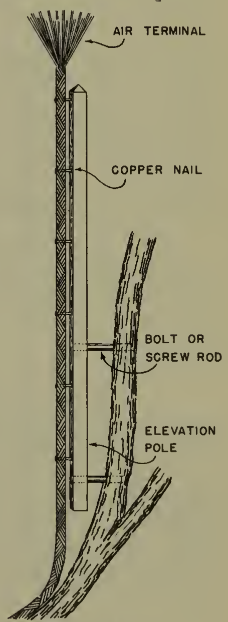


FIG. 5
ELEVATION POLE

With the main air terminal attached the cable should be firmly nailed to the limbs and trunk at intervals of two to four feet leaving 1/2-inch of each nail protruding. This will allow for some tree growth.

If secondary air terminals are to be used in the tree they should then be installed after measured lengths of main cable have been drawn up into the tree. Branch conductors of miniature cable to all bracing cables should also be connected at this time. Splices should be formed by unwinding the end of the cable and twisting these individual wires successively around the main cable. If the splice is formed between two different kinds of metal the joint must be soldered or painted with waterproof paint. It is necessary, of course, to form splices before the conductor is rigidly nailed in place.

Let us suppose that the vertical conductor and branch conductors are now in place. At the ground end of the vertical conductor the cable is still a part of the main coil. Three trenches should be dug twelve inches deep radiating at approximately equal angles from the tree. These should extend beyond the drip line of the tree crown. The main cable should be laid in the trench leading to the most moist and downhill location of the three trench ends. The cable then can be cut, leaving about twelve inches surplus beyond the trench end. The end of this ground conductor and a ground rod should be run through a ground rod clamp, and the ground rod driven into the earth until about one foot is above the surface.

If a bar is driven into the earth and then withdrawn and the ground rod pushed into the hole it will avoid battering the ground rod in rocky soils. It is desirable that some driving of the ground rod itself be done, however, in order to assure a tight fit. If the rod is smaller than the hole, the electrical resistance will be high and will be retained until the earth settles around the rod.

The clamp should be tightened on the end of the rod, and the protruding ends of the ground conductor frayed out and wrapped tightly and consecutively around the ground rod below the clamp. The rod may then be driven completely into the earth. A short distance away from the base of the tree at the intersection of the radial trenches, lengths of radial branch conductors should be spliced to the main conductor cable, and the ground rods connected in the manner described above. The trenches then may be backfilled. If economy is an important factor in the installation, cable may be substituted for the ground rod as described in paragraph 5, page 8.

For a short period of time the copper cable will be shiny and conspicuous, but the superficial layer of copper will soon corrode so as to be almost indistinguishable at a short distance. Normally, surface corroding has no effect on the durability of the cable.

A lightning protection system for a tree can never be considered a completed job because it will need periodic maintenance due to the growth of the tree. The system should be checked every three to five years in order to extend the air terminals upward because of terminal tree growth, and to draw out or replace the copper nails if growth tends to imbed the conductor. The ground terminals and splices should be examined periodically to check corrosion and electrolysis. Replacement or repair at these points may be necessary from time to time.

If the tree being protected is one of exceptional size, say four feet or more in diameter, it would be well to use two main down conductors on opposite sides of the tree and interconnected near the top. In this case, three ground terminals should be run from each of the two main conductors and spaced evenly around the tree.

In very dry ground or when the tree is of especially high value it may be well to connect the ground terminals together by means of a circular conductor buried the same depth as the other ground conductors to serve as an additional means of distributing the discharge or gathering the ground current. (See Fig. 4)

Special Note

The installation of lightning protection systems is a phase of tree preservation requiring considerable skill and judgment. No tree should be given this treatment without special approval of the Branch of Forestry.

Definitions

Air terminal.--The highest point of a lightning cable.

Cable.--A number of wires twisted or braided to form a conductor.

Conductor.--The portion of a lightning protection system designed to carry the discharge from the air terminal to the ground terminals.

Branch conductor.--A conductor which branches off from the main cable such as to lateral air terminals or to bracing cables.

Down conductor.--The vertical portion of a run of conductor which ends at the ground.

Radial conductor.--The horizontal portion of a conductor extending from the lower end of a down conductor to a ground rod.

Circular conductor.--A rotary conductor connecting ground rods.

Elevation pole.--A wooden pole fastened in the top of a tree to extend the air terminal to the highest possible point.

Ground rod clamp.--A screw clamp to bring the ground terminal and the ground conductor into electrical continuity.

Ground rod or terminal.--A buried rod of metal connected at the end of the ground conductor by means of a ground rod clamp to bring the lightning system into electrical continuity with the earth.

Section II

Treatment of Lightning-Struck Trees

Types and Cause of Lightning Damage

Lightning damage to trees falls into three general categories. The first and most apparent is the physical shattering of the entire tree, or some part of it. The second is more difficult to ascertain since it concerns internal injuries which may not be apparent immediately or without thorough examination. The third type of damage may affect the tree by killing all or part of the roots.

Under the first heading lightning may affect the tree in one or more of the following ways:

1. Completely shatter the woody structure of the tree.
2. Strip all bark or strips of bark from the tree.
3. Shave off the loose outer flakes of the bark.
4. Shatter the base and fell the otherwise uninjured tree.
5. Shatter and set fire to the woody structure.
6. Strip bark in nonconnected strips along limbs or trunk.
7. Girdle and kill by tearing out spiral bark strip.

The second general phase of lightning damage, as mentioned above, consists of unseen or less visible injury to the internal structure of the tree as in the cambium and sapwood. Such injury sometimes causes the leaves on one side of a tree or a single limb to brown and die with no other external symptoms of injury. Dodge 3/ has attributed many of such injuries to earth to cloud discharges and possibly to "resurges" resulting from direct strokes elsewhere. Occasionally the tree will show no visible symptoms of being struck and some years later may develop a very small ridge on the bark which follows the grain of the wood. Minute examination of the cross section of the cambium at such a point might reveal a small pinhole extending under the ridge. We have all noted medium-sized or heavy spiral ridges on trees which can be diagnosed only as lightning damage since they differ materially from frost cracks and have no other probable cause.

Lightning damage to root systems also is common. When this type of injury occurs alone it is extremely hard to diagnose accurately since the evidence is hidden in the ground and the only visible symptom is the death of all or part of the tree. The discharge may be so severe that the tree or some portion of it dies because the food and water supply was cut off when all or part of the roots were killed. The extent of this damage often may be ascertained by examination of the feeder roots. If a large portion of these have been injured and turned black the tree will probably die.

Factors Influencing the Effect of Lightning

The varying effects of lightning upon trees may be explained partially by the variations in voltage of the discharges. A bolt of low voltage is apt to show little or no visible evidence of its passage, while a discharge of high voltage may cause extensive and often irreparable damage. This damage may be laid to the resistance of the woody structure to the passage of the electricity. The resistance raises the sap to such a high temperature that steam is produced which exerts a high pressure on the cellular structure and rips and tears the wood and bark.

Other factors which vary the effect of lightning may be dependent upon the moisture content of the tree. It is believed that the cambium and sapwood normally offer less resistance to lightning than the heartwood due to the greater amount of moisture present.

Cases have been observed where the damage to a tree from lightning has been slight because of the film of moisture on the bark due to rain. In other cases where the rain has not thoroughly wet the trunk and limbs from the top to the ground, the lightning followed the wet parts and then jumped to the cambium and sapwood as the course of least resistance and caused great damage to the tree.

The starch and fatty content of trees of different species may be considered a factor in lightning injury. The starchy trees such as oak, poplar, ash, maple, etc., are good conductors, while oily trees such as beech, walnut, and birch are poor conductors. This may partially explain the supposed greater susceptibility of the former group to lightning injury.

Repair of Lightning Injury

Since the total damage done to a tree by a bolt of lightning is not always immediately apparent, it would appear that economy and good judgment would dictate that a minimum of repair work should be done until at least the next growing season after the injury.

Of course, the obvious first step in the treatment of a lightning-struck tree is to ascertain the damage. This may be done by observation of the trunk and limbs, digging in the root area to examine the condition of the feeding roots, tapping of the bark to determine amount of springing, etc.

Sensible immediate care might include the removal of badly shattered limbs, hanging bark, and large splinters. If the surface of the wound is smooth or can be chiseled off quickly to a fairly smooth surface, it is well to remove the obviously dead bark and paint the exposed wood with a tree dressing to preserve the wood and retard or prevent infection by fungi or attack by borers. The injection of a quick-acting fertilizer, preferably liquid, into the feeding area beneath the tree followed the next year by a complete tree food may also assist the tree in recovering from the damage. It is also suggested by some that wrapping the loosened bark tightly to the trunk with burlap or tacking the bark in place might assist in saving the cambium in some cases. The use of paraffin wax to cover moist cambium has also proven beneficial under certain conditions.

Immediate thorough treatment is not recommended for the reason that later symptoms may show that the work has been wasted on a dead tree or one which is so badly damaged that it should be removed. Very often dead bark will cling so tightly to a trunk or limb that it is practically impossible to trace a wound back to assuredly living tissue. Time and effort would be wasted on such a wound and might better be expended later when the edge of the growing cambium is defined by nature by means of a small callus roll.

Final treatment of the injured tree will vary, of course, with the type and extent of the damage. If the tree is worth the attention, the wound or wounds should be smoothed with chisels or gouges and the loose bark traced back to live tissue in such a fashion that the wound will heal readily. Of course, such wood as is exposed should be dressed with an approved wound dressing. Mechanical bracing to strengthen structural weaknesses is often necessary on shattered trees and, of course, dead and badly injured limbs should be pruned where they occur. Feeding to assist the tree in reestablishing itself is usually good judgment, but care should be exercised that the tree is not overstimulated.

Even after one or two growing seasons have passed there is no certainty that the treatment has been successful, for lightning does strange things, and the total damage may only appear in later years. For this reason no cavity work should be done on a lightning-struck tree for a period of at least three years, and then only if the damage is minor and the tree is one of especial value.

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