A. A. Dowell.

BULLETIN NO. 110 15,000 AUGUST, 1911

DIVISION OF HORTICULTURE

Oregon Agricultural College

Corvallis, Oregon

"Preliminary Frost Fighting Studies in the Rogue River Valley"

BY C. I. LEWIS AND F. R. BROWN

The Bulletins of this Station are sent free to all residents of Oregon who request them.

Oregon Agricultural College Press
Corvallis, Oregon
1911

BOARD OF REGENTS OF THE OREGON AGRICULTURAL COLLEGE AND EXPERIMENT STATION.

Hon J. K. Weatherford, *President*.....Albany, Oregon
Hon. E. E. Wilson, *Secretary*.....Corvallis, Oregon
Hon. B. F. Irvine, *Treasurer*.....Portland, Oregon
Hon. Oswold West, *Governor of the State*.....Salem, Oregon
Hon. Ben W. Olcott, *Secretary of State*.....Salem, Oregon
Hon. L. R. Alderman, *State Supt. Public Instruction*.Salem, Oregon
Hon. Charles E. Spence, *Master of State Grange*.....Canby, Oregon
Hon. J. D. Olwell.....Medford, Oregon
Hon. William W. Cotton.....Portland, Oregon
Hon. Walter M. Pierce.....La Grande, Oregon
Mrs. Clara H. Waldo.....Portland, Oregon
Hon. J. T. Apperson.....Park Place, Oregon
Hon. C. L. Hawley.....McCoy, Oregon

OFFICERS OF THE STATION STAFF

W. J. Kerr, D. Sc.....President
James Withycombe, M. Agr.....Animal Husbandry, Director
A. B. Cordley, M. S.....Entomologist
C. I. Lewis, M. S. A.....Horticulturist
H. D. Scudder, B. S.....Agronomist
F. L. Kent, B. Agr.....Dairy Husbandman
H. S. Jackson, A. B.....Botanist and Plant Pathologist
T. D. Beckwith, M. S.....Bacteriologist
James Dryden.....Poultry Husbandman
H. V. Tartar, B. S.....Acting Chemist
Helen L. Holgate.....Station Clerk

INTRODUCTION (HISTORY.)

The Division of Horticulture of the Oregon Experiment Station began frost fighting investigations in the Rogue River Valley in 1909. In 1908 there had been some loss in the Valley, and as a result of this loss C. I. Lewis, Horticulturalist of the Experiment Station, was invited to meet the growers at Medford to give an address on frost fighting. A representative of the Southern Pacific Railroad Company was also present. This representative kindly offered to donate some oil in order to enable certain demonstrations to be conducted in frost fighting. It was the general opinion of the growers that frost injury probably would be very slight in the future, and this prevented many growers from undertaking experiments. However, pots were secured, and Mr. C. E. Whisler, of the Bear Creek Orchard kindly offered to allow demonstrations to be conducted in his orchard. Mr. Whisler also gave valuable assistance in conducting the experiments. The experiments for that year were in charge of Mr. C. C. Vincent, assistant in the Horticultural Division, and he was assisted by Mr. C. E. Whisler, and also Mr. W. S. Brown, a graduate of Cornell University, who was giving special assistance to the Horticultural Division at that time.

This meeting was not called in ample time to allow one to make the best of preparations, and most of the work for the year 1909, as shown in this report, was of a negative nature, due largely to three things: first, to an inferior grade of oil; the locomotive oil which was furnished contained too much water, and other impurities, for frost fighting; second, a lack of sufficient pots for the work; and third, unusual low temperatures, 25 degrees being recorded. No work was undertaken in 1910, although many growers of the Valley resorted to various methods of frost fighting in order to save their crops. Unfortunately, in their rush of work few of them kept data and notes of such a nature as to be very valuable in frost fighting work.

The Division of Horticulture, owing to a lack of assistance and funds, was unable to carry on the work that was desired in 1910. Work was again resumed this past spring on a more etxensive and very thorough scale. We were enabled

to do this work largely through the kindness of two pot manufacturing companies, namely: The Round Crest Co. of Denver, Colo., and the Bolton Orchard Heater Co. of San Francisco, Calif.

Mr. Karl L. Wundt, who represented the Round Crest people, made a proposition to the College that these two companies would like to conduct competitive experiments in an orchard in the Rogue River Valley, and asked the Division if we could secure an orchard, and also be willing to serve on a committee of three to judge the contest. They also wished the College to take the records of both companies. The College accepted the proposition, although the details were not completed until late in March, which was more or less of a handicap. While some competitive work was conducted, a great part of it was never undertaken, owing to a lack of understanding between the two companies. However, the pots and oil were secured, and considerable valuable data has been obtained, which is published in this bulletin under the title of "Experiments Conducted in 1911."

EXPERIMENTS CONDUCTED IN 1909.

Experiment No. 1:

On April 14, 1909, in the block of pears northeast of the pumping plant in the Bear Creek Orchard, a smudging experiment was conducted, the fuel being oil furnished by the Southern Pacific Railroad Company, which was used in the Fresno pots. Mr. C. C. Vincent of the Division of Horticulture, Oregon Experiment Station, and Mr. C. E. Whisler, of Medford, Ore., conducted the work. Forty-five pots were used, and thermometers were hung 6 feet from the ground. The temperatures recorded were the following:

Outside Reading.

Time.	Reading.
3:50 A. M.	28 deg. F.
4:50 A. M.	25 deg. F.
5:10 A. M.	25 deg. F.
5:40 A. M.	25 deg. F.

Reading in Area.

Time.	Reading.
3:50 A. M.	28 deg. F.
4:20 A. M.	28 deg. F.
4:40 A. M.	27 deg. F.
4:55 A. M.	26 deg. F.
5:10 A. M.	26 deg. F.
5:25 A. M.	26 deg. F.
5:40 A. M.	26 deg. F.

There was not a sufficient number of pots to raise the temperature above the danger point, and second the oil was shown to be of an inferior grade, since it was noted that 7 pots exploded the first hour, and 25 pots had exploded in two hours. This boiling over and exploding of pots troubled us the entire season.

Experiment No. 2. Conducted April 20, 1909.

This experiment was conducted in what is known as the Eisman orchard at Grants Pass. The oil used was furnished by the Southern Pacific Railroad Company, and was used in the Fresno pots. Two hundred twenty-five pots were used on an area of three acres. This likewise was a very cold night, as the lowest temperature recorded was 25 degrees. The tem-

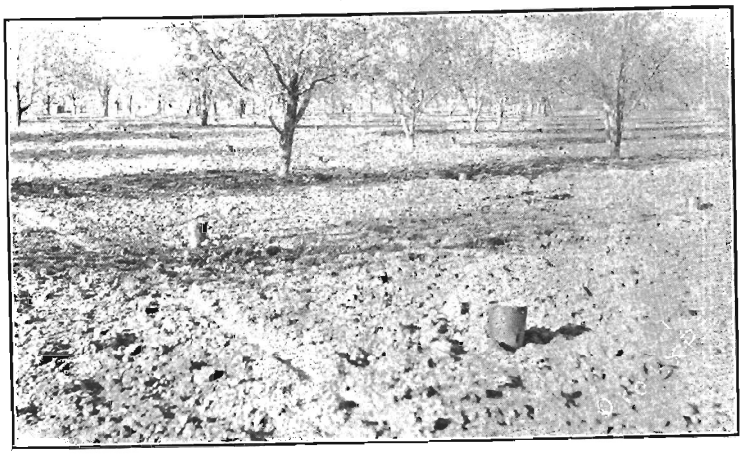

Plate 1—Bolton Orchard Heaters placed 17x25 ft. ready for firing

peratures for outside and inside the plots are given in the following tables:

Readings. Outside Area.

Time.	Reading.
11:15 P. M.	34 deg. F.
12:15 P. M.	32 deg. F.
1:00 A. M.	29 deg. F.
2:00 A. M.	26 deg. F.
2:15 A. M.	25 deg. F.
3:00 A. M.	25 deg. F.
4:30 A. M.	25 deg. F.

Readings. In Fired Area.

Time.	Reading.
11:15 P. M.	34 deg. F.
12:15 P. M.	31 deg. F.
1:00 A. M.	30 deg. F.
2:00 A. M.	29 deg. F.
2:15 A. M.	28 deg. F.
3:00 A. M.	28 deg. F.
4:30 A. M.	28 deg. F.

It was found impossible even with this number of pots to the acre to save a crop with the grade of oil used. It required three men 11 minutes to light the 225 pots. Refuse from gasoline motor car shops saturated with oil was used as as wicks to assist in lighting the pots.

Experiment No. 3. Conducted April 27, 1909.

Seventy pots were used in a block of pears in the Bear Creek Orchard, Medford, Ore. This was not an experiment to protect against frost, as the temperatures were not dangerous, but

Plate 2—Troutman Orchard Heaters placed 17x25 ft. ready for lighting

was more to test the oil in the pots. The temperatures given were recorded in the following tables:

Outside Reading.

Time.	Reading.
3:25 A. M.	52 deg. F.
4:05 A. M.	49 deg. F.
4:45 A. M.	49 deg. F.
5:05 A. M.	48 deg. F.

Reading in Area of Fire.

Time.	Reading.
3:25 A. M.	52 deg. F.
4:25 A. M.	51 deg. F.
4:45 A. M.	52 deg. F.
5:05 A. M.	52 deg. F.

It required two men 12 minutes to start 70 pots. The action of the oil at this time can be shown in the following table:

NOTES ON ACTION OF OIL.

Row.	Time.	No. of Pots.	No. of Pots Boiled Over.
1	4:05 A. M.	6	5
2	4:05 A. M.	5	3
3	4:05 A. M.	11	4
4	4:05 A. M.	7	3
5	4:05 A. M.	3	0
6	4:05 A. M.	6	2

This experiment also demonstrated the impossibility of using this grade of oil.

Experiment No. 4. Conducted April 29, 1909.

This experiment was conducted in the Bear Creek Orchard. Mr. C. C. Vincent and Mr. C. E. Whistler were observers.

PLOT 1.

Composed of Sawdust and Shavings.

Outside Reading.

Time.	Reading.
9:00 P. M.	43 deg. F.
9:40 P. M.	40 deg. F.
10:40 P. M.	38 deg. F.

Reading in Area.

Time.	Reading.
9:00 P. M.	43 deg. F.
9:30 P. M.	43 deg. F.
10:30 P. M.	40 deg. F.

PLOT 2.

Coal Basket.

Outside Reading.

Time.	Reading.
9:00 P. M.	43 deg. F.
9:40 P. M.	40 deg. F.
10:40 P. M.	38 deg. F.

Reading in Area.

Time.	Reading.
9:00 P. M.	43 deg. F
9:30 P. M.	42 deg. F.
10:00 P. M.	42 deg. F.
10:35 P. M.	41 deg. F.

PLOT 3.

Fresno Pot.

Outside Reading.

Time.	Reading.
9:00 P. M.	43 deg. F.
9:40 P. M.	40 deg. F.
10:40 P. M.	38 deg. F.

Reading in Area.

Time.	Reading.
9:10 P. M.	43 deg. F.
9:30 P. M.	43 deg. F.
10:35 P. M.	41 deg. F.

PLOT 4.

Troutman Pot.

Outside Reading.

Time.	Reading.
9:00 P. M.	43 deg. F.
9:40 P. M.	40 deg. F.
10:40 P. M.	38 deg. F.

Reading in Area.

Time.	Reading.
9:00 P. M.	43 deg. F.
9:30 P. M.	42 deg. F.
10:40 P. M.	40 deg. F.

PLOT 5.

Fresno Pot Having Cover with 2-inch Hole.

Outside Reading.

Time.	Reading.
9:00 P. M.	43 deg. F.
9:40 P. M.	40 deg. F.
10:40 P. M.	38 deg. F.

Reading in Area.

Time.	Reading.
9:10 P. M.	43 deg. F.
9:45 P. M.	42 deg. F.
10:30 P. M.	41 deg. F.
10:45 P. M.	39 deg. F.

PLOT 6.

Fresno Pots with Sawdust and Sand. Handful of Each in Oil to Keep from Boiling Over.

Outside Reading.

Time.	Reading.
9:00 P. M.	43 deg. F.
9:40 P. M.	40 deg. F.
10:40 P. M.	38 deg. F.

Reading in Area.

Time.	Reading.
9:10 P. M.	43 deg. F.
9:40 P. M.	43 deg. F.
10:10 P. M.	42 deg. F.
10:30 P. M.	41 deg. F.
10:45 P. M.	40 deg. F.

PLOT 7.

Wood Covered with Wet Straw.

Outside Reading.

Time.	Reading.
9:00 P. M.	43 deg. F.
9:40 P. M.	40 deg. F.
10:40 P. M.	38 deg. F.

Reading in Area.

Time.	Reading.
9:10 P. M.	43 deg. F.
9:45 P. M.	46 deg. F.
10:15 P. M.	45 deg. F.
10:35 P. M.	44 deg. F.
10:50 P. M.	43 deg. F.

PLOT 8.

Wood Covered with Damp Manure.

Outside Reading.

Time.	Reading.
9:00 P. M.	43 deg. F.

Reading in Area.

Time.	Reading.
9:10 P. M.	43 deg. F.

9:40 P. M.	40 deg. F.	9:45 P. M.	45 deg. F.
10:40 P. M.	38 deg. F.	10:15 P. M.	46 deg. F.
		10:30 P. M.	42 deg. F.
		10:50 P. M.	41 deg. F.

PLOT 9.

Wood Covered with Wet Sawdust.

Outside Reading.

Time.	Reading.
9:00 P. M.	43 deg. F.
9:40 P. M.	40 deg. F.
10:40 P. M.	38 deg. F.

Reading in Area.

Time.	Reading.
9:10 P. M.	43 deg. F.
9:45 P. M.	47 deg. F.
10:10 P. M.	45 deg. F.
10:30 P. M.	42 deg. F.
10:50 P. M.	39 deg. F.

PLOT 10.

Prunings, Using Paper Sack with Coal Tar Residue for a Starter.

Outside Reading.

Time.	Reading.
9:00 P. M.	43 deg. F.
9:40 P. M.	40 deg. F.
10:40 P. M.	38 deg. F.

Reading in Area.

Time.	Reading.
9:10 P. M.	43 deg. F.
9:45 P. M.	51 deg. F.
10:15 P. M.	45 deg. F.
10:50 P. M.	39 deg. F.

OBSERVATIONS.

Plot 3 had 2 pots out at 10 o'clock.
Plot 4 had 1 exploded, 3 out at 11 o'clock.
Plot 5 had 1 exploded, 2 out at 11 o'clock.
Plot 6 had 3 exploded at 11 o'clock.
Plot 7, fires all out at 11 o'clock.
Plot 8, fires all out at 11:30 o'clock.
Plot 9, fires burning at 11 o'clock.
Plot 10, fires all out at 11 o'clock.

INVESTIGATIONS CONDUCTED 1911. G. E. MARSHALL ORCHARD.

The orchard consists of seven acres of seventeen-year-old trees. The block heated is twelve rows in width, there being 28 trees to the row, three rows of Winter Nelis on the west, five rows of Bartletts on the east, and four rows of d'Anjous between. The trees were set 25 feet each way. The orchard

being very nearly level, the conditions were practically the same throughout the entire block. The arrangement of the heaters was as follows:

The Bolton heaters were arranged on the north half of the block, being placed 17 feet by 25 feet apart, 299 heaters being used. The Troutman pots were placed on the south half, and arranged 17 feet by 25 feet, with a total of 304 heaters. Around the outer edge of the orchard was placed a row of Bolton pots for reinforcement. On the west of this tract was a block of young Bartletts five years old, 25 feet apart, which were heated with 70 pots per acre. On the east was a block of Yellow Newtowns which were not heated. To the north was a block of trees consisting of the same varieties as the one heated. This was originally a part of the same orchard.

SIZE OF TREES.

WINTER NELIS.		D'ANJOU.		BARTLETT.	
Height.	Spread.	Height.	Spread.	Height.	Spread.
13	9.5	14	15	15	13
12	9	15	15	15	16
12	8	14	15	16	13.75
12.5	10.5	16	15.5	14	12
11	9	13	12	12	8
10	10	14	13	14	10
15	14	15	14	15	12
16	18	15.5	13	14	13
12.7	11	14.6	13.9	14.5	13.5

The northeastern corner and part of the eastern end of this block was slightly higher, and the soil much lighter, and slightly higher temperatures were noticed in that part.

BLOCK OF RED CHEEKS.

This block of red cheek apples, consisting of about two acres, was selected with the idea of obtaining a different arrangement of trees, and noting the effect the different distances in planting would have upon the temperatures maintained. Within this block the Troutman heaters were arranged 21 feet each way, making as nearly even distribution

as possible of the heaters. The trees in this block are planted on triangular system, the base of which is 50 feet, with the sides 34½ feet, making the shortest distance between trees 34½ feet, and the longest 50 feet. The age of the trees is 17 years, and the size will be noted from the following chart:

RED CHEEKS.

Height.	Spread.
14	13
15½	20½
14	18½
18¾	21½
19	21
15	18
16	16½
17½	18
Average ..16 ft. 2 in.	18 ft. 4 in.

WEATHER CONDITIONS.

March 27th to April 3rd was a period of extremely warm weather, with bright sunshine. The maximum temperature on March 29th and 30th was 86 degrees. Following this period came one of cloud and rain, the temperature being much lower. During the week from April 3rd to April 9th very little rain fell, but the temperature was low, and the sun shone but very little. April 9th and during the week following the temperature dropped still lower, ranging on April 10th, 11th and 12th about 45 to 50 degrees during the daytime, and from 34 to 38 degrees during the night. During this week, and especially on April 10th and 11th, some snow fell; in fact, during the whole day of April 11th snow fell intermittently. Very little snow remained, however, after it struck. On April 12th the weather cleared, and on the night of April 12th a light bank of clouds prevented a low temperature. April 13th also being clear, and the night following being clear, a forecast was given out to be prepared for frost. By 12:00 o'clock the temperature had reached 34 degrees, and dropped steadily until 3:00 o'clock, when there was an average temperature of 29.6 degrees, with the temperature still dropping, the lowest temperature for the morning being 27 degrees, and occurring between 5:00 and 5:30.

The following day, April 14th, was somewhat cloudy, and the temperature did not rise very high, remaining around 55 and 60 degrees. In the evening the sky again cleared, and another frost was forecasted. About 3:00 o'clock in the morning the temperature had reached 30 degrees. At 3:30 for a short period only the temperature reached 26 degrees. From 3:30 until 5:00 the temperature varied between 27 and 29 degrees. At 5 o'clock it again dropped to 26 degrees, and remained there until 5:30, and from 5:30 until 6:00 the temperature remained from 27 to 28 degrees. The day following, April 15th, was cool, and slightly cloudy, but the temperature had risen enough so that there was no more frost until the following week. During this period the condition of the bloom was as follows:

The extremely warm period between March 27th and April 3rd had forced the bloom out on the Bartletts, and the d'Anjous, until they were in full bloom by the 5th of April. The Winter Nelis, however, were just beginning to open on the 5th, and during the cloudy cool weather which followed they opened very slowly, so that they did not come into full bloom until about April 15th or 16th. During their blooming period very few bees were noticed in any orchard.

OIL USED.

The oil used on all of this work except in the test with 20 heaters to the acre, was a "slop" distillate, testing about 20 degrees Baume'. This oil cost 80c per barrel at the refinery, and the freight rate is $2.19 per barrel. This oil had been guaranteed free of water, but unfortunately through some accident or other unexplainable reason, the first carload shipped to the Valley contained such a large quantity of water that it could hardly be used . The car of oil used in this test was apparently free from water, and gave fairly good results. The oil used for the first test where the 20 heaters per acre were used was of much better grade, being known as 28 degree distillate. The expense of this, however, is almost prohibitive, costing about 9c per gallon at Medford. The Union Oil Company, however, have stated that it is quite probable that they will be able to place it at Medford for 6c per gallon. Just what grade of oil will be used in the future we cannot

state, as it is still an open question, there being at present about three different grades used in the Valley, each having its special advantage. The test which was attempted to determine the relative burning qualities of the three grades proved to be of no value, because of the large amount of water contained in the samples. Five gallons each of oil testing 16 degrees, 20 degrees and 28 degrees, respectively, were used. Bolton orchard heaters were used in making the test. These were of the lard pail type, each holding one gallon. The five-gallon can of 28 degree distillate which was turned over by a representative of the Union Oil Co. of California contained two gallons and one quart of water, so that only one heater was filled with oil containing no water. At the end of three hours all the heaters had gone out, leaving one quart to three quarts of water in each heater. Five Bolton heaters were filled with one gallon each of 20 degree "slop" distillate, and at the end of one hour three had gone out on account of the large amount of water present. Of the remaining two, one burned out clean in 3½ hours, and the other in 4½ hours. It was noticed that this grade of oil gave off a much more dense smudge than the other two during the first hour and a half. Five heaters were used with one gallon each of 16 degree fuel oil, and of these, three contained water enough to cause them to boil over, and go out. Of the other two, one burned 4¾ hours, leaving one inch of heavy residue. This grade of oil was much easier to light than either of the distillates, for the reason that gasoline was used as a lighter, and remained on top, burning very rapidly, whereas on the other grades it mixed slightly with the oil. The test was in no way successful, and of very little value, due to the fact that only small amounts of oil were used, and no attempts were made to obtain the temperatures created by the different fuels.

The oils in use on the Pacific Coast all have an asphalt base, and do not burn up as cleanly as the oil used in the middle West, which has a paraffin base. At the present time it is not possible to obtain this oil, but if it could be obtained such an oil testing 28 to 30 degrees would probably be the best fuel for orchard heating.

THERMOMETERS.

The thermometers used in this work were those sent out by the Bausch & Lomb Co. These thermometers are of the laboratory type, graduated in two degree spaces up to 300 degrees, and were not very satisfactory for this work, owing to the fact that they were graduated so high, and were very delicate. However, by careful handling they may be used, as they are very accurate. The ideal thermometer for this work would be one which has a long cylindrical mercury bulb exposed entirely to the atmosphere. The thermometer should be fastened to some substantial back as a protection.

In all, 60 thermometers were used in the tests. These

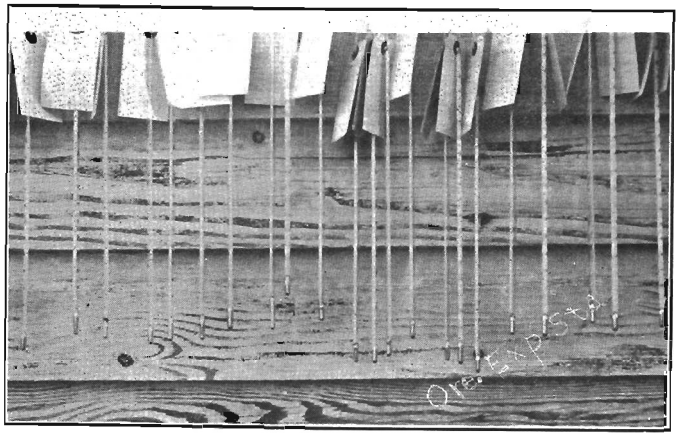

Plate 3—The type of thermometer used in the test. Tags used to note corrections

had been tested at different points on the scale, and the corrections noted on the tag accompanying each. All of the thermometers with the exception of three were correct, and read the same at 32 degrees. Three of the number were too high at 30 degrees, but with the corrections always with them could be satisfactorily used.

The arrangement of the thermometers was made with the idea of obtaining an even distribution throughout the heated area, and as far as possible obtain a fair outside temperature. Three lines of thermometers were run through each block,

one directly through the center, and the other two nearer the outside. The outside thermometers were placed on the southeast, east, and north of the block; none were placed on the west, and none on the northwest, due to the fact that the drift came principally from the east, and southeast, and the effect of the heat on the opposite side of the orchard could be noted 300 and 400 feet distant. In fact, on the morning of April 15th much difficulty was experienced in getting the outside thermometers away from the effect of the heat. Three thermometers on the north side of the heated area had been placed 150 feet distant from the fires, but showed the effect of the heat to such an extent that they had to be moved entirely. Even then at a distance of almost 300 feet when the wind was blowing strongly a slight difference could be noticed. However, the majority of the thermometers on the outside were arranged along the northeast, east, and southeast sides of the heated area, and hence were not affected by the inside temperature.

All of the thermometers were hung in the trees about 4½ feet from the ground, and always placed as far as possible from the burning pots. Thus we were able to obtain the minimum temperature at all times within the heated area.

The question of suitable thermometers for orchard work is one which has not been taken up, but is one of very great importance, due to the fact that a valuable crop depends upon the thermometers used. However, a cheap thermometer if it is carefully tested may be just as good as some of the higher priced ones, but it would seem that where a large valuation was involved it would be better to invest in expensive thermometers, and have them accurately tested, than to depend upon the cheaper grades. The majority of the thermometers which are being used throughout the Valley are of a cheap grade, with a metal back, the bulb being entirely surrounded by metal, and mostly of a round bulb type. This type of a bulb is not at all as satisfactory as a long cylindrical one, as it is noticed that many of these do not respond very quickly to changes in the temperature. Perhaps one of the best thermometers which was noticed in all of the orchard work is that put out by the Cederborg Engineering Co. It, however, is no better than any other thermometer of similar construction,

so far as we were able to judge. It has a particular advantage in that it was graduated to one degree spaces to 120 degrees, and at 32 degrees had been carefully tested. It also had a long cylindrical bulb which was very sensitive to a change in temperature. The thermometers used in the test block were very sensitive, and had they been graduated to but 120 degrees in one degree spaces would have been all that could have been asked. However, we think it best for general orchard use to have a thermometer with some sort of a rigid back.

TYPES OF HEATERS.

Two types of heaters were used in this test. One was the Bolton or Fresno orchard heater, manufactured by the Frost Prevention Co., of San Francisco, and commonly known

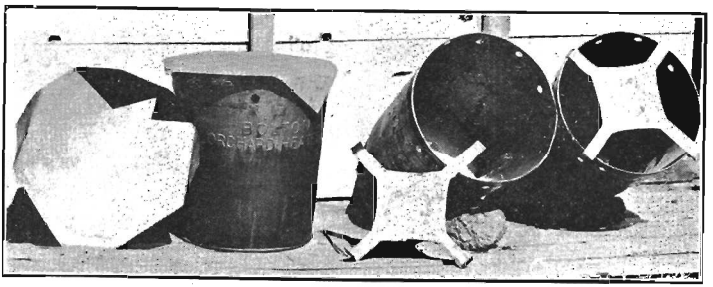

Plate 4—Bolton Orchard Heater (from left to right), Heater covered, without carbon arrester, with carbon arrester attached

throughout the Rogue River Valley as the Fresno pot. However, the present company put it out under the name of the Bolton Orchard Heater. It is of a lard pail type holding one gallon of oil, and has as its special feature a circle of small holes around the top. They also advocate with this the carbon arrester, claiming that with it a double burning period may be had with only a loss of 10 per cent of the maximum amount of heat produced. That is the Bolton pot burning 4 hours without the arrester will burn 8 hours with the arrester, and at the same time produce 90 per cent as much heat. This is one of the simplest of orchard heaters on the market today, and is very popular in the Rogue River Valley.

The other other type of heater is known as the Troutman

heater, manufactured by the Round Crest Orchard Heating Co., of Denver, Colo. The heater has a capacity of 5 quarts, and is circular in form, but differs from the lard pail type in that it has a draft coming through the bottom of the pots and carried to the center of the burning area by a funnel shaped opening through the center of the pot. One difficulty was experienced with these heaters which was not noticed in the other, and that was in the filling; it was more difficult to pour the oil into the heater without pouring it through the opening in the center. This draft funnel through the center, however, extends to about 1 inch above the edge of the pot, so that

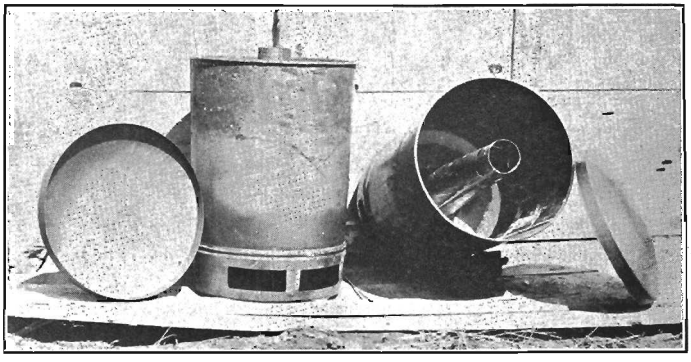

Plate 5—Troutman Heater showing the cover and draft

with a little care no trouble need be experienced in filling the pot.

The test which was to have been carried out originally was to have been competitive between the two companies, but owing to a misunderstanding of conditions and the rules as laid down by one of them, it was found impossible to carry it on as originally planned. Such work as was done was carried on under almost exactly the same plan as for the competitive tests. The same results were obtained as would have been obtained under the other conditions.

FORECASTING FROSTS.

In localities where there is a local branch of the Weather Bureau the forecast may be given out from that office. This forecast is usually made up from a local report sent in to the

central office, or the branch office of that division, about 5:00 o'clock in the evening. As soon as returns can be had from the central office the forecast is then given out. At Medford Mr. P. J. O'Gara sends in his local report to Portland about 5:00 o'clock in the evening. As soon as Mr. Beals can make up his general forecast he sends it to Medford, where it is then posted. If frost is imminent a copy of the forecast is written out, and given to the local central of the telephone system, so that any time after 6 o'clock anyone in the Valley wishing to know the forecast for the night can obtain it by calling up central. During the past season this method proved very satisfactory, and the telephone companies and the operators at central deserve a great deal of credit for the manner in which they handled these reports. This system of forecasting frost is probably the best in use at the present time, and while it has been quite effective in the past there are some ways in which it can be bettered. In as large a valley as the Rogue River where there are orchards under as varying conditions, more stations for reporting temperature should be established.

In connection with the forecast and the work of the local Weather Bureau, the fruit grower should establish a system of electric alarms, and make a practice of keeping the minimum temperatures, as well as the dew points, for each day throughout the season. He would find that he would be enabled to tell the temperature more accurately, and to insure his crop more efficiently. Since there is a great variation of temperature in the Rogue River Valley, some orchards experiencing a much lower temperature than others, it will be necessary for each grower to rely more or less upon his own forecast and alarms.

In the work carried out in the Marshall orchard, a record of the dew points was kept on the nights when a frost was predicted, and in all cases the minimum temperature for the night very closely compared to that obtained through the dew point chart. Each fruit grower will find it of value to keep a psychrometer, and by spending a few moments each day in making a reading of this will be enabled to keep closer in touch with the changes of temperature. In order that this may be done a brief description of a psychrometer and how to use it will be given, also a chart taken from Bulletin No. 235 of the

United States Weather Bureau. The means of obtaining the dew point is by a simple instrument consisting of two thermometers fastened to a rigid back, and arranged so that they may be whirled rapidly. One of the thermometers is placed with the bulb extending below the rigid back. This lower bulb, which will hereafter be known as the wet bulb, should be covered with a good grade of muslin, which has been previously washed to get out all particles of sizing. The importance of muslin covering is to keep the bulb of one thermometer moist, so that motion through the air will cause evaporation to take place, and lower the temperature in that thermometer to the point at which by comparison with a chart the dew point may be found. To make an observation with the psychrometer we first saturate the cloth about the wet bulb, then whirl it rapidly for a few moments, and pause long enough to make a reading. We again whirl for fifteen or twenty seconds, pause and make a second reading. If the temperature of the wet bulb thermometer is still falling, continue whirling until two or more successive readings show a constant temperature. Then noting the temperature of the other thermometer take the difference between the two, and by the aid of the chart find your dew point. The whirling and stopping of the psychrometer should be done carefully and easily. It should be whirled at the rate of about 15 feet per second. The observation should be made in the shade of a building, or trees, and in all cases must be made where there is a free circulation of air. The psychrometer reading should be taken each day at about the same time to insure uniform results, and the best time to take this will probably be about 6:00 o'clock in the evening.

A complete table for determining the dew point at the different pressures or different heights of the barometer, and also an explanation of the method of obtaining the dew point, may be had by sending to the United States Department of Agriculture, for their Weather Bureau bulletin No. 235. This may be had for the price of 10c per copy. However, for those who do not wish the entire table, there is appended a table of pressures from .5 of a degree difference up to 15 degrees difference in the reading of the dry and wet bulb thermome-

ters, at temperatures ranging from 40 to 70 degrees Fahrenheit.

The following table is given to determine the dew point when the barmometer stands at 30 ins.:

TABLE 1.

Temperature of Dew Point in Degree Fahrenheit Pressure 30.

Air Temperatures.	Difference in Reading of the Wet and Dry Bulb Thermometers.													
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5
40	.39	.38	.37	.35	.34	.33	.32	.30	.29	.28	.26	.25	.23	.21	.20
41	.40	.39	.38	.36	.35	.34	.33	.31	.30	.29	.27	.26	.24	.23	.21
42	.41	.40	.39	.38	.36	.35	.34	.33	.31	.30	.29	.27	.26	.24	.23
43	.42	.41	.40	.39	.37	.36	.35	.34	.32	.31	.30	.28	.27	.25	.24
44	.43	.42	.41	.40	.38	.37	.36	.35	.34	.32	.31	.30	.28	.27	.25
45	.44	.43	.42	.41	.40	.38	.37	.36	.35	.34	.32	.31	.30	.28	.27
46	.45	.44	.43	.42	.41	.40	.38	.37	.36	.35	.34	.33	.32	.31	.29
47	.46	.45	.44	.43	.42	.41	.40	.38	.37	.36	.35	.34	.33	.32	.31
48	.47	.46	.45	.44	.43	.42	.41	.40	.38	.37	.36	.35	.34	.33	.32
49	.48	.47	.46	.45	.44	.43	.42	.41	.40	.38	.37	.36	.35	.34	.33
50	.49	.48	.47	.46	.45	.44	.43	.42	.41	.40	.38	.37	.36	.34	.33
51	.50	.49	.48	.47	.46	.45	.44	.43	.42	.41	.40	.38	.37	.36	.34
52	.51	.50	.49	.48	.47	.46	.45	.44	.43	.42	.41	.40	.38	.37	.36
53	.52	.51	.50	.49	.48	.47	.46	.45	.44	.43	.42	.41	.40	.38	.37
54	.53	.52	.51	.50	.49	.48	.47	.46	.45	.44	.43	.42	.41	.40	.38
55	.54	.53	.52	.51	.50	.50	.49	.48	.47	.45	.44	.43	.42	.41	.40
56	.55	.54	.53	.53	.52	.51	.50	.49	.48	.47	.46	.44	.43	.42	.41
57	.56	.55	.54	.54	.53	.52	.51	.50	.49	.48	.47	.46	.45	.43	.42
58	.57	.56	.55	.55	.54	.53	.52	.51	.50	.49	.48	.47	.46	.45	.44
59	.58	.57	.56	.56	.55	.54	.53	.52	.51	.50	.49	.48	.47	.46	.45
60	.59	.58	.57	.57	.56	.55	.54	.53	.52	.51	.50	.49	.48	.47	.46
61	.60	.59	.59	.58	.57	.56	.55	.54	.53	.52	.51	.50	.49	.48	.47
62	.61	.60	.60	.59	.58	.57	.56	.55	.54	.53	.53	.52	.51	.50	.48
63	.62	.61	.61	.60	.59	.58	.57	.56	.55	.55	.54	.53	.52	.51	.50
64	.63	.62	.62	.61	.60	.59	.58	.57	.57	.56	.55	.54	.53	.52	.51
65	.64	.63	.63	.62	.61	.60	.59	.59	.58	.57	.56	.55	.54	.53	.52
66	.65	.64	.64	.63	.62	.61	.60	.60	.59	.58	.57	.56	.55	.54	.53
67	.66	.65	.65	.64	.63	.62	.62	.61	.60	.59	.58	.57	.56	.55	.54
68	.67	.67	.66	.65	.64	.63	.63	.62	.61	.60	.59	.58	.57	.57	.56
69	.68	.68	.67	.66	.65	.64	.64	.63	.62	.61	.60	.59	.59	.58	.57

OIL STORAGE TANKS.

Where any form of crude oil is used for orchard heating, some form of storage tank will be necessary. There are several types of these tanks in use in the valley at the present time, cement, galvanized iron and wood. Of these for the lighter oils such as the 28 degree distillate, or "slop" distillate, wooden tanks are of no value, as it is very difficult to make them so that they will hold the oil. Perhaps one of the most popular tanks, and one which is most satisfactory for all purposes, and for all grades of oil, is the cement tank. One of the best types

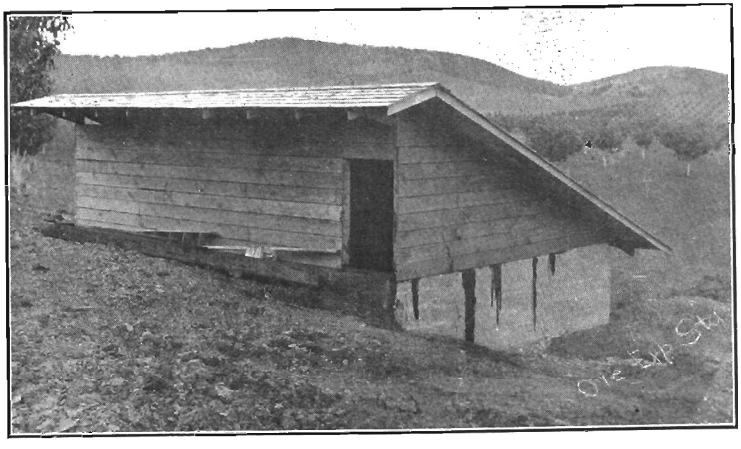

Plate 6—Oil storage tank, Foothills Orchard of Geo. Carpenter, showing opening for filling. Orchard heaters in orchard in background

of the cement tank in the valley is to be found in the Foothills Orchard of Mr. Geo. Carpenter. This is placed on a side hill so that it is possible to fill it by gravity, and it has a pipe from the lower side from which the oil is taken by gravity into the wagon to distribute in the orchard. This system is by far the easiest and simplest method of handling the crude oils, for as a rule the fuel oil which is used is too heavy to work well through a pump; in fact some of it will not work at all. With such an arrangement too, the water can be drained off very easily, in that way lessening the

amount of boiling over in the orchard. Mr. Carpenter's tank has walls 8 inches thick, is roofed over with shingles to protect it from the rain, and has a capacity of 8,000 gallons.

Another tank which is similar to this is at the Fiero orchard near Central Point. This tank is cemented over, leaving only a small manhole through which the oil is run. The outlet to this tank is about 100 feet away, and at that distance the outlet pipe is about 7 feet above ground. Both of these tanks are located in the orchards.

Another type of cement tank was found in the Burrell orchard, where the tank was placed below the level of the ground, but this arrangement increases the cost of handling the oil, as

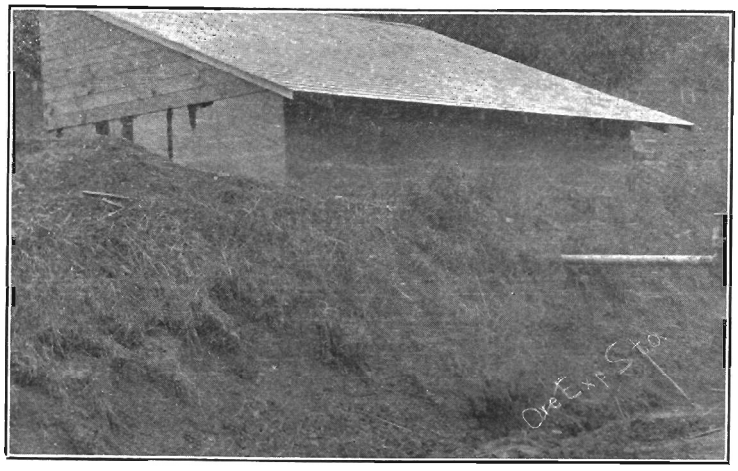

Plate 7—Opposite side of plate 6, showing outlet pipe.

it necessitates either pumping or dipping from the tank into the wagons before distributing in the orchard. This type of tank also has the disadvantage of having no outlet at the bottom, so that whatever water may get into the tank must stay there unless the tank is cleaned each year. As there is more or less water in all of the heavier crude oils, this will mean that in time a large quantity of water will collect in the bottom of the tank, and where dipping is practiced a great deal of trouble will be experienced with pots boiling over, as it will be impossible to dip the oil off without

getting some of the water. Where it is impossible to have a gravity system or where the tank is to be placed above the surface of the ground high enough so that there will be a slight drop from the tank into the wagon, it will be necessary probably to use galvanized tanks. Mr. G. E. Marshall has such a tank placed about 5 feet above the ground; just high enough so that a barrel may be filled from the outlet pipe, thus giving a gravity system one way. This also affords an opportunity for draining off the water after it has settled, though probably it could not be used with oils that could not be pumped, as it

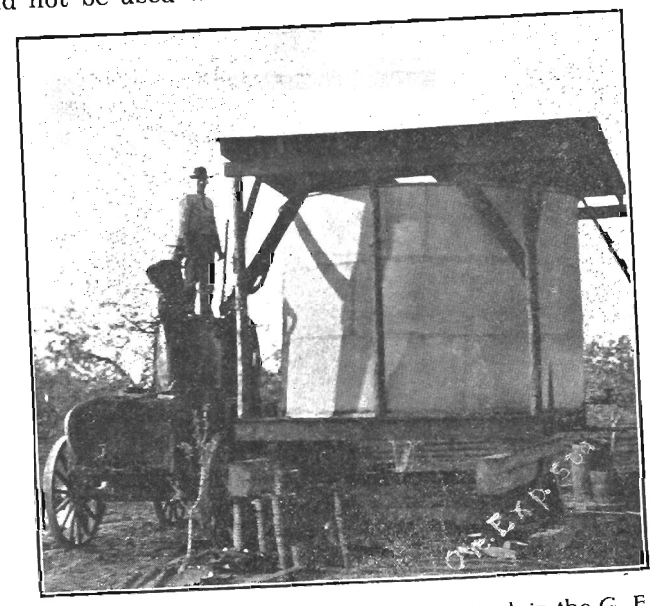

Plate 8—Filling galvanized iron storage tank in the G. E. Marshall orchard. Outlet on the right.

will be necessary to pump the oil into the tank in the first place.

The tanks which are used for distributing the oil in the orchard, and the methods of filling pots are various. In some of the orchards a galvanized iron tank with a capacity of about 400 gallons is used. Some of these tanks are furnished with two leads of hose, so that two rows of pots may be filled at the same time. Others simply have an escape pipe, and oil is drained first into buckets, and then poured into the heat-

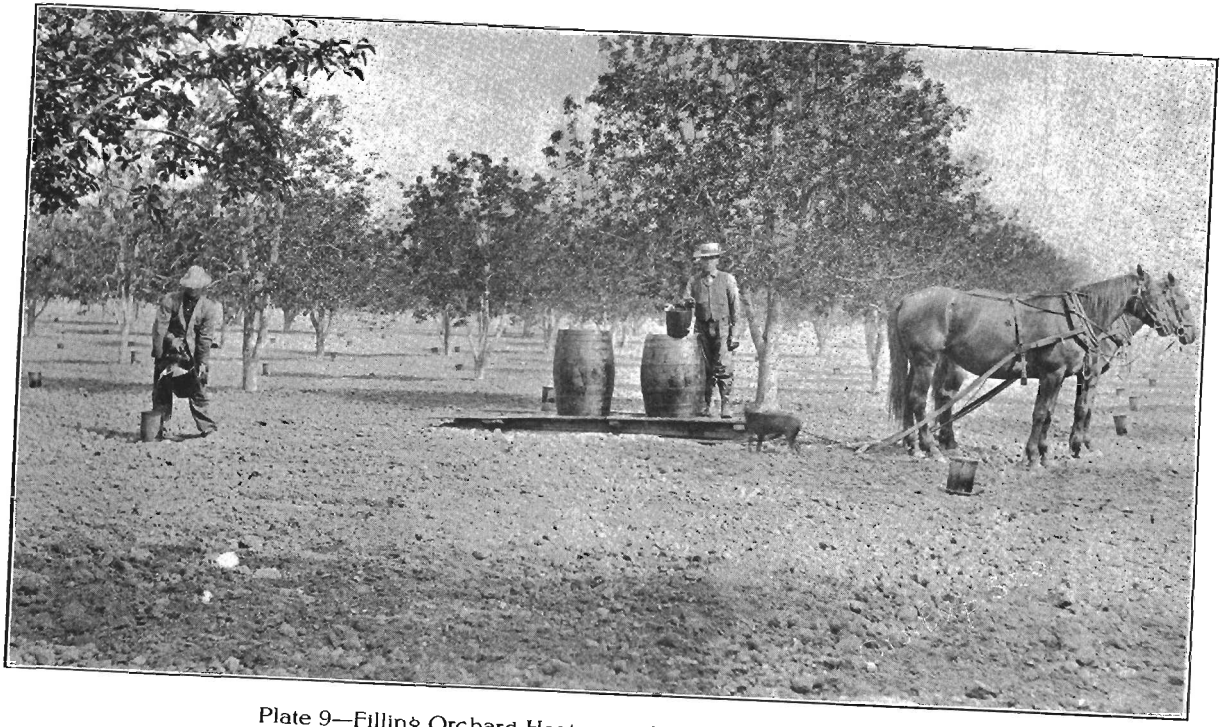

Plate 9—Filling Orchard Heaters in the G. E. Marshall Orchard

ers. Other orchardists use 50 gallon barrels, hauling them about on stone-boats or light sleds. Where this is done two men can fill four rows of pots at a time very easily. For Bolton orchard heaters no special type of bucket for filling is required, but some of the other heaters which are more difficult to pour into need a special bucket. However, in filling any of the pots a bucket with a good spout will perhaps mean the saving of oil. Some orchardists claim that two men with a team can easily fill from 2,000 to 3,000 heaters per day. Others claim that it requires two men and a team one day to fill 1,000 pots. This difference is probably due to the different distances apart of the heaters. Where 50 to 75 heaters per acre are used a safe estimate would probably be 1,500 heaters per day for two men and a team, provided the supply of oil is near at hand.

LIGHTERS.

A number of different methods of lighting orchard heaters have been tried during this test. The first method was that of placing a small handful of straw on the surface of the oil, and lighting it. This was not very satisfactory because after burning a short time the straw settled to the bottom, and in time became a collector of refuse in the pot. Also in cases where the oil had to be emptied or returned to the storage tank this straw always had to be strained out.

Another type of lighter used was the Patent Rapid Lighter, which works with a spring, allowing a small quantity of gasoline to be placed in the heater. A cut of this lighter will reveal its working parts, which consist of a torch, a small spring, and a gallon can. This will light about 2500 heaters without refilling. The method of using these lighters is very simple, all that is necessary being for the man to walk along, pressing the lever as he reaches the pot, and touching the torch to the surface of the oil. The spring on the lever immediately throws it into position for the next heater. On the heavier grades of oil, which are harder to ignite, two charges are often necessary to properly light them. This was especially found to be true where the 20 degree "slop" distillate was used. These lighters proved to be of no value, as they lasted but a short time. In fact, after using them to light 600 pots during

two different firings, three of the five failed to work. Before the end of the season only one of the lighters could be used, and as they are sold at $4.00 each they would hardly pay for themselves. In fact, when compared to other types in use they are practically valueless.

A third type of lighter which was used, and which proved satisfactory in all of the tests, was one which was made locally, and which we found in use in a number of orchards of the valley. This consists of a straight piece of ¾-inch gas pipe two feet long, closed at the upper end, and fitted with a reducer at the lower end. Into this reducer is fitted a six inch or eight inch piece of ½ inch gas pipe. The ¾ inch gas

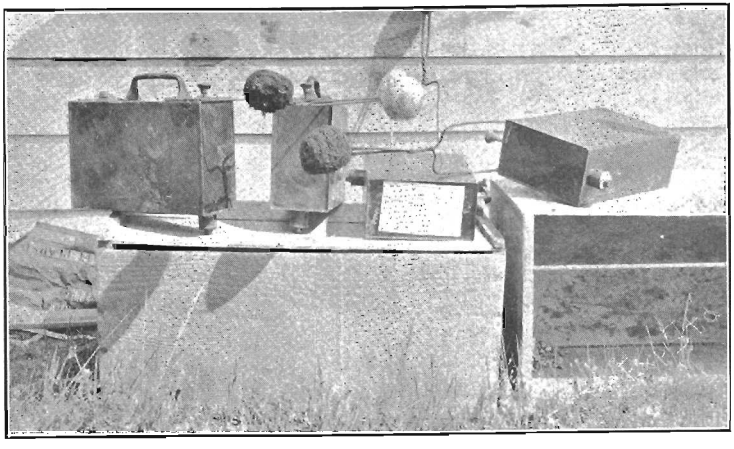

Plate 10—Rapid Lighters patented by John Steel, Omaha, Neb.

pipe is used as a storage chamber for kerosene. Through the ½ inch pipe, and extending for a distance up into the storage chamber, a wick made of candle wicking should be drawn. This should be fitted in very tightly, so that it will not allow the oil to leak out faster than it will burn. With this as a torch, and an ordinary ½ gallon oil can in the other hand, one man can easily light 15 heaters per minute when they are located 20 to 25 feet apart. There is, however, with this lighter some danger from fire. If the wind should be blowing the gasoline as it is poured into the pot might possibly spatter onto the clothing of the operator, and become ignited

by the torch. However, with a little care they will be no more dangerous than the patent types, and there is practically nothing about them to wear out. By studying the accompanying cut one will be able to see the construction of these lighters. There are many types of lighters in use, but as these three were the only ones used in our test work we have only described them, and of the three the latter proved much the most satisfactory.

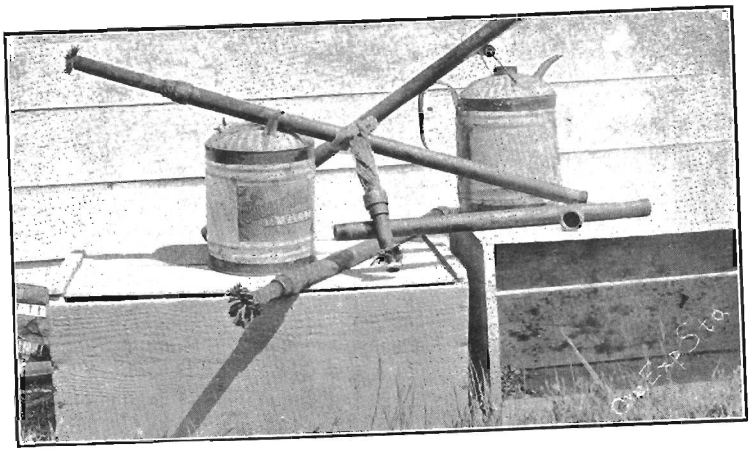

Plate 11—Gas pipe torch and ½ gal. gasoline cans. One torch in three showing cap for upper end, oil chamber, and wick.

TEST FOR THE NUMBER OF HEATERS PER ACRE APRIL 7TH.

Temperature at 4:30 A. M. was 31 degrees. Twenty heaters per acre were lighted. No change in temperature was noticed, as will be seen by the following chart:

Inside.

TIME.			
4:30	5:00	5:30	6:00
TEMPERATURE.			
31	30	30	30.5
30.5	30	29.5	29
31.5	30.5	29.5	30
31	30	30	30.5

Outside.

TIME.			
4:30	5:00	5:30	6:00
TEMPERATURE.			
30.5	30	30	29.5
31	30.5	30	30.5
31.5	30.5	29.5	30
31.5	30.5	29.5	30

31	30	30	30.5	31	30	30.5	30
31.5	31	30.5	31				
Average:							
31.1	30.2	29.9	30.2	31	30.3	29.8	30

The night was very still, and a dense smudge hung over the orchard, so that the sun was not visible until about 7:00 A. M. Only a very light drift occurred at sun-up so that the smudge did not leave the orchard very rapidly. The fires were put out at 6:00 o'clock.

TEST WITH TROUTMAN HEATERS (39 to the acre) APRIL 14TH.

The heaters were arranged in a block 17 x 25 feet, and covered approximately three acres. They were filled to capacity, which was five quarts, and lighted at 2:30 A. M. Every third row was lighted one way, in this way lighting about one-third of the heaters in the block. However, enough more around the edge of the block were lighted to bring the total to 118 heaters, which were burned in this test. During the entire test the wind kept shifting back and forth from north to south, not remaining constant in one direction more than 20 minutes at a time. It was noticed that when coming from the north the outside temperature rose from ½ to 1 degree, and would drop again when the wind came from the south. The shifting of the wind, which was blowing at a rate of about 2 miles per hour, made it almost impossible to hold a smudge in the orchard, being so light within the heated area that the thermometers could be read by moonlight. The smudge rose above the orchard and spread.

HEAT CHART, INSIDE TEMPERATURE, APRIL 14, 1911.

Troutman Heaters.

Time	3:00	3:30	4:00	4:30	5:00	5:30	6:00
Temperature .	30	32	30	30	30	28	30
" ..	31	31	30	30	30	29	31
" ..	30	30	29	30	30	28	29
" ..	32	32	31	30	30	29	30
" ..	31	32	30	31	30	31	31
" ..	32	32	32	31	30	31	32
" ..	32	32	32	31	30	33	33
" ..	30	32	30	30	30	31	32
" ..	31	32	31	30	30	32	32
" ..	31	32	30	30	30	32	32
" ..	30	32	29	30	29	30	31
" ..	31	32	30	30	29	32	33
Average 30.9		31.8	30.3	30.2	29.8	30.5	31.4

HEAT CHART, OUTSIDE TEMPERATURE, APRIL 14, '11.

Time	3:00	3:30	4:00	4:30	5:00	5:30	6:00
Temperature	..29	30	29	29	29.5	29.5	28.5
"	..28	30	29.5	29.5	29	29	30
"	..28.5	30	30	28	28.5	29.1	30.5
"	..29	30	29.5	30	28.1	29	32
"	..29	30.5	30	30	27	28.5	32
"	..31	30	30	31	28.5	30	31.5
"	..31	29.5	30	30.5	29	30.5	32
"	..30	29.5	29	29	29	28	30
"	..30	29	30	30	28	30	32
"	..30	30	32	30	28	30	31
"	..30	30	31	30	28	30	32
"	..30	30	31	30	28	30	32
Average 29.6		29.8	30	29.7	28.3	29.4	31

Average outside temperature for whole period (29.6).

Average increase .....1.3 2 .3 .5 1.5 1.1 .4

Highest increase, 2 degrees.

Lowest increase, .3 degree.

Average increase, 1 degree.

The following day before refilling the heaters the oil which was left in the pots was measured back. In this way we were able to find the amount of oil consumed during the burning period, and extended from 2:30 to 6:00 o'clock. The sun rose at 5:52, and no temperatures were taken later than 6:00 o'clock. At 6:00 o'clock 38 heaters had gone out. For this burning period 127 gallons and 2 quarts of oil were used, or just slightly more than 1 gallon per heater.

MAXIMUM BURNING TIME OF THE BOLTON HEATER WITH A CARBON ARRESTER ATTACHED, APRIL 14.

This arrester is a small piece of light sheet iron used to cut down burning surface, being about 4 inches square, with

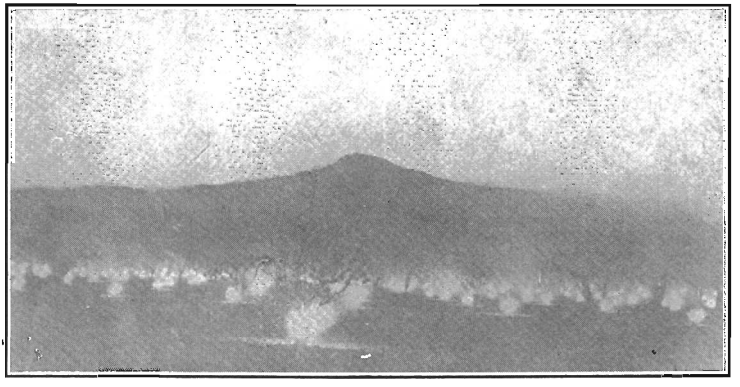

Plate 12—Belton orchard heaters with carbon arrester. Picture taken at 2 A. M. April 14, 1911

a projection from each corner, which rests upon the edge of the pot. The test was carried out the morning of April 14th. The heaters were filled to their capacity, which was 1 gallon, and placed 17 feet by 25 feet apart, and were lighted at 12:00 o'clock. The lighting was done by one man, and the 299 heaters were fired in 20 minutes. The outside temperature at the time of lighting was 34 degrees, and a light wind was blowing.

Temperatures were taken in this plot every half hour with a total of 12 inside thermometers, and 12 outside thermometers. The wind died down shortly after the pots were lighted, and began shifting back and forth from north to south. The

temperature by 2:00 o'clock had dropped to 31½ degrees, and from this time until 6:00 was very changeable, due to the fact that when the wind blew from the north the temperature rose slightly, and when coming from the south the temperature dropped. At 5:30 fifteen pots had gone out, but in each of these pots there was at least a quart of oil left. On account of some moisture which had collected in the pots, and the soot on the arrester, the pots had gone out. Some of these when the arresters were removed, and the oil relighted, burned until after 8:00 o'clock. The sun rose at 5:52, and on account of the heavy drift there was a very poor smudge in the orchard at that time. At 6:00 o'clock 7 heaters were not burning, the attachments had been taken off, and all were again relighted. At 6:30 a heavy wind began blowing so that no further record of temperatures was kept. At 8:00 A. M. 145 out of the 299 heaters were still burning. As the pots were fired at 12:00 o'clock the burning time was 8 hours. However, the last four hours would have given no protection, or at least very little protection, as the flame was scarcely visible above the top of the heater. A few of the pots boiled over, but such a small percentage as to be of little account, and all of the following tests showed no such trouble.

The maximum inside temperature was 34 degrees, and the minimum 28.5 degrees.

MAXIMUM BURNING TIME FOR BOLTON HEATER WITH CARBON ARRESTER, INSIDE TEMPERATURES.

INSIDE TEMPERATURES.

Time.	12:30	1:00	1:30	2:00	2:30	3:00	3:30	4:00	4:30	5:00	5;30	6;00
Temp..	34	32	33	32	30	31	31.5	31	30	30.5	30.5	29.5
Temp.	34	33.5	32	32	31	31	31.5	30	30	29	29	30
Temp.	34	34	33	32	32	32	31	30.5	30.5	30	29.5	30
Temp.	34	34	32.5	31.5	31	30	30	29.5	30	29.5	29	29
Temp.	33	32.5	33	32	30	30	32	30	31.5	29	29	31
Temp.	33.5	33	34	32	32	31	31	30	30	30.5	30	33
Temp.	34	33	34	32	32	31	33	30	31	30.5	30	33
Temp.	34	34	34	32	32	32	33	30.5	32	31	30	32.5
Temp.	34	32.5	33.5	31.5	32	30.5	33	31	31.5	30	30.5	32
Temp..	34	32.5	34	31.5	33	30.5	32.5	31	31	30	30.5	32.5
Temp.	34	33	34	32	32	31	32	31	31.5	30	31	32.5
Temp.	33.6	33.6	33.6	31.6	31.6	30.6	31.6	31.6	30.6	30.1	30.6	33.1
Temp.	34	33	34	30.5	30	30	30	30.5	29.5	28.5	30	33
Av'r'ge	33.9	33.2	33.4	31.8	31.4	30.8	31.7	30.5	30.7	29.9	30	31.6

OUTSIDE TEMPERATURES.

Time.	12:30	1:00	1:30	2:00	2:30	3:00	3:30	4:00	4:30	5:00	5;30	6;00
Temp.	33	31	31	31	29	29	30	29	29	29.5	30.5	29.5
Temp.	34	31	31	31	30	28	30	29.5	29.5	29	29	30
Temp.	33.5	30.5	31.5	31	29.5	28.5	30	30	28	28.5	29	30.5
Temp.	31	30.5	31	28.5	30	29	30	29.5	30	28	29	32
Temp.	31	31	32	28	30	29	30.5	30	30	27	28.5	32
Temp.	32	31	31.5	28	30.5	31	30	30	31	28.5	30	31.5
Temp.	33	31	31	29	30	31	29.5	30	30.5	29	30.5	32
Temp.	33.5	32	31	28.5	30	30	29	30	30	28	30	32
Temp.	33	31.5	30.5	28	30.5	30	30	32	30	28	30	31
Temp.	32	31	31	28	29	30	30	31	30	28	30	32
Temp.	33	32	31	29	29.5	30	30	31	30	28	30	32
Temp.	32.5	32	31.5	29.5	30	30	29.5	29	29	29	28	30
Av'r'ge	32.6	31.2	31.1	28.9	29.9	29.7	29.9	30.1	29.8	28.4	29.5	31.1

Average increase (1.3).

Average increase per hour:

1.2 1.9 2.3 2.9 1.5 1.1 1.8 .4 .9 1.5 .5 .5

Highest increase, 2.9°.

Lowest increase, .4°.

TEST FOR MAXIMUM AMOUNTS OF HEAT PRODUCED WITH 50 POTS PER ACRE, AND 100 POTS PER ACRE, APRIL 15.

Bolton orchard heaters were used, being placed 17 x 25 feet apart. At 3:15 A. M. April 15th, 50 heaters per acre were lighted. These were lighted in alternate rows each way. It was intended to carry out this test with only 50 heaters per acre, but after taking the four o'clock reading it was noticed that the inside temperature began to drop rapidly, so that 50 more heaters per acre were lighted.

At the time the 4:30 reading was taken 100 heaters per acre had been burning for about 10 minutes. The night was very still, very little drift being noticed, so that a dense smudge was formed in the orchard. About 5:00 A. M. a gentle drift from the southeast began. This increased until about 6:00 o'clock, when the breeze was blowing at the rate of about 2 miles per hour. The sun rose at 5:40, so no temperatures were taken after 6:00 o'clock, and at 6:30 the fires were put out.

The accompanying chart will show the temperatures maintained both inside, and the temperature during the same period on the outside of the heated area:

Inside.

Time	3:30	4:00	4:30	5:00	5:30	6:00
Temp.	30	31	32	34	33	33
Temp.	30	32	31	33	32	32
Temp.	30	31	30	30	32	32
Temp.	30	32	32	32	34	32
Temp.	30	32	34	32	32	32
Temp.	31	31	34	30	33	32
Temp.	31	33	35	31	32	32
Temp.	31	33	33.5	31	33	32
Temp.	31	32	34	30	31	31
Temp.	30.6	33	34	31	31	32
Temp.	31	32.6	33.6	30.6	30.6	32.6
Temp.	29	31	31	29	30	30

Outside Temperature

Time	3:30	4:00	4:30	5:00	5:30	6:00
Temp.	26	28	28	27	27	29
Temp.	28	29	28	26	27	30
Temp.	28	30	28	26	27	30
Temp.	26	28	28	26	27	30
Temp.	26	28	29	27	27	30
Temp.	26	28	29	25.5	27	30
Temp.	28	29	28	26	28	28
Temp.	28	29	28	26	27	28
Temp.	29	29	29	27.5	29	30
Temp.	27	28	29	27	28	28
Temp.	28	29	29	27	28	30
Average..	27.3	28.6	28.5	26.5	27.5	29.4
Average inside	30.4	31.9	32.8	31.1	32	31.9
Average outside	27.3	28.6	28.5	26.5	27.5	29.4
Increase	3.1	3.3	4.3	4.6	4.5	2.5

Highest increase, 4.6.

Lowest increase, 2.5.

Average increase, 3.7 with 50 heaters per acre.

Average increase with 100 heaters, 4 degrees.

The small difference between the two averages is largely due to the heaters burning low at the end of the test.

At the same time and under the same conditions a maximum test was carried on with the Troutman heaters. These

were placed 100 to the acre, 17 x 25 feet apart, but only 50 were lighted per acre at 3:15 A. M. At this time the outside temperature was 29 degrees. The Troutman heaters were lighted in alternate rows one way only. At 4:15 the remainder of the Troutman heaters were lighted, so that when the 4:30 reading was taken 100 heaters per acre had been burning for about 15 minutes.

The accompanying chart will show the temperatures maintained within the heated area for that period:

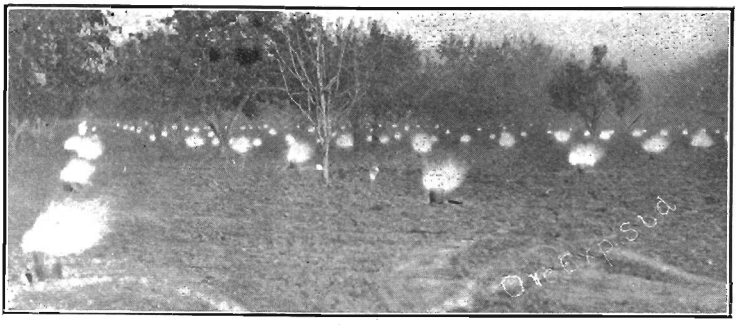

Plate 13—Troutman Heaters burning. 100 heaters per acre

Inside.

Time	3:30	4:00	4:30	5:00	5:30	6:00
Temp.	29	30	33	33	30	31
Temp.	29	31	33	33	31	31
Temp.	29	30	32	32	30	30
Temp.	30	31	34	33	32	31
Temp.	30	30	33	30	31	30
Temp.	30	30	33	30	32	31
Temp.	32	32	33	30	32	30
Temp.	30	30	33	30	32	30
Temp.	29	30	32	29	30	30
Temp.	29	30	32	30	32	32
Temp.	29	30	31	29	30	30
Temp.	30	31	32	29	30	30

Outside.

Time	3:30	4:00	4:30	5:00	5:30	6:00
Temp.	26	28	28	27	27	29
Temp.	28	29	28	26	27	30
Temp.	28	30	28	26	27	30
Temp.	26	28	28	26	27	30
Temp.	26	28	29	27	27	30
Temp.	26	28	29	25.5	27	30
Temp.	28	29	28	26	28	28
Temp.	28	29	28	26	27	28
Temp.	29	29	29	27.5	29	30
Temp.	27	28	29	27	28	28
Temp.	28	29	29	27	28	30
Average inside	29.6	30.4	32.6	30.6	31	30.5
Average outside	27.3	28.6	28.5	26.5	27.5	29.4
Increase	2.3	1.8	4.1	4.1	3.5	2.1

Average increase 3 degrees with 50 heaters per acre.

Average increase with 100 heaters per acre, 3.5 degrees.

*The low average with 100 heaters is due largely to the fact that at the time the last temperature was taken the heaters were burning very low.

A TEST WITH 100 TROUTMAN HEATERS PER ACRE,

(April 20th.)

A test was made in this block April 20th with 100 heaters per acre, or a total of 195 heaters. The outside temperature at 4:00 o'clock was 29 degrees. A light drift of about two miles per hour came from the south. The heaters were lighted at 4:00 o'clock, and beginning at 4:15 readings were taken every 15 minutes, with six thermometers on the inside of the heated area, and three on the outside. The outside thermometers were placed 200 feet from the edge of the heated area. This block of trees was such that it was possible to arrange the heaters in a square 294 feet each way, and having a strip on the south and one on the north which were not heated. At 4:45 the drift almost entirely ceased, and a very dense smudge formed. At this time also the outside temperature rose slightly.

Observations were taken May 10th, and it was noticed that the farther the trees were from the heated area the more damage was done by frost.

At 5:00 o'clock a cold drift set in from the southeast, varying from southeast, south to southwest. The sunrose at 5:40.

At a few minutes past six smudge from the Bear Creek Orchards, which were located about ¾ of a mile to the southeast, reached the plot, but just before it reached the orchard the temperature of the outside thermometer dropped 1 degree, and remained there until the smudge had reached us, when it again rose to its former position. This was seemingly due to a bank of cold air which immediately preceded the smudge.

The following chart will give the temperatures maintained during that period:

Outside.

Time	4:15	4:30	4:45	5:00	5:15	5:30	5:45	6;00
Temp.	29	29	30	29	28	28	28.5	29
Temp.	29	29	29	29	28	28	28	29
Temp.	29.5	29.5	30	29	28.5	29	29	30

Inside.

Time	4:15	4:30	4:45	5:00	5:15	5:30	5:45	6;00
Temp.	32	33	33	32	32	31	31.5	32
Temp.	34	34	34	35	34	32	31	32
Temp.	34	35	34	32	33	32	32	33
Temp.	34	35	34	34	34	33	33	33
Temp.	35	34	34	34	32	33	34	32
Temp.	32	33	33	32	31	32	32	31
Average Outside:	29.1	29.1	29.6	29	28.2	28.3	28.5	29.3
Average Inside:	33.5	34	33.7	33.2	32.7	32.2	32.2	32.2
Increase:	4.4	4.9	4.1	4.2	4.5	3.9	3.7	2.9

Highest increase, 4.9.

Lowest increase, 2.9.

Average increase, 4.1.

MAXIMUM BURNING TIME OF THE TROUTMAN HEATERS FILLED TO THE CAPACITY, WHICH IS FIVE QUARTS OF OIL.

The oil used for this burning was a 20 degree "slop" distillate. Three hundred and three heaters were lighted at 2:00 A. M. The outside temperature at this time was 34 degrees.

The arrangement of heaters in the plot was 21 x 21 feet. During this night there was no danger of frost, but as the season was getting late, and no maximum test had been carried out for this heater, it was thought best to carry it out regardless of the temperatures. It was noticed that the coldest time of this morning occurred shortly after 2:00 A. M.

The following chart will show the temperatures maintained during the burning period with 100 heaters per acre:

	Inside.			*Outside.*			
Time.	2:30	3:00	4:00	5:00	2:30	3:00	4:00	5;00
Temp.	.36	49	48	48	34	44	44	44
Temp.	.36	48.5	47	46	34	45	45	44.5
Temp.	.36	48.5	47	47	34	45	44	44
Temp.	.36	49	47	47	34	44	44.5	44
Temp.	.	49	48	48				
Temp.	.37	49	48	47				
Temp.	.38	49	48	49				
Temp.	.48	48.5	48	47				
Average inside				.36.7	48.7	47.6	48.6	
Average outside				.34	44.5	44.4	44.1	
Increase				2.1	4.2	3.2	4.5	

Highest increase, 4.5.
Lowest increase, 2.1.
Average increase, 3.6.
At 6:00 A. M. 9 heaters were out.
At 6:30 A. M. 34 heaters were out.
At 7:00 A. M. 71 heaters were out.
At 7:30 A. M. 190 heaters were out.
At 8:00 A. M. 276 heaters were out.
By 8:30 all had burned out.
Average burning time, 5½ hours.
*Outside temperature had raised to 44 degrees.

After 5:00 o'clock the outside temperatures had raised so high that it was not thought of value to continue registering temperatures. In all of the pots after they had gone out there remained from one to four inches of heavy residue, which would not burn, and when cool was very hard. This was partially due to the fact that on two previous occasions the heaters had been extinguished with about one quart of oil left in the bottom, and refilled without emptying. Probably each time the lighter oils had burned away and the residue mentioned above was an accumulated residue, rather than the product left from one burning.

The average increase of temperature with the heaters arranged 17 x 25 feet was 3.6 degrees for a period of three hours, and with the same heaters in the same block arranged 21 x 21 feet an average increase of 4.3 degrees was obtained.

MAXIMUM BURNING TIME FOR THE BOLTON HEATERS WITHOUT THE CARBON ARRESTER.

One hundred heaters filled to their capacity of one gallon were lighted at 2:00 A. M. April 26th. These had also been re-arranged so they were placed 21 x 21 feet apart. As there was no danger of frost during the night, temperatures were taken once every hour.

The following chart will show the temperatures maintained during the burning time:

	Inside.				*Outside.*			
Time	2:30	3:00	4:00	5:00	2:30	3:00	4:00	5;00
Temp.	36	47	48	48	34	44	44	44
Temp.	37	49	48	48.5	34	44	45	44.5
Temp.	36	47	47	48	34	45	44	44
Average inside				36.2		47.5	47.5	48.1
Average outside				34.1		44.5	44.3	44.1
Increase				2.1		3	3.2	4

Highest increase, 4 degrees.
Lowest increase, 2.1 degrees.
Average increase, 3.1 degrees.
Average burning time, 4¼ hours.
At 5:00 A. M. 3 heaters had gone out.
At 5:30 A. M. 21 heaters had gone out.

At 6:00 A. M. 46 heaters had gone out.
At 6:30 A. M. 91 heaters had gone out.
At 7:00 A. M. 99 heaters had gone out.

This test was carried on at the same time and under the same conditions as the Troutman test.

At 6:30 when 91 of the heaters were out a count was made of those which had burned clean. Eighty-two of the 91 heaters had burned clean, leaving nothing but a heavy coat of soot around the upper part of the sides of the heaters. Of the nine that contained a residue four had only a quarter of an inch in depth, part of which was soot which had been scraped down before. Two contained one inch of heavy residue, and the other three not more than two inches of heavy residue. Of these three, two when relighted burned clean. The other, however, contained some water, and would burn no more.

MAXIMUM TEST OF THE TROUTMAN HEATER WITH A MEASURED GALLON OF "SLOP" DISTILLATE.

This was carried on April 26th at the same time of the other two maximum burning time tests. In this block, however, temperatures were taken every 15 minutes until 5:45. This test was carried on in the block of Red Cheek Pippins with the heaters arranged in the square 21 x 21 feet. One hundred ninety-five heaters were lighted at 2:35, and the following charts will show the temperatures maintained and the length of burning time:

Inside.

Time	3:15	3:30	3:45	4:00	4:20	4:50	5:20	5;45
Temp.	47	47	48	48	48	48	48	48
Temp.	47	48	48	48	48	48	48	48
Temp.	48	48	48	48	48	48	48	48
Temp.	48	48	49	49	49	48	48	48
Temp.	48	48	48	48	48	48	48	48
Temp.	46	46	46	46	46	46	46	46

Outside.

Time	3:15	3:30	3:45	4:00	4:20	4:50	5:20	5;45
Temp.	44	44	44	44	44	44	44	44
Temp.	44	45	44	45	45	44.5	44	44
Temp.	44	44	44	44.5	44.5	44	44	44
Temp.	44	44.3	44	44.5	44.5	44.2	44	44

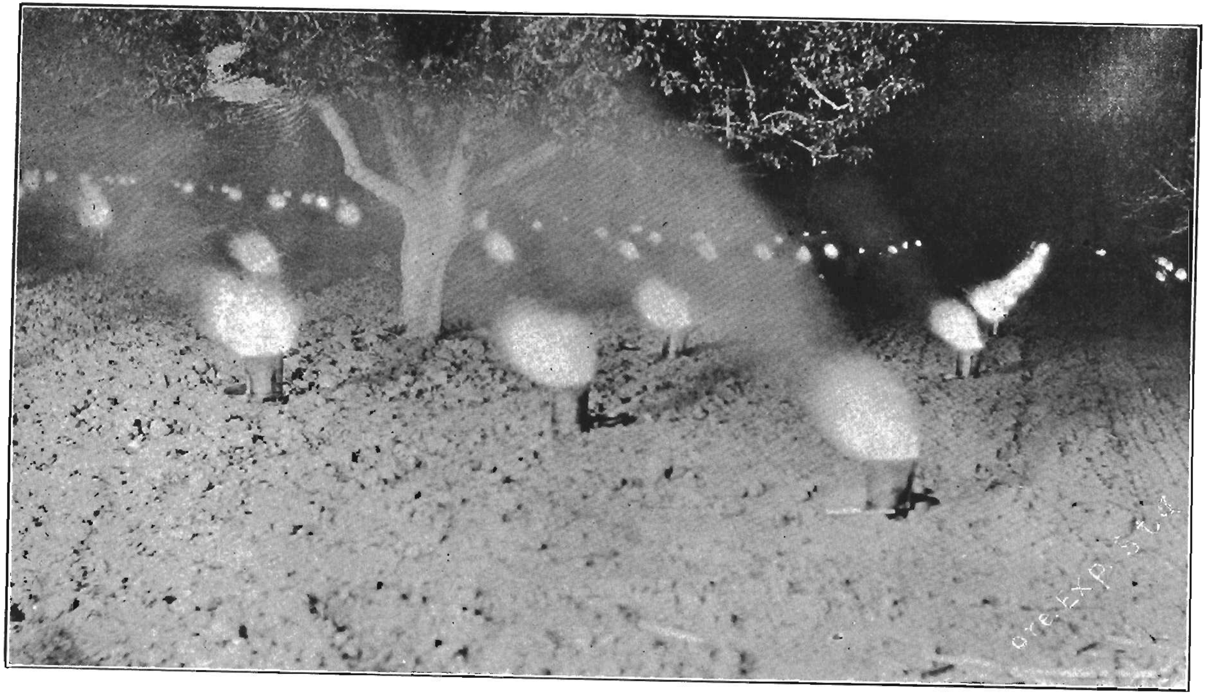

Plate 14—Troutman Heaters burning. Showing method of reinforcement

Average Inside:							
47.3	47.5	47.8	47.8	47.8	47.7	47.7	47.7
Average Outside:							
44	44.3	44	44.5	44.5	44.2	44	44
Increase:							
3.2	3.8	3.3	3.3	3.5	3.7	3.7	3.7

Highest increase, 3.8 degrees.
Lowest increase, 3.2 degrees.
Average increase, 3.5 degrees.
At 6:00 A. M. 9 pots were out.
At 6:30 A. M. 67 pots were out.
At 7:00 A. M. 156 pots were out.
At 7:30 A. M. 166 pots were out.
At 8:00 A. M. 195 pots were out.
Average burning time, 4½ hours.

A TEST WITH THE TROUTMAN HEATERS WITH THE COVERS INVERTED, ACTING AS A CARBON ARRESTER, APRIL 29.

This test was carried out in a block of Red Cheeks with 193 heaters lighted. The arrangement was the same as in previous tests. The test was made on the morning of the 29th of April. This was the coldest morning throughout the valley which was experienced during the season, the temperature in many places going as low as 22 degrees. However, in the orchard where the test was carried out 26 degrees was the lowest temperature recorded.

The heaters were lighted at 3:30 A. M., when the outside temperature was 29 degrees, and the mercury falling. The first reading was taken at 4:00 o'clock, when the outside temperature was 28 degrees.

The following charts will show the temperatures maintained from 4:00 o'clock until 5:30. After 5:30 the temperature outside rose steadily until 6:00 o'clock, but no reading was taken, as the heaters were put out. Between 5:00 and 5:30 the inside temperatures began to drop so that the covers were entirely removed, and the heaters allowed to burn free. This was necessary largely because of the large amount of soot which collected on the covers. The amount of oil consumed

during this burning period of 2½ hours was 135 gallons, and one quart, or an average of 2.8 quarts per heater. A very gentle drift from the south was noticed during this entire test. The temperature during the next day was quite high until about noon, when it became cloudy, and a cool breeze began blowing.

Air Temperatures.

	Difference in Reading of the Wet and Dry Bulb Thermometers.														
	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0
40	18	15	13	10	7	†3	−1	−6	−14	−26					
41	19	17	15	12	10	6	†2	−2	−8	−16	−30				
42	21	19	17	14	12	9	6	†2	−3	−9	−18	−36			
43	22	20	19	16	14	11	9	5	†1	−4	−11	−21	−45		
44	24	22	20	18	16	13	11	8	4	0	−5	−12	−24	−60	
45	25	23	22	20	18	15	13	10	7	†4	−1	−6	−14	−27	
46	27	25	23	21	20	17	15	13	10	7	†3	−2	−7	−16	−30
47	28	26	25	23	21	19	17	15	12	9	6	†2	−3	−9	−17
48	29	28	26	25	23	21	19	17	14	12	9	5	†1	−4	−10
49	30	29	28	26	24	23	21	19	16	14	11	8	5	0	−5
50	32	30	29	27	26	24	22	21	18	16	13	11	8	†4	0
51	33	32	30	29	27	26	24	22	20	18	16	13	10	7	3
52	34	33	32	30	29	27	26	24	22	20	18	16	13	10	7
53	36	34	33	32	30	29	27	26	24	22	20	18	15	13	10
54	37	36	34	33	32	30	29	27	25	24	22	20	18	15	12
55	38	37	36	34	33	32	30	29	27	25	24	22	20	17	15
56	40	39	37	36	34	33	32	30	29	27	25	24	22	19	17
57	41	40	39	37	36	34	33	32	30	29	27	25	24	21	19
58	42	41	40	39	37	36	35	33	32	30	29	27	25	23	21
59	44	43	41	40	39	37	36	35	33	32	30	29	27	25	23
60	45	44	43	41	40	39	38	36	35	33	32	30	29	27	25
61	46	45	44	43	42	40	39	38	36	35	33	32	30	29	27
62	47	46	45	44	43	42	40	39	38	36	35	33	32	30	29
63	49	48	47	45	44	43	42	41	39	38	36	35	34	32	30
64	50	49	48	47	46	44	43	42	41	39	38	37	35	34	32
65	51	50	49	48	47	46	45	43	42	41	40	38	37	35	34
66	52	51	50	49	48	47	46	45	44	42	41	40	38	37	35
67	53	53	52	50	49	48	47	46	45	44	43	41	40	38	37
68	55	54	53	52	51	50	49	48	46	45	44	43	42	40	39
69	56	55	54	53	52	51	50	49	48	46	45	44	43	42	40
70	57	56	55	54	53	52	51	50	49	48	47	46	44	43	42
71	58	57	56	55	54	53	52	51	50	49	48	47	46	45	43
72	59	58	58	57	56	55	54	53	52	51	50	48	47	46	45
73	60	60	59	58	57	56	55	54	53	52	51	50	49	48	46
74	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48

Note: † in the foregoing table signifies plus.

	Outside.			*Inside.*			
Time	4:00	4:30	5:00	5:30	4:00	4:30	5:00	5;30
Temp.	28	28.5	27	27	31	32	32	30
Temp.	27.5	28	26.5	26	32	34	32	29.5
					31.5	33	31.5	29.5
					31	33	32	30
					32	34	36	31
					30.5	31	31	29
Average outside				27.7		28.7	26.7	26.5
Average inside				31.4		32.9	32.4	29.8
Average increase				3.7		4.2	5.7	3.3

Average for entire period, 4.2 degrees.

Average with arresters, 4.5 degrees.

The morning of May 6th, when a frost had been predicted, a test was made in the Burrell orchard with the Bolton orchard heaters burning a 14 degree fuel oil. The trees were 24 feet apart, and 8 or 9 years of age. Nine thermometers were used in the heated area, and thre e on the outside. About 2.3 acres of young Bartletts with 47 heaters per acre were used. These were lighted at 3:45, with the outside temperature at 32 degrees. Readings were taken every half hour until 5:00 o'clock, when they were taken every 15 minutes. At 5:45 the temperatures had risen so much on the outside and the sun was shining upon some of the thermometers, so that no attempt was made to take a reading. A few of the heaters burned out within an hour and a half, due to the fact that 8 previous firings had been made, with no attempt to clean out the residue. In two heaters which were examined fully a half gallon of thick deposit was found, and in many of the other heaters which went out shortly after 6:00 o'clock almost as much residue was left. A steady wind was blowing from the south at about 3 miles per hour, making it quite difficult to form a heavy smudge. However, by 4:30 the north half of the block was sheltered by a very dense smudge.

Inside.				
Time 4:00	4:30	5:00	5:15	5:30
Temperature 32	34	34	33	33
Temperature 32	34	33	33	33
Temperature 32	36	36	34	34
Temperature 35	34	35	34	34
Temperature 34	34	35	34	34.5
Temperature 34	34	34	34	34
Temperature 34	34	34	34	33.5
Temperature 34	34	34	34	34
Temperature 34	33	34	33	33.5
Average 33.4	34.1	34.3	33.7	33.7
Outside.				
Time 4:00	4:40	5:00	5:15	5:30
Temperature 32	32	32	31	32
Temperature 33	32	32	31	33
Temperature 33	32	32	31	32.5
Average 32.6	32	32	31	32.5
Increase 8	2.1	2.3	2.7	2.2

Average increase, 2.02.

The results of the work this season are very gratifying, for after one of the most trying seasons in the history of the valley there still remains a fair crop of fruit.

In the orchards where the test was carried out a good crop was saved in the apples and pears, and with the exception of the d'Anjous no injury occurred. The d'Anjou pears were located between the other varieties, and a portion of each variety was used in each block. There was also a strip across the end of each variety which was not in the heated area. There was considerable ringing and russeting in the d'Anjous, but practically none on the other varieties. This injury occurred both where the heaters were used and where they were not, and it would seem from all indications that it was the effect of a late frost, and occurred on a night when no heating was done. The fact that the d'Anjous were the only ones injured would indicate that under the conditions experienced this season the d'Anjous are more susceptible to frost injury than the other varieties. This also indicates that the danger point for frost injury has not been worked out definitely as yet.

OBSERVATIONS TAKEN IN THE DIFFERENT ORCHARDS THROUGHOUT THE VALLEY, AND EXPERIENCES OF SOME OF THE GROWERS.

Wood Fire.

Mr. Allen of the Hollywood orchard during the past three years has practiced smudging, but previous to this year, 1911, has used nothing but manure smudges. In 1909—1910 he saved his entire crop without using wood. In 1911, when the cold period of April 12th and 13th came, he decided that the temperature would be too low to be safe with only manure smudges, as the ground was very cold. He then placed wood

Plate 15—Using wood and twigs in G. E. Marshall Orchard

in his orchard at 60 feet apart where the trees were 30 feet apart. On his 50 acres he used 9 cords of wood to make the first fires. The first three nights he had used approximately 5 cords of wood. His trees being small he found that he was unable to save the entire crop in that way. In fact around the outer edge and across one end of his orchard the fruit was almost entirely killed, and throughout the entire block, a great many of the blossoms were injured. However, on a large per cent of the heated area enough fruit was saved to

make a fair crop. The lowest temperature which he noticed inside the heated area was 26 degrees. On the morning of April 13th at 4:30 A. M. the temperature reached 29 degrees, and at 5 o'clock had reached 27 degrees. On the morning of April 14th at 2:15 the temperature had reached 26 degrees, and on the morning of April 15th at 5:00 o'clock the temperature reached 26 degrees.

Mr. Allen uses a Cederborg alarm, which he finds to be reliable. The arrangement of the alarm he has changed some-

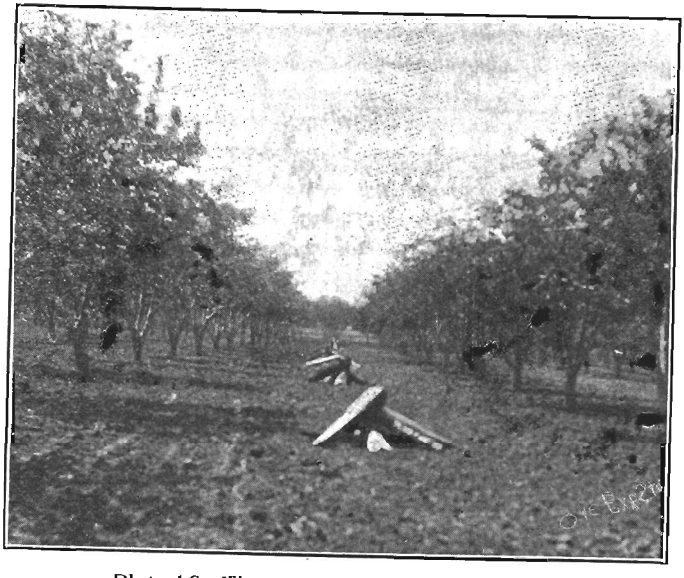

Plate 16—Wood properly piled for firing

what from the original plan. He uses two sets of batteries, one for the current through the thermometer, and the other for the bell. He has two points on his thermometer, one at 33 degrees, which rings first, at which time he notes the hour, and returns to bed. The second point is at 31 degrees, and when the temperature reaches this point and rings the alarm he notes the time required for the temperature to drop the two degrees, and estimates at that rate how long it will be before the danger period is reached, and before it will be necessary to fire.

The advantages and disadvantages of the Cederborg alarm will be taken up in another place, so nothing more need be said here.

Mr. Allen found it necessary to use 15 to 18 men in handling wood fires on 50 acres. His wood cost him $6.25 per cord, but could have been obtained at $5.25 earlier in the season. He practices firing when the temperature reaches 30 degrees.

THE MIDVALE ORCHARD.

This orchard consists principally of young trees. However, there was a block of about an acre and a half of 18 year old trees, Bartletts and Winter Nelis. Mr. Norris places

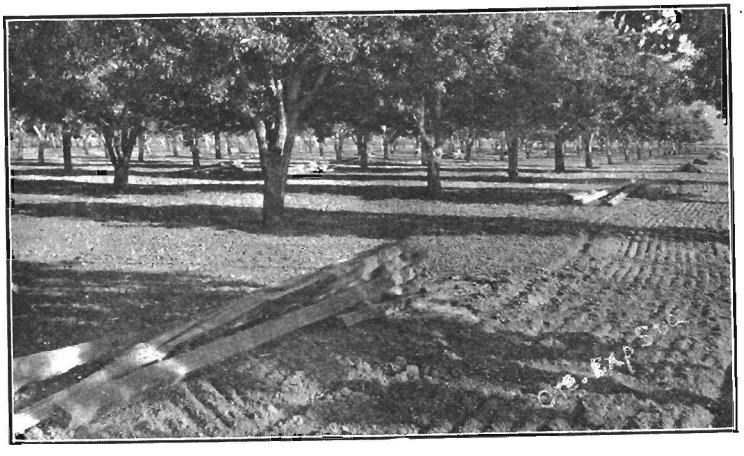

Plate 17—Old rails used in Midvale Orchard

his fires 50 feet apart, and alternates them so he gets a very even distribution of the fires throughout his block. He had in this block 30 fires, using old rails and a pile of manure for each fire which he added late in the morning just before the sun rose, to obtain a smudge. He states that while having only 30 fires to look after he found that it was too much work for one man to do, and be sure of saving his crop. On the morning of April 14th when the temperature dropped to 26 degrees, he was unable to keep his fires going well enough to be sure he was saving his entire crop. However, enough of his bloom remained so that he will have

a good crop of pears, with the exception of a few Comice and Bartletts on the outer edge.

THE BUCKEYE ORCHARD.

The Houston Bros. of the Buckeye orchard were successful in saving their crop of Bartletts of about three acres where during previous seasons no frosts were experienced. The danger during the present season, however, was so evident that they made preparations to protect their crop. Their orchard is in a long narrow strip, and very difficult to heat. However, with the fires 40 feet apart where the trees are 24 feet apart, they were able to protect the fruit entirely. The coldest temperature which they noted during the season was 26 degrees, occurring on the morning of April 15th. The cost of firing was as follows:

Distributing material, two men and a team one day....$7.00
One man on duty lighting..... 2.50
Two extra men to light fires 2½ hours..... 2.00

The fence rails and manure which were used cost nothing. Figuring three acres in the block, the cost of the first firing averaged $3.83 per acre. The second firing was less, due to the fact that most of the material used in the second firing was left from the material placed for the first firing. It required one man one half day to pile the material, so that the cost of firing the second time averaged $2.33 per acre, not counting the cost of fuel. A third firing, however, would have been as expensive as the first firing.

MR. WORKMAN'S ORCHARD.

In this orchard four rows of Howells were severely injured, due to the fact that they were long rows, and difficult to heat. An attempt was made to protect them with two rows of wood fires 60 feet apart. In a four acre block of Bartletts 30 feet apart, trees about 12 years of age, about 50 per cent of the bloom was damaged, but enough was saved to insure a good crop. Old rails were used in this orchard, the fires being placed 30 x 60 feet apart. After each firing it required two men and a team almost a day to prepare for the next firing. The lowest temperature noticed in this orchard was 25 degrees on the 15th of April.

J. G. GORE'S ORCHARD.

Old rails were used in this orchard, being placed 40 x 60 feet apart. Crude oil was used to assist in firing, as the rails were damp. There were 8 acres in this block, and no damage was noticed. Apples adjoining were damaged about 20%. In the center of the block of apples little or no damage was noticed. Mr. Gore found it very difficult to obtain a satisfactory temperature during the first two nights of firing, principally because just previously considerable rain had fallen, causing the rails to burn very slowly.

MR. PHIPP'S ORCHARD.

This orchard was equipped with coal heaters, but wood fires were used to assist in smudging. The coal used in the heaters was obtained about a mile and a half from the ranch, and cost $5.00 per ton at the mine. The grade of coal was only fair, but proved quite satisfactory for short burning periods. Mr. Phipps states that he would use 100 heaters to the acre, but only fired 50 at a time. In using the 100 heaters he would then be prepared to fire for seven or eight hours in succession. Twenty to 25 pounds of coal were used in each heater. The method of lighting is to place a small amount of kindling in the bottom of the heater with a piece of oil-soaked waste sticking out through the bottom. This waste ignites very easily, and soon fires the coal.

Mr. Phipps figures the cost of firing with coal heaters to be about $5.00 per acre for each firing, 20 pounds of coal being estimated to burn about three hours. He also states that he has good success with wood fires, but would use nothing but a good grade of fir cordwood for that purpose, and if such were used the cost of firing would be approximately $10 00 per acre for one night burning from five to six hours.

Mr. Phipps states that in no case would he prepare less than 100 fires per acre, using 50 at first, having as many more to fall back on in case he was unable to hold the temperature.

PALMER ORCHARD.

This consists of young trees 5, 6 and 7 years of age, and gave promise of producing a very heavy crop of pears this

year. Mr. Palmer protected the crop one night, but the second night between 5:00 and 6:00 A. M. April 15th the temperature dropped to 25 degrees, and damaged his crop so severely that he made no further effort to protect it. On this morning the temperature at 5:00 o'clock inside the heated area was 29 degrees, and on the outside 26 degrees. Between 5:00 and 6:00 o'clock the temperature dropped both inside and outside of the heated area to 25 degrees, and while he had a double number of heaters in his orchard it was too late to save his crop after the drop was noticed. He placed about 150 heaters per acre, and at the time of the damage 75 per acre were burning. At this time in a small block of peaches a great percentage of them were killed. In an orchard adjoining Mr. Palmer's the man saved the fruit on seven isolated trees by burning from 5 to 7 fires around each tree. For this purpose he used wood.

THE MERRITT ORCHARD.

This consists of four acres of Spitzenberg and Newtown apples. Eighty heaters per acre were placed in this block. The early frosts which threatened to damage the pears did no injury to this orchard, and the first firing was done April 25th. Four firings were made, April 25th, 26th, and May 5th. The trees are 24 feet apart, very large, and almost meet between rows. The coldest temperature occurred April 29th, when 24 degrees was registered. Part of the orchard was supplied with a double row of heaters for reinforcement in case of a long firing time.

A. C. FIERO ORCHARD.

One block of old trees 20 feet apart consisting of about three acres were protected, using about 110 heaters per acre. However, only 50% were lighted at first, and when they had burned out the remainder were fired. In this way the firing period was doubled. In this block practically no damage was done. In a block of young trees just across the road, where the trees were 35 feet apart, and only one pot to the tree was used, about 50% of the fruit was damaged, and on one or two small trees the entire crop was killed, the coldest temperature

occurring April 29th, and the thermometer registering 23 degrees.

The cost, not counting refilling, was $3.50 per acre for one firing, where one gallon of oil was used. It required two men and a team one day to fill a thousand heaters. A total of 10 firings was necessary in this orchard. Both the "slop" distillate and the crude oil were used, and no difference was noticed in the temperature maintained by the two. The burning time, however, with the crude oil was slightly longer for the first firing, but shortened with each successive firing, due to the fact that each time a considerable amount of heavy residue was left in the pots.

It was noticed in the young orchard where 35 heaters per acre were used, that it was impossible to hold the temperature above the outside temperature, so practically all the advantage gained in smudging was a heavy bank of smoke, which remained in the orchard until late in the morning.

THE FOOTHILLS ORCHARD.

This orchard consists of 40 acres of Winter Nelis, d'Anjou and Bartlett pears. It lies with a slight slope to the southeast, there being usually a fairly good air drainage from the northwest to the southeast.

Seventy-one Bolton or Fresno heaters were used per acre, half of which were lighted at a time. With an outside temperature of 26 degrees they were able to maintain a temperature of 30 degrees within the heated area, and in some places the temperatures ranged from 31 to 33 degrees. However, when the outside temperature dropped to 25 degrees they were unable to keep the inside temperature above 29 degrees. Ten thermometers were used in this block. Most of them were of the cheaper grade, but all were tested and compared with a standard Taylor thermometer.

Fuel oil testing 15½ degrees was used in this orchard. This cost $3.77 per 100 gallons at their siding, which was about two miles from the orchard.

There was no trouble whatever in this orchard with the pots boiling over. This is due largely to the fact that the oil was taken from the bottom of the tank, and each time the water was allowed to drain off before the oil was taken out.

Fuel was distributed to the heaters by means of a galvanized iron tank, mounted on a wagon. The usual trouble with a heavy residue forming in the bottom of the heaters was noticed in this orchard. However, Mr. Carpenter thinks he has a means of overcoming this difficulty. A small knife with a tin box attachment is run around the pot, collecting this residue immediately after the pots are extinguished. This means a waste of considerable material during the season. The practice of emptying this heavy residue onto the soil is questionable.

Mr. Carpenter practiced keeping his fires going until 7:30 A. M. This was from an hour to an hour and a half longer than in most of the other orchards. This orchard was one of three where a single frosted flower could not be found inside the heated area. An extra row of heaters was used on the outside for reinforcement, and were placed about 15 or 20 feet from the first row of trees. All of the varieties were setting a heavy crop except the Winter Nelis. These were planted in alternate rows with the Bartletts, and with the exception of a few trees on the northeast corner, where the soil is considerably lighter, and the bloom earlier, no pears were setting. Of those few trees which were noticed to bloom earlier, a fair crop had set.

Four men and a team were required to fill two thousand heaters in a half day. Mr. Carpenter states that if crude oil is used it requires one more day to unload the car on the siding than if the distillates were used, as the latter will run much more freely and can be handled faster. In this orchard it was noticed that the heaters having once been burned had to be refilled before they could be relighted. The coldest temperature occurred April 29th, when the thermometer reached 25 degrees for a short time. Nine firings were necessary during the season.

EDEN VALLEY OR BURRELL ORCHARD.

This orchard consists of a block of Winter Nelis, Bartlett, Howell and Bosc, and comprises about 42 acres. With the exception of about three acres of young Bartletts this is in a solid block, the trees about 18 years of age, and 24 feet apart. Sixty-five heaters per acre were used, burning a fuel oil testing 14 degrees. Five cheap thermometers which had been tested

the year before were used in this block. The pears were not injured on the inside of the heated area of the large block. On the east and south the outer row was damaged slightly, and in the block of young Bartletts some damage was noticed. However, there will be a good crop on the entire tract, with the exception of the Winter Nelis, which did not set well. Only a few of the smaller trees in the Winter Nelis block had more than a very light set. One row of heaters was used outside of the orchard for reinforcement, but was set only about 8 feet from the outside row, so was not effective. Next year Mr. Roth plans on adding an extra row 20 feet from the outside row of trees. Fourteen to sixteen men are used to light the heaters. Refilling the heaters is the greatest expense in heating this orchard. A storage tank for the crude oil with a capacity of 10,000 gallons is used.

The lowest outside temperature noted during the season was 24 degrees. This occurred April 29th. At the same time the lowest inside temperature was 29 degrees. The Bolton or Fresno orchard heater was used in all eleven firings which were made in this orchard during the season.

THE SNOWY BUTTE ORCHARD.

In this orchard, which consists of Winter Nelis pears planted in a solid block, 140 heaters per acre were used. Two were placed in the center of each square of trees, which were 24 feet apart. Only half of the pots were lighted at a time, the remaining half being held in reserve in case the cold period extended over a long period. No frost injury was noticed in this orchard, but the pears were setting very lightly. A few trees on the outside of the heated area were examined and showed the effect of frost very badly.

BEAR CREEK ORCHARD.

The Bear Creek Orchard was divided into three different blocks. In the first, consisting of young Comice and Bartlett, the trees are 24 feet apart, and a heater was placed for each tree, making about 70 heaters per acre. Only half were lighted when the temperature reached 30 degrees, and as long as the inside temperature remained above that, no more were lighted. This number of heaters proved enough protection in that block

during this season, and on May 12th, when an examination was made, the pears were in good condition, and a heavy crop had set, with only a few showing any frost injury.

The second block consisted of old Bartlett trees, which were large enough to almost meet between the rows, forming a very good screen for holding the heat. It was noticed that a much higher temperature could be maintained with 35 heaters per acre than in the other plot, and that at any time 70

Plate 18—Coal Heaters ready to light, Reading thermometers at the left, Bear Creek Orchard 1909

heaters per acre would be ample protection in a block of this kind. No injury from frost was noticed, and a few Comice trees even 50 to 150 feet away from the heated area showed only a slight injury from frost. In the third block, which is known as block 12, the trees are younger, somewhat smaller, and placed 30 feet apart. Sixty heaters per acre were used. In this block considerable difficulty was experienced in maintaining a satisfactory temperature, and some damage occurred.

However, enough of the crop was saved to insure a fair yield, with perhaps only a small percentage of the fruit scarred with frost injury. It is the plan of the foreman of this orchard to double the number of heaters in this block next year in order to be able to absolutely protect the crop in this block from all injury.

Mr. Brooke uses a Cederborg alarm. This in conjunction with the local branch of the Weather Bureau makes a very satisfactory combination. Mr. Brooke states that he has been very well pleased with the Cederborg alarm, and is planning

Plate 19—Using oil to light manure smudges in Bear Creek Orchard in 1909

to install an alarm for each block, fitting up his packing house for sleeping quarters during the frost season. In this way he will be able to know in what place the danger is, and at once be ready to protect that block. He has tried the Cederborg thermometers, and found them very satisfactory, and is planning on using more. He also expects to keep an accurate record both of the inside and outside temperature, on the nights when it is necessary to fire.

The fuel used in this orchard was 14 degree fuel oil, and 20 degree "slop" distillate. He finds that there is very little difference between the two, so far as the production of heat and smudge is concerned. The crude oil has a slightly longer burning time.

ORCHARDS NEAR EAGLE POINT.

There were two separate blocks in this vicinity, both of old trees 20 feet apart, so large that they met in the center of the row. In the large block of Spitzenberg there was a heavy bloom, but all of the blossoms examined on a number of trees throughout the orchard were either killed or severely injured by frost. In a small tract of about three acres near the creek a great deal of damage was found. However, a few of the tops of the trees in this block will probably have a fair set of apples. Near the creek the damage seemed to be less than at the opposite end of the orchard. No attempt was made to protect this orchard, since there was no record of previous frost injury in the orchard. On the morning of April 29th a temperature of 22 degrees was noticed. A few pear trees near the house apparently escaped with only partial injury. These were also near the creek, and all showed considerable damage, but will have enough pears left to make a fair crop.

THE PROBLEM OF THE FAILURE OF THE WINTER NELIS PEARS TO SET

After the frost season was apparently over, and the growing season fairly well started, a great deal of comment was heard from all sides in regard to the setting of Winter Nelis pears. At first this comment came principally from those orchardists who had used oil for smudging, and at first was attributed to the fact that the oil deposited from the soot on the blossoms had prevented the insects from working, and effecting pollination. As the season advanced, and this complaint became more general, an investigation was carried on in most of the orchards of the valley to ascertain if possible some reason for the non-setting of the Winter Nelis pears. Working upon the basis first that the failure was due to the cold, cloudy weather which prevailed during the blooming period, and not to the effect of smudging, the investigation

was begun in those orchards where heating with oil was practiced. A comparison of the results in these orchards, and those orchards which were heated with wood fires was made. The first important fact in relation to this problem concerns itself with the blooming period of the different varieties. As has been stated elsewhere in this bulletin, the excessive warm weather between March 27th and April 5th had forced the Bartlett, Howell, d'Anjou and Comice pears into full bloom. At the same time the Bosc and Winter Nelis were developing, and in fact the Boscs were very nearly as far along as the early varieties. However, the cold period beginning about April 5th seemed to check the bloom on the Winter Nelis so that the buds opened very slowly, and they did not come into full bloom until about April 15th, and later. This was just at the time of the two heavy smudgings, and gave rise to the idea that the lack of pollenation was due to smudging. It was noticed in the Marshall orchard that the Monday following the smudging on Saturday that the blossoms were not coated with soot. A heavy wind on Sunday had blown the petals from the Bartletts and d'Anjous to a considerable extent, On examining the Winter Nelis it was found that very little soot had collected on the open flowers, due to the fact that a large percentage of the buds had only been partially opened previous to Saturday morning, but that the larger percentage had entirely opened on Sunday and Monday. Thus the flowers and pollen of these buds were protected from any deposit of soot. Later an examination of this block showed that much of the fruit which was setting on the Winter Nelis trees in this orchard was around the lower part of the trees on the lower branches, where in all cases the heaviest deposit of soot was noticed.

In the Foothills Orchards of Mr. Carpenter, where the Winter Nelis were alternated with Bartletts, the same lack of setting was noticed, with the exception of a few trees in one corner of the orchard where they bloomed slightly earlier. These few trees set quite a full crop.

In the Gore orchard, and in the Workman orchard adjoining, where wood fires were used, the same results were noticed with the Winter Nelis pears.

In the Midvale Orchard, which consisted of a few rows

of Winter Nelis, and about the same number of Bartlett, it was noticed that some of the Winter Nelis trees near the Bartletts were setting a full crop, but others in the same row did not, and practically all of the second row from the Bartletts were setting very poorly. In some instances a single branch on a tree would be heavily laden, with only a few on the remainder of the tree. In this orchard the Bartletts were in full bloom when the cold weather came on, or about April 5th, and the Winter Nelis had been held back for at least 10 days. Apples adjoining the pear orchard were entirely killed on the morning of April 29th, as no attempt was made to smudge. The pears were all saved by the wood fires used. In two small blocks which were heated with wood fires entirely, very few Winter Nelis pears were found to be setting fruit. In the Snowy Butte Orchard, which consists of about 15 acres of Winter Nelis pears in a solid block, only a few scattering trees have set a crop. A very peculiar thing was noticed in this orchard:—occasionally two-thirds of a tree would be heavily loaded, while all around there was no fruit. Furthermore, a great many trees had one, two and three limbs which bore heavy crops, while the rest of the tree had but a few.

Having investigated the principal orchards which were heated or smudged with oil, wood or manure, the next step was to hunt up an orchard which had not been heated or smudged, and where it was known that the soot could not have done the injury. Such an orchard was found along the side hill between Jacksonville and Central Point. This orchard belonged to Mr. Griffis, and the same condition prevailed here, and in two adjoining orchards, as had been found in the orchards which had been heated. In an orchard owned by the York Real Estate Company, which has a large number of varieties, it was noticed that all of the pears were setting and free from injury of frost, except the Winter Nelis. This orchard is located on the steep hillside extending a short distance on top of the hill. Two small trees on top of the hill were setting a heavy crop. Very small Winter Nelis trees were also setting a fair crop. The large trees in this orchard were setting only a few scattering fruits. These were near some of the small trees mentioned, and surrounded in each case by other varieties which were bearing heavily.

In an orchard at the foot of this hill which was not heated, four rows of Winter Nelis pears were planted, alternating with one row of Comice. No effect due to pollenation was noticed between the two. There was one very small tree which was setting a full crop.

After going over a large number of orchards, and finding that under all conditions, whether heated or not, the Winter Nelis pears showed similar peculiarities in setting, it would appear as though this condition was due to the kind of weather which prevailed during the blooming period. The investigations carried on this year were not conclusive, and simply opened up a large problem for future solution.

WILLAMETTE VALLEY CONDITIONS.

Through the courtesy of Mr. Powers of the Agronomy Department of this Institution, we are enabled to present a summary of the temperatures at Corvallis during the season of frosts. As in southern Oregon, during the latter part of March the weather was extremely warm; in fact the month of March averaged about 3½ degrees above normal. This had a tendency to force the buds into full bloom. The warm period was followed by a succession of cool days and frosty nights.

The following temperatures for April are given:

Date	Minimum Temp.	Dew point night before taken between 6 and 6:30 P. M.	Time the temperature remained below the danger point
4/2	29	38	From 4:30 to 6:30 A. M.
4/6	28	34	From 5:00 to 6:00 A. M.
4/11	31	34	From 4:00 to 7:00 A. M.
4/12	29	—	From 3:30 to 6:30 A. M.
4/13	25	32	From 5:00 to 6:00 A. M.
4/14	27	33	From 4:30 to 6:30 A. M.
4/15	30	39	From 6:30 to 6:00 A. M.

On the 17th and 29th of April the temperature reached 31 degrees for a short time only. During the time of the most severe frosts, and especially the 13th of April, when the temperature reached 25 degrees, most of the fruit was in full bloom, especially the cherries, peaches, prunes and pears. Apples were hardly far enough out to be seriously injured. By comparing these temperatures with the tables of temper-

atures reputed to be injurious, one would expect a very light fruit crop in the Willamette Valley. However, such is not the case, for there was a good set of apples and pears. Cherries were slightly injured, some of them probably 50 per cent. Peaches were hurt more than any of the other fruits, in some places as much as 60 to 75 per cent being injured. Prunes in some places were very badly hurt, and in other places hardly injured. An average of about 40 to 50 per cent injury to this crop would probably be a fair estimate. At Corvallis, where the temperatures were taken, the most serious injury was noticed on some of the earlier varieties of strawberries. With these figures before us it would seem as though an arbitrary table of temperatures for frost injury could not be made, as the humidity of the air and the weather conditions generally seemed to cause a very wide variation in the effect of the frosts. It may be possible in the future to work out figures under certain conditions which would be arbitrary, but that will necessarily be a rather difficult problem. In most of the tables which are found in print we find the temperatures at which injury will occur between 27 and 30 degrees. With all kinds of fruits, both in the Rogue River Valley, and in the Willamette Valley, it was noticed that these temperatures did not apply, for in many instances peaches passed through a temperature of 27 and 28 degrees without injury. In other cases pears and apples in the bud appeared to be injured at a temperature of 29 degrees. It might be well, however, to state that under normal conditions the general rule seems to be that unless there is a large amount of moisture in the air a temperature of 29 to 30 degrees will be dangerous to most varieties. The peach is generally considered much more susceptible to frost injury than the pear. However, in one orchard where peach fillers were used with pears, the pears were about 50 per cent killed, and no injury was found on the peaches, so that further investigation may prove that supposition incorrect.

SUMMARY.

1. Six and one half acres of seventeen year old pears were used in one block and two acres of apples in another. The apples planted thirty-four and one half feet apart were appar-

ently as easy to heat as the pears planted twenty-five feet apart.

2. The latter part of March was very warm, followed by a very cold April. Only a little rain fell and some snow, but the days were cloudy. The pears were in full bloom by the 10th of April. From April 12th to May 5th, six frosts were recorded. The lowest temperatures for each being 29, 27, 25½, 28, 26 and 31 degrees, respectively.

3. Two grades of oil were used, 28 degree distillate and 20 degree "slop" distillate. The cost of the latter was $6.25 per 100 gallons. The heavy fuel oil left an inch of residue for each firing. This would not burn and if left in the heater decreased the burning time. Oils with a paraffin base are to be preferred to those having an asphalt base.

4. Bausch and Lomb Laboratory Thermometers graduated to 300 degrees were used in this work. Two certified thermometers were used to test these at 32 degrees. At least one thermometer per acre should be used, and should be tested each season. A thermometer with a long cylindrical bulb and graduated to 120 degrees is the best. The round bulb type is not sensitive enough.

5. Two types of heaters were used, the Bolton Orchard Heater of the lard pail type with a capacity of one gallon and the Troutman Heater, with a center draft and holding five quarts. These were both made of light sheet iron and cost about 20 cents each.

6. The local branch of the U. S. Weather Bureau, the telephone companies and frost alarms are all used to warn the fruit growers when the temperature reaches the danger point. Some patent alarms are used, but cannot be depended upon entirely.

7. Storage tanks of three types, cement, galvanized iron and wood, are used. The latter are of little value. Cement tanks are best for large amounts of oil and for use where they can be placed on the ground. Galvanized iron tanks are good where small amounts of oil are stored, and are especially valuable where it is necessary to elevate the tank.

8. At 30 degrees outside temperature no increase was obtained with 20 heaters per acre. With 39 Troutman Heaters per acre an average increase of 1 degree was obtained. The

same heaters gave an increase of three and one half degrees with one hundred heaters per acre, arranged 17 by 25 feet, and four and one-tenth degrees when arranged 21 by 21 feet. The Bolton Heater with the carbon arrester gave an average increase of one and three-tenths degrees with one hundred heaters per acre and arranged 17 by 25 feet, and without the arrester gave an average of four degrees.

9. The Troutman heaters gave an average burning time of five and one-half hours with five quarts of oil, and four and one-half hours with four quarts of oil. There was some trouble with a residue with these heaters. The Bolton heaters averaged four and one-quarter hours with four quarts of oil without the carbon arrester, and eight hours with the attachment. One quart of twenty to thirty degree distillate will burn for one hour with these heaters under most conditions.

10. The average cost per acre for a four hour period is $5.10 for oil, not counting the equipment, and for wood under the same condition the cost would be $5.40, as more labor is required. Oil is the best fuel, as less help is required and an even temperature may be maintained. Oil should be handled by a gravity system so far as possible.

11. Under the conditions experienced this season there is absolutely no doubt but that a crop can be saved by orchard heating. A very good example was furnished by the block of apples, where the rows that were heated have a crop, and the farther away the trees were from the heated area the less fruit was saved. d'Anjou pears showed a slight injury from a late frost, indicating that they were more susceptible to injury than other varieties. Winter Nelis pears did not set a good crop, but that is probably due to weather conditions and not the effect of frost or smudging.

12. The effect of the low temperatures in the Willamette Valley indicates that no arbitrary table of temperatures for frost injury has been worked out for all conditions. The temperature dropped below 29 degrees on several nights, and as low as 25 degrees at one time, and was below 28 for more than two hours. A fair crop of fruit is left. The early varieties of strawberries were injured the most.