ORCHARD HEATING

Untimely cold weather in the spring and fall and excessively low temperatures during the winter often do immense damage. In the spring fruit crops such as apricots, peaches, plums, and apples are sometimes severely injured or entirely killed. In the fall, early frosts frequently cut short the vegetable crops. Excessively cold weather during the winter sometimes seriously injures the citrus fruit industry in this State. For these reasons the attention of the fruit growers has been attracted to frost-fighting methods.

Orchard heating is comparatively a new practice in this country. It had its beginning with the California orange growers, but since then it has been taken up by the fruit growers all over the United States. When we stop to consider the amount of money and labor invested in a bearing orchard we can see that a considerable expense to prevent loss from freezing is justified.

In any new practice many mistakes are made and many failures recorded. Orchard heating is not an exception, but every year its possibilities and limitations are being more clearly defined. It is entirely possible to control a few degrees of frost when proper methods are followed. Many experienced men believe that it is possible to control a ten-degree drop in temperature if the wind is not blowing more than three miles per hour. This is enough to prevent loss except on very unusual occasions.

Frosts occur on still, cloudless nights. Rarely does the temperature drop more than a few degrees below the point at which damage is done. It is on still nights that orchard heating is the most effective. At times, however, the temperature may go extremely low or a cold spell may be accompanied by wind and snow. Under these conditions the problem of holding the temperature at a safe point is much more serious and difficult. To combat these conditions large equipment and thorough preparation are necessary.

The question as to the most economical methods of orchard heating is largely one of fuel. Wood, coal, and oil are the materials used in this country. All have given good results when properly used. Which is the cheapest depends upon local conditions.
Where wood can be obtained for the hauling and there is only a small orchard to heat, it will probably prove the most economical. However, the labor of cutting, hauling, and distributing the wood, the difficulty of keeping it dry, and the time required to start it burning are all disadvantages. The fires are slow to start and cannot be put out easily when no longer needed and hence a waste of fuel occurs. The piles also interfere seriously with other farm operations, such as irrigating and cultivating.

Ordinary four-foot lengths of wood are best. From fifty to one hundred piles are placed to the acre. Three or four sticks are placed in a pile and arranged with their ends piled together. As the wood burns away the sticks are shoved together and the fires kept burning. To aid in starting the fires quickly, a small amount of kindling and a paper sack filled with shavings soaked in crude oil are placed underneath the wood. Tree prunings, if dry, make excellent kindling. By means of a torch the fires can be started quickly. In case the wood has become wet from rains, crude oil poured over the piles will assist in starting the fires.

The wood should be cut and hauled and the piles arranged in the orchard well in advance of the first possible danger of frost. An ample supply should be kept in reserve to replenish the fires. The amount of wood required will depend on its burning quality, the amount of wind, the length of time necessary to heat and the degrees of temperature to be raised.

The cost of coal practically prohibits the use of this fuel in Arizona. Where it is used it is burned in various wire or sheet-iron devices holding from a peck to a bushel. These coal heaters are on the market. A serviceable wire basket can be made of chicken wire netting mounted on a stiff wire support. From fifty to one hundred of these heaters are used to the acre. They should be equipped with a sheet-iron cover to keep the fuel dry and it should be fastened so that it cannot be blown off by the wind. In the bottom of these heaters is placed a small quantity of excelsior or cotton waste soaked in crude oil; on top of this, a few pieces of short dry kindling and then the coal. With a torch it is quick work to start the fires on a large area.

Coal has the same objections as wood. The fires are slow to start and hard to put out. A waste of fuel occurs because the fires cannot be extinguished when no longer needed. When the fires are to be put out the heaters are overturned and the fuel scattered. Later the unburned coal and coke are gathered for future use. Coal gives off more heat than wood without much soot. This soot does no damage to the fruit blossoms but causes considerable trouble on oranges and lemons.

Oil has been used to a greater extent than any other fuel. It is the best material where heating is to be practiced over a large area, and where labor is a big item. The advantages of oil over the other two fuels are: the ease of handling and storing; the less time required to start burning; and the ease and quickness with which the fires can be extinguished, thus saving fuel. Oil gives off a quick intense heat which is effective at once; thus firing may be delayed longer than when wood or coal is used.
The grade of oil ordinarily used gives off an immense amount of soot which, although disagreeable, does no damage except to oranges and lemons. Various methods of washing these fruits have been developed to free them from soot. Washing powder or a layer of kerosene added to the wash water is effective.

For burning oil a large number of sheet-iron pots of various sizes and shapes has been put on the market. Each manufacturer claims for his pot the greatest amount of heat with the least amount of soot. After thorough testing, but little difference has been found in the efficiency of these different types of heaters. The important point is that the heater should have a capacity large enough to burn all night. At first these oil pots were made to hold about one gallon of oil. This was soon found to be inadequate and the pots had to be refilled when the period of heating lasted more than two or three hours. Filling oil pots after dark is a most disagreeable task, and all who have had to do this work are unanimous in saying that it is entirely impracticable. An oil heater should have a capacity of at least three gallons, and six are better.

Some pots are made in such a way that the size of the fire can be regulated. These have a certain advantage over the others in that the amount of heat given off can be more nearly adjusted to the amount of cold to be overcome. The open type of heaters gives off the most heat when first lighted and the heat given off constantly decreases. On the other hand the temperature to be raised is usually less at first, and constantly increases. To overcome this objection the manufacturers of the open type heaters recommend the use of a larger number of pots to the acre, part of these to be started at first and more as the occasion demands. The small open type heaters cost less than the adjustable, reservoir types, so that the cost of equipment for a given area is about the same. Moreover, a large number of small fires is better than a few large fires, as the heated air does not have such a tendency to rise and there is less danger of scorching the trees.

The following points should be considered in choosing an oil heater; it should be made of good material with as few seams as possible to rust and leak; it should have a tight-fitting cover to protect the oil from the rain; it should be of such shape that the pots will “nest together” and store in a small space, and it should be durable and cheap.

At least one hundred pots of three-gallon capacity should be used to the acre. This is more than is usually recommended but it is essential to have extra heating equipment if needed. On ordinary occasions only a part of this equipment will be used, but experiences of the past few years have taught us that it is essential to be prepared for the worst possible conditions.

Various heavy oils are left in the refining process of crude oil. These are not in much demand and are usually cheap. These oils are used for orchard heating and are called by various trade names, such as Smudge oil, Fuel oil, Slop distillate, Stove distillate, and others. They are usually described as having a certain specific gravity varying from 15° to 35° on the Beauvoisé scale. The 35° oil is lighter and more fluid than the 15° oil. The lighter oils are
Oil suitable for orchard heating can be obtained for a little less than four cents a gallon delivered in southern Arizona in tank car lots. Oil must be obtained in large quantities to secure the advantage of a cheap price. An ample supply of oil for at least one year's use should be kept on hand. For these reasons some kind of storage tank is necessary. It can be either of steel or cement. A cement tank should be treated on the inside with one or two coats of neat cement to prevent leaking of the oil. To facilitate the loading and unloading of oil, the tank should be located on a slope if possible so that the oil may be unloaded from a wagon into the tank and from the tank into the wagon by gravity. If a side hill is not available the tank may be located on level ground and a driveway built up on one side to allow the oil to flow into the tank, and a driveway excavated on the other side for unloading the storage tank.

The tank should have a tight-fitting cover to keep out the rain and should be constructed so that the bottom slopes to one point where the oil can be drained out. The water that these heavy oils contain as they come from the refineries will settle to the bottom after standing and can be drawn off. Large pipes and valves should be used, at least two inches in diameter. Heavy oil acts much like molasses when cold.

Some kind of tank wagon is necessary for filling the oil pots where a large number are to be filled. Two leads of two-inch hose with a stop cock on the free ends are fastened to this wagon. With one man to drive and two men to fill the heaters two rows can be filled at a time, making rapid work possible. On a small scale, or where the ground is too soft to permit the use of a wagon, a sled and barrel may be used with buckets for distributing the oil. The buckets should have a long spout to facilitate filling the pots.

To assist in lighting the oil a small quantity of gasoline or kerosene, or preferably a mixture of the two, is placed on top of the oil in the heaters. Various patented lighters are on the market. Some of these consist of a rather large oil can with a spout two feet long. A trigger arrangement worked with the thumb deposits a small quantity of the starting oil on the heavier oil in the heaters. With this in one hand and a torch in the other the heaters can be lighted as fast as one can walk.

The torch may be made of stiff wire with a ball of burlap soaked in heavy oil, on one end. It should have a hook near this end to jerk off the covers of the pots.

The oil method of heating has some objections. After burning, the heavy oil leaves a thick residue in the heaters which decreases their capacity and must, after a few firings, be cleaned out. The heaters often leak, wasting the oil. This oil on the soil in an orchard certainly does no good, although as yet no damage has been attributed to this cause.

As the oil comes from the refineries it usually contains a large amount of water. This causes the pots to "splatter" while burning and often boil over. After burning, the unused oil reappears in the heat...
is very difficult to relight without refilling. After the first \textit{season's} use the heaters become bent out of shape and when stored stick together, making them difficult to handle.

The principles of orchard heating consist in having a large number of small fires scattered evenly over the area to be protected. The fires are started at, or a short time before, the danger point and kept burning only as long as it is necessary to heat. Lighting the fires before needed, raising the temperature higher than necessary and allowing the fires to burn after all danger is past, is a needless waste. Orchard heating is not like cultivating a crop where the results obtained are commensurate with the labor expended, but requires a finished job. It would be folly to heat on three occasions and lose the crop on the fourth because the fuel gave out or the equipment was inadequate. Thorough preparation and eternal vigilance are necessary to successful orchard heating.

In any system of orchard heating it is a good plan to place double the number of fires on the outer edges of the heated area and especially on the sides of the prevailing winds. The larger the area and the more nearly it is in the shape of a square, the more easily it can be heated. Large trees have a tendency to hold the heat close to the ground, making the practice of heating somewhat more successful where the trees have some size. If the temperature has fallen so low during the night as to freeze the blossoms or \textit{fruit}, it is a good plan to keep a cloud of smoke over the frosted area until the sun has been up some time and the frozen parts have had a chance to thaw out gradually. This will often prevent a large amount of injury. For the purpose of making smoke, any damp, strawy material may be used on wood or coal fires. The oil heaters usually give off enough smoke for this purpose.

It is a risky practice to attempt to heat where the ground in an orchard is covered with dry grass and weeds. This material is almost sure to catch on fire and seriously damage the trees. Care, also, should be taken not to have the fires too large and too close to the trees.

\textbf{Forecasting} frost is largely a local problem. The \textit{U. S. Weather Bureau} forecasts are useful in anticipating times of frost. Frost usually forms on still, cloudless nights following a windy spell when the barometer is high. A close observation of weather conditions when frosts occur will enable one to predict frost with a considerable degree of accuracy. However, since one mistake may make useless a whole \textit{season's} watchfulness, some kind of automatic alarm thermometer is highly desirable. These alarms are made to ring a bell placed anywhere desired, when the temperature falls to a certain point in the orchard. They are rather expensive but are usually quite accurate and are always ready to sound an alarm.

If \textit{everything} has been prepared in advance and the alarm has been set to ring at a few degrees above the danger point it will give \textit{the warning} in time to get ready to fire in case the temperature goes lower.

A number of tested thermometers should be scattered through \textit{the orchard} as the \textit{temperature} varies in different places. These \textit{thermometers} need not be \textit{expensive} but they should be tested
against a standard thermometer and the corrections, if any, plainly marked on them. The mercury column should be large and the figures plain enough to make the reading at night easy. For this purpose an electric pocket flash light is useful as it does not give off enough heat to affect the temperature of the thermometer as a lantern might do. All thermometers should be placed at the same distance from the ground, about four feet. One or two thermometers should be placed well outside the heated area. It is essential to watch the outside temperature as well as the inside. A sudden drop in temperature might not be noticed inside the heated area until too late to provide for it, but by watching the outside thermometers a sudden fall in temperature may be provided for by increasing the size and number of the fires.

The temperature at which damage is done varies so greatly with the different fruits at different stages of development and under different weather conditions that it is almost impossible to give an arbitrary set of temperatures that will be accurate in all cases. It is safe to say that any temperatures at 32° or below are dangerous. It is a general rule that fruit blossoms and young fruit are more susceptible to frost injury as they become older.

The following tables are given as the danger point for different fruits at different stages of development:

**APPLES AND PEARS**
- Blossoms showing pink: 20°
- Full bloom: 27°
- Other times: 30°

**PEACHES**
- Blossoms showing pink: 15°
- Blossoms almost open: 25°
- Blossoms open: 26°
- Petals falling: 28°
- Petals off: 30°
- Shucks or calyx tubes falling: 32°

**ORANGES**
- Nursery stock and yearling trees, well hardened: 27°
- Mature trees: 25°
- Fruit: 30°

These tables show the range of temperature that the fruit can withstand at different periods of growth and are not intended to be accurate under all conditions.

It is the safest plan to commence firing a few degrees above the danger point. As a general rule it is easier to hold a falling temperature than to raise it. If the air is lull of moisture the temperature will not fall rapidly. On the other hand, it is difficult to raise the temperature after it has fallen under these conditions.

The California orange growers, when protecting their fruit from freezing, place shallow pans of water on the ground throughout the orchard. When ice begins to form in these pans it is the signal to commence firing in that area.
Although there have been many failures, orchard heating is becoming an essential part of modern horticultural methods. Each year finds the more progressive fruit growers better prepared in experience and equipment to save their crops under the most trying circumstances. It must be remembered that when crops are saved by heating, the grower has the advantage of the increased price due to the scarcity of fruit.

Orchard heating should be considered as frost-insurance against a more or less certain loss in some years. It justifies the expense of thorough cultivation, spraying and general good care being given the orchard as it insures a crop every year. Many of our neglected and unsightly orchards are due to the uncertainty of returns.

To give some idea of the possible initial cost of a heating equipment for a ten-acre orchard using oil as the fuel the following table is given:

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
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<tbody>
<tr>
<td>1000 three-gallon heaters, 100 to the acre</td>
<td>$400</td>
</tr>
<tr>
<td>Storage tank to hold 12,000 gallons of oil</td>
<td>150</td>
</tr>
<tr>
<td>12,000 gallons of oil</td>
<td>480</td>
</tr>
<tr>
<td>Tank to be mounted on ordinary farm trucks for hauling and distributing oil</td>
<td>40</td>
</tr>
<tr>
<td>Automatic alarm and thermometers</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>$1100</td>
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</tbody>
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This does not include the cost of hauling and distributing pots, and oil or firing.

This rather high cost is only justified in saving a high-priced crop, and then only when the best care and attention is given to other factors to insure maximum returns.

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