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THE SCIENCE OF TREE SURGERY



Seminar Thesis

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CHAPTER I

INTRODUCTORY

The beginning of the twentieth century might be referred to as the milestone separating pioneer America and the highly industrialized civilization which we now know.

With the shifting of populations and the consequent grouping of human beings into large and closely knit social units, contact with the outdoors has been all but lost. This has led to the establishment of parks and recreational areas in most large cities, as well as park areas set aside by the federal government. Not a small part of the value of these areas lies in the forest growth which they support. However, in the case of city parks, the municipal environment is not conducive to healthy development of trees, and more often than not their natural resistance is incapable of keeping them in the best of condition.

It is a commentary on our wasteful methods; the treatment accorded the finest trees of our cities. They have been entirely subordinated to development in every way; their branches lopped to make way for a power line, their roots torn up in paving and laying water mains, and no thought given to their welfare.

It is not to be implied from this that development

should be hindered in order that tree growth be preserved. It is entirely possible, however, to insure a measure of compatibility between the two. The exercise of a reasonable amount of care in construction, the proper care of necessary injuries, and the minimizing of injuries should do much to improve the condition of trees in the cities.

It is not strictly within the province of Forestry to deal with the repair and care of trees in this country, though this may assume a position of greater importance in the future. At the present time the condition of the forests in the United States does not warrant any individual tree treatment as is the case in many of the European countries.

But the development of large recreational areas both in cities and elsewhere has led to a peculiar situation which calls for a knowledge of tree surgery on the part of the manager of these areas. This duty often falls to the municipal forester employed by so many cities. It is imperative that he have some knowledge of tree repair as well as the more conventional phases of Forestry.

CHAPTER II

THE HISTORY AND DEVELOPMENT OF TREE SURGERY

So far as history is concerned, literature contains but vague allusions to the development of this branch of natural science, though its rough applications probably arose simultaneously with the cultivation of fruit trees. Earlier than the late Eighteenth Century only the most meager references are available.

The modern history probably dates from the year 1800 when William Forsythe, king's gardner at Kensington, made the odorous discovery that a mixture of cow's dung, lime, and wood ashes was very efficacious in the treatment of tree wounds. This was challenged from many parts of the continent where less plebian materials were the rule, and for some time letters of protest and defense flew thick and fast. With this impetus, and the investigation resulting, principles and rules of procedure were formulated which indicated a surprising grasp of the subject by early practitioners.

Perhaps the foremost of these investigators was one William Pontey, an Englishman who in 1805 published his "Forest Primer", and laid down fundamental rules which stand

to this day. He principally advocated making pruning cuts close to the trunk of the tree, and insisted that cuts be allowed to dry before the dressings were applied. He also suggested drainage of holes and refilling with dry sand, the mouth being plugged with wood. The soundness of his observations and the accuracy of his deductions are illustrated by the fact that he recognized the importance of the cambium in the healing of wounds and instructed that the wooden plug be level with the inner bark.

Robert Monteath of Edinburgh published in 1824, "The Forester's Guide", containing a description of wound treatment which shows that its author was exceptionally modern in his approach to the problem and knew almost as much about the subject as is known today.

Some years later there appeared the work of Count Des Cars whose "Pruning of Forest Trees" appeared in 1867. Des Cars' main contentions were the value of close pruning and heavy pruning in the restoration of old trees. Cavities, however, also interested him, and since he was primarily concerned with timber trees, he confined his efforts to comparatively small openings. These he advocated cleaning, coating with paint, and plugging with wood.

It is logical that the development of the science should have its inception in the improvement of timber trees. Those which were not fit for this purpose were disregarded. It was a

relatively short step, then, to the tree work which we know today and with the increase of wealth in this country, and the urbanization of the population, repair on trees valuable mainly for their aesthetic value was merely a thing to be expected.

The practice of filling timber trees in the early stages of the science also led to the selection of materials which could be sawed or chopped when time for utilization came. These restrictions were removed, however, with the development of modern repair in America where the emphasis was placed on trees not primarily valuable from a timber standpoint. It was more often that large holes were filled after this time, than small ones, and the most common, plastic substance readily available naturally filled the role. It so happened that bricks, mortar, and concrete became the modern materials, being displaced to some extent more recently by asphalt.

Until recently the position of the tree surgeon was somewhat unfortunate. Every unemployed carpenter, gardner, mechanic, and alienated agriculturist fancied himself a "tree doctor", and went about with his axes and saws and a surprising dearth of knowledge to leave upon the city streets the deformed results of his experimentation. With the advent of the larger companies however, the situation is improving rapidly and is coming to be recognized as a distinct profession with the obligations which this standing entails.

CHAPTER IYI

TYPES OF TREE INJURY

Despite the popular conception of the longevity and hardihood of trees in general, it is necessary to realize that injuries are as widespread among this class of organisms and constitute as real and everpresent a danger, as is the case with living and growing things of less impressive stature. Except in the case of sudden and violent injuries following storms, the factors which affect the health of trees are so slow acting and inconspicuous that to the ordinary individual, they may remain unnoticed for long periods of time even though they may constitute the deadliest kind of menace.

This, and the apparent tendency to over rate the powers of resistance in trees, probably accounts for the neglect which so often claims the lives of many of the finest specimens.

It is the first duty of the tree surgeon to recognize the signs of ill health in his arboreal clients before serious damage has been done. Injuries are by no means confined to breakage, rots, and insects; those which are easily seen and the extent of their harm measured. These are frequently but secondary effects and have little to do with the true cause

of the disturbance. Lack of sufficient moisture due to an excess of paving above the roots, drainage which lowers the level of the water table to which the tree has become accustomed, smoke and gases in the air, and compacting of the soil by domestic animals and human beings all serve to reduce the tree's vitality to such an extent that the final coup de grace, inflicted by the host of enemies always present, is merely a matter of time.

The diagnosis of such obscure welfare factors will be discussed later. This chapter confines itself to the more conspicuous and easily detectable injuries.

Mechanical

Mechanical injuries may be reduced to the simple statement that any breach in the tree's first wall of defence, the bark, constitutes an injury. Whether this be the result of traffic on a city street or the result of grazing animals in the wild state, the delicate inner portions of the tree are laid open to infection.

The first aid rule, immediate treatment, applies in the case of trees as well as elsewhere. It is imperative that the wound be cleansed and covered before insects or fungi obtain a foothold in the exposed wood, as they will do very quickly. This is especially so in the warmer portions of the year and frequent inspections are necessary after dressing to see that the work has been effective.

Insects

It will be unnecessary here to go into the innumerable genera and species of insects which exact a toll of one hundred million dollars annually from the forests and parks of the United States alone. Some conception of this damage may be gained upon occasions of visitations of the gypsy moth of the east, or the extent to which the locust borer has dampened the hopes of those who predicted the bright future of the black locust for post and tie production. In the latter case, the growing of locust has proved, in the last few years, to be a thankless proposition; scarcely a sound tree is available.

The shade and park trees have taken the brunt of this devastation; changing conditions having reduced the greater proportion of them to the statue of weaklings. Drainage of the soil, fumes of factory smoke, injuries of numerous kinds have lowered their natural resistance to this type of injury.

The province of the tree surgeon, from a repair standpoint, embraces mainly the results of the boring insects. These are classed according to the peculiarities of their damage.

Perhaps the most injurious are the bark beetles which infect the cambium layer and the outer sapwood. The larval stage of these insects is spent boring between the bark and the wood

of the infected tree, with the result that the tree is often completely girdled and, of course, killed. At any rate, an infection of this kind always proves very weakening, interrupting the flow of sap and opening the way for spores of fungi.

The boring beetles come to the attention of the tree surgeon more frequently than any other kind of insect. The treatment of this kind of injury is distinctly within his field. The usual methods of excavation and refilling are used.

While the boring insects are of more conspicuous habit than the bark beetles, their damage is of a lesser extent so far as the health of the tree is concerned. They confine the major portion of their activities to the inner wood, and while they may riddle the inside of the tree, their action does not interfere so seriously with its physiological functions.

Those insects which act as defoliators are perhaps better known in connection with park and street trees than the borers. The borers and defoliators may be roughly divided into separate groups of insects, though this classification is by no means entirely consistent. To the Coleoptera, or beetle order, can usually be assigned the damage due to boring attacks, though not always. The leopard moth, a European insect imported to this country, is an example, and belongs to the order Lepidoptera which is usually associated with the defoliators. The leopard moth, however, usually confines its activities to the smaller limbs and seldom attacks the trunk. In its boring

activities the larvae may girdle rather large limbs. The Hymenoptera, or wasp order, is also a notable exception to this rule, and may well be represented by the "pigeon tremex" which is often found on shade trees.

As has been mentioned, the defoliator group is largely confined to the order Lepidoptera, which consists of the moths and butterflies. Of this group the moths are the most important from the standpoint of tree injury. The army worm, the gypsy moth, the Nantucket tip moth, and many other well known tree parasites belong to this group. Certain of the Coleoptera act as defoliators also, but their damage is relatively slight^{as} compared to the Lepidoptera.

Fungi

To the rot fungi belongs the dubious honor of providing the tree surgeon with the bulk of the work which he is called upon to do. Were it not for this type of parasite the majority of trees would live twice as long as they normally do. There would be no gnarled, hollow boles to occupy the perplexed owners of forested estates, and the earth would be cluttered with debris which should have rotted and had failed to do so.

The rot fungi present to the tree surgeon the most difficult situations with which he has to work. Particularly in his diagnosis it is essential that he be somewhat of a pathologist. The obscure nature of many infections presents baffling

difficulty in the making of clean and complete excision of infected material. It is the nature of many rot fungi to discolor the infected wood so that it is easily recognizable and may be removed without great difficulty. There are others, however, wherein the incipient stages are scarcely discernable from the sound wood and it is necessary to resort to microscopic analysis in order to delineate the lines of decay. Others, while infecting the heartwood and spreading slowly through it, will advance the incipient stage at a much greater rate through the easily penetrable pith and thus defy detection.

It is these things that make diagnosis and complete repair especially uncertain.

According to the manner in which they affect the host tree, the rot fungi may be placed into four rough groups, each of which presents its own specific problem; those which infect the bark, sapwood, heartwood, or root system.

Perhaps the best known of the bark infecting fungi are the two which have been instrumental in endangering the existence of two of America's most valuable tree species; the Chestnut Blight and the White Pine blister rust. The former has accounted for the majority of the existing Chestnut timber, and the latter is even now ravaging the last great white pine stands to be found on the continent. In orchard trees, the several bark rots and cankers which affect the susceptible apple tree are the most representative. The bitter rot, as

well as a number of others, also affects the fruit, causing great damage in many parts of the country. The characteristic action of the bark decay consists mainly of injury to the cambium, destroying it in large patches which become cracked and sunken and dry in the final stages of infection.

The fungi attacking sapwood scarcely merit the designation of true parasites. In the main, they confine their injury ~~of~~ living trees to those which are so injured by fire, sunscald, or frost as to be readily susceptible. Usually the dead bark is attacked first, ^{the damage} spreading later into the sapwood.

Of all the rots discussed, the heartrots are probably the most important commercially. They are truly parasitic and enter the tree from any exposure of raw wood surfaces. After gaining entrance through a wound or branch stub they penetrate to the heartwood and spread upward and down through the heart. Their one redeeming feature, and that does not apply to timber trees, is the fact that their infection is of no immediate danger to the physiological processes of the tree. With the sapwood intact, the tree's functions may continue uninterrupted and weakening of the bole be the only harmful result for a period of many years.

Fortunately the root infecting fungi are comparatively few numerically, for their infection is almost impossible to combat and extremely destructive. The most common rot of this kind is the honey mushroom, or *Armillaria mellea*. This rot is characterized by the production of black, string-like

rhizomorphs which enter the roots by way of a wound beneath the soil, spreading through the roots and killing the cambium. They work in the most inconspicuous place possible and often the only intimation of infection is the throwing of the tree by the wind when the roots are incapable of supporting it further.

So persistent is this fungus in the soil that, after infection has been discovered and the tree removed, it is unsafe to plant again in the vicinity for several years.

CHAPTER IV

REPAIRING MECHANICAL INJURY

It is unnecessary, in the consideration of wounds and other mechanical injuries, to go deeply into the physiological functions of the tree which need to be considered when repairing injuries of this kind. However, it may not be out of place to call attention to the flow of water and dissolved materials within the tree, and the healing process which takes place when a wound is sustained.

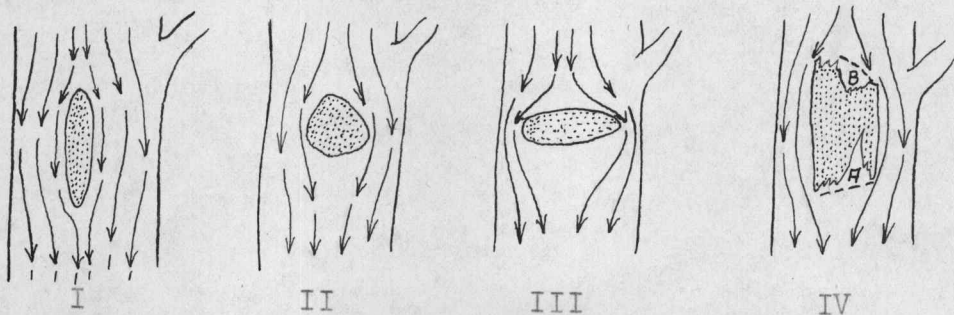


Fig. I - How wounds affect the flow of sap.

It must be remembered, in the treatment of wounds, that the flow of sap is confined largely to the longitudinal directions; the sapwood carrying water and materials up from the roots, and the downward transportation toward the roots is taken care of by the live portions of the inner bark. It may be readily seen from this that wounds of any great extent are likely to interfere seriously with the vital processes of food transportation.

When a wound is inflicted in the bark of a tree, there

is a diversion of the downward flow, and this diversion increases directly with the width rather than with the length of the wound as shown in Fig. I. A long and narrow wound is the less harmful as the sap is diverted the least and a healing callus may be quickly formed.

Illustration IV, Fig. I shows this condition and the results of a jagged wound which is not handled properly. The areas A and B, receiving less than their proper proportion of sap, may be expected to die back and this should be considered in treatment. The two areas must be removed and the wound rounded as nearly oval as possible so that an equal flow of sap will be available to all parts.

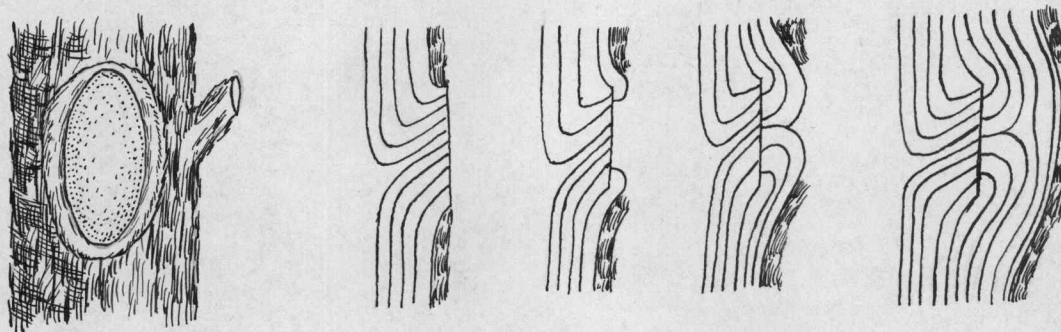
In cavity work, where an incision is necessary in order to remove infected material, this is a rule which must be kept in mind. A cut which is long and narrow, running longitudinally with the bole or limb being treated, is preferable at any time to a wider one.

Likewise, the proper location of incisions is a consideration of paramount importance. In view of the principles mentioned, it is obvious that an incision should never be made just below a growing limb if it is at all possible to locate it elsewhere. Sap, tending to flow in straight lines, would be cut off from the limb by removal of the sapwood directly beneath it. The same rule holds for placing an incision above a healthy root. Either the incisions should be a

sufficient distance away from the limb or root for the flow of sap to be undisturbed, or a more suitable location should be chosen.

In borings made for the purpose of locating the extent of rot or cavities, the holes should be bored one directly above the other, or if the tree is spiral, following the twist of the grain.

It may be well to note the phenomenon of healing which takes place in the tree, and becomes a factor with which the tree surgeon must reckon. It is necessary, in order to apply the principles of healing, that the practitioner understand the manner in which this is accomplished.



When a wound is inflicted, the first reaction of the tree is an attempt to repair the break in the bark, and since the cambium is the only means of replacing destroyed tissue, it falls to this part of this organ to repair the damage.

In the first stages of the process, a greatly stimulated rate of growth may be noted in which a heavy roll of tissue is formed at the edges of the wound. This is the first effort of

the cambium to replace that which was lost. Fig. 2 illustrates this. Gradual layers of callus are built up in the years or growing seasons which follow until the wound is completely covered and the bark is again intact.

However, it is during the time that the wound is inflicted and the time that the callus covering once more excludes it from the outside enemies which take advantage of such a situation, that the tree surgeon comes in.

There may be a period of years, here, when the raw wood is open and unprotected, and it is this type of injury that ultimately leads to most of the cases of decay and death. It is obvious that, in such a case, two necessary procedures must be followed to lessen the danger of the wound; it must be covered or coated to exclude the insects and fungi which would otherwise gain entrance, and the natural healing faculties of the tree must be assisted. Once these two objectives are accomplished, the wound will heal over satisfactorily and the physiological processes of the tree will go on undisturbed.

It is traditional that paint and tar should be used for both purposes stated above. The value of these two dressings has remained unquestioned for years despite the evidence of their inferiority. This is due largely to the prevalence of the opinion that wounds on trees are dressed for appearance alone.

There is no question, however, that it is difficult to obtain a dressing which fulfills all the necessary requirements

of tree work. Any freshly exposed wood surface is moist and will remain so for some time. Thus, it is sure to season and check as it dries out. It can readily be imagined the effect of this process on inelastic substances like paint and tar.

So far there has been discovered no way to prevent a wound from drying, and the result on a tar or paint dressing is a multitude of cracks which allow easy access to insects and spores.

In order to prevent this, it must be realized that the method of application of paint and tar is at fault as well as the materials themselves. The wound should be sterilized as well as possible and allowed to dry before being dressed. Then care should be taken to renew the application until all seasoning checks and cracks are filled with both the antiseptic and the protective dressing. Frequent care is often the criteria of success in tree work of any kind.

To the antiseptic solutions used for disinfecting wounds before dressing, belong all sprays and powders used to combat fungus diseases. Included in these are copper sulphate solution and lime-sulphur wash. It may be noted here, also, that whenever trees are sprayed with a fungicide, it is well to attend to all bark wounds at the same time. The bark should be sprayed, especially any broken places, as well as the leaves.

Among the antiseptic solutions may be listed further, corrosive sublimate and formalin. To mix the former, two ounces to fifteen gallons is used, and one ounce to two gallons for the latter.

The commercial wood preservatives are among the best antiseptic dressings. Coal tar creosote is probably among the best, with carbolineum about equal. However, care should be taken to be certain that the creosote is distilled only from coal tar. Any of the well advertised brands are satisfactory.

Carbolineum is the subject of much disagreement among arboriculturists. There are those who maintain that it is harmless to cambium and sapwood, and there are those who are able to demonstrate that trees have been killed by its unwise use in this respect. Whatever the case, it is best, until matters have been settled, to confine its use to heartwood. For the treatment of large wounds it is very valuable as it has great antiseptic properties and penetrates deeply into the wood, especially when heated.

It is not, however, a substitute for heavier materials when the wound has thoroughly dried. It should be followed by a dressing of sufficient consistency to bridge the checks which result from drying,

This is the proper function of paint. After drying, the wound should be covered with a heavy application of white lead. This should be followed by a second application as soon as any checking is noticed.

Slaters' cement is coming into rapid favor as the idea of two dressings; one of antiseptic and one of filler, becomes more general. Slaters' cement is plastic and is applied with a spatula to the wound. It has no antiseptic properties, however, hence the double application. It has the further advantage of being rel-

atively inexpensive.

Grafting wax also has its place in the treatment of tree wounds. Though it adheres imperfectly, it is harmless to the most delicate tissue and may be used to protect fresh wounds. However, it is costly and is not suitable for a permanent dressing.

Tar, as previously mentioned, is one of the most popular dressings in use at the present time. However, attention should be called here to the "coal tar paints" which are often erroneously supposed to be satisfactory for dressings. These consist merely of an asphaltum material dissolved in benzine or some other solvent, and have no value whatever for dressings. Their principal drawbacks are that they are too thin, dissolve easily in water, and dry brittle. Obviously this makes them unfit for tree work. The same might be said for any tar product with these qualities.

Coal tar itself, extracted from the distillation of bituminous coal, has its uses, however, and may be listed as one of the satisfactory dressings under the proper conditions.

It is best used in heavy applications in winter when it is heated to be applied. It should be applied to dry surfaces which are not too large.

One of the drawbacks of tar which should be remembered is its tendency to crack, and if applied to a moist surface, to blister. This necessitated frequent redressing. A coat of tar must be applied to large wounds twice the first year and every

second year thereafter until a heavy, impervious layer is formed.

Recently there have appeared on the market a number of substitutes for tar which, in most cases, are a definite improvement. For the most part they are not so subject to cracking as coal tar. In applying the heavier forms, which must be heated, a number of difficulties are met with. To avoid the drawbacks incident to heating, it is well to ^{thin} flux the material with some kind of flux; gasoline, various petroleum oils, linseed, and other vegetable oils being used.

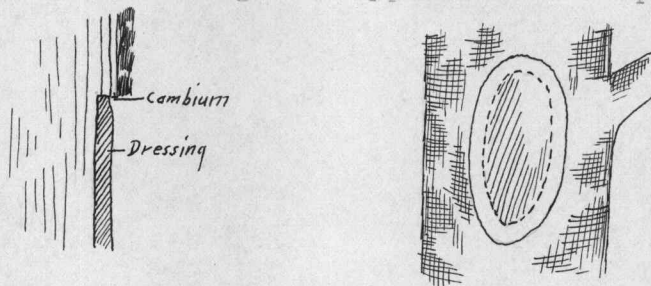
The cheaper mineral oils are to be preferred for this purpose, and the use of gasoline or benzine is to be discouraged as the mixture dries brittle.

Though, in most cases, a dressing of the materials discussed is sufficient treatment for injuries, there are times when an even stronger and more impervious material is needed. This applies when the possibility of future redressing is uncertain, or when the wood beneath the dressing is infected with borers which may be able to penetrate the regular dressing. It is possible, in a case like this, to apply a sheet of copper or zinc to the wound, properly painted over with tar.

Sheet metal for such work is relatively expensive, however, and usually a fabric, saturated with the dressing compound, is used instead. There are many materials which may be used for this purpose, cotton padding being the best. This costs about five cents per square yard and may be bought anywhere.

In applying the reinforced dressing, a thorough coat of

asphalt compound, preferably, is applied to the wound. This is allowed to dry a few days. Then the cotton padding, cut to fit, is saturated with the dressing and pressed to the wound. The rough edges of the cotton are removed with a razor blade and several coats of dressing are applied at the proper intervals.



It is well to keep in mind, in any work involving bark injuries, the exact nature of the healing process which takes place, and to make allowances accordingly. Fig. 2 illustrates the growth of the cambium to repair a wound, and this manner of repair should be considered. That is to say, when a wound is being dressed, a powerful antiseptic such as carbolineum should not be allowed to touch the delicate cambium. It should be painted on to within half an inch of the bark and the dressing completed with some less toxic material. Also, it is unwise to apply too heavy a dressing if complete and inconspicuous healing is desired. There must always be sufficient room left for the growth of the cambium over the dressing. This is shown in Fig. 3.

Bracing

Bracing is an important phase of tree repair which has for its objective prevention of injury rather than actual repair after an injury has been inflicted.

It may be said that any factor which causes a tree, or any portion of a tree, to become so heavy in proportion to its strength that breakage is imminent, requires correction by bracing. This may be due to the presence of decay, insects, a bad crotch, or merely natural growth.

Breakage is quite often the result of decay either in a limb or the trunk. If the decay is attended to, and the limb or trunk braced, the "expectancy of life" may be prolonged indefinitely.

So long, in a tree which is decayed, as the bark and the sapwood are in good enough condition to allow the functions of the tree to proceed uninterruptedly, mechanical weakness may be compensated for wholly or in part by proper bracing.

There is considerable variation in the necessity for bracing between the different species of trees. However, it is a good rule that trees with horizontal, spreading limbs, weak wood, subject to bad crotches, and like weaknesses will require bracing more frequently than others.

A widespread method of bracing which should be discouraged is the practice of strengthening the limbs of old trees by means of iron bands passed around the limbs and

~~and~~ anchored to the trunk, or the use of chains for the same purpose. It is usually found that these bands break in time, after having first crushed the cambium and sunken deeply into the wood. Thus the bark is killed and the very object of bracing is defeated. No method of bracing should ever be used which will constrict the bark and hinder growth.

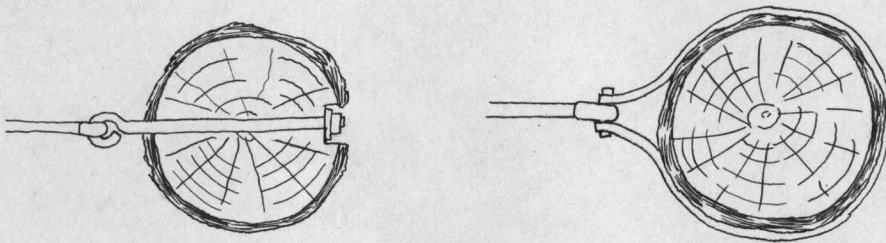


Fig.4- The right and the wrong way to brace a limb.

The above figure shows the results of improper bracing by the use of bands, and likewise the proper method which does away with the tendency to constrict the bark by the use of a bolt.

When a band is placed around the limb of a tree, from one fourth to one half the cambium is ultimately killed. By using a bolt instead, this may be reduced to approximately one fifteenth or even less. Machine bolts should be used for this purpose, and the nut and washer countersunk through the bark and about an eighth of an inch into the wood. This allows the cambium to quickly grow a callus over the wound.

A great many materials have been used for bracing in the past. Chains have always been widely used and have the advantage of being easily applied, though they are expensive and conspicuous and rust badly. Iron rods have the same drawbacks, and in

addition require a great deal of blacksmith work to fit them to the job being done. The more modern materials used are heavy wire and wire rope, connected to bolts through the limb instead of bands. These have the advantage of being easily worked, relatively inexpensive, and entirely adequate for the purpose.

In bracing limbs, the brace should be allowed to sag somewhat to allow for the natural movement of the limb. The resiliency of the wood will be adequate for most movement. The purpose of bracing is to check any movement beyond the capacity of the limb.

Obviously, this cannot be applied where the brace is used to close a crack such as a split crotch. In this case, the brace must be drawn up tightly and assume the entire burden of supporting the limb.



Fig. 5- Bracing a split tree and a double trunk.

The bracing of limbs is not the only mechanical repair which the tree surgeon is called upon to handle, however. It is not an infrequent occurrence to find the entire bole of small, especially crotched trees, split as a result of a storm or heavy snowfall. In this case bracing is indicated and it may

be that with proper treatment the damage may be completely repaired. The simplest form of bracing is necessary in a case of this kind. Namely, a straight bolt or two through the trunk. The bolts should be painted with tar before being inserted, and likewise the counter-sinks for the head and the nut of each. What has been said previously regarding the placing of a bolt through a limb applies here also. All exposed wood and iron should be coated with dressing to prevent the entrance of spores and insects. The bolt head and nut will soon be grown over by the cambium and the tree will be as strong as ever.

It is unwise to bolt two separate limbs together with a single bolt as the twisting motion of the limbs will be likely to split one or the other. In such a case it is better to use wire or wire rope attached to two eyebolts. A jointed rod may be used also, providing sufficient play is allowed for lateral movement.

In bracing weak, vertical limbs, eyebolts and turnbuckles may often be used to advantage, the turnbuckles being used for tightening.

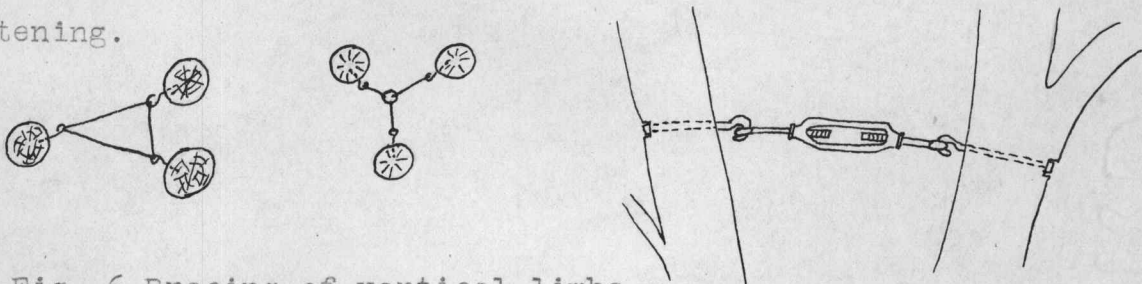


Fig. 6-Bracing of vertical limbs.

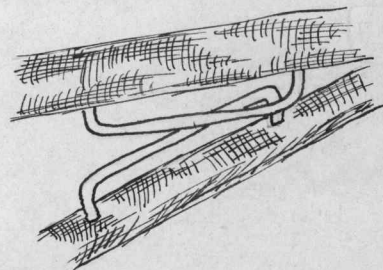
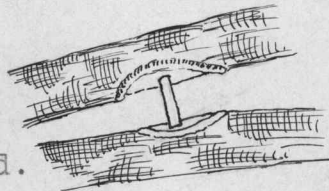
Usually, in bracing of this kind, it is preferable to have weak limbs on opposite sides balance one another. If a large limb must be braced up tight to the trunk to close a crack or relieve the strain on a filling, an iron rod should

be used. A rod hooked at each end to two eyebolts is best for this purpose. Tightening may be done by bolts, and a long thread on the rod should be provided for this purpose. A turnbuckle may be used with this also, especially where the strain is great.

In the cases of some limbs, where bracing to other limbs or the trunk is impossible, a pole brace may be necessary. An iron rod or a pole with an iron point may be used here. The point is deeply inserted into the under side of the limb and the connection dressed. The rod is made firmly to the limb in such a way that it is lifted with the limb in stormy weather.

Occasionally it may be necessary to brace two limbs or sections of a split trunk apart to keep them from rubbing and producing wounds in this way.

Generally, the least valuable of the two limbs should be removed. Failing this, however, a hole may be bored into the worn surface of each and a short iron rod inserted to hold them apart.



Buffers may be used to correct this condition also. The above figure shows how these are placed on each limb at the point of contact, the buffers receiving the wearing action incident to movement.

CHAPTER VI

TYPES OF CAVITIES AND TREATMENTS

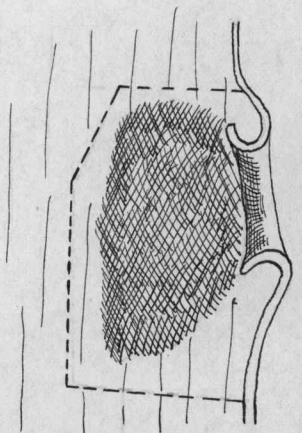
In the treatment of cavities of any type it is necessary to remember that constant modification of practice is the rule. Each individual case must be diagnosed according to its own peculiarities, and proper allowances made accordingly.

Perhaps the commonest type of cavity which the tree surgeon will be called upon to treat will be those resulting from incorrect pruning of limbs or incorrect care of the wound after pruning.

Rotten branch stubs and knot holes are the fore-runners of a great percentage of large cavities which develop later.

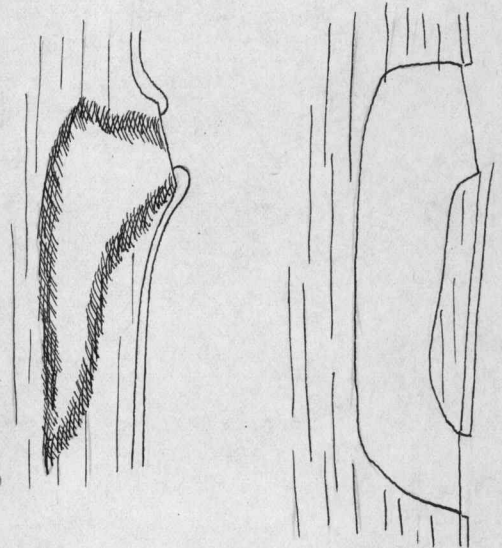
Due to the essential nature of such injuries it is necessary, in most cases, that treatment be rapid and economical. In the case of shallow cavities of this kind it is advisable to use the open system of treatment in which no filling is used.

In the case of deeper cavities, however, an incision is necessary and the infected wood must be removed and the cavity filled with the best material for the purpose. In some such cases, complete removal of the infected wood is not desirable, but on the whole, it may be



said that the general principles for cavity work apply here as elsewhere.

Often the removal of the infected wood itself presents a problem of considerable difficulty. It is often necessary to cut in below the hole in order to get at the infected material which is not within reach from the mouth of the cavity. In this case, as much distance as possible should be left between the holes in order that the bark remain alive between them. This is particularly true when the cavity is extended far into the limb or trunk.



It may be that more than one such opening be required, though this must be resorted to only when absolutely necessary as each additional opening increases the danger of water seeping into the cavity.

When the excavation has been completed, the mouth of the cavity must be enlarged and the ingrowing callus removed.

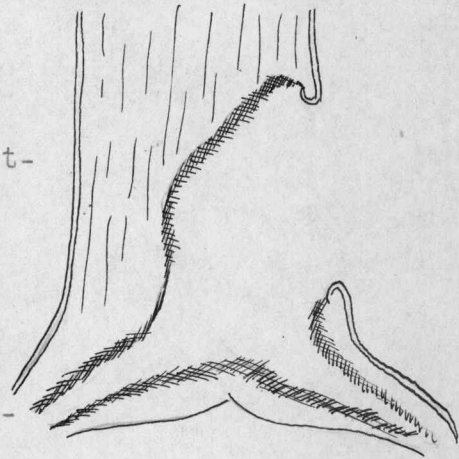
The filling to be used depends both upon the extent of the cavity and its position in the tree. A trunk cavity may very well be filled with cement, particularly where there is little likelihood that the filling will be subject to strain. If the

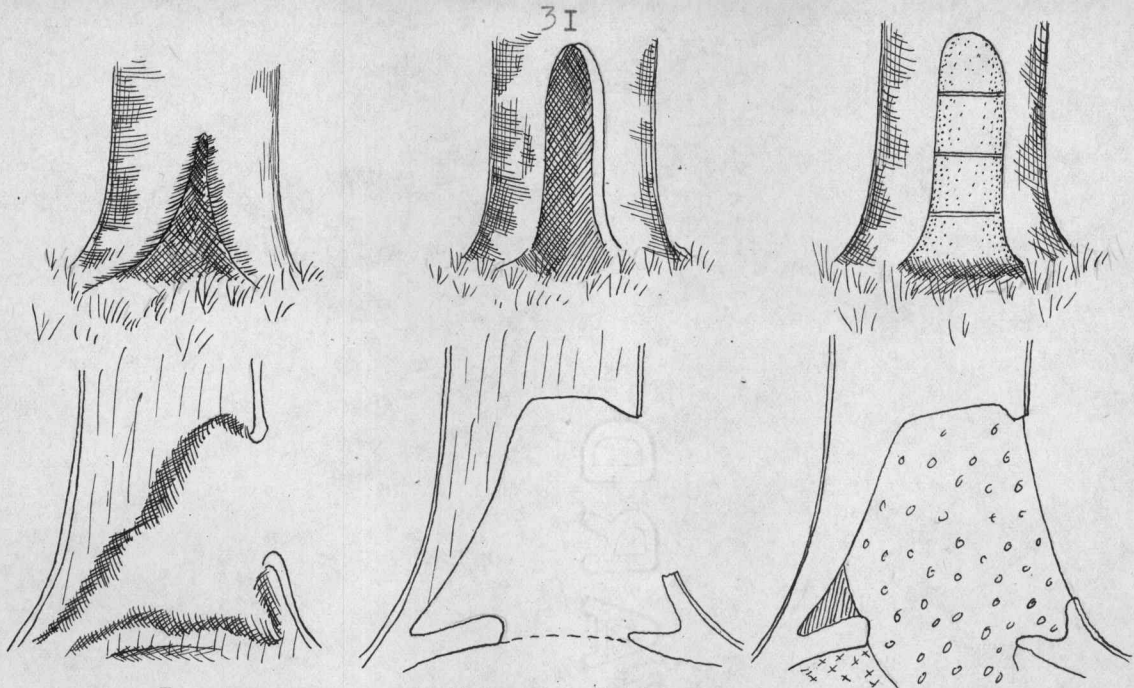
cavity is in a limb where the twist and strain of movement would tend to crack the cement however, a more elastic filling is required. A dressing of asphalt is the best in this case; either briquettes, hot asphalt and sawdust, or a mixture of the two.

For the general class of small holes in any portion of the tree, when filling is desirable, the best material is asphalt and sawdust mixture or asphalt and excelsior. Such a case may occur when treating large, shallow bark wounds. In cleaning the wound, the callus may be undermined to some extent, and this hollow may be successfully treated in this way. The mixture may be held firm by driving several nails through the filling and into the wood.

Perhaps the commonest type of large cavity is found in the base of the trunk where decay has set in from either bark wounds or infected roots.

These cavities are not particularly difficult to treat except in that excavation may be complicated by removal of the dead material in the root system. It is necessary, however, that the excavation be as complete as possible, even to working deeply into the large roots. It may be necessary to make one or more secondary openings in the roots to facilitate removal of the hidden material. These openings are usually better made in the depressions between the roots where feasible, as this does not interfere so greatly with the root functions.





In any case of this kind it is imperative that due consideration be given to the functions of the root system, and that excavation not interfere with the flow of sap.

It is usually necessary, in basal cavities, to "ground" the filling by digging down a foot or more in front of the cavity so as to provide an anchorage for the filling. Where decay is present or likely in the roots below the repair, the soil should be dug away and proper precautions taken. Drainage of the cavity should be adequately provided for also. This is especially important in those species of trees which do not have taproots as the decay may creep in beneath the filling.

Bracing is seldom required in this type of filling as the center of the cavity is usually so much larger than the opening that there is little danger of the material becoming loosened. Neither, in this case, are braces required for strengthening.

Tar is adequate for treatment of the walls of the cavity as drainage is good enough to keep it sufficiently dry.

In filling, care should be taken that any pockets caused by excision of material from roots and smaller protuberances of the trunk are filled with an asphalt mixture or a mixture of tar and ashes. Before the concrete filling is begun, any soil which has been removed from around the roots and the base of the cavity should be replaced with ashes or gravel.

When the concrete filling is put in, adequate allowance must be made for cracking. Although it would seem that there is little trunk movement so low, it is necessary to anticipate a certain amount, and the filling should be divided into sections.

Fillings of concrete may be left without any kind of dressing in most cases, though it is sometimes advisable to paint the surface with tar or asphalt, paying particular attention to the edges.

In cases where the decay has advanced a considerable way up the trunk of the tree, the method of filling is identical, except that bracing is often required to strengthen the concrete and prevent excessive cracking.

In contrast with the comparatively simple basal cavities, the decay of the upper trunk presents a more difficult operation. These cavities are usually caused by the wrenching out of a large limb or a serious bark wound.

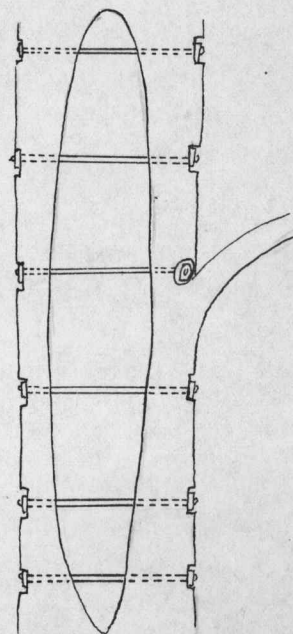
Extensive decayed areas especially make for laborious excavation. In such a case, sounding is indicated to determine

the extent of the decay. This is done with a half inch bit.

Once the boundaries of the infected area are located, the material may be removed in one of several ways. If the shell of the trunk is relatively thin, it is best to simply enlarge the present opening as much as is necessary. However, when there is considerable thickness of wood left, a number of holes may be made and the material removed through these. In making such openings it is wise to consider the effects on the strength of the tree and to space them so that a minimum of weakening may be expected.

The principal consideration in an excavation of this kind is to see that drainage is well provided for. The inside of the cavity should be sloped to insure the drainage of any water which may seep in before the growth of the callus has covered the crack between the tree and the filling.

Usually, in filling a cavity of this kind, adequate bracing is essential. Cavities having great vertical dimensions must be braced horizontally. If the cavity has left the trunk in a very weak condition, the entire tree may be braced to another one nearby. It is also advisable, in some cases, to prune back the heavy branches, and thus decrease the weight of the crown.



Once the excavation is complete, strict attention should be paid to the matter of dressing. If the cavity is easily

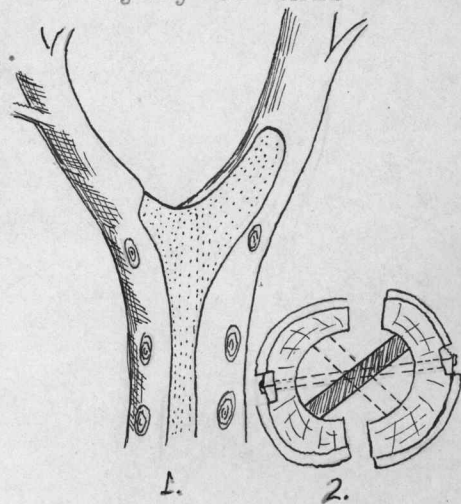
accessible melted asphalt is very satisfactory. If not, dissolved asphalt may be used with good results.

So far as fillings for this type of cavity is concerned, asphalt is by far the best material. However, this is only applicable to small cavities where a great outlay of material is not necessary. If the portion of the trunk containing the cavity is not subject to great strain, a braced concrete filling may do very satisfactorily. If concrete is used a surface coat of some waterproof dressing should be applied.

Injuries to trees near crotches may develop into cavities which are extremely difficult to treat. This is due to the difficulties of making the repair waterproof and to the great amount of strain which develops in these locations.

Perhaps the primary consideration in an injury of this kind is proper bracing preceeding filling.

Usually, in the case of a crotched tree, it is most advisable to apply a rather heavy brace to the two branches of the trunk above the wound. This relieves the strain on the "saddle", and allows the filling to remain more stationary.

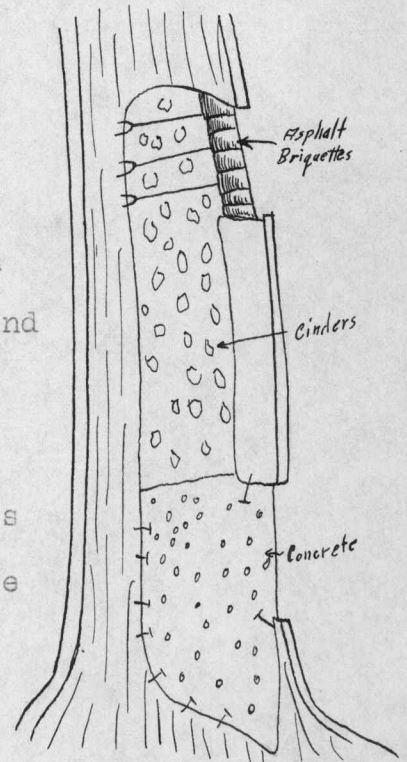


Several heavy bolts should be placed through the thickest portion of the saddle and tightened to minimize the strain and reduce the mouth of the opening. Furthermore, the walls of the trunk must be made as rigid as possible by the addition of

heavy pieces of hardwood forced crosswise inside.

Concrete should never be used to fill a "saddle" cavity. If the tree is not worth the expense incident to filling with asphalt it is better removed entirely.

The most extensive form of tree repair is in the treatment and filling of "chimney cavities" where the entire heart-wood of the tree is rotted away. The main difficulty in treating a cavity of this kind lies in the removal of dead wood. Where the rot is extensive and has infected limbs as well as the trunk, it is sometimes more feasible to merely fumigate the inside of the tree, spray it thoroughly with Carbolineum, and close all openings tightly.



By the use of large openings, correctly located, it is often possible to remove the decayed wood by using long-handled tools. Sometimes the decay may be removed by firing the inside, being sure to control the draft through the upper opening.

Filling this kind of cavity completely with concrete is at once wasteful and unnecessary. The figure above shows the proper procedure by the use of concrete, cinders, and asphalt briquettes. The bulk of the cavity may be left open in some cases, the briquettes being supported by an inside platform.

CHAPTER VII

SYSTEMS OF CAVITY REPAIR

Open System

There are two schools of thought among tree surgeons as to the relative value of fillings in the treatment of cavities.

There are those, with considerable support to their claims, who contend that if all possible moisture is excluded from the cavity, a thorough coat of antiseptic, and dressing applied, and the openings well plugged, no further treatment is necessary. These are the exponents of the open system or the capping system.

On defense of filling on the other hand, it is held that the strengthening of the tree by the filling more than compensates for its increased cost.

There are arguments on both sides; all having some merit.

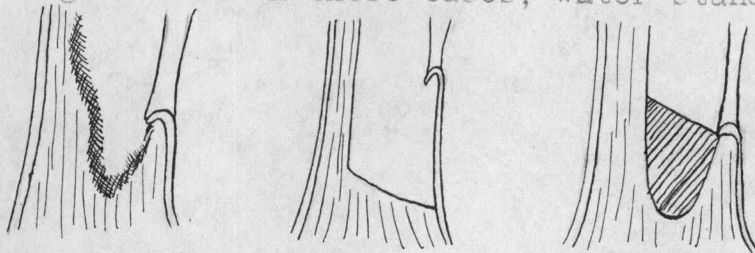
The open system of tree repair is relatively simple. In the case of smaller cavities caused by the breakage or loss of limbs from the trunk, it is merely necessary to gouge out the decayed wood, trim the bark around the wound, and apply a heavy coating of preservative and dressing. Both in this type of

injury and in more extensive cavities, no allowance is made for the rolling of the callus into the wound. According to the exponents of this method no physiological harm is done by allowing unrestricted growth of the callus.

The very nature of this kind of treatment presupposes frequent reinspection. This, and exceptional care in the dressing of the interior of the cavity are the principal prerequisites to successful work of this kind.

So far as excavation is concerned, the method followed is essentially the same as for other types of treatment with the exception that no sound wood need be removed so as to shape the cavity to retain a filling.

The problem of "pot holes", or depressions at the bottom of the open cavity may be handled in several different ways. It is claimed by some that if a sufficiently heavy coating of dressing is used in these cases, water standing at the bottom of



the cavity will do no harm. This may be true in some instances, though the action of frost must be taken into account also.

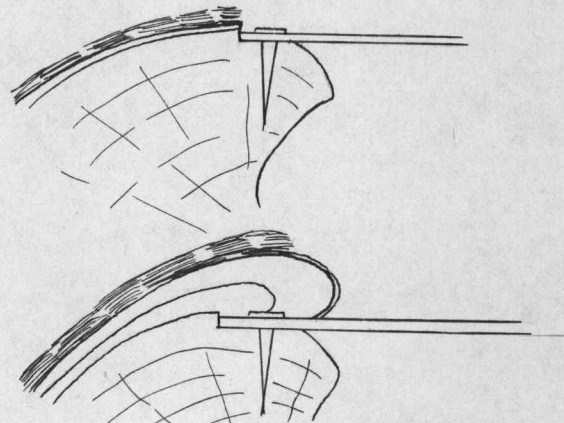
There are several ways of assuring drainage of "pot holes". The figure above illustrates the most common; a partial filling of asphalt may be used to the level of the opening, or the opening may be extended by cutting.

Capping

Capping with metal was one of the first methods of dealing with cavities in trees. From the very nature of the materials however, its use is now limited to special cases.

Treatment, up to the point of covering, is not unlike that of the open method, though the callus must be handled in a different manner.

After the cavity is cleaned and a dressing applied to the inside, the callus must be cut back so that firm wood is available for nailing the sheet metal over the opening. At least three quarters of an inch must be cut back, as nearly on the same plane as possible, and all living tissue removed. Care must be used to see that no live bark remains in the cavity as this would mean that the capping would ultimately be displaced.



The metal cap should be laid in such a way that the edges of the sheet and the nail heads will be grown over as quickly as possible. The metal sheet must be sunk slightly below the level of the cambium, in any case, to insure quick and adequate healing.

It is obvious, from the manner of this kind of repair, that

there are many instances in which it is the most undesirable type of treatment. This is particularly true where there is a great deal of movement of the limb or trunk in which the cavity occurs. It may be stated as a general rule that any portion of the tree which is subject to strain should not be treated by this method.

There have been attempts made to overcome this defection by the use of overlapping plates of metal which would allow for a certain amount of movement. This has hardly proven practical, however, as the cutting and fitting consume more time and expense than the conditions usually warrant.

The capping method may be used with success on the cavities incident to stub branches and other small injuries.

In treating the cavity to be capped, no especially heavy dressing on the inside is necessary. Usually a thorough coating of Carbolineum is ^{sufficient.} ~~all that is necessary.~~

A heavy coating of dressing should be applied to the metal, especially around the edges. This is both to prevent the entrance of water and to protect the nails which otherwise might rust out. Copper nails, of course, would obviate this danger.

Fillings

The excavation of cavities for filling differs only slightly from excavations for other types of repair. The principal objective of such excavations is to so shape the cavity that the filling will be easily retained once it is in place. This necessitates removing a good deal of sound wood which would otherwise be left in place.

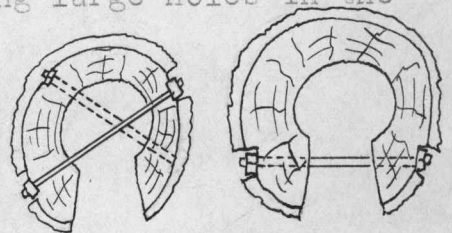
In filling work, particular attention should be paid to the mouth or opening of the cavity. The lip, whether covered by ingrowing calluses or not, should be cut back so that two or three inches of sound sapwood will surround the orifice. The inside should be shaped so that a minimum of cracking will take place. This is especially important when the filling is located in a portion of the tree that is subject to a great deal of strain.

What has been said before concerning the shape of the mouth goes doubly here, since further shaping is much more difficult after the filling is in place. The opening must be rounded carefully to prevent the dying back of patches of bark above and below it with consequent infection by insects and fungi.

Bracing is an important item in filling work and should be done carefully, the stresses occurring in the region of the filling being studied before-hand to determine the exact placement of the braces.

The machine bolts usually used for this work are better threaded at both ends so that either end may be used to tighten the bolt. The smallest size bolt practicable must be used to prevent the necessity of cutting large holes in the bark and sapwood for inserting them. The sockets in the bark and sapwood must be kept as small as possible.

A deep socket which may be covered over has a better appearance, but ^{this advantage} is gained at the expense of strength.



Two methods of bracing a cavity.

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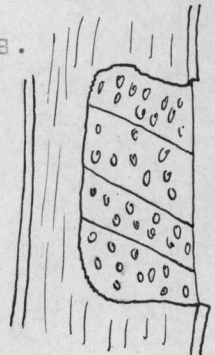
Special care must be used in dressing of the cavity when fillings are to be made. After excavation, if the cavity is relatively dry, antiseptic and dressing may be placed in the cavity immediately. However, if the interior is moist to any considerable extent, drying is absolutely necessary or reinfection is certain to develop. The drying may be accomplished either by leaving the work unfinished for several weeks or months, or a blowtorch may be used if the work must be completed at once.

Carbolineum is perhaps the best antiseptic to use, and a dressing no lighter than asphalt should follow. Tar may be used here with good results. Needless to say, the dressings should be applied after bracing is complete and a thorough coating must be given to all exposed metal and wood surfaces.

If boring insects have penetrated beyond the region of the decay, fumigation may be necessary. The holes must all be closed tightly and a rag soaked with a teaspoon of carbon disulphide for every cubic foot of space placed into the hollow.

Concrete fillings are perhaps the best known of all work done in tree repair. The previous assumption as to its strengthening properties has been questioned, however, and the present opinion is that its value lies principally in its ease of application and adaptation to irregular cavities.

Concrete is set into cavities in one of two ways; the dry method, whereby a mixture of one part cement to four parts natural gravel is mixed dry in the cavity with wet stones. This method has the advantage of dispensing

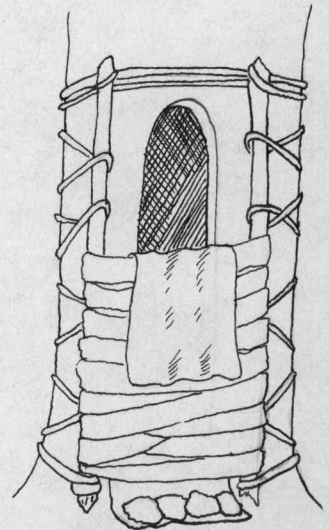


with the building up of a barrier of material before the opening of the cavity to hold the mixture until it sets, one disadvantage of the wet method.

The wet method consists of building up the wet concrete mixture in the cavity, following it upward with a dam of braced tarpaper or canvas.

In either of these methods, due consideration must be given to the movement of the tree, depending on the location of the filling.

Divisions of the filling may be made by laying a section of tarpaper or other material between the sections. These sections should be made sloping downward to prevent the entrance of water into the cavity. Newspaper is advocated by some for this purpose, as it can be cut readily when dressing the surface.



When the concrete is dry, a thick coating of dressing or paint should be applied.

Asphalt and mixtures of asphalt and sand, sawdust, or excelsior is probably the most satisfactory dressing that can be used for cavity work, though the cost is in some cases prohibitive. This is especially true when the cavity is large and the tree not overly valuable.

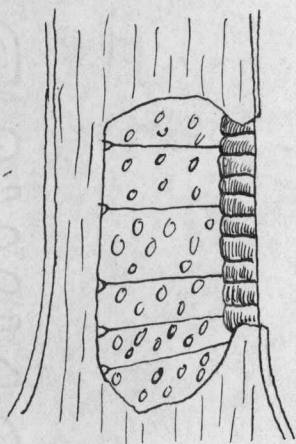
One of the most satisfactory fillings for cavities which are rigid, either through bracing or their location in the tree, is an asphalt mixture faced with a metal cap. This is an expensive process, however, and modification may be best by using

a cheaper backing for the cap.

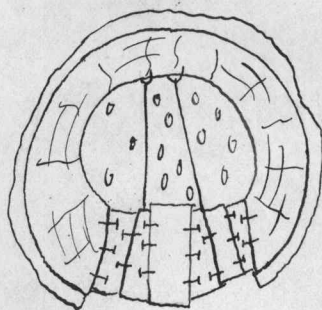
The most adaptable material from every standpoint are asphalt briquettes, of which mention has been made previously. This method has the advantage of utilizing a plastic material, an important consideration in any work of this kind.

The briquettes are built up in the cavity after the proper excavation and treating and the whole mass bound together by melted asphalt. To prevent the inevitable cracks from forming between the filling and the sides of the cavity, especially at the mouth, the briquettes are nailed firmly to the sides of the opening. Usually the briquettes are merely built up into a wall in the front of the cavity, a solid filler of some compound being used behind.

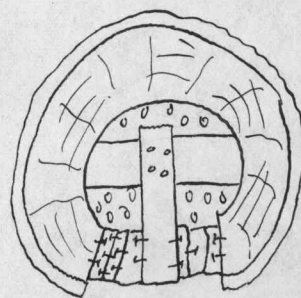
There are slight differences in the preparation of the cavity for the use of briquettes and concrete. In concrete it is desirable that the cavity be larger behind than in front in order to hold the filler in place. In using briquettes, the walls of the cavity should be as nearly perpendicular as possible.



Cement and asphalt
briquette filling.



X section.



Wooden brace with
cement-briquette filling.

CHAPTER VIII

IMPLEMENTS AND MATERIALS

The tools used for excision work consist mainly of the conventional wood-working tools specially adapted to removing decayed wood from cavities. Foremost among these are carpenter's gouges. The larger sizes are especially useful, the inch and a half and two inch sizes being preferred. Smaller sizes have their special uses also.

The gouges should be the outside-ground, socket-handled type and an iron ring is best around the butt to prevent splitting.

For a longer reach, in inside work, a hardwood wagon spoke may be inserted in the socket.

Mallets are necessary adjuncts to the gouges, those of lignum vitae being the longest lived. The heavier weights make for faster work, though lighter heads have their uses as well for small cavities and those hard to reach.

In large cavity work a hand axe may often be useful as will an adze. Pruning saws are valuable for shaping the openings.

As yet no satisfactory machines have been devised for tree work, the very nature of the task making human labor a necessity.

In this connection some mention may be made of scaffolding which is a useful adjunct on any work which is extensive and

confined to the upper portions of the tree. Anyone with an elementary knowledge of construction will be able to adapt the proper scaffolding to individual requirements.

For cement work, especially for use with the dry method of cavity filling, a garden trowel is as efficient, and often more so, than the triangular masons' tool.

In the interests of cleanliness it might be stated that cavity excision is an activity which leaves yards and lawns littered with debris. It is always wise to provide adequate canvas to catch the chips of dead wood which will necessarily be scattered around the base of the tree.

Enough has been said in the chapters on repair concerning the various materials used in tree work and their relative merits. Many of the preparations commonly used for this work, however, are covered by patents and this must be considered when they are used. It is now possible to find on the market a vast assortment of preparations ready mixed for many needs, both for cavity work and that of less extensive character. Most of these have their advantages and may be relied upon with the use of a moderate amount of caution. However, it is sometimes less expensive to obtain the ingredients and prepare them as the work progresses.

CHAPTER VIII

PREVENTION BETTER THAN CURE

From the foregoing discussions of the difficulty, expense, and uncertainty of repairing tree injuries, it is fairly obvious that proper care in the prevention of these injuries will yield returns in vast disproportion to the initial cost.

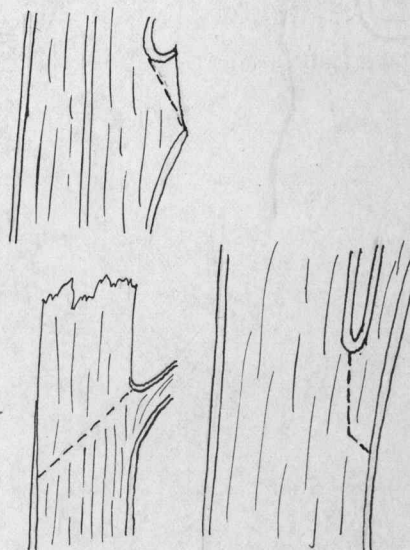
A large percentage of the cavities and wounds which the tree surgeon is called upon to treat are the results of incorrect pruning of limbs. This is one of the fundamental elements of tree work which, if properly done, has no deleterious effect upon the physiology of the tree and actually improves its condition.

The primary rule for pruning is the removal of limbs close to the trunk; so close, in fact, that the silhouette shows no protuberance whatever. This is necessitated by the structure and function of the cambium. By removing the limb as close as possible to the trunk the wound is assured of a plentiful supply of sap and consequent healing in a minimum of time. Elementary though this is there are innumerable cases in which this principle has been neglected.

The same general rule applies to removal of part of the main stem. In order to prevent the entrance of water and the decay resulting it is necessary to slope all cuts of this nature

so that there is no flat surface for the collection of water.

The gouge is an item of auxiliary equipment which is quite important in the removal of limbs, being used to so shape the cut that healing is easy. The small pocket formed above a stub after the initial sawing off of the limb, must be removed with this tool and the whole surface smoothed.



The lower point at which a limb is removed will often become a pocket for the collection of water unless special care is used to remove it. In the second dressing, applied after the wound has dried out, this pocket may be shaved off or filled so as to prevent the entrance of decay.

In the healing process, callus growth is usually best where the bark pressure is least. For this reason it is often desirable to accelerate the callus growth by lightly slitting the bark on a forming callus. This will stimulate growth and make the time of healing much shorter.

It may be in trees having a fast and heavy bark growth, particularly of the corky layer, that the callus will become "bark bound." Slitting the bark of the callus is especially valuable under such conditions.

What has been said of bracing may be taken to include not only the time after injury, but also as a preventative measure.

Proper bracing of weak or deformed trees, where pruning will do no good, may be the means of saving costly and dangerous repair work later.

The multitude of small, seemingly unimportant injuries suffered by trees in the process of gardening, clipping lawns, or most of all in constructing new buildings, must be handled when and ^{as} ~~how~~ they occur.

An instance of this is the habit of placing planks between two trees for the purpose of forming a seat. The usual result is, that in time, the cambium is crushed and circulation of the sap stopped at each of these points. As the tree continued to grow, the ends of the planks may be completely buried, and rotting out, provide an excellent entranceway for rot.

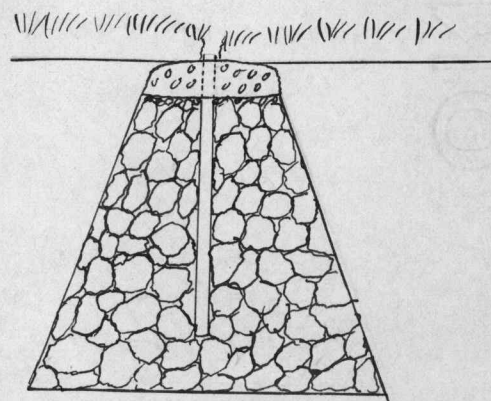
Diagnosis of Tree Ailments

It is inevitable that the tree surgeon will be called upon at times to diagnose the obscure causes which often lead to the death of trees, particularly those which are placed in entirely alien surroundings. The growth of trees in the confines of cities and parks is uncertain at best, and the competition offered by drainage of the soil, compacting, and the presence of great blocks of paving often proves too much.

This requires a thorough analysis of the conditions under which the tree in question happens to be growing, or attempting

to grow.

In the case of compacting the remedy is obvious. Breaking up of the soil as much as is possible, and a certain amount of fertilization will often remedy the trouble. In those trees which are growing surrounded by lawn, however, this cannot be done. The Davey Institute of Tree Surgery has devised a method of combating this condition which both preserves the appearance of the grass and allows the tree to obtain the necessary water.



In this, a system of "wells" ^{is} dug surrounding the tree, about the capacity of a good sized barrel. The sides are sloped back and the bottom filled with broken stones or brick. Then a pipe is placed in the center and the entire hole filled with the bricks or stones. A cap of cement is placed in the neck, below the surface of the grass, ^{with} and the pipe projecting slightly above this. This enables a hose to be turned into the cavity below and the roots of the tree may be watered directly.

APPENDIX

NOTES ON SPECIES

In the treatment of pathological conditions in any living organism the factors of variation must be considered. It is impossible, in any natural science, to lay down blanket rules and regulations arbitrarily and expect results which will be consistently uniform at all times.

The foregoing chapters have attempted to approach this state of affairs as closely as possible and yet leave room for individual reactions and variations. The apple cart, in any biological science, is easily upset; reducing previously tried and tested methods and theories to so much rubbish. It is essential that individual peculiarities be dealt with first in diagnosing ailments of any kind. This applies to trees as well as more plastic organisms.

The following is a brief summary of special points which may influence the treatment of the more common types of trees which would come under the jurisdiction of this science.

Beech

In common with a great many deciduous trees, the beech is subject to the attacks of the white heart rot. This disease, which in time affects the majority of deciduous trees, is especially severe in beech. It may be that in old stands, over ninety percent of all individuals will be affected.

It is not an uncommon occurrence in many parts of the east to come upon a fine stand of mature beech timber, which upon closer inspection, proves to be literally permeated with this destructive rot; great, hollow resounding boles being the rule in tree after tree and soundness confined to the young timber of the group. Many of the old trees will exist decade after decade, apparently resisting the rot until nothing more than a mere shell remains.

There are no special rules to be observed in treating the cavities thus formed, and the rules which apply elsewhere may be safely used here. The bark is more likely to dry out, however, than in many other species and it is well to keep the cut waxed until the healing process is under way.

In diagnosis it must be remembered that the beech, as a species, is highly intolerant of any changes in its natural environment, particularly as regards its water supply. Any appreciable increase or decrease is quite likely to result in the dying back of the top, forming a nest of dead branches which make an ideal spot for the entrance of rot fungi. The deficient soil conditions must be remedied at once, in a case of this kind, and the dead top trimmed severely back. The greatest of care is necessary in dressing the cuts.

The individual beech may fall into one of two general form types. There are those in which the branches, instead of arising at right angles to the trunk, shoot abruptly upward and form many bad crotches. This type is more subject to decay than the other, and the limbs remain longer after they are dead.

This provides entry for rot.

Beech does not react well to severe pruning for purposes of rejuvenation unless the remaining structure is well supplied with foliage.

Birch

No great problem of special treatment is involved in consideration of the birch. In the white-barked species, however, there sometimes arises the necessity of avoiding conspicuous and unsightly applications of tar and asphalt. Some measure of disfiguring materials may be avoided by the use of white lead shaded so as to match the bark as nearly as possible. This, of course, applies to other genera than birch when a light barked tree is being treated.

A common situation is seen in the black scars which are so abundant on many birches. These may be avoided to some extent by using a coating of clear varnish as soon as possible after the wound is inflicted. The drying and cracking of the inner bark may be lessened in this way. The application of white lead paint may be used here also with satisfactory effect so long as the tree is not near enough to view for the patching to be conspicuous.

Catalpa

Catalpa, particularly the globular catalpa, (*C. bungei*), is especially subject to breakage after it has attained

moderate size. To prevent this from occurring it is advisable to prune annually and hold the tree within a safe size. In case of severe breakage, the split limbs should be removed and the remainder pruned back heavily. The tree will regain its form and size in a few years.

Cherry

The cherry, in common with most of the stone fruits, is subject to the widespread attacks of the black knot disease. So far, it is impossible to destroy the causative fungus by any antiseptic application. The only effective measure is removal of the infected parts which should be immediately burned.

The bark of the cherry is peculiar in that it is continually under tension, and as the tree grows, it splits off in horizontal fragments. This is a handicap in the making of incisions as the bark will roll back from the wound and allow the softer inner bark to dry out and crack. The same thing occurs when the trunk is frost cracked and injures not only the health but also the appearance of the tree.

To prevent the bark rolling, it is necessary to drive several small nails half an inch from the incision and not driven too deeply. It is sometimes customary to slit the bark back of the incision to release the tension. This is likely to mar the surface of the bark, however, and cause more or less permanent welts.

Chestnut

Due to the prevalence of the chestnut blight, it is obviously unwise to invest a large amount of time or money in the repair of old trees infected with any disease whatever within the zone of the blight. Even in a locality in which the blight is not of epidemic proportions there is seldom any justification for extensive work.

The chestnut reacts well to pruning, however, and old, hollow trunks may be made to support luxurious tops by heavy pruning.

Polyporous sulphureous, the red heart rot, is especially liable to be found in overmature trunks. Infection by this fungus practically obviates effective repair. If any work whatever is done, it should be confined to protecting the cavity from insects. In most cases cleaning of the open cavities and shortening of the larger limbs to take the strain off the trunk constitutes the only desirable repairs.

In healthy trees, continual caution should be exercised to prevent infection through dead limbs and stubs. These must be removed and treated as they appear.

Elm

While the elm is subject to the usual number of hardwood diseases, no special procedures should be followed except that, in cavity work, ample time should be allowed for the moisture

of the green wood to dry out. Elm, characteristically, contains a great deal of moisture, and special note should be made of this point. Ordinarily, a minimum time of a month or two should be allowed for the cavity to dry, infection being forestalled by the use of some non-filling antiseptic such as copper sulphate or corrosive sublimate.

The characteristic branching habit of the elm makes it necessary, quite often, to resort to bracing of various kinds to prevent excessive breakage. Bolts should be used for this purpose; never bands or chains.

Hemlock

Usually, this tree is not in a position to come under the jurisdiction of the tree surgeon. However, there are cases where it may be planted in parks and municipal recreational areas.

Red heart rot is the most usual disease of the hemlock. The fungi gain entrance to the bole through dead branches and broken limbs. These should be removed and treated as in other species.

Hickory

Many of the usual diseases affect hickory, though all things considered, it is a hardy species. It is especially liable to become bark bound, due to the toughness of the bark. In such a case the bark should be slit vertically.

Horse-Chestnut

Has a tendency to crotch rather badly. This may be avoided by proper pruning in the early stages of development. Also subject to bifurcate division of the trunk which should be checked early. Not greatly bothered by disease as it is a planted species and rather hardy. Frost cracks will occur occasionally, but these cannot be helped and must be treated as a wound.

Linden

The linden is frequently attacked by a great variety of fungi. It may so happen in some cases that the entire top will be broken off, leaving a high trunk from which numerous adventitious buds will develop, and later a dense growth of lateral branches.

These should be thinned and pruned occasionally to prevent them breaking loose from the trunk. Such trees as this react favorably to severe pruning for purposes of rejuvenation. Many apparently hopeless cases may be reclaimed in this way.

Due to the weakness of the wood, the linden may assume many wierd shapes in the course of its growth. Although the wood is weak and the branches may bend, the bark is strong and tough and the limbs may develop in a twisted manner. Bracing is an important factor in maintaining the appearance of these trees.

It is fortunate that the linden has a strong tendency to replace old branches which may have to be removed because of

disease or malformation. By proper care this species may overcome great handicaps incident to its development.

Black Locust

The locust may be included in the category of trees which it is not worth while to expend excessive effort and money to reclaim. Due to the consistent and deadly attacks of the locust borer, any chance of survival under adverse conditions is open to question.

There is also a yellow heart-rot which enters the wood through the tunnels of the borers and takes its toll.

Maple

Maples have few tendencies or weaknesses which make special precautions necessary in its treatment. Red maple is somewhat subject to frost cracks, which, of course, must be treated in the regular way. Silver maple is inclined to form bad crotches which must be attended to in its earlier years. In older trees the crotch formation may be made less dangerous by proper bracing.

In almost any species of maple there is a tendency for the larger limbs to tear out of the trunk and other more primary limbs. This forms long, shallow cavities which should be treated by the open method. Often ^{capping} ~~limbing~~ is effective.

Severe pruning, in all maples except sugar maple, and to some extent in that also, is effective to a greater extent than in most trees. Adventitious shoots are readily developed.

Oak

So representative a tree is the oak that almost any rules laid down for procedure may be applied to it. Not only is it exceptionally wind-firm and adaptable to changing conditions, but its wood is so resistant to decay that large excavations and filling are invariably followed by a large percentage of success.

The very qualities of the wood, however, may make the location of decay a difficult matter. Apparently sound wood may in many cases, conceal extensive rot beneath. For this reason it is wise to use exceptional care in the diagnosis of its condition.

Sycamore

Frequent and extensive hollows are the rule in this species, and this condition may often be remedied more readily by the use of open cavity systems than by fillings. The tree reacts well to severe pruning and this quality may be considered to advantage when applying restorative measures.

Tulip

Weak wood makes breakage and cavities of frequent occurrence in this species. The larger limbs have a tendency to split longitudinally when their weight becomes too great for the strength of the wood. This may be remedied by heavy bracing and the application of antiseptic dressings. The condition may often be prevented by bracing or removal where possible.

Walnut

The principal infections result from attack by both red and white heart rots. A peculiar condition sometimes develops whereby the entire base of the tree may be decayed and hollow and the upper trunk and limbs remain sound.

The red and white heart rots are not serious however, and the resistance of the wood is great enough to insure the well being of the majority of individuals.

Willow

Extremely subject to breakage, as are the allied poplars and cottonwoods. Due to the very rapid growth of this species, however, wounds which have been properly treated heal rapidly and treatment is usually worthwhile on younger trees.

The gnarled and contorted trunks of very old specimens may not be worth the expense necessary to reclaim them, and it may be taken for granted that the great majority of old willows are infected with rot. This is due to the breakage of the larger limbs and the resulting wounds which allow the ingress of fungi.

Much of this may be prevented or minimized by proper bracing.

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