packs that lie out in the open, solid from the effects of the sunshine, wind, and rain, the softer snow in the forests and other shady places having disappeared in April, May, or June.

ORCHARD HEATING.

By ALFRED H. THIESSEN, Section Director.

GENERAL.

On a recent visit to Grand Junction, Colo., the writer had an opportunity of studying methods of frost fighting as carried on in the Grand Valley. This valley has 20,000 acres in fruit trees and 10,000 in bearing, reaching from Palisade to Fruita. The valley is similar to a huge trough, bordered, as it is, on each side by high mesas. This natural conformation assists the growers immensely in their frost-fighting campaigns, lessening the strength of the wind, moderating the temperatures, and forming a pocket to hold the smoke generated by the heaters.

ORGANIZATION.

The one thing that makes orchard heating so effective in the Grand Valley is the close cooperation which exists between the growers, the chamber of commerce, and the local office of the Weather Bureau at Grand Junction. The fruit section is divided into districts, and a grower who owns an orchard representative of his district acts as weather observer. On nights of expected frost the local office of the Weather Bureau remains open all night to receive hourly and sometimes half-hourly readings from thermometers exposed throughout the fruit section and to send out warnings, if necessary. By this system the worry of watching for frost devolves on only a few trusted observers, who by their self-sacrifice make it possible for the majority of the growers to rest quietly.

On nights when heating is necessary, a great deal of assistance is required by the farmers. To aid them, the town people offer their services gratuitously. In order to distribute this help quickly the chamber of commerce keeps a card list of farmers desiring aid, and details certain helpers to certain farmers. The volunteers are taken to the orchards in all manner of conveyances—buggies, wagons, automobiles, and interurban and railroad cars—the owners of which freely contribute their use for the general good.

When frost is expected, the fruit growers' association and the local office of the Weather Bureau work harmoniously together, and the temperature conditions over the entire valley are carefully watched. This detailed supervision is necessary, owing to the fact that at times it has been found needful to heat one section and not another, a difference of several degrees frequently existing between the warmest and coldest parts of the district; and these conditions may on other occasions be reversed—the coldest part one night may be the warmest part on another.

Watchfulness and preparedness are the keynotes of success. Sometimes only one or two districts are in danger; at other times the entire section is warned. Warnings are sent from the Weather Bureau office to the secretary of the chamber of commerce, who requests the telephone operators to awaken the growers in the endangered district, and the work of firing is begun at once. To quote the Weather Bureau official at Grand Junction:

> As if by magic the entire district becomes a blaze of light overhung by a pall of fiery red smoke clouds. The heat produced is regulated by varying the number of pots lighted per acre and through changing, by means of covers, the size of the flames from the individual pots. From a distance the scene reminds one of fairyland. Within the orchards, among the smoke and smell, a lurid glare lighting up the trees, move the fleeting figures of the smudgers poking the flaming, sizzling pots, and one might imagine the purpose of the operation one of evil rather than good.

In order to work so quickly, all growers who intend to heat prepare to the last detail. Before the frost period begins pots are set out between the trees, placing them slightly to one side of the center to provide a passageway for a team, and filled with oil or with kindling and coal. All over the orchard in handy locations lie piles of coal ready for the recharging process as soon as the fires begin to get low. Oil wagons filled with oil are also in readiness to be hauled into the orchards to refill the pots when necessary. The growers in the Grand Valley believe in firing long after sunrise.

MATERIAL.

All kinds of orchard heaters are used, burning either oil or coal, although occasionally, if a grower has accumulated a large quantity of brush, prunings, or the like, he will pile it to windward of his orchard and burn it.

The fruit growers' association buys crude oil direct from the refineries at $0.035 per gallon and sells it to the grower at $0.0482—just enough in advance of the purchase price to pay for handling it. Many growers own 600-gallon tank wagons in which they haul oil to their farms, where it is stored in large steel or cement tanks.

Coal is sold to the growers at prices ranging from $2 to $2.75 per ton. Some growers are located very near mines, and buy direct from them.

RESULTS.

The question of whether it pays or not to fire an orchard is one which can not be easily answered offhand. Of course, one can easily see that a grower may fire so many times that the amount of money realized from the fruit saved will not pay for the fuel, extra help, and deterioration of his heaters. This question is complicated by the varying market conditions. In general the growers are enthusiastic over the results of orchard heating, but there are always a few growers in all sections who do not believe in it.

PROBLEMS IN CONNECTION WITH ORCHARD HEATING.

The question as to just what temperature will kill a bud, blossom, or fruit is a very complicated one, and I doubt whether it can be answered without giving many qualifications. The killing temperatures will vary with the stage of advancement of the fruit, the previous treatment of the tree, the character of the previous season, the length of time that the fruit is subjected to certain temperatures, and other influences more or less important.

If the killing temperature for fruit at any particular stage can be given, then the grower has an inkling when to fire. Observations of the temperature of the air are, however, not good indications of the temperature of the buds; other meteorological conditions vary the relation. The temperature of a bud surrounded by clear, dry, calm air at 32° may be quite different from that of one enveloped by moist, moving air at the same temperature but with a cloudy sky.

At present it seems best, with a condition of falling temperature and a fair assurance that a killing tempera-

ture will be reached, to fire at 34°. It is much easier to maintain a certain temperature than to raise it.

An estimate of the probable limit of the minimum temperature is one of great economical importance. An experienced grower should know what his heaters can do, and from his knowledge of the probable minimum temperature judge whether he is able to keep the temperature above the danger limit. In cases it may be more economical for him to save his fuel and stand a fruit loss than to burn his fuel and effect only a slight saving of fruit.

Further investigation should be carried on with the end in view of determining just how long buds must be subjected to certain temperatures to be killed, and also to ascertain other unknown factors which determine the resistivity of a bud to frost.

The whole question of materials used for and methods of smudging or heating should be carefully studied. The kind of fuel to use is oftentimes a purely local question, but even where one kind of fuel is just as available as another there is a wide difference of opinion as to which is the better. The style of heaters is a subject on which practical growers differ greatly. Some believe in a large number of small pots, others in a smaller number of large ones. A new kind of pot is a combination of a heater and a vaporizer, supplying moisture as well as heat to the air.

Last spring the writer advised that experiments be made regarding the advisability of throwing a canopy over each tree on nights of expected frost, tying it under the branches so that only the tree would be enveloped. A sheet-iron lantern hung among the branches might be sufficient to save the buds, or heat could be introduced in any quantity by means of a pipe from a suitable heater. The cost of fuel by this method would be very low. The practicability of the scheme depends entirely on how cheaply a suitable fabric could be obtained. The size of the hood or canopy could be greatly reduced by first tying the branches together.

Retarding the blossoming period has been tried by many to save the fruit from frost. This has been done by heavily mulching the ground around the trees after a hard freeze in winter. Little seems to be known regarding the efficacy of this process, some contending that the blossoms are kept back, others that they are not. The writer suggested retarding the blossoms by covering the foliage with a hood made of some waterproof material and well ventilated. This hood should be kept on the trees during a portion of the late winter or early spring, thereby not exposing the buds and twigs to the sun, and their temperatures would at all times be nearly that of the free air. It is thought that by this method the buds could be prevented from swelling sufficiently to withstand the hardest of the spring freezes.

It is the opinion of some authorities that under ordinary circumstances there is enough nutrient matter in the twigs, branches, and trunk of a tree to nourish the buds even if the ground around the roots is frozen.

I noted that better results were obtained in orchards that were surrounded by other orchards. These orchards acted as windbreaks, making artificial heating much more effective. Efficient windbreaks should be established on the north and west sides of all orchards. Poplar trees, headed low, willow, cherry trees, and high hedges could be used for this purpose.