Installing PLASTIC TUBING to collect SUGAR MAPLE SAP

by H. Clay Smith
and Albert G. Snow, Jr.

U.S.D.A. FOREST SERVICE RESEARCH PAPER NE-240
1972
NORTHEASTERN FOREST EXPERIMENT STATION, UPPER DARBY, PA.
FOREST SERVICE, U. S. DEPARTMENT OF AGRICULTURE
WARREN T. DOOLITTLE, DIRECTOR

The Authors

H. CLAY SMITH, silviculturist, received a bachelor's degree from West Virginia University and a master's degree from Purdue University. He joined the Northeastern Forest Experiment Station in 1962 and did research on the silviculture of Appalachian hardwoods in West Virginia before joining the Station's sugar maple sap production project at Burlington, Vermont, in 1967. He is now attending the State University of New York College of Forestry at Syracuse.

ALBERT G. SNOW, JR., received his bachelor of science degree in forestry from Washington State College and his master of science degree from Yale University. He joined the Northeastern Forest Experiment Station in 1935 and worked as a research forester in spruce management and forest genetics. He transferred to the Southeastern Forest Experiment Station, Lake City, Florida, in 1942 as a research forester in naval stores. Returning to the Northeastern Station, he served as center leader at the Virginia Pine-Hardwood Research Center, Laurel, Maryland, from 1952-61. He served as project leader and chief of laboratory of the Station's unit in Burlington, Vermont, from 1961 until he retired in May 1971.

MANUSCRIPT RECEIVED FOR PUBLICATION 29 NOVEMBER 1971.

COVER PHOTO: Off into the sugarbush, shod with snowshoes and festooned with tubing and tools for setting up the sap-collecting system.

IN THE LATE 1950's and early 1960's, maple syrup producers began using plastic tubing to collect maple sap for processing into maple syrup. At first, tubing was thought to be a neat solution to the problem of high cost in collecting maple sap. Although many producers did have excellent results with tubing, a large number could not make it work. Lack of success led these producers to quit using tubing and return to the traditional sap bucket.

Today there is much renewed interest in plastic tubing, due primarily to the success that many producers have had. Much information is now available about use of tubing. Plastic tubing *will* work on many sugaring operations.

The research unit of the Northeastern Forest Experiment Station at Burlington, Vermont, has been doing research on methods of installing tubing since 1966. We have studied several ways of hanging tubing and have found that there are certain techniques to use if plastic tubing is to be installed and to operate successfully.

The movement of sap through a tubing system can be compared to a number of small streams flowing together and into a reservoir. In a sugarbush, tubing is installed so that the sap from a number of trees can flow into a collecting tank (fig. 1).

Figure 1.—Schematic design for a plastic-tubing sap-collecting system.

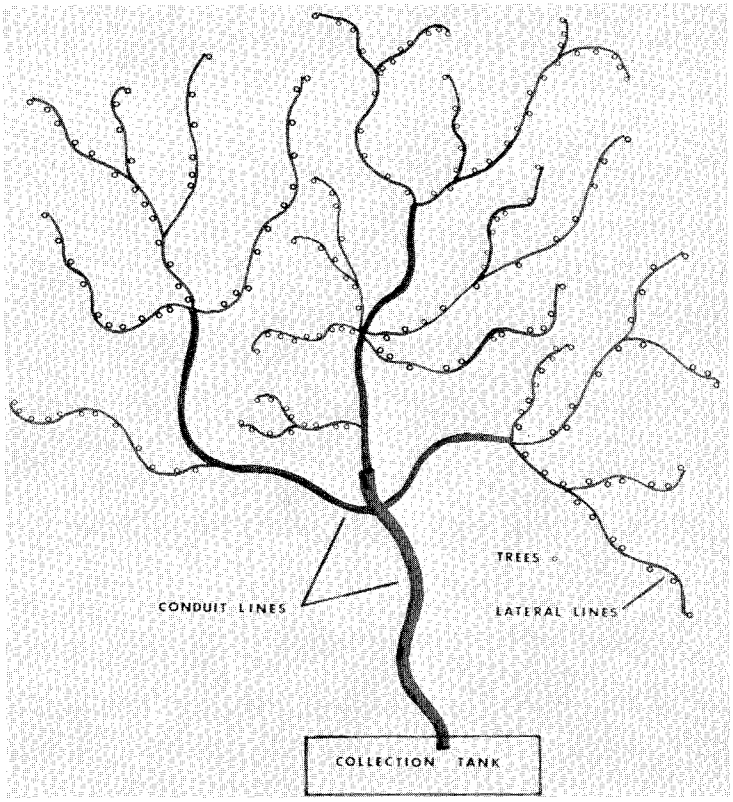
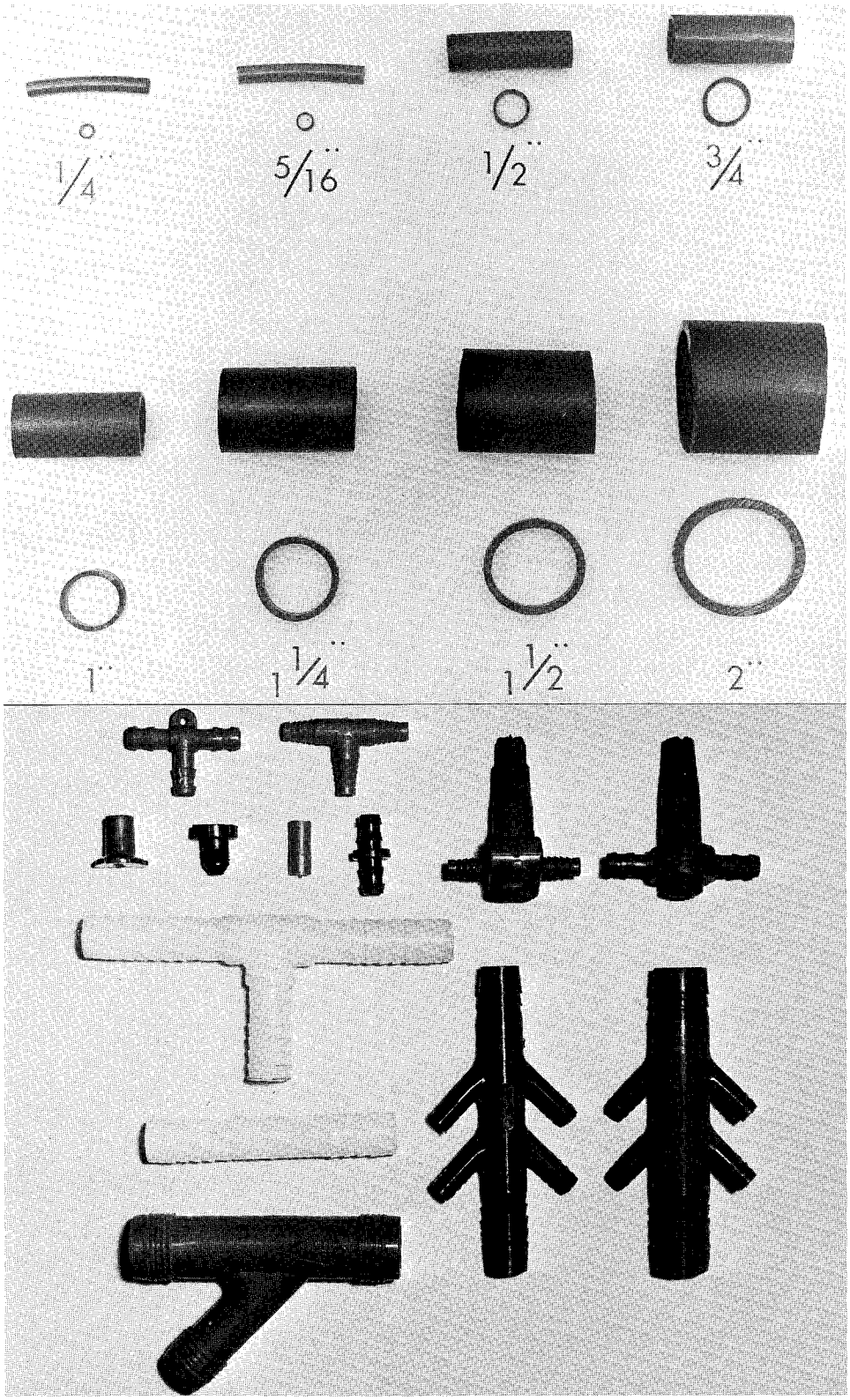


Figure 2.—Top, typical sizes of tubing used in a sap-collection system. Bottom, fittings used to join tubing.



Lateral lines of small tubing (1/4 inch to 5/16 inch) are used to collect the sap from the trees. These small lines lead into larger conduit lines (3/4 inch to 1-1/2 inches), which carry the sap down to collecting tanks. Progressively larger tubing is used in the lower stretches of the conduit lines to carry the greater flow (fig. 2).

Make sure that the tubing you use is large enough to carry the greatest flow. Each drop of sap must have a place to go. During periods of good sap flow, a small tubing line may receive more sap than it can carry. When a line becomes overloaded, some of the sap may be lost. Though this may happen only a few times in a season, plan to avoid it.

TUBING SYSTEMS

Maple syrup producers use many combinations of tubing, but basically tubing is installed in one of two ways. Tubing may be hung in the air from tree to tree (an aerial line) or placed on the ground (a ground line). With either type of installation, the most important factor for success is that the tubing must have sufficient slope for the sap to flow by gravity to a collection tank.

If the topography of the sugarbush is steep, installing tubing so it slopes downhill is relatively easy. However, when the topography is nearly flat, installing tubing successfully can be a nightmare. On flat land, you must carefully survey the heights of your tapholes and tubing lines to be certain that the lines slope down as much as possible. An artificial vacuum can be applied to the tubing installation to draw the sap through the lines *(Morrow and Gibbs 1969)*.

In many early tubing installations, the lateral lines were connected directly from spout to spout. This proved unsatisfactory because sap was often lost through reabsorption or bad tapholes. Droplines (fig. 3) attached to the spouts prevent this sap loss by carrying the sap away from the taphole. This technique is used by most producers.

Aerial System

In the aerial system, the lateral tubing is usually hung 2 to 4 feet above the ground or snow level. With aerial lines, 18- to 24-inch droplines are generally used. If shorter drop-

Figure 3.—Spout droplines. Left: an 18-inch aerial-line dropline. Right: a 4-foot ground-line drop. The small lateral-tubing lines are parallel to the ground.

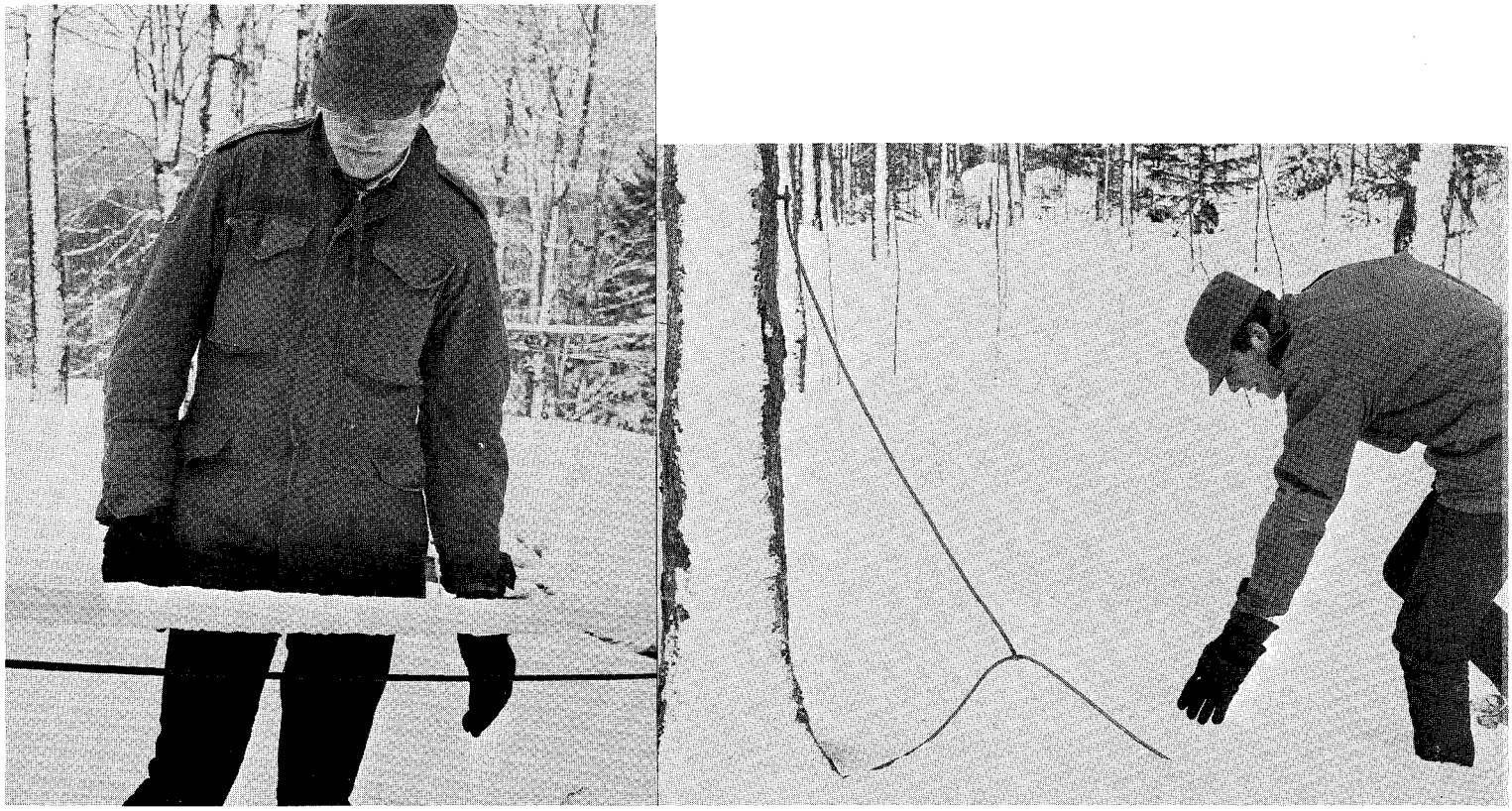


Figure 4.—Snow problems. Left: how snow accumulates on aerial lines; snow has been removed from the lower line. Right: the ground-line tubing is buried under the snow.

lines are used, there is little leeway for moving the dropline to an untapped area on the tree when the tubing is re-installed another year. If droplines longer than 24 inches are used, the installation approaches that of a ground-line setup. Some producers used both 18- and 24-inch droplines on the same line to reach new areas of the tree when tapping in later years.

There are both advantages and disadvantages in using an aerial line for collecting sap. The advantages:

1. Minimum freezing problems because most of these lines are above the snow.
2. The slope of the tubing line is easier to control.
3. A minimum amount of tubing is used per taphole.
4. Problem areas are easier to locate and correct.
5. Tubing can be used on nearly flat areas because slope of line can be regulated to a degree by height of tapping. However, this is difficult to do, especially for a sugar producer who has little experience in installing tubing.

The disadvantages of aerial lines:

1. They are harder to install than ground lines. To install the tubing properly, it should be stretched. Even after stretching, new tubing may develop sags. If the tubing is stretched too tightly, it may separate from the tubing fittings.
2. If the distance between trees is great—say 30 feet—the tubing may have to be supported to minimize sagging.
3. In some instances, freezing rain, ice, or wet snow can collect on the lines and cause damage (fig. 4).
4. Falling branches may cause damage and leaks; and animals and people may also damage the lines.

Ground-Line System

In the ground-line system, the tubing is placed on the ground or on top of the snow. Usually no attempt is made to slope the tubing because it follows the lie of the land.

Spout droplines are 4 to 4-1/2 feet long. The tapholes are drilled at a height of about

5 feet above the ground, and the dropline is attached to the lateral lines.

Although there may be advantages to using ground lines, in our opinion these are overshadowed by the snow and ice problems. If snow accumulation is high, it is risky and costly to use a ground line. The lines must be pulled free from the snow periodically (fig. 4). If this is not done, sap will freeze in the tubing; and when sap flow begins, the snow, acting as an insulator, delays the thawing process. Considerable sap can be lost.

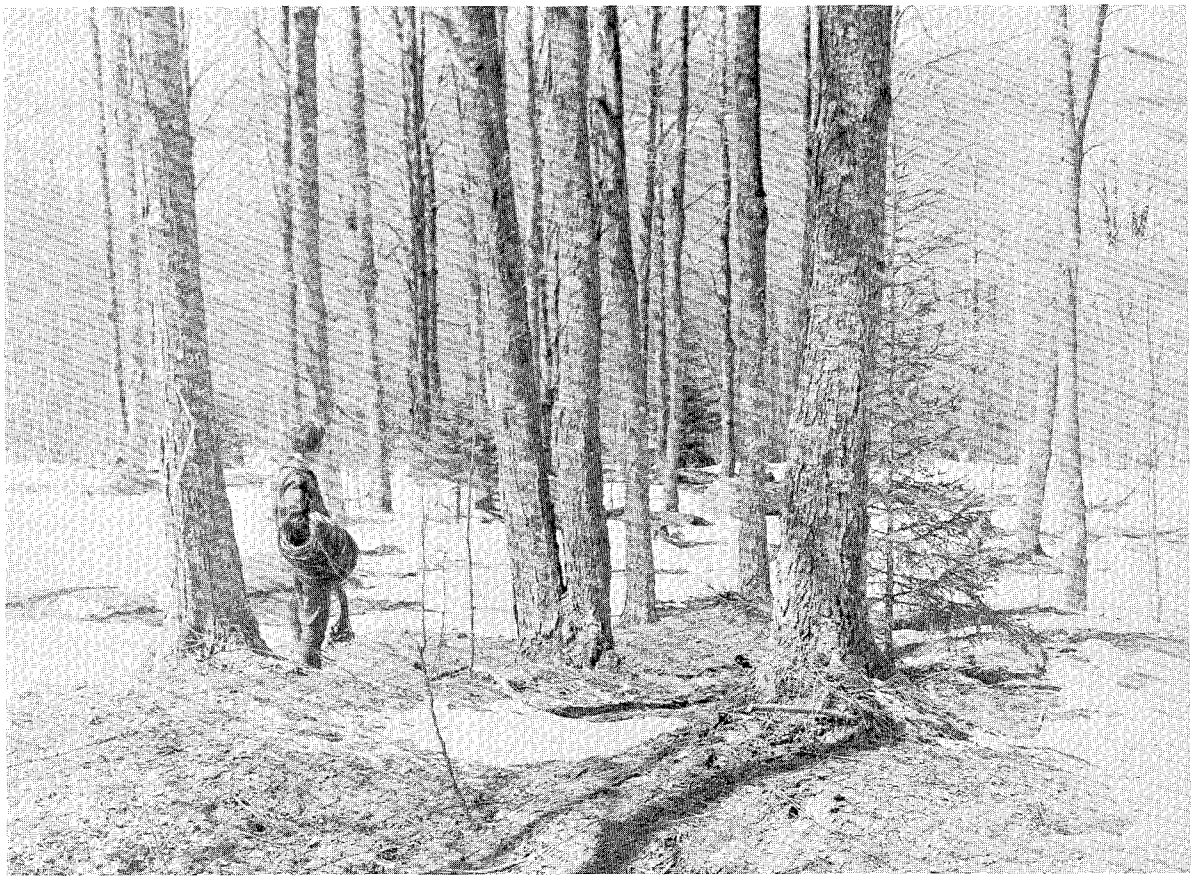
If snow is not a problem, there are advantages to using ground lines:

1. The ground lines are easier to install than aerial lines, for they do not have to be stretched when hung.
2. Since longer spout droplines are used, retapping is easier because this extra length allows the spout to be moved to an untapped part of the bole.
3. If the tubing is disassembled and reinstalled, it does not require the same exact layout. An extra foot of loosely installed tubing on the ground is of little concern to the sugar producer.

There are several disadvantages other than pulling the lines from the snow:

1. More tubing is used per spout because of the longer droplines and the fact that the tubing is not stretched from tree to tree.
2. If the area has a lot of potholes or undulating topography, the sap inside the tubing may collect in low spots and freeze. This can block sap movement through the lines.
3. Sap that collects in low spots can spoil, and it may contaminate sap in the next sap run.
4. Leaks are difficult to find and repair, particularly in snow.

Figure 5.—Examine the area before hanging the tubing.



5. This method is very poorly suited to flat land, because there is no control over tubing slope.

INSTALLATION

Plan the System

Before installing any lines, decide which tubing method to use—aerial line or ground line. Use the method that you are confident will be successful for you.

Before installing tubing, consult producers who have experience with tubing. A mistake many producers make when they are using tubing for the first time is to try to install tubing on a large area. It is better to start with 50 tapholes and learn the techniques before trying larger operations.

The first time tubing is installed on a new area is critical. All major changes should be made as soon as possible because later changes may be difficult and costly. Initial planning and experience with tubing are very important.

Examine the Area

It is important to know the general topography of the sugarbush area. In general, the steeper the slope, the better the area is for tubing. First count the number of maple trees, by tree diameter class, in the area. This will give you an idea of tree spacing and the number of tapholes to drill. Study the general slope of the area and determine where the large conduit tubing should be placed so that all the trees can be tapped and the tubing lines can be connected to a central point—the collecting tanks (fig. 5).

Install Conduit Lines

The conduit tubing lines (1/2 inch and larger) can be installed a few months before the sap season begins—in summer or fall. Many syrup producers have these lines installed permanently. If this is done, the lines should be plugged to keep foreign objects out, and should be flushed clean before being put into use again.

Bear in mind that tubing installed early is subject to damage from falling limbs, weather, animals, and people (hunters, snowmobiles, etc.). Most tubing is placed between November and March.

Conduit lines can be installed on the ground surface, under the ground, or suspended above the ground. We think that aerial conduit lines are best, because freezing and thawing are minimized. Placing tubing on the ground presents problems because, when the lines are covered with snow, the sap in the line may freeze and will be slow to thaw. Placing tubing under the ground keeps the sap cooler, minimizes freezing, and prevents rodent damage; but if a leak develops, it is hard to find.

The conduit lines must, above all, have a slope so that the sap will flow through them by gravity. The tubing must be large enough to carry the greatest sap flow.

Install Lateral Lines

The smaller lateral lines can also be partially installed—placed but not connected—before the sap season begins. As with any tubing placed early, there is risk of damage.

We place lateral lines by working down from the top of the hill to the bottom. We try to have about 20 tapholes on each lateral line. However, for trees that are notably high sap producers and are growing on gently sloping land, you should use fewer tapholes per lateral line.

The following instructions are for an aerial line system (fig. 6).

Begin with a roll of tubing (usually 500 feet long). Start at the top of the sugarbush. Tie one end of the tubing around the uppermost tree. Then lead the tubing down the slope, from one tapable tree to the next. Pull the tubing tight as you go, so the pressure holds it in place against the tree stem.

Keep the slope of the line as uniform as you can.

Keep the line as straight as you can, with a minimum of turns. The straighter the line, the faster the sap will flow through the tubing. Use as few connectors as possible, because each fitting is a potential source of leak.

At the bottom of the line, near where it will connect into the conduit line, tie the tubing to a tree. Keep the tubing tight to maintain the slope of the line.

Re-examine the line to make sure that it has a downward slope in all sections, so that the sap can move down the tubing by the pull of gravity. If some parts of the line do not have downward slope, adjust the line till they do.

At this point, you have established the general pattern of the line.

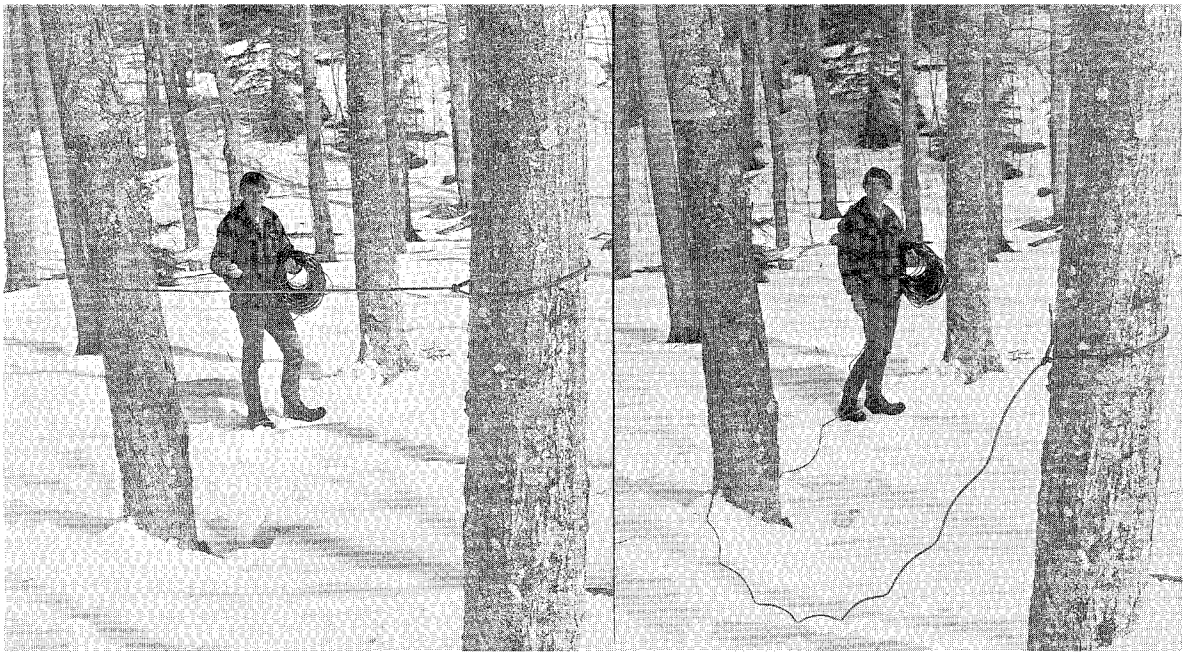


Figure 6.—The difference in installation between an aerial line and a ground line. Left: the lateral tubing of the aerial line is strung tightly from tree to tree. Right: the ground line lies loosely on the ground.

Tap the Trees

After the lateral lines have been placed, you are ready to tap the trees. The first step is to determine the position for the tapholes.

Never drill a taphole above or below an old visible taphole or taphole scar. For best results, drill tapholes in sound, unstained wood. Stained wood may not always be unproductive; however, wood that is dry or very dark indicates decayed tissue and should not be tapped.

Most producers prefer to drill tapholes on the south side of the tree, but this is not always convenient. In most cases, it is more important to have the tubing supported by the tree bole than to drill all tapholes on the south side of the tree.

Use the dropline to measure the height of the taphole above the lateral tubing line (fig. 7). This keeps the lines at approximately the same slope and minimizes line sagging after the lines fill with sap. Tapholes are normally 4 to 6 feet above the ground; of course, this height varies with snow depth and the height of the person tapping.

Several types of tappers are used to drill tapholes, including gasoline-, battery-, and hand-operated tappers (fig. 8). Standard tapholes are 7/16-inch in diameter. Larger holes have been tried, but did not increase the sap yields *(Robbins 1968)*.

Figure 7.—The dropline is used to determine the height of the taphole above the lateral line.

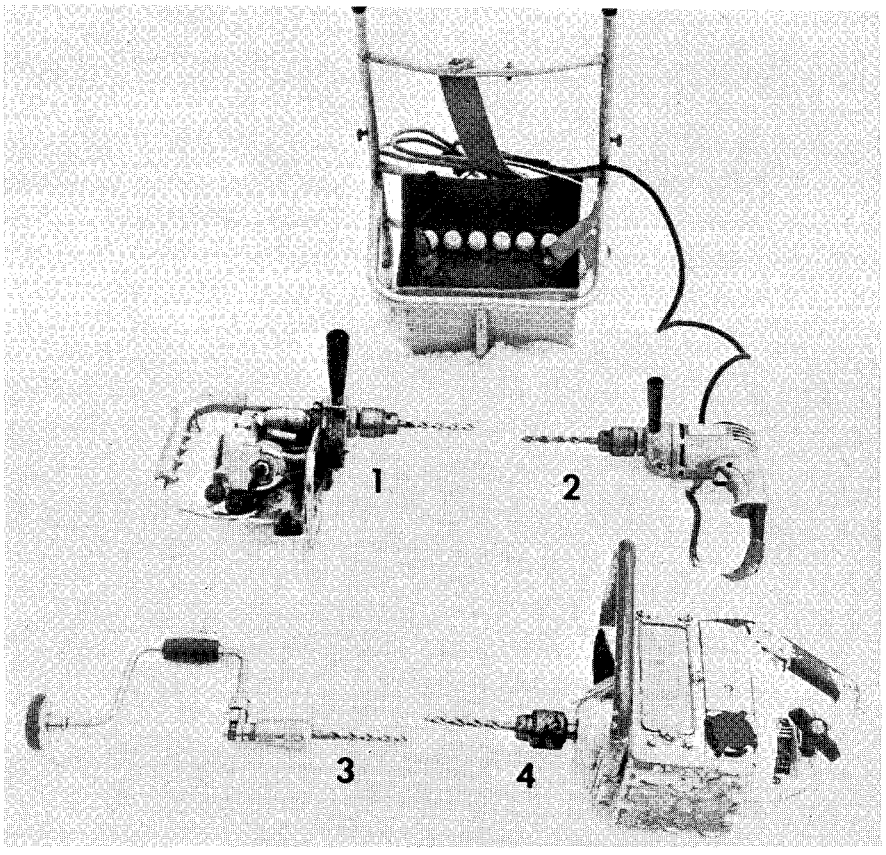


Figure 8.—Tapping equipment. 1, a gasoline-powered drill. 2, a battery-powered electric tapper. 3, a hand auger. 4, another type of gasoline-powered drill.

Drill the tapholes at a slightly upward angle, so the sap will flow easily out of the hole. Hold the tapper very steady in drilling, so that the hole is clean and round (fig. 9). An unsteady hand on the drill may produce holes that are oval rather than round; and spouts do not fit snugly into oval holes; then leaks occur.

Drill tapholes to a wood depth of 3 inches, excluding bark. However, if the tree has considerable rot or appears to be hollow, tapholes should not be so deep. For poor trees, drill tapholes to a wood depth of 2 to 2-1/2 inches.

Hammer the spout—with dropline attached—into the taphole (fig. 10). Be careful not to drive the spout in too hard. There is a definite sound or feeling that indicates when the spout is seated well. If the spout is driven too deep, the bark may split, particularly on a cold day. If the bark is split, there is a possibility for leaks and invasion of the tree tissue by decay organisms.

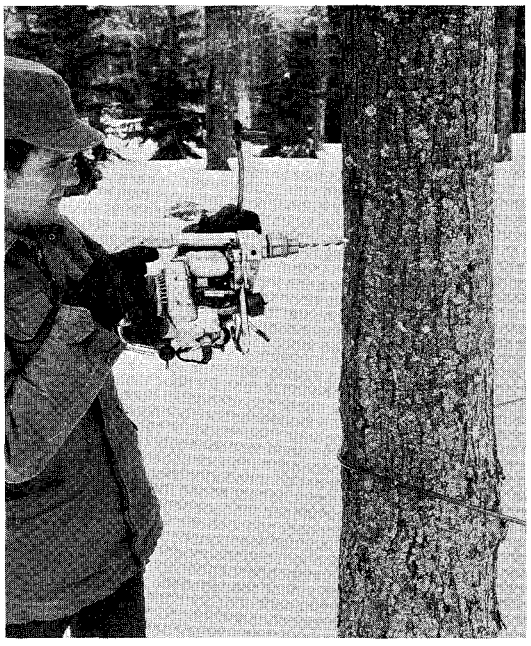


Figure 9.—Using a gasoline-powered tapper to drill the taphole.

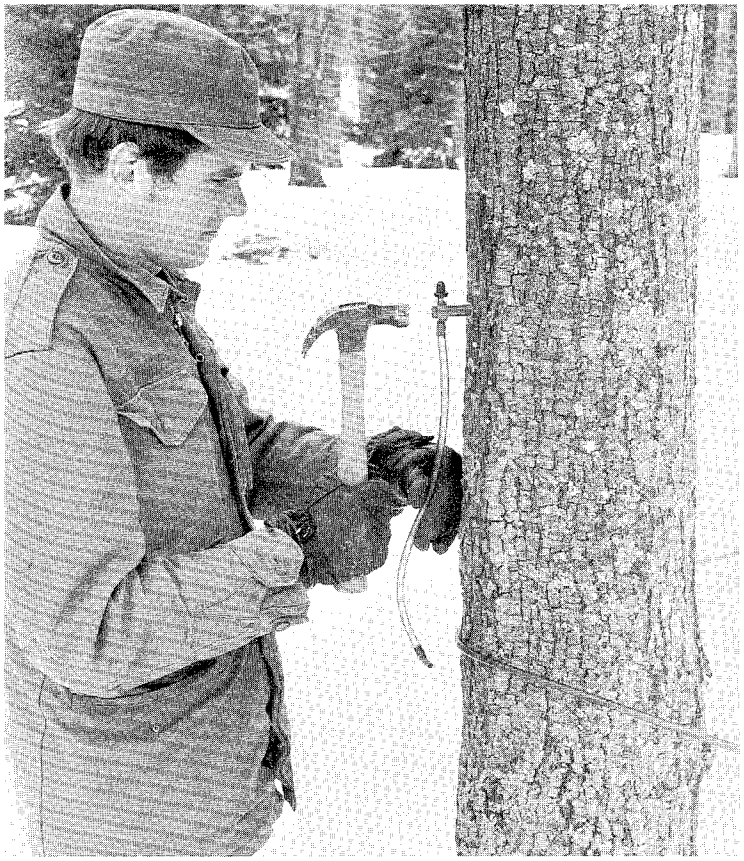


Figure 10.—Driving the spout—with dropline attached—into the taphole.

Check for Leaks

After attaching the spout dropline to the taphole, check the dropline and taphole for leaks. One way to do this is to suck on the dropline (fig. 11). If you suck air, you know that there is a leak somewhere. However, checking each spout dropline and taphole does not always guarantee a leakproof installation. For example, in a hollow tree, a plug of ice may make the taphole seem sound when it isn't; and later sap may be lost by leaking down inside the tree.

After the tubing has been installed, it is difficult to find leaks. If unvented spouts are used, you can attach a vacuum pump to the tubing installation and check systematically when the temperatures are above freezing.

Once the spout droplines and tapholes have been checked for leaks, you are ready to attach the droplines to the lateral tubing line.

At the first spout at the top of each lateral tubing line, the dropline tee is usually attached to the tree (fig. 12). Use a nail or string to anchor this first dropline tee and reduce stress on the plastic fittings. U-shaped staples may also be used. This is normally

Figure 11.—One way to check the dropline for leaks: suck on it.

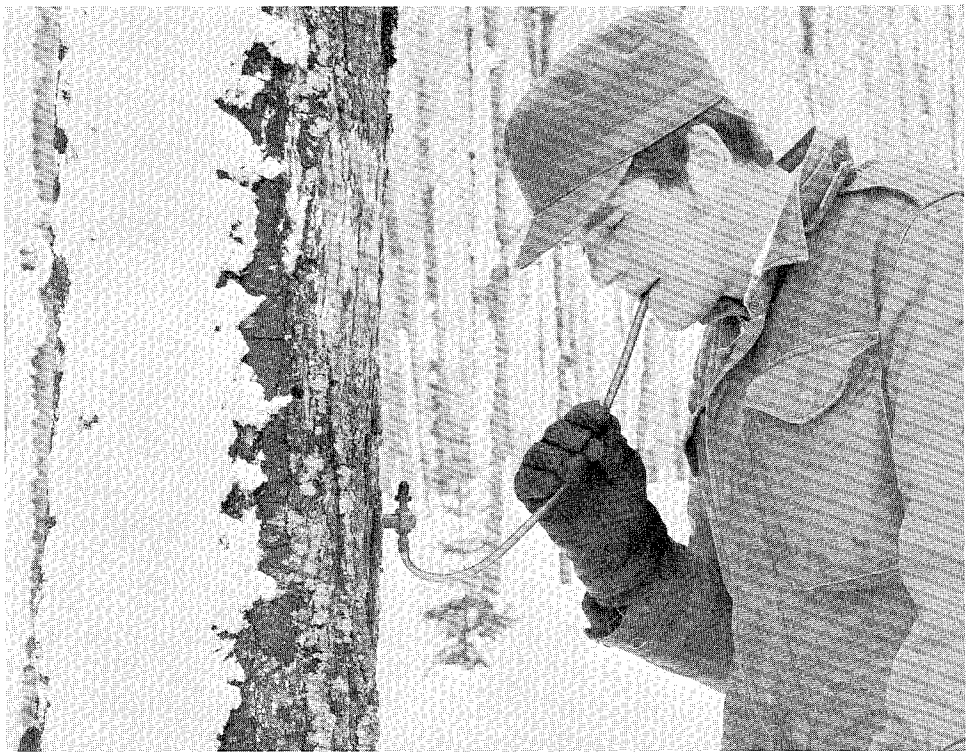
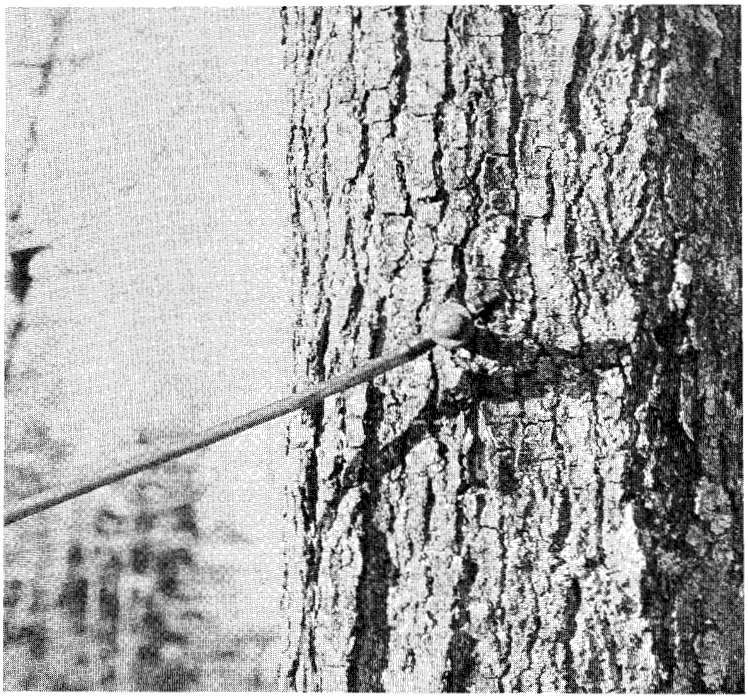


Figure 12.—At the uppermost tree in the sugarbush, the end of the lateral line is secured to the tree with a small nail through the tee. Note that one end of the tee is capped.

Figure 13.—Sometimes—if there will not be much strain on the join, the lateral line can be fastened directly to the spout.



done only at the uppermost spout dropline of each lateral line.

Some producers, instead of using a dropline for the first upper spout, attach the lateral line directly to the spout (fig. 13). The bottom of the spout is twisted at an angle so that the tubing is not crimped.

Join Droplines To Lateral Lines

Before joining the lines, stretch the tubing between the two trees (fig. 14). Stretching is especially necessary for new tubing.

If the tubing has been used in previous years and is being re-installed, you do not need to stretch it as tightly as new tubing. Stretching it too tightly might pull the tees out of position in relation to the trees; then later you might have to cut the tubing and

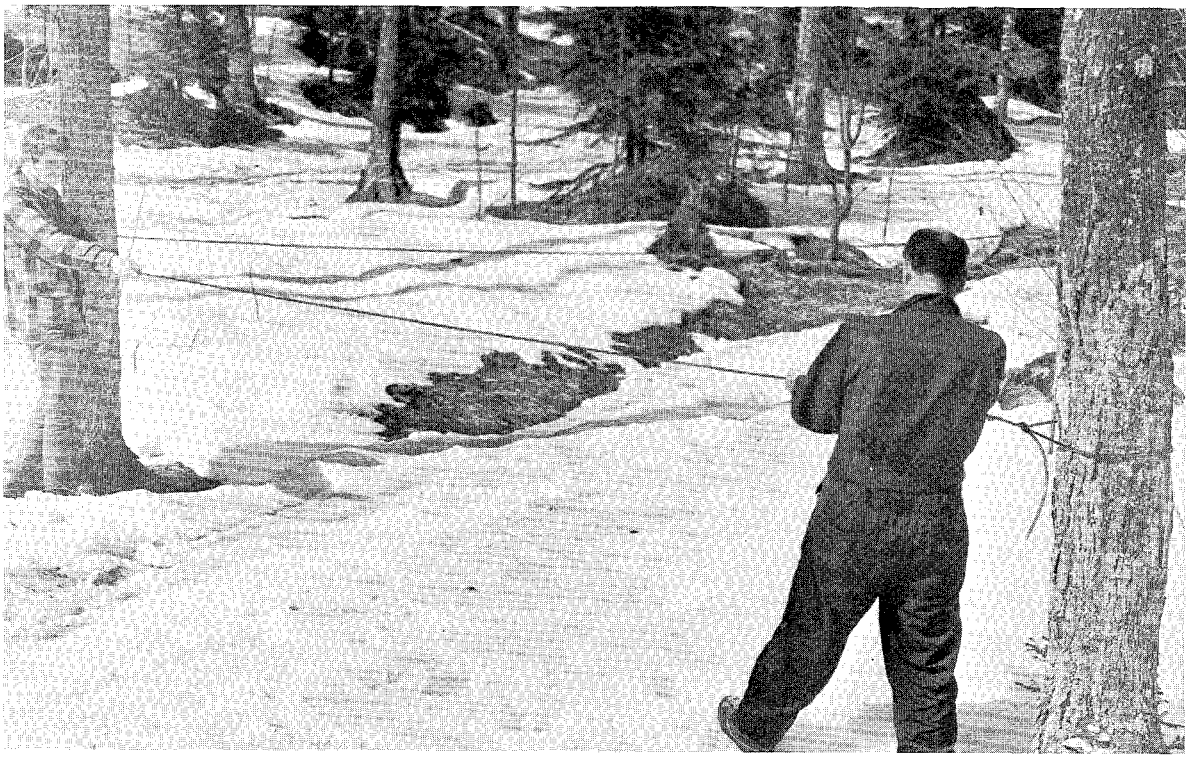


Figure 14.—Stretching the lateral tubing.

add extra tubing and connectors to adjust the line.

To attach a dropline to a lateral line, cut the lateral line and fit the two cut ends onto the tee at the end of the dropline (fig. 15).

If the tubing is cold and stiff, it may not fit easily onto the tee. Warm it. You can use a small portable heater to warm a small pot of water; placed in the hot water, the ends of the tubing will soften quickly. Other types of heaters—such as hand-warmers—are also used. Some people use cigarette lighters, but this kind of heat may distort the tubing ends so they do not make a good joint on the tee. Some people say that the simplest way is to put the end of the tubing in your mouth and chew on it till it softens.

We have also used a tubing spreader—automobile brake-piston needle-nose pliers—to spread the tubing (fig. 16).

Be sure to push the tubing all the way onto the fitting (fig. 17). This reduces the possibility of leaks around the fitting and keeps the tubing from pulling off when tightly hung. Small tubing clamps may be used to get a secure joint.

Figure 15.—Joining the dropline into the lateral tubing line. The lateral line is cut, and the tubing ends are fitted onto the tee at the end of the dropline.

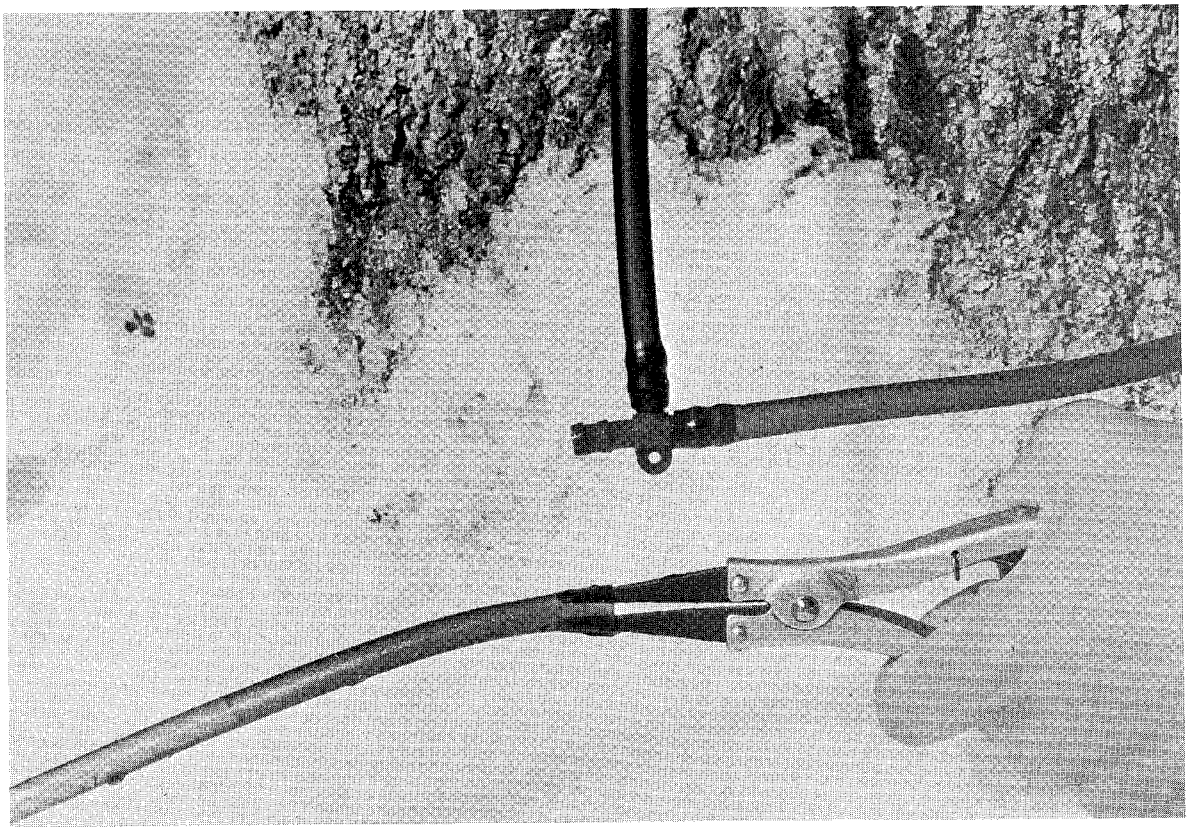
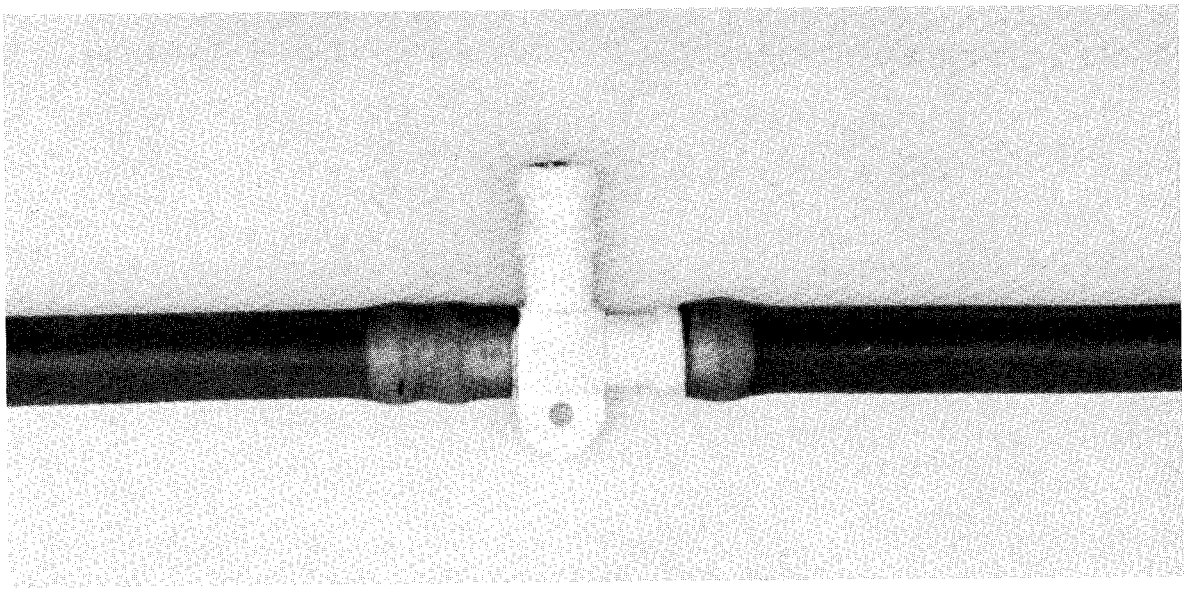


Figure 16.—Needle-nose pliers can also be used to spread the tubing before fitting it onto the tee.

Figure 17.—Make sure the tubing is fitted completely onto the tee. The joint at the right probably will not hold. Small hose clamps can be used to get a secure joint.



Join Lateral Lines To Conduit Line

After the desired number of tapholes have been connected to the lateral line, connect the lateral line to the larger conduit line. Conduit tees fit into the conduit line are commonly used for making the joints (fig. 18).

There is another way, which we call "the Swayze method", for connecting lateral lines to the conduit lines (fig. 19). A small drill bit is used to drill a hole into the top of the conduit line. The hole should be slightly smaller than the tee-cap fitting; use about a 19/32-inch drill for 5/16-inch fittings. A hole punch is sometimes used to ream the hole. Then insert into the drill hole a lateral tubing tee with a cap that has the end cut off. The cap acts as a gasket or bushing. If done properly, the fitting does not leak; but applying plastic cement to the fitting assures a better seal.

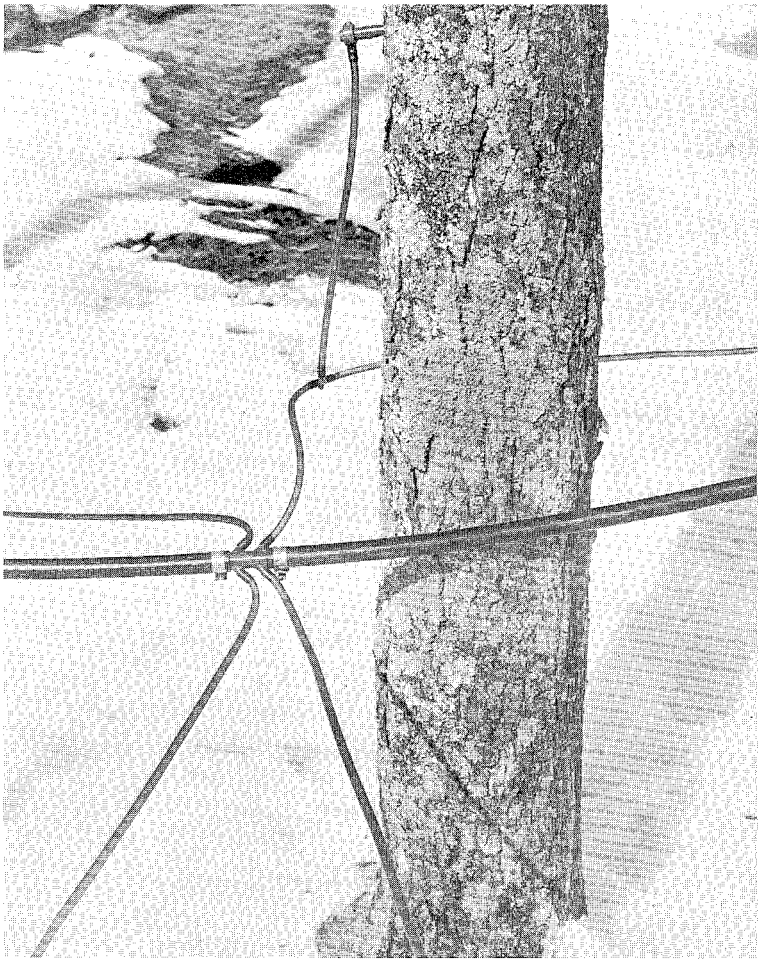
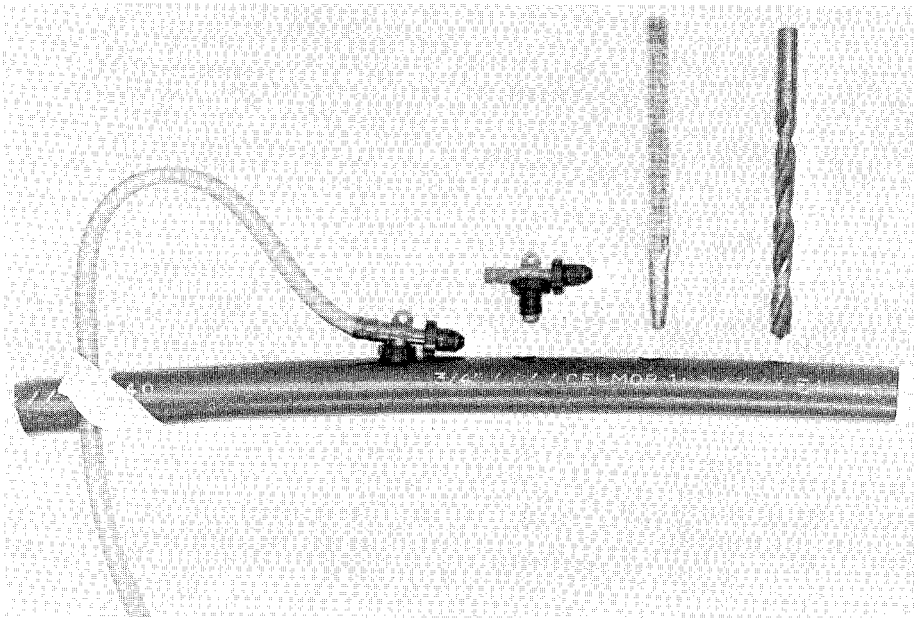


Figure 18.—Joining lateral lines to the larger conduit line. Here a 4-way connector is used to lead four lateral lines into the conduit line.

Figure 19.—Another way to join a lateral line to a conduit line. In this "Swayze method", a hole is drilled into the conduit line, and the lateral line is joined into it with a capped tee.



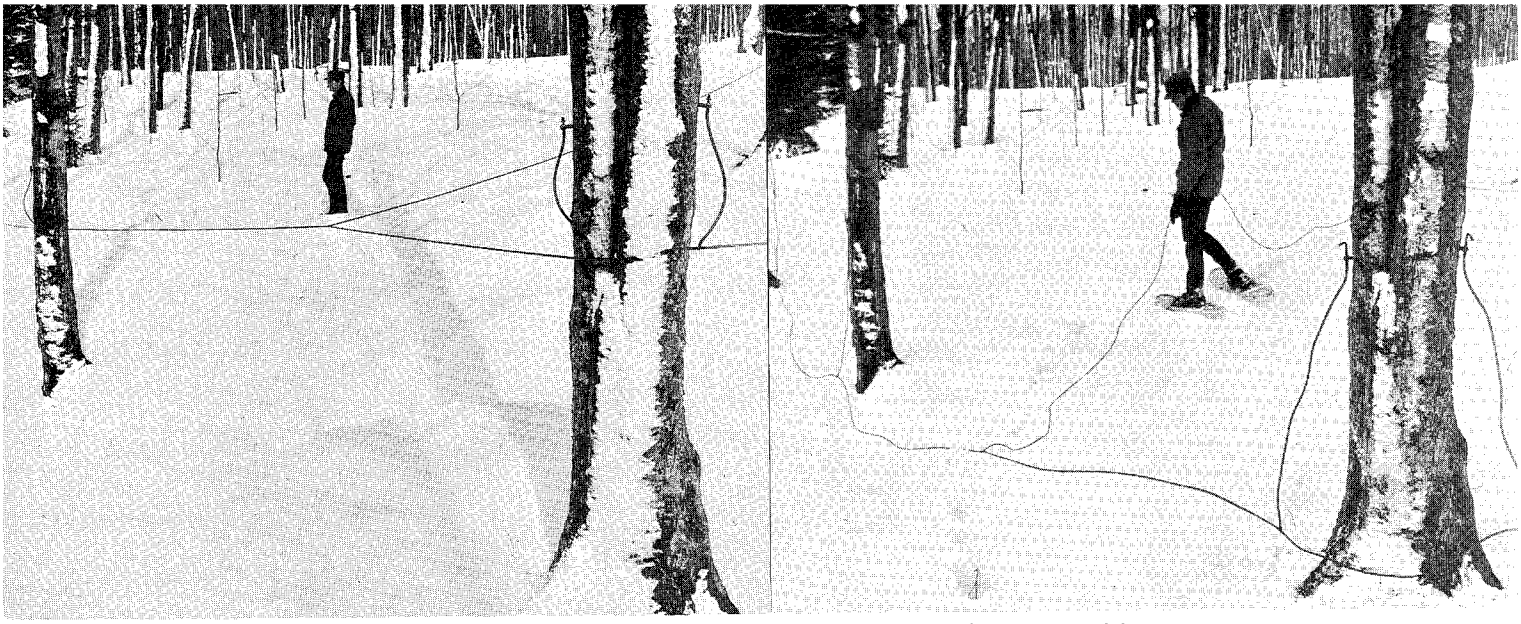


Figure 20.—Completed lines. Left: an aerial line. Right: a ground line. Notice that in both of these lines a lateral branch has been joined into the main line.

Ground Lines

The above instructions are for an aerial system. The procedure for installing a ground-line system is in general the same. The only difference is that longer droplines are used, and the lateral lines are laid loosely on the ground rather than stretched from tree to tree (fig. 20).

OTHER CONSIDERATIONS

Adding Extra Lines

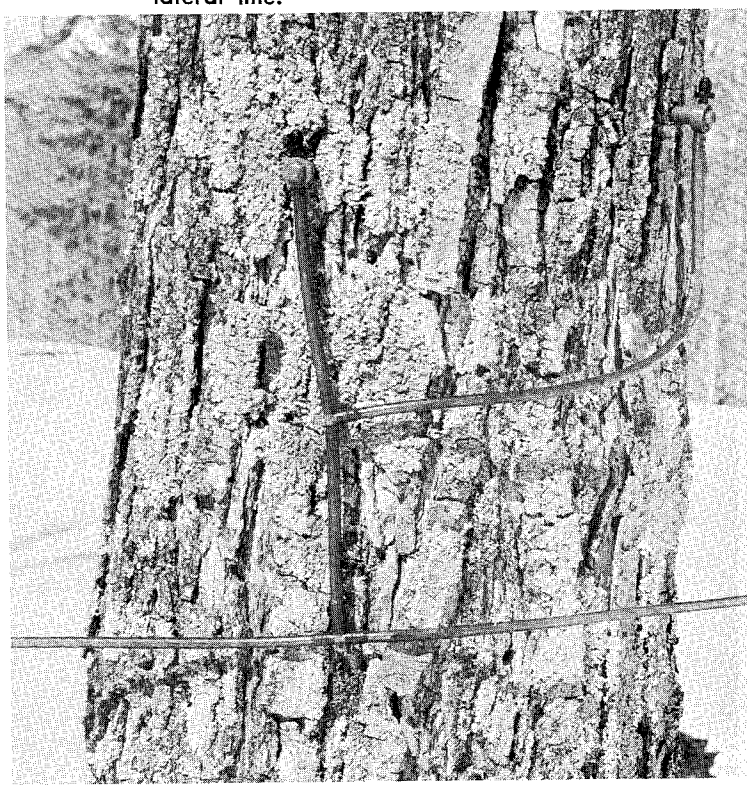
Other groups of trees can be added to an existing sap-collecting system by cutting a new branch line into the lateral line (fig. 20.)

More than One Taphole per Tree

If more than one taphole is drilled into the same tree, there are several ways to connect the additional tapholes into the tubing system. One obvious way is to run the lateral line completely around the tree, cut it, and install a tee for each dropline.

Another way is to run the lateral line past the trees, as is normally done for a single taphole tree, then connect one spout dropline to the other (fig. 21). Of course, droplines of different length should be used, or the height of the tapholes should be varied so that the sap will flow by gravity to the tee on the drop-

Figure 21.—One way to join two tapholes on a tree to the lateral line: one dropline is joined to the other dropline. You could also join droplines directly to the lateral line.



line. When this technique is used, only one tee is attached to the lateral line.

Size of Fittings

For very tight tubing systems, you can use 5/16-inch fittings with 1/4-inch tubing. We have found that this technique works satisfactorily.

Spout Venting

Several research studies have shown that tubing installations with unvented or capped spouts will produce more sap than tubing with vented spouts (fig. 22). The main reason for this increase in sap yield is a natural vacuum that develops in the tubing lines, resulting primarily from the weight of the sap as it moves through these lines *(Blum 1967)*.

Supporting the Tubing

In some sugarbushes, the trees are widely spaced. If an aerial-line tubing installation is used, the distance between trees may be so great that the tubing will sag nearly to the ground even though it is stretched tightly. It is advisable to support long spans of aerial tubing by using wire, string, wooden or metal props, tree saplings, etc. (fig. 23). Supporting will reduce tension on tubing fittings, minimize sagging, maintain tubing slope, and keep the aerial line in the air.

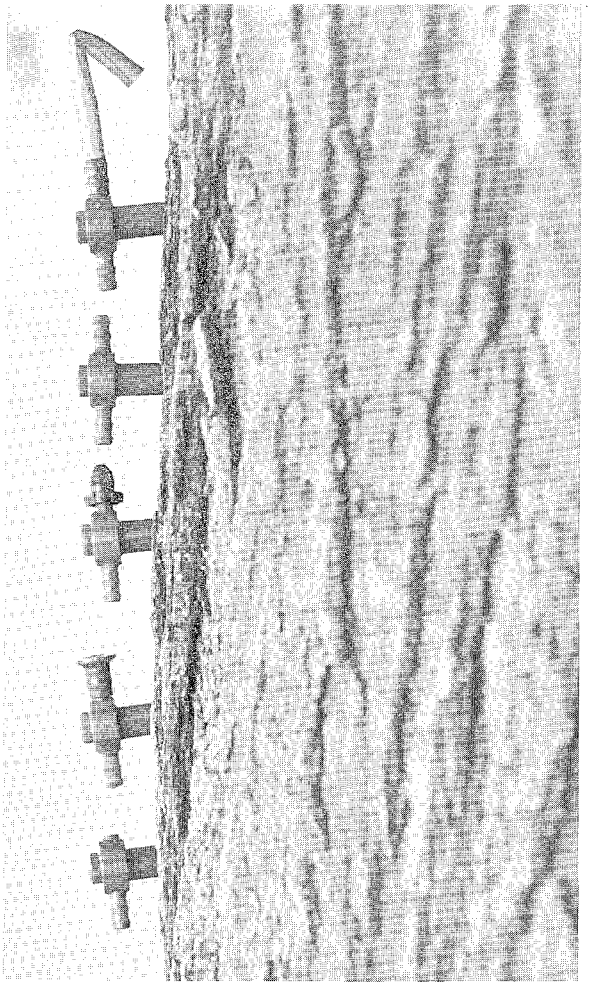


Figure 22.—Different types of spouts used with plastic tubing. The upper two spouts are vented. The lower three are unvented.

Figure 23.—If the distance between trees is so great that tubing will sag badly, the tubing should be supported.

Coding

After the tubing is hung, the trees and tubing should be marked or coded so that the tubing can be re-installed in the same position next year. With proper coding, the tubing can be re-used for several years.

You can mark the trees with paint or tags or plastic tape of different colors. Mark the upper and lower ends of tubing lines the same way. Usually each lateral tubing line that is connected to the conduit line is coded to the conduit fitting.

The spout droplines may be disconnected from these lateral lines, but the dropline tees usually remain in the lines. A sketch map of the tubing area, showing the location of tubing lines, is very helpful when the tubing is re-installed.

Leaks

Check the tubing installation periodically for leaks and damage and blockage. Sometimes tubing can be stretched too tight; and on warm days during a sap flow, the tubing may separate from the fittings.

A number of other circumstances can cause leaks. Sometimes lines are not connected securely during the initial tubing installation. Fittings may be cracked or broken. Rodents may gnaw holes or slits in the tubing (fig. 24). People may damage lines. Heavy snow or ice may tear a line down.

Let Tubing Hang?

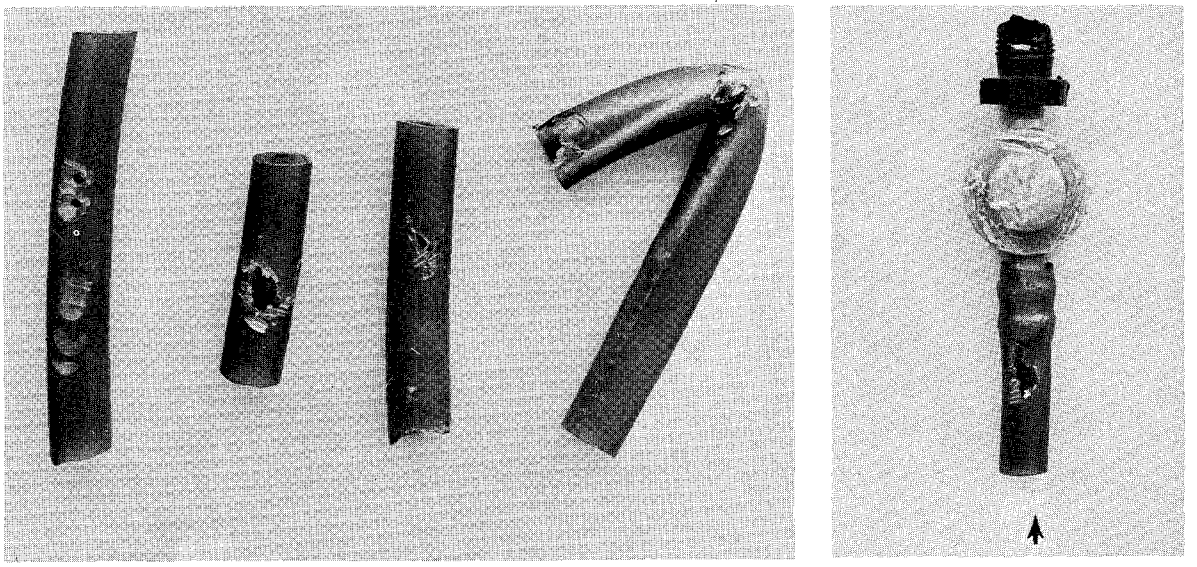
Some producers leave their conduit lines hanging in the sugarbush from season to season. A few also leave their lateral tubing in place. If the lateral tubing is left hanging, a pressure pump or hand backpump should be used to flush the lines with a cleaning solution.

When spouts are removed from the taphole, both vent and spout and end should be capped. The tubing may then be left hanging until the next sap season. Assuming that the lateral tubing is clean and there is no severe damage from rodents and people, it may be economically desirable to leave all tubing installed in place from year to year. Try this on a small-scale basis before you try it on your whole operation.

Use of the Pellet

Many maple syrup producers insert a small aspirin-size pill—a paraformaldehyde pellet—in each taphole to prolong sap flow and increase sap yields. The University of Vermont, the Vermont Department of Forests and Parks, and the Northeastern Forest Experiment Station are cooperating to study the effect of the pellet on the woody tissue surrounding the taphole *(Shigo and Laing 1970; Smith et al. 1970)*.

Figure 24.—Typical damage done to tubing installation by rodents (rabbits? squirrels? mice?).



☆U.S. GOVERNMENT PRINTING OFFICE: 1972-707-507/363

LITERATURE CITED

Blum, Barton M.
1967. PLASTIC TUBING FOR COLLECTING MAPLE SAP; A COMPARISON OF SUSPENDED VENTS AND UNVENTED INSTALLATION. USDA Forest Serv. Res. Pap. NE-90, 13 pp. NE. Forest Exp. Sta., Upper Darby, Pa.

Morrow, Robert R., and Carter B. Gibbs.
1969. VACUUM PUMPING DOUBLES SAP YIELD ON FLAT LAND. USDA Forest Serv. Res. Note NE-91, 5 pp. illus. NE. Forest Exp. Sta., Upper Darby, Pa.

Robbins, Putnam W.
1968. INFLUENCE OF TAPPING TECHNIQUES ON MAPLE SAP YIELDS. Mich. State Univ. Agr. Exp. Sta., 3 pp.

Shigo, Alex L., and Frederick M. Laing.
1970. SOME EFFECTS OF PARAFORMALDEHYDE ON WOOD SURROUNDING TAPHOLES IN SUGAR MAPLE TREES. USDA Forest Serv. Res. Pap. NE-161, 11 pp. illus. NE Forest Exp. Sta., Upper Darby, Pa.

Smith, H. Clay, Bradford E. Walker Alex L. Shigo, and Frederick M. Laing.
1970. RESULTS OF RECENT RESEARCH ON THE PELLET. Nat. Maple Syrup Digest 9: 18-21. illus.

■

THE FOREST SERVICE of the U. S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives — as directed by Congress — to provide increasingly greater service to a growing Nation.