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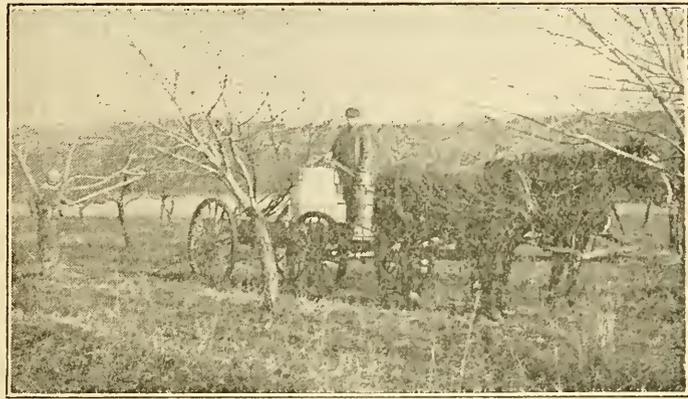
# CONNECTICUT AGRICULTURAL EXPERIMENT STATION

NEW HAVEN, CONN.

BULLETIN 146, OCTOBER, 1904.

ENTOMOLOGICAL SERIES, No. II.

## San José Scale-Insect Experiments in 1904.



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# San José Scale-Insect Experiments in 1904

BY

W. E. BRITTON AND B. H. WALDEN.

Bulletin 144 of this station contains an account of the experimental spraying work against the San José scale-insect for 1903. In December of that year tests were made in Bridgeport to determine whether fall or early winter spraying with lime and sulphur could be depended upon to hold the scale in check in Connecticut. About 770 trees, mostly Japan plum, with a few peach and pear trees, were treated. A few trees in New Haven were also sprayed in the fall.

In the spring of 1904, spraying experiments were conducted at New Haven, Westville, Wallingford, Milford and Southington. The boiled mixture did not seem to adhere to the trees as well as last year, doubtless owing to the different climatic conditions. Wherever the lime and sulphur mixtures are used there is a decided tendency for the young scales to set upon the fruit and leaves instead of the twigs that have been covered with the spray mixture. This is doubtless the case where any adhesive mixture is used, and often the fruit is disfigured by the scales when they are not abundant on the twigs.

All of the lime and sulphur mixtures seem to have considerable value as fungicides.

Young scales were first observed crawling on June 25, at New Haven.

The whole number of trees and plants treated in these experiments was approximately as follows:

|                   |      |                       |
|-------------------|------|-----------------------|
| Bridgeport .....  | 772  | } December treatment. |
| New Haven.....    | 14   |                       |
| Westville.....    | 150  | } Spring treatment.   |
| Wallingford ..... | 130  |                       |
| Milford.....      | 481  |                       |
| Southington ..... | 2552 |                       |
| New Haven.....    | 35   |                       |
| Total.....        | 4134 |                       |

The effects of the winter on the trees make it impracticable in many cases to express the results of the spring treatment in exact figures, as was done in bulletin 144. In some cases, however, this can be done, and we consider the general results to be of sufficient value for publication, and so present them in the following pages:

## EFFECT OF THE WINTER ON THE TREES.

It would be manifestly unfair to give any account of experimental spraying work against the San José scale-insect without mentioning the very unusual effect of the season in causing injury to trees and orchards. The extraordinary winter killed many peach and plum trees in Connecticut, and thousands were seriously injured. Scale-infested trees, as a rule, were the first to show this injury and thousands of such trees in peach orchards went into the winter in a weakened condition never to leaf out again. But the damage was by no means confined to infested trees. In some places young and vigorous peach trees were frozen and killed to the snow line and had to be cut away, while in many orchards, especially on the lower levels, the fruit buds were entirely destroyed. In some instances trees leafed out, but soon withered and died. Large apple trees in different parts of the State appeared sickly in June and July and some of the branches withered and died. An examination failed to show the presence of any parasitic trouble, and their condition could be ascribed only to winter injury. On the whole, Connecticut orchards suffered a vast amount of damage, from which some of them will not recover in several years, if ever.

At the time of cutting twigs to examine the insects prior to spraying, the best looking infested twigs were selected, but the extent of this winter injury could not then be determined. But in many cases the infested wood was injured or dead and most or all of the scale-insects were dead in consequence, before the spray was applied.

In June, when the twigs were cut for the second examination to show the effect of the treatment, the trees were in leaf and it was easy to distinguish the living from the dead branches. Only living branches, of course, were examined at this time, and in some cases the number of living insects after the treatment exceeded the number found on the injured branches at the first examination.

## EFFECT OF THE WINTER ON THE INSECTS.

Ordinarily we find that a portion of San José scale-insects are killed each winter—probably by the climatic conditions. Twenty-five per cent. is about the average mortality and 75 per cent. of living insects is about the number that we expect

to find when we cut twigs for examination in March or April. The past winter proved to be an exception to this rule, the mortality being much greater than usual. Seldom did we find 50 per cent. of the scale-insects alive, even on healthy twigs. So many of the twigs were injured that much less than 50 per cent. of the whole number of scale-insects actually survived the winter.

## MATERIALS USED IN SPRAYING.

Various materials prepared after 15 different formulas were used in these experiments. The formulas are given below, each with a separate number, by which it is designated in the following pages. The details of preparing each are given on pages 21-28.

## BOILED MIXTURES.

- |  |   |  |
|--|---|--|
| 1.—14 lbs. lime.<br>14 lbs. sulphur.<br>40 galls. water. | } | Flowers of sulphur made into a paste and slaked with lime. Mixture boiled 30 minutes with steam. |
| 2.—14 lbs. lime.<br>14 lbs. sulphur.<br>40 galls. water. |   |  |
| 3.—20 lbs. lime.<br>14 lbs. sulphur.<br>40 galls. water. |   |  |

## MIXTURES NOT BOILED.

- |   |   |  |
|---|---|--|
| 4.—20 lbs. lime.<br>20 lbs. potassium sulphide.<br>40 galls. water.                   | } | Lime slaked and potassium sulphide dissolved separately and then put together with the proper quantity of water. |
| 5.—20 lbs. lime.<br>20 lbs. sodium sulphide.<br>40 galls. water.                      |   |  |
| 6.—20 lbs. lime.<br>10 lbs. sodium sulphide.<br>40 galls. water.                      | } | Fused sodium sulphide broken into small lumps and added to the slaking lime.                                     |
| 7.—20 lbs. lime.<br>6 lbs. sulphur.<br>6 lbs. sodium sulphide.<br>40 galls. water.    |   |  |
| 8.—20 lbs. lime.<br>11 lbs. sulphur.<br>11 lbs. sodium sulphide.<br>40 galls. water.  | } | Light sulphur flour, sulphide in lumps, both added to slaking lime.  |
| 9.—14 lbs. lime.<br>6 lbs. sulphur.<br>6 lbs. sodium sulphide.<br>40 galls. water.    |   |  |
| 10.—14 lbs. lime.<br>11 lbs. sulphur.<br>11 lbs. sodium sulphide.<br>40 galls. water. | } | Flowers of sulphur, sulphide in lumps, both added to slaking lime.   |
|   |   |  |

- |  |   |
|--|---|
| 11.—20 lbs. lime.<br>14 lbs. sulphur.<br>6 lbs. sodium sulphide.<br>40 galls. water. | } Flowers of sulphur, sulphide in lumps,<br>both added to slaking lime. |
| 12.— 8 lbs. caustic soda. }<br>40 galls. water.                                      | Dissolved soda in cold water and applied.                               |
| 13.— 7 lbs. caustic soda. }<br>40 galls. water.                                      | Dissolved soda in cold water and applied.                               |
| 14.—14 lbs. lime.<br>14 lbs. sulphur.<br>7 lbs. caustic soda.<br>40 galls. water.    | } Light sulphur flour and caustic soda added<br>to the slaking lime.    |
| 15.—20 lbs. lime.<br>14 lbs. sulphur.<br>5 lbs. caustic soda.<br>40 galls. water.    | } Light sulphur flour and caustic soda added<br>to the slaking lime.    |

#### EARLY WINTER SPRAYING.

On account of the unfavorable weather and the rush of work in late winter and spring, it would frequently be more convenient for orchardists to spray in the fall. Ordinarily in Connecticut the San José scale-insect continues breeding until about December 1. Last fall the young were observed crawling on December 2. We believe that if the spraying can be done as soon as the leaves drop or during November, that a large proportion of the young will be killed, and that they are much more susceptible to the effect of the sprays than after they are partially grown and better protected by their shells or armor. The mature insects die naturally, before spring, and it is only the half or partially grown individuals that carry the species through the winter.

The experiments in fall spraying herein described were made December 10 and later, and though satisfactory it seems reasonable that even better results might follow from a treatment made two weeks earlier in the season.

#### *Experiments at Bridgeport.*

At Bridgeport an orchard of about six hundred Japanese plum, one hundred and twenty-five peach, thirty-four pear and ten quince trees was sprayed with the lime and sulphur mixture December 10 and 11. The trees were quite close together and irregular in size. This orchard was sprayed in the spring of 1902 with crude oil and water. While this treatment was quite successful, some scales came through alive, and as the orchard is in a badly infested locality, conditions were favorable for the scale to continue to breed. Since the treatment in 1902,

trees which became badly infested were sprayed with kerosene emulsion, whale oil soap, or other similar mixtures. At the time of the last treatment, the orchard was not badly infested, but scales could be found on nearly every tree.

The lime and sulphur mixture was prepared at a near-by woodyard, where a twenty horse-power upright boiler furnished steam to cook the mixture. A fifty gallon cask was used for boiling the mixture, steam being conveyed through a hose connected to the boiler.

The following formula (No. 1) was used:

14 lbs. fresh finishing lime.  
14 lbs. flowers of sulphur.  
40 galls. water.

The sulphur was made into a thick smooth paste with water as hot as could be conveniently borne by the hands, which were used to work the lumps out of the paste. The lime was put into a barrel, hot water added, and as soon as it commenced to slake the sulphur paste was poured in, and the whole stirred to prevent the lime from "burning." By the time the lime was slaked we had a smooth mixture which was assuming a darker color, showing that the sulphur was being dissolved. About one-third the required amount of water was then added, the steam turned on and the mixture boiled vigorously for thirty minutes. This was stirred frequently, and the hose moved to different places in the barrel so that the mixture was kept well agitated. The boiled mixture was dipped out and strained into the pump barrel.

The sulphur appeared to be all dissolved, and very little sediment was present, that which accumulated in the strainer being practically all washed through with cold water. After the boiled lime and sulphur mixture was transferred to the pump barrel, cold water was added until the barrel was filled within about four inches of the top. This made practically forty gallons.

The spraying outfit consisted of a barrel pump, mounted on the end of a forty-five gallon barrel. This was placed on a low wagon, and fitted with two lines of one-half inch hose from thirty to forty feet long. To each line of hose was attached an eight-foot bamboo extension with a double Vermorel nozzle.

The trees were coated as thoroughly as possible. On some of the trees that had been sprayed with the soap and oil solutions the mixture did not seem to stick as well, and when the trees dried the coating was of a bluish grey color.

TABLE I.—LATE FALL SPRAYING AT BRIDGEPORT, DEC. 10 AND 11, 1903.

| Kind of trees. | Number of trees treated. | Condition of trees before treatment. | Materials applied.              | Out of 100 Scales on Twigs. |                                 |                    |                      | Effect of treatment on trees. |
|----------------|--------------------------|--------------------------------------|---------------------------------|-----------------------------|---------------------------------|--------------------|----------------------|-------------------------------|
|                |                          |                                      |                                 | Winter-killed.              | Killed by treatment and winter. | Alive Jan. 2, 1904 | Alive June 22, 1904. |                               |
| Pear -----     | 34                       | Moderately infested.                 | Formula No. 1—<br>14 lbs. lime. | 00                          | 93                              | 18                 | 7                    | No injury.                    |
| Peach -----    | 125                      | "                                    | 14 lbs. sulphur.                | 00                          | 91                              | 19                 | 9                    | "                             |
| Jap. Plum -    | 600                      | "                                    | 40 galls. water.                | 00                          | 84                              | 18                 | 16                   | "                             |
| Wild Plum      | 3                        | "                                    | "                               | 00                          | 85                              | 15                 | -----                | "                             |
| Quince ----    | 10                       | "                                    | "                               | 00                          | -----                           | -----              | -----                | -----                         |
| Average.       | 772                      |                                      |                                 |                             | 88                              | 17.5               | 10.6                 |                               |

No twigs were cut for the purpose of examining the scales at the time of treatment, but it was assumed that 100 per cent. were alive at that time, as the insects had been breeding up to a few days previous and there had been no cold weather to cause wholesale destruction of them. Twigs were cut January 2, 1904, and examined, and again on June 22. The figures are given in Table I. on page 8.

#### *Results at Bridgeport.*

It has already been stated that the trees were not made very white by the mixture (Formula No. 1). This is partly due to the fact that oil had previously been used on some of the trees, and partly due to the small quantity of lime in the mixture. Nevertheless, the adhesive qualities were good and the mixture could be seen on the trees in some places when the final examination was made on October 20.

On December 10-11, when the spraying was done, the scales were about all alive. On January 2, less than a month after the application, twigs were cut and examined, with the result that an average of 17.5 per cent. of living insects were found. This can fairly be attributed to the effect of the treatment, principally because no severe weather or ice storms had occurred to kill the scale-insects in unusual numbers.

The results of the second examination of twigs on June 22 are somewhat disappointing, as an average of 10.6 per cent. of living insects were found after one of the most severe winters known in recent years. In spite of the rather large percentage of living insects in this test, the writers believe that fall or early winter spraying can and soon will be practiced by the growers. We shall make further tests along this line. The following account of fall spraying at New Haven shows better results in figures than the Bridgeport experiments.

When the final examination was made of the sprayed trees at Bridgeport on October 20, they were found to be in a very satisfactory condition. The trees had made good growth, borne a crop of fruit and few living scale-insects could be found.

#### *Experiments at New Haven.*

On December 19 a number of small trees and shrubs in the western part of the city were sprayed with the lime and sodium sulphide mixture (Formula No. 5). The sulphide was broken into lumps not larger than butternuts and was added to the

lime after the slaking process was well started with hot water. After slaking the lime the whole was allowed to stand for a few minutes, utilizing the heat to help dissolve the lumps of sodium sulphide. Then cold water was added and the liquid sprayed

TABLE II.—LATE FALL SPRAYING AT NEW HAVEN, DECEMBER 19, 1903.

| Kind of trees. | Number of trees treated. | Condition of trees before treatment. | Materials applied.       | Out of 100 scales on Twigs. |                                  |                        | Effect of treatment on trees. |
|----------------|--------------------------|--------------------------------------|--------------------------|-----------------------------|----------------------------------|------------------------|-------------------------------|
|                |                          |                                      |                          | Winter-killed.              | Killed by treatment and winter.* | Alive after treatment. |                               |
| Peach .....    | 2                        | Badly infested.                      |                          | 00                          | 98                               | 2                      | No injury.                    |
| Japan Plum.    | 1                        | "                                    |                          | 00                          | -----                            | -----                  | "                             |
| Cherry .....   | 1                        | "                                    | Formula No. 5—           | 00                          | -----                            | -----                  | "                             |
| Pear .....     | 2                        | Slightly infested.                   | 20 lbs. lime.            | 00                          | -----                            | -----                  | "                             |
| Hawthorn ..    | 1                        | "                                    | 20 lbs. sodium sulphide. | 00                          | 96                               | 4                      | "                             |
| Currant .....  | 3                        | Moderately infested.                 | 40 galls. water.         | 00                          | 94                               | 6                      | "                             |
| Gooseberry.    | 2                        | "                                    |                          | 00                          | -----                            | -----                  | "                             |
| Apple .....    | 2                        | "                                    |                          | 00                          | 95                               | 5                      | "                             |
| Average...     | 14                       |                                      |                          |                             | 96                               | 4.2                    |                               |

\* Winter had killed none at time of treatment. Probably the mortality is due to both treatment and effect of winter.

upon the trees. This makes a mixture which is ash-grey in color and does not disfigure the trees and shrubs to which it is applied like the boiled mixture; but it is very caustic in its action, and therefore needs to be handled with more care. Sore spots are formed wherever it strikes the skin and it corrodes the finger nails; therefore face and hands should be well protected if this mixture is to be used.

A few trees on the station grounds were also sprayed during December, using the same formula.

Table II. contains the data connected with these tests.

#### *Results at New Haven.*

Most of the trees sprayed with lime and sodium sulphide were on rented land and were destroyed by the tenant on vacating the premises in April. The twigs examined, therefore, were cut during April instead of June, as in most of the other experiments. Nevertheless the percentage of living insects was reasonably small, though probably the winter is partly responsible. Two larger trees (apple) on the station grounds received similar treatment, and though only 5 per cent. of living insects were found in June the trees were fairly well coated with scale-insects in October at the writing of this bulletin.

### SPRAYING IN LATE WINTER AND SPRING.

#### *Westville Experiments.*

About 150 pear trees were sprayed on March 21 and 24. This is the same orchard that was sprayed last year and described in bulletin 144, page 9. The condition of the trees generally was about the same as last year, except that those treated last season with Bordeaux mixture and plain white-wash were more scaly than was the case a year ago, and also more scaly than the other trees. Nearly all were seriously infested, but had not suffered from winter injury as much as most peach and plum trees in the same region.

March 21 was a bright, still day, becoming cloudy in the afternoon, with a light snow at night and a light drizzle of rain in the forenoon of the 22.

The boiled mixture (see formula No. 2, page 5) was used on the first five rows, beginning on the northwest side. Hot water and light sulphur flour were added to the hard finishing

TABLE III.—WESTVILLE EXPERIMENTS, MARCH 21-24, 1904.

| Experiment Numbers. | Kind of trees. | Number of trees treated. | Condition of trees before treatment. | Materials applied.   | Alive after treatment. Average percentage. | Effect of treatment on trees.                        |
|---------------------|----------------|--------------------------|--------------------------------------|--|--|--|
| 1-15                | Pear.          | 50                       | Majority badly infested.             | Formula No. 2—<br>14 lbs. lime,<br>14 lbs. sulphur,<br>40 galls. water.                              | 7.7  | No injury by spray. Some injury by scale and winter. |
| 16-27               | "              | 40                       | Majority badly infested.             | Formula No. 9—<br>14 lbs. lime,<br>6 lbs. sulphur,<br>6 lbs. sodium sulphide,<br>40 galls. water.    | 6.1  | No injury by spray. Some injury by scale and winter. |
| 28-38               | "              | 40                       | Majority badly infested.             | Formula No. 10—<br>14 lbs. lime,<br>11 lbs. sulphur,<br>11 lbs. sodium sulphide,<br>40 galls. water. | 4.4  | No injury by spray. Some injury by scale and winter. |
| 39-42               | "              | 10                       | Majority badly infested.             | Formula No. 14—<br>14 lbs. lime,<br>14 lbs. sulphur,<br>7 lbs. caustic soda,<br>40 galls. water.     | 4.3  | No injury by spray. Some injury by scale and winter. |
| 43-46               | "              | 10                       | Majority badly infested.             | Formula No. 12—<br>8 lbs. caustic soda,<br>40 galls. water.  | 10.7                                       | No injury by spray. Some injury by scale and winter. |

lime and the mixture well stirred until the lime was thoroughly slaked. It was then boiled for 45 minutes in a feed cooker corresponding to a kettle over a wood fire. This outfit is shown on plate II. *b*. The next eight rows were sprayed with lime, sulphur and sodium sulphide, four receiving formula No. 9, and four formula No. 10. One row was sprayed with lime, sulphur and caustic soda (Formula No. 14) and one row with the caustic soda solution (Formula No. 12).

#### *Results at Westville.*

These spraying tests show the boiled lime and sulphur mixture to be no more efficient in destroying the scale-insects than similar mixtures containing lime and sulphur and prepared without boiling. Apparently there was not much difference in the adhesive qualities of these mixtures. When twigs were cut in June for final examination, the whitish coating could be seen, especially on the under sides of the branches of all the trees, except, of course, those receiving the caustic soda solution containing no lime. Caustic soda solution as used here (1 lb. in 5 gallons water) was less effective in destroying scale than any of the lime and sulphur mixtures. (See Table III.)

None of the pear trees of the orchard showed any injury that could be ascribed to the spraying, though some branches were killed by scale and winter. When examined October 22, most of the trees had made good growth and there were few scales on the new wood, though the old wood was well covered with dead ones. The trees sprayed with the caustic soda solution were far more scaly than any of the others. There was but little difference in effectiveness between formulas No. 2, No. 9, No. 10 and No. 14, though No. 9 was probably the least efficient.

#### *Wallingford Experiments.*

The trees sprayed at Wallingford were seven years old, of good size, and but slightly infested with the San José scale-insect. The damage to the trees by the winter was slight. The applications were made April 8. Ninety trees were sprayed, using the following formula (No. 9) :

|                               |                         |
|-------------------------------|-------------------------|
| 14 lbs. fresh finishing lime. | 6 lbs. sodium sulphide. |
| 6 lbs. flowers of sulphur.    | 40 galls. water.        |

The materials were weighed out, the lime placed in a barrel and just enough cold water added to start it slaking. When the lime began to slake the sulphur and sodium sulphide were added and the mixture kept well stirred. Just enough cold water was added to prevent the lime from becoming dry or "burning," thus keeping the mixture hot in order to dissolve the sodium sulphide, and as much of the sulphur as possible. After the lime had slaked, a small amount of water was added and the mixture allowed to stand for at least twenty minutes, with occasional stirring. It was then dipped out, strained and diluted. This preparation was of a dark muddy olive-green color, becoming greenish yellow when diluted. Upon straining this into the pump barrel no more sediment remained than with the boiled lime and sulphur mixture.

The spraying outfit consisted of a No. 6 "Hardie" pump mounted on the side of a fifty-gallon barrel. The trees were covered thoroughly. Upon drying, the coating was not as white as on the trees sprayed with the boiled mixture (Formula No. 3). This, of course, was due to the smaller amount of lime used in our mixture and the darker color which the sodium sulphide imparted to it.

About forty trees in the same block were sprayed with a mixture made after formula No. 10.

This was prepared in the same way as the above mixture. The additional amount of sulphur and sodium sulphide made very little difference in the appearance of the mixture, making it a trifle darker in color. The following table gives the chief data:

#### *Results at Wallingford.*

Though 130 trees were sprayed here by the writers, the owners of the orchard sprayed the remaining 9,000 trees with boiled lime and sulphur mixture, using for the most part formula No. 3. (See page 5.) Their work was done with thoroughness and twigs were cut from some of the trees for comparison with our tests. The mixture made after formula No. 9 did not appear to stick on the trees as well as the boiled mixture, and the figures show that it was less effective as a scale-destroyer. Though where more sulphur and more sodium sulphide were used (No. 10) the results were much better; the average number of surviving scale-insects being smaller even than where the boiled mixture was used.

TABLE IV.—WALLINGFORD EXPERIMENTS, APRIL 8, 1904.

| Experiment numbers. | Kind of trees.        | Number of trees treated. | Condition of trees before treatment.                  | Materials applied.   | Alive after treatment. Average percentage. | Effect of treatment on trees.                          |
|---------------------|-----------------------|--------------------------|---|--|--|--|
| 55-60               | Peach.                | 90                       | Slightly infested.                                    | Formula No. 9—<br>14 lbs. lime,<br>6 lbs. sulphur,<br>6 lbs. sodium sulphide,<br>40 galls. water.    | 9.5  | No injury by spray. Slight injury by scale and winter. |
| 61-65               | "                     | 40                       | "   | Formula No. 10—<br>14 lbs. lime,<br>11 lbs. sulphur,<br>11 lbs. sodium sulphide,<br>40 galls. water. | 2.4  | No injury by spray. Slight injury by scale and winter. |
| —                   | Peach and Japan Plum. | 9000*                    | A few badly infested; most of them slightly infested. | Formula No. 3—<br>20 lbs. lime,<br>14 lbs. sulphur,<br>40 galls. water.                              | 3.9  | No injury by spray. Slight injury by scale and winter. |

\* These trees were thoroughly sprayed by the owners, and do not form a part of our experiments except as a basis for comparison of results.

The orchard was examined on October 26, and the trees were found to be in a very satisfactory condition. It was difficult to find living insects on any of the sprayed trees in the orchard.

*Experiments at Southington.*

The small peach orchard sprayed last year and described on page 14 of bulletin 144 should be mentioned here. That half of the orchard receiving lime and sulphur mixtures remained quite free from scale, and though the trees suffered injury from the winter, were in much better condition than the trees in the other half of the orchard where whitewash was used and kerosene emulsion applied in August. The whitewashed trees went into the winter in a badly infested condition and were killed, or injured to such an extent that they were cut out in the spring. Twigs and branches were dead.

The remaining trees, 100 in number, were sprayed on April 4 and 5. Seventy received boiled lime and sulphur. (See formula No. 2, page 5.) The other trees were sprayed with lime, sulphur and sodium sulphide, 18 with formula No. 9, and 12 with formula No. 10.

A much larger peach orchard at Spring Lake farm, owned by Mr. L. V. Walkley, was found to be seriously infested by the scale-insect, and though winter injury was at first apparent it was considered a good place for experimentation, and about 950 large trees and 1,500 small ones were sprayed with various mixtures April 4-19. The boiled mixtures were cooked with steam from the boiler of a Kinney "Safe" portable engine. The data are presented in Tables V. and VI.

*Results at Southington.*

The percentage of living insects shown in Tables V and VI are all low and would indicate that the mixtures were efficient had not the winter killed such a large proportion of the scales. On the whole, the mixtures adhered well to the trees and could be seen on the trunks and larger branches when the twigs were cut in June. The boiled mixtures remained perhaps longer than those made without boiling, though the differences were not great. The effect of the winter on this orchard makes it difficult to draw any accurate conclusions regarding the efficiency of the various mixtures used. It seems safe to say, however, that the spread of the scale was greatly checked by



a. The noon hour in spraying time. Portable boiling plant and outfits for applying the lime and sulphur mixture.



b. Nearer view showing methods of mounting pump and barrel. The proper method is shown at the right. This is an excellent outfit for a rough orchard.





a. Applying the mixture to infested pear trees.



b. Boiling the lime and sulphur mixture in a kettle or feed cooker.

WESTVILLE EXPERIMENTS.





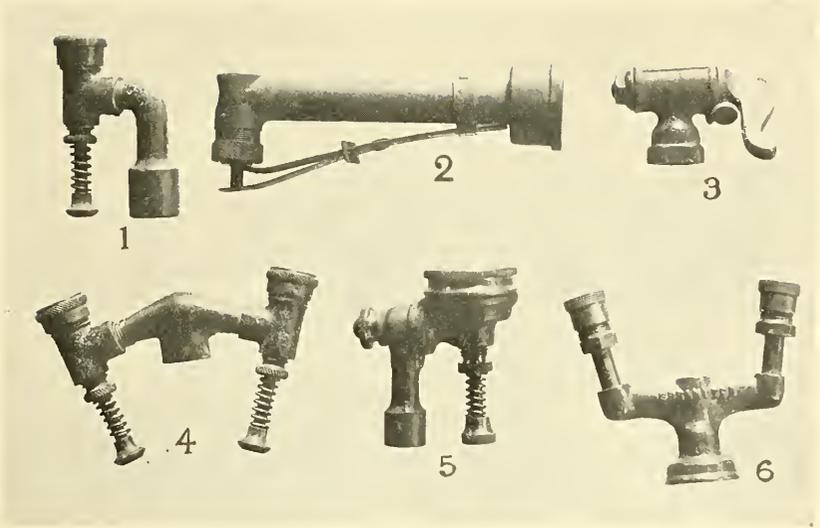
a. Improved stationary cooking plant of J. H. Hale, South Glastonbury. Capacity of this plant is about 50 barrels of mixture per day.



b. The common method in Connecticut orchards. A portable engine with boiler is placed near the orchard where water can be obtained. Steam is conveyed to the barrels through common rubber hose.

STATIONARY AND PORTABLE STEAM COOKING PLANTS.





a. Some spray nozzles in common use. 1. Single Vermorel: 2. McGowen: 3. Bordeaux: 4. Double Vermorel: 5. Mistry: 6. Double Spramotor.



b. An excellent home-made strainer and funnel.



c. Spraying a tree with a bucket pump. This is an excellent outfit for the garden and the city yard.



TABLE V.—SOUTHINGTON EXPERIMENTS, APRIL 4-19, 1904.

| Experiment Numbers. | Kind of trees. | Number of trees treated. | Conditions of trees before treatment. | Materials applied.  | Alive after treatment. Average percentage. | Effect of treatment on trees.           |
|---------------------|----------------|--------------------------|---------------------------------------|---|--|---|
| 51                  | Peach.         | 70*                      | Slightly infested.                    | Formula No. 2—<br>14 lbs. lime,<br>14 lbs. sulphur,<br>40 galls. water.<br>Formula No. 10—<br>14 lbs. lime,<br>11 lbs. sulphur,<br>11 lbs. sodium sulphide,<br>40 galls. water. | 6.9  | No injury by spray. Some winter injury. |
| 52                  | "              | 12*                      | "                                     | Formula No. 9—<br>14 lbs. lime,<br>6 lbs. sulphur,<br>6 lbs. sodium sulphide,<br>40 galls. water.   | 4.9  | No injury by spray. Some winter injury. |
| 53                  | "              | 18*                      | "                                     | Formula No. 2—<br>14 lbs. lime,<br>14 lbs. sulphur,<br>40 galls. water.   | 2.9  | No injury by spray. Some winter injury. |
| 72-104              | "              | 322                      | Seriously infested.                   | Formula No. 3—<br>20 lbs. lime,<br>14 lbs. sulphur,<br>40 galls. water.   | 4.2  | No injury by spray. Some winter injury. |
| 105-134             | "              | 1962†                    | "                                     | Formula No. 7—<br>20 lbs. lime,<br>6 lbs. sulphur,<br>6 lbs. sodium sulphide,<br>40 galls. water.   | 2.1  | No injury by spray. Some winter injury. |
| 135-169             | "              | 128                      | "                                     |   |  |   |

\* Barnes orchard. These trees were sprayed last year.  
† 1500 were small trees slightly infested.

TABLE VI.—SOUTHINGTON EXPERIMENTS, APRIL 4-9, 1904.

| Experiment numbers. | Kind of trees. | Number of trees treated. | Condition of trees before treatment. | Materials applied.  | Alive after treatment. Average percentage. | Effect of treatment on trees.           |
|---------------------|----------------|--------------------------|--------------------------------------|---|--|---|
| 158-159             | Peach.         | 12                       | Seriously infested.                  | Formula No. 11—<br>20 lbs. lime.<br>14 lbs. sulphur.<br>6 lbs. sodium sulphide.<br>40 galls. water. | 3.6  | No injury by spray. Some winter injury. |
| 163-172             | "              | 28                       | "                                    | Formula No. 8—<br>20 lbs. lime.<br>11 lbs. sulphur.<br>11 lbs. sodium sulphide.<br>40 galls. water. | 2.4  | No injury by spray. Some winter injury. |

the treatment and that all the mixtures here used were fairly efficient. The final examination made on October 26 showed the trees to be almost free from scale, though the winter injury was more serious than was supposed early in the season.

#### *Experiments at Milford.*

On April 22-23, various mixtures prepared without boiling were applied to 217 fruit trees and 256 currant bushes at Milford. The spraying season was nearly at an end and the buds were opening on plum trees, currant and gooseberry bushes. The lime, sulphur and sodium sulphide mixture (formula No. 7), lime and potassium sulphide (formula No. 4), lime, sulphur and caustic soda (formula No. 15), and caustic soda solution (formula No. 13), lime and sodium sulphide (formula No. 6) were used in these tests.

Most of the trees and bushes were moderately infested with scales, and some were killed or injured by the winter, so that leaves did not start from the branches. In some cases growth started from the upper portion of the trunks.

Data connected with these experiments are given in the accompanying table.

#### *Results at Milford.*

Trees sprayed with mixtures No. 4 and No. 15 gave the lowest percentage of living insects in June. Those receiving No. 6 and No. 13 gave the highest. No. 6 probably washed off sooner than the other mixtures containing lime, though there was little difference in this respect between 4, 7 and 15. Though no boiled mixture was employed here for comparison, it certainly seems as if mixtures Nos. 4 and 15 gave about as good results as could be expected of a boiled mixture. The sprayed trees were examined October 25. Formulas Nos. 7, 4 and 15 gave very satisfactory results, the new growth of the trees being mostly clean. Nos. 6 and 13 were less efficient and more living scales were found on trees sprayed with these preparations.

#### CONNECTICUT ORCHARDS SPRAYED IN 1904.

It is safe to say that over 100,000 fruit trees in orchards and gardens were sprayed in Connecticut during 1904 with the lime and sulphur mixtures. Mr. J. H. Hale sprayed about 16,000 trees in his orchards at Glastonbury and Seymour; Mr.

TABLE VII.—EXPERIMENTS AT MILFORD, APRIL 22-23, 1904.

| Experiment Numbers. | Kind of trees.  | Number of trees treated. | Condition of trees before treatment. | Materials applied.  | Alive after treatment. Average percentage. | Effect of treatment on trees.                        |
|---------------------|---|--------------------------|--------------------------------------|---|--|--|
| 175-181             | Japan plum.<br>European plum.<br>Cherry.<br>Pear.<br>Currant. | 20<br>135                | Moderately infested.                 | Formula No. 7—<br>20 lbs. lime.<br>6 lbs. sulphur.<br>6 lbs. sodium sulphide.<br>40 galls. water. | 6.2  | No injury by spray. Some injury by scale and winter. |
| 182-187             | Peach.<br>Plum.<br>Currant.                                   | 11<br>36                 | "                                    | Formula No. 4—<br>20 lbs. lime.<br>20 lbs. potassium sulphide.<br>40 galls. water.                | 2.3  | No injury by spray. Some injury by scale and winter. |
| 188-195             | Pear.<br>Plum.<br>Currant.                                    | 6<br>20<br>70            | "                                    | Formula No. 15—<br>20 lbs. lime.<br>14 lbs. sulphur.<br>5 lbs. caustic soda.<br>40 galls. water.  | 1.8  | No injury by spray. Some injury by scale and winter. |
| 196-201             | Peach.<br>Pear }<br>Apple }                                   | 11<br>14                 | "                                    | Formula No. 13—<br>7 lbs. caustic soda.<br>40 galls. water.                                       | 8.9  | No injury by spray. Some injury by scale and winter. |
| 202-204             | Plum.<br>Currant.   | 8<br>150                 | "                                    | Formula No. 6—<br>20 lbs. lime.<br>10 lbs. sodium sulphide.<br>40 galls. water.                   | 10.7                                       | No injury by spray. Some injury by scale and winter. |

C. E. Lyman sprayed 12,000 trees at Middlefield, and it has already been mentioned that the Highland Fruit Co. of Wallingford sprayed their entire orchard of 9,000 trees. Other growers who have done more or less spraying with the lime and sulphur mixture are A. C. Sternberg, West Hartford; C. I. Allen, Terryville; T. H. & L. C. Root, Farmington; Barnes Brothers, Yalesville; A. E. Plant & Son, Branford; G. F. Platt & Son, N. D. Platt & Son, Milford; Hall & Barnes, Wallingford, and many others.

In Keney Park, Hartford, a great deal of spraying was done in the ornamental planting of trees and shrubbery, and the writers are informed that the lime and sulphur mixture is considered preferable to any of the oils or soaps previously used here for the purpose of killing the scale.

So far as can be learned, the results of this spraying work have been on the whole satisfactory. The boiled mixture has been used in most cases, and the work done in the spring. The care with which the mixtures are made and applied, the condition of the trees, and the climatic conditions all affect the final results.

#### MAKING THE BOILED MIXTURE.

A portable steam boiler is probably the most convenient outfit for cooking the lime and sulphur mixture for the average orchard. The boiler can be set up in the orchard, preferably near a water supply, and the mixture cooked in open barrels. Common rubber hose is more convenient than iron pipe for conveying the steam to the barrels, as it can be removed more readily. The mixture can then be applied as fast as it is made. Each line of hose should be fitted with a valve. If there is no spring or stream of water near the orchard it is not impracticable to cart water to the boiler, as was done at Wallingford by the Highland Fruit Co., or to cart the boiled mixture a mile or more from the boiler to the orchard. Mr. Plant of Branford cooked the spraying mixture near his house, drawing water in a spout directly into the cooking vats from a spring on the hillside. From the boiler the mixture was carted in tight casks into the orchard about a mile distant, drawn off into the spray barrels and applied. The portable boiler can be used in any moderate sized orchard, but is capable of cooking material for large orchards. The Kinney "Safe" engine

with boiler is a common source of power on Connecticut farms, and this has probably been used more than any other forms of portable boilers for cooking the mixture, and has been very satisfactory; one of 5 h. p. capacity furnished steam to cook all of the mixture used in spraying 9,000 good sized peach trees in the orchard of the Highland Fruit Co. at Wallingford. An outfit of similar size and pattern was used in an orchard of 12,000 trees by Mr. C. E. Lyman of Middlefield. Some of the largest orchards, however, are provided with more permanent stationary cooking plants. That of Barnes Brothers of Yalesville has already been described and figured in the Report of this Station for 1902, page 120. A much more elaborate outfit has been devised by Mr. J. H. Hale of South Glastonbury. (See plate III. *a*.) Mr. Hale's plant consists of a horizontal boiler of 20 h. p. connected by pipes with eight barrels in which the materials are boiled. Above each barrel the steam pipe has a valve, and at the bottom of the barrel the pipe is fitted with a 4-way connection containing short pipes drilled with small holes for the escape of the steam. By this arrangement no stirring is necessary. The bottom of each barrel is also connected by pipe to the water supply, and by means of valves the boiled mixture can be diluted, and drawn off through the same pipes into the spray barrel or into casks to be carted away. This appears to be a good type of a large cooking plant.

It is not essential, however, for the owner of a small orchard to go to the trouble and expense of fitting up an elaborate outfit of this sort. Neither is it necessary to employ the portable boiler, as the mixture can be cooked very satisfactorily with steam from the heating plant of the house; in a set kettle or portable feed cooker, such as are in use on many farms, or even in a kettle on the stove, where small quantities are required. A feed cooker used in our Westville experiments is shown on plate II. *b*.

Finishing lime should be used where possible, as this slakes completely, leaving little sediment to clog strainer and nozzles. It comes in hard white lumps, costs more than mortar lime and generates more heat in slaking. It is important that the lime should be properly slaked, for upon this depends in a large measure the amount of sediment. Water should be added to

the lime only as needed to prevent burning. Lime needs air as well as water in order to slake well. Therefore too much water will hinder the slaking process or "drown" it, as the bricklayer says. Constant stirring is also required to prevent "burning" in spots. The weight of the lime should equal or slightly exceed that of the sulphur. A great excess injures the mixture. Sulphur should be used either in the form of the sublimed "flowers," or the finely ground "light sulphur flour." The particles are somewhat smaller in the sublimed product, but there is a greater tendency to become lumpy under pressure and this, of course, retards solution. The writers believe that the light flour is the better, all things considered.

The sulphur should be added to the lime before slaking, as the heat of the slaking lime can be utilized to help dissolve the sulphur, though this heat alone will probably dissolve only a small portion of it. It is well to stir the materials thoroughly during the slaking process to prevent "burning" of the lime. Water should be added as needed, and after the lime is slaked the barrel can be filled about one-third full of water and the steam or heat applied. The mixture should boil for a period of time varying from forty-five to sixty minutes. Of course, the heat can be applied during the slaking process, and in this case it should be turned on for at least an hour to make sure that the sulphur is well dissolved. In our Bridgeport experiments, the sulphur was made into a paste by working it over with the hands, warm water being used. This prepared the sulphur for more immediate action, and the materials were boiled only thirty minutes and very little or no sulphur remained undissolved. But in most cases it will be found more economical to add dry sulphur to the slaking lime and boil it for a longer time. There should not be more than a pint of sediment for each barrel of mixture if properly made, and the mixture should be strained when put into the spray barrel.

Salt may be added to this mixture and is still used in some orchards, though in most cases it is omitted. In previous tests conducted by us and by many other experimenters, salt was found to have no value either in making the mixture more adhesive or in rendering it more destructive to the scale-insects.

## MAKING THE MIXTURE WITHOUT BOILING.

The fact that the ordinary lime and sulphur mixture requires boiling has kept many from using it, in spite of the small cost of the mixture, even when boiled. In large orchards, where suitable outfits can be procured, the question of boiling is not such a serious one, but in hundreds of small orchards and gardens the trees would be sprayed if some easily made mixture could be used. There is a demand for a mixture that can be prepared without hot water, and this has prompted us to try several things with the view of possibly supplying this demand.

Last year we used potassium sulphide and found it a valuable addition to our list of scale insecticides. It has been used the present season with good results. It is too expensive for large spraying operations, but is very convenient for spraying a few small trees or shrubs near the buildings or in a city yard. Knowing that sodium compounds are usually cheaper than potassium compounds, and have similar properties, we sought the former, and through considerable correspondence we learned that two grades of sodium sulphide could be obtained at a low price. The crystallized form contained less than 30 per cent. of sodium sulphide and cost  $1\frac{3}{4}$  cents per pound in 500 lb. barrels. The fused form has nearly 60 per cent. of sodium sulphide and costs  $2\frac{3}{4}$  cents per pound in drums of over 700 lbs. Both kinds were tested in the laboratory and mixtures with lime were made from each and sprayed upon trees. The mixture from the crystallized sulphide did not stick as well as that from the fused, and as it contained such a small quantity of sodium sulphide, was not employed extensively. The fused sulphide, however, promised to be of value and was used quite extensively in these experiments. The worst feature about it is the form in which it comes—in a fused mass, hard as a rock. When freshly broken it is of a reddish color, resembling the mineral cinnabar. On exposure to the air it soon blackens and gives off a strong odor of sulphuretted hydrogen. The large lumps are hard to dissolve, but the finely pulverized material is very soluble in cold water. The entire mass was broken with hammers into small pieces—no larger than a hen's egg. In this form it would nearly all dissolve when added to the slaking lime, but in uniting with the lime to form calcium sulphides caustic soda was also formed, and the mixture was so very caustic that it went through the skin, making sore spots wherever it struck.

In our laboratory tests the dissolved sodium sulphide was found to be an excellent solvent of sulphur, exceeding caustic soda when in cold solution, though the latter would dissolve more sulphur if heated. In discussing the properties of this sodium sulphide, Director Jenkins suggested to the writers that by using this as a solvent for sulphur in connection with lime, the causticity would probably be much reduced—which was found to be the case.

An effort then was made to prepare a mixture without boiling based on the same cost of materials as the boiled mixture. Formula No. 7 is the result, and No. 8 was simply a test of larger quantities of sulphur and sodium sulphide with the same amount of lime. When prepared after either formula, this mixture is no more caustic or unpleasant to handle than the boiled lime and sulphur mixture, and while we are not yet prepared to state that it is just as good, it certainly has given favorable results that warrant further trial. If this sodium sulphide could be obtained in pulverized form it would be much more convenient to use, and we have taken up the matter with the manufacturers in Germany to try and bring it about.

In making the mixtures without boiling, the unslaked finishing lime was used. This generates more heat in slaking than the mortar lime, and heat aids in dissolving the sulphides. The best solution resulted when the greatest amount of heat was produced by the slaking lime. The light sulphur flour is the grade of sulphur best adapted for the unboiled solutions. As has already been mentioned, this does not form as many dry lumps as the flowers of sulphur. Boiling will break up some of these lumps, but it is more necessary in the unboiled mixture to use the form that is least inclined to become lumpy.

Cold water was used in most cases. Warm, or hot water, of course, assists greatly in slaking the lime and dissolving the sulphides. But it requires nearly as much of an outfit to heat the water as to boil the lime and sulphur mixture, and the chief object of an unboiled mixture is to do away with such an outfit.

*Lime and Potassium Sulphide Mixture.*

Formula No. 4.  $\left\{ \begin{array}{l} 20 \text{ lbs. lime.} \\ 20 \text{ lbs. potassium sulphide.} \\ 40 \text{ galls. water.} \end{array} \right.$

This can be prepared in two ways, either of which is satisfactory.

1. Place the weighed potassium sulphide in a half-barrel and add three or four pails of water. Stir occasionally. Place the lime in a barrel and slake carefully, the same as for a boiled mixture. When the potassium sulphide has all dissolved add it to the slaked lime, with water to make about one-third the required volume. Then strain the mixture into the pump barrel, dilute to make the right proportion and apply to the trees.

2. Weigh out the materials. Put the lime in a barrel and start it slaking. When it begins to slake vigorously add the dry sulphide. Then stir the mixture vigorously and add just enough water to keep the lime from burning. After the lime has slaked, add a small quantity of water and allow the mixture to stand for a short time, with frequent stirring. Then dilute and apply.

The above formula has been given in several Experiment Station bulletins with directions that the potassium sulphide be dissolved in warm water and the lime slaked with this solution. We do not recommend this method, because the sulphide when dissolved makes a soapy, caustic solution which, when added to the lime, immediately coats over the lumps, excluding the air and checking the slaking process. Besides, there is practically nothing gained by this method.

*Lime, Sulphur and Sodium Sulphide Mixture.*

|          |   |           |   |
|----------|---|-----------|---|
| No. 5. { | 20 lbs. lime.<br>20 lbs. sodium sulphide.<br>40 galls. water.                   | No. 8. {  | 20 lbs. lime.<br>11 lbs. sulphur.<br>11 lbs. sodium sulphide.<br>40 galls. water. |
| No. 6. { | 20 lbs. lime.<br>10 lbs. sodium sulphide.<br>40 galls. water.                   | No. 9. {  | 14 lbs. lime.<br>6 lbs. sulphur.<br>6 lbs. sodium sulphide.<br>40 galls. water.   |
| No. 7. { | 20 lbs. lime.<br>6 lbs. sulphur.<br>6 lbs. sodium sulphide.<br>40 galls. water. | No. 10. { | 14 lbs. lime.<br>11 lbs. sulphur.<br>11 lbs. sodium sulphide.<br>40 galls. water. |

These mixtures are made practically in the same way as the last preparation. It is important to use as little water as possible in slaking the lime and to let the lime get well started before the other ingredients are put in.

Weigh the materials, put the lime in a barrel, add water, and when it begins to slake vigorously add the dry sulphur and lumps of sodium sulphide. Keep the whole well stirred. When the lime is slaked, add a few pails of water, and let the solution

stand for about twenty minutes. It can then be strained, diluted, and sprayed upon the trees. The sodium sulphide used in these mixtures is dissolved by the water, aided by the heat of the lime. The caustic properties of the sulphide and lime, together with the heat, dissolve the sulphur flour, thus forming sulphides of lime similar to those formed in a boiled lime and sulphur mixture.

This appears much like the regular boiled mixture, except that it is olive-green in color instead of yellow.

*Lime, Sulphur and Caustic Soda.*

Formula No. 14.  $\left\{ \begin{array}{l} 14 \text{ lbs. lime.} \\ 14 \text{ lbs. sulphur.} \\ 7 \text{ lbs. caustic soda.} \\ 40 \text{ galls. water.} \end{array} \right.$

In this mixture caustic soda is added to assist in dissolving the sulphur. Start the lime slaking and add the sulphur and caustic soda. The caustic soda causes violent boiling of the mixture, and water must be added at intervals to prevent the mixture from boiling over the top of the barrel. The mixture becomes reddish in color very soon after adding the caustic soda, and by the time the action ceases the color reaches deep reddish brown. Then dilute with water and apply. This mixture is convenient and effective. Common household lye can be used instead of caustic soda.

This is similar to the mixture originated at the New York (Geneva) Experiment Station and used extensively there in the orchards. (See Bulletins 228 and 247 N. Y. Expt. Station, Geneva, N. Y.)

*Caustic Soda and Water.*

No. 12.  $\left\{ \begin{array}{l} 8 \text{ lbs. caustic soda.} \\ 40 \text{ galls. water.} \end{array} \right.$       No. 13.  $\left\{ \begin{array}{l} 7 \text{ lbs. caustic soda.} \\ 40 \text{ galls. water.} \end{array} \right.$

Dissolve the weighed amount of caustic soda in water and dilute ready for use. This solution is very disagreeable to use; every drop that strikes the skin makes it smart violently.

OUTFIT FOR APPLYING THE MIXTURE.

Spraying with the lime and sulphur mixture is looked upon as one of the arduous and disagreeable jobs of the fruit grower. The spring spraying comes at a time when each day brings the grower nearer the regular spring work. Especially if a few days of bad weather occur, the spraying must be rushed as fast as possible. The above reasons alone are suf-

ficient to show that the best and most practical outfit procurable should be used, to make the work go as smoothly and pleasantly as possible and to obviate the loss of time from the breaking down and the giving out of an inadequate spraying outfit.

As spraying is more and more practiced, the good and bad points of spray pumps and their accessories are being brought out.

Many inquiries have come to the station during the past year in regard to the best kinds of spray pumps, nozzles, etc. It seems, therefore, advisable to describe a practical outfit in this bulletin.

#### *Pump, Barrel and Carriage.*

It has not yet been demonstrated that power sprayers are as practical or can take the place of the hand barrel pump for orchard work in Connecticut. The first thing to consider is the pump, which should be of large size, furnishing ample pressure to supply at least two lines of hose fitted with double Vermorel nozzles. This should be made so that when it is mounted on the end of a fifty gallon cask, the highest point should be the fulcrum or post on which the pump handle or lever works. This should be just high enough to give the handle a good working distance,—that is, when pushed down it will just clear the chine of the barrel. The air chamber should be under the handle post, the larger part of it being in the barrel out of sight. It is essential that the cylinder be of good size and the plunger must be packed in such a manner that it can be tightened quickly and easily. The valves should be made as simple as possible. It must be possible to take the whole pump apart and put it together with a monkey wrench. The lime and sulphur mixture requires a pump with an agitator that will keep the liquid well mixed.

There are several pumps on the market which are of this type. One which has recently been brought to the attention of the Connecticut fruit grower is the "Hardie." This pump has several features worth pointing out. The plunger is made so the packing can be tightened by turning the plunger rod with a wrench without removing it from the cylinder. The plunger consists of two cone-shaped pieces, one screwing upon the other; the groove between them is wound full with cotton waste. This is pushed into the cylinder and a projection on the lower cone holds it stationary while the upper one is screwed

down by turning the rod. This crowds the packing together until it fills the cylinder. The mixture enters the pump through a strainer at the side instead of the bottom, and the agitator works up and down in front of this place, keeping the strainer from becoming clogged.

Among the pumps used in Connecticut that have given fairly good satisfaction are the "Eclipse," manufactured by the Morrill & Morley Co., Benton Harbor, Mich.; the pumps manufactured by the Goulds Mfg. Co., Seneca Falls, N. Y., of which the "Pomona" is a type; and the "Century," manufactured by the Deming Co., Salem, Ohio. These pumps all have some good features as well as weak ones. All pumps should be made so that they can be removed from the barrel more readily.

Plate I. *b.* shows one of the most practical ways of mounting a pump. The pump is mounted on the side of the barrel instead of the end. One can readily see many advantages in this method. The barrel is less liable to tip over in rough places. It is much easier to fill than when mounted on the end. When a strainer like the one described is used a hole only large enough to take in the pipe is necessary in filling the barrel. This can be plugged tightly. A drag or sled is made of two pieces of 4 x 6 inch scantling for runners, and spiking a platform of plank to the upper edge of them. The front ends of the runners are rounded. The barrel is placed crosswise of this sled on wooden blocks cut to fit the curve of the barrel and fastened to both barrel and sled. There should be standing room behind the barrel for the man who pumps. A piece of scantling is placed close to each side of the barrel and fastened to the wooden blocks, thus forming a frame around the barrel, securely fastening it to the sled. Iron straps may also be used for holding the barrel in place. Plate I. *b.* shows two pumps. One is mounted in the manner just described, the other is placed lengthwise of the runners. It took but a short time to prove which was the practical way of mounting. Where it was mounted lengthwise there was more chance for the barrel to tip over. The handle was at the side and liable to catch on the trees and branches in going through the orchard. The man pumping was continually in the way of the hose on one side. The hose leads from the back and front of the outfit instead of the sides, as in the other case, consequently the hose was continually bent at the point of attachment and soon gave out.

When the barrel was mounted crosswise of the drag, the man pumping stood back on the platform out of the way of the men handling the hose.

Pump manufacturers make outfits consisting of small-sized barrels holding from 15 to 25 gallons, mounted on wheels, for hand use in the garden. The ordinary barrel pump is used in these outfits, though sometimes of a smaller size than would be chosen for orchard work. These hand wheel outfits are most useful in the home garden of four or five acres. For still smaller places, like the ordinary city yard, or for spraying a few large trees, a bucket pump costing from four to six dollars is perhaps the best form of outfit. Such a pump is shown on plate IV. *c.* and can be used with any wooden pail or bucket. The small compressed air pumps on the market, and the knapsack pumps, will answer the purpose, but most of them are badly corroded by the lime and sulphur mixtures.

Clean water should be run through pump, hose and nozzles at the end of each day's work, and at the end of the spraying season the pump and nozzles should be well cleaned and oiled to prevent corrosion.

#### *Hose.*

For general spraying work, we prefer half-inch rubber hose in lengths of not less than 25 feet. Where two lines of hose are used it is frequently of advantage to have one of them 50 feet long for reaching the opposite side of trees or for working a long distance behind the pump. Most of the pumps are sent out with a piece of hose seven or eight feet in length, which is altogether too short for practical work. This hose, though of good quality, usually costs 16 or 18 cents per foot, making it too expensive for orchard use. We have been using a grade of hose which can be purchased from the rubber stores in the larger cities of Connecticut for eight or nine cents per foot. This hose has been very satisfactory, withstands the pressure, and for dragging about in the orchard seems to wear about as long as the more expensive hose. The points of breakage are always near the ends where sharp bending occurs.

#### *Extension Rods.*

For reaching into the trees it is necessary to use some form of rod six to ten feet long, and the lightest and best is a hollow one which screws onto the end of the hose and permits

the liquid to pass through it. Bamboo rods have been designed for this purpose, each consisting of a brass tube inside of a piece of bamboo. Screw connections are made between the brass rod and the hose at one end, while the other end takes the nozzle. The hose connection should also have a stop cock or "shut off" to avoid wasting the spray mixture. The bamboo extensions are light and convenient, but not durable, as the screw connections soon break off or the bamboo splits or becomes loosened on the brass rod. For this reason many orchardists have adopted an extension made of quarter-inch gas-pipe. Though heavier and harder to hold in the hand on account of the smaller diameter, the gas-pipe rods are more durable and considerably cheaper than the bamboo extensions.

#### *Nozzles.*

The double Vermorel nozzle has been used probably more than any other in orchard spraying and has given satisfaction. For large trees the MacGowen is preferred by some operators. During the past season the Gould's Mfg. Co. has put upon the market a new nozzle called the "Mistry." The "Mistry" is a large and somewhat complicated nozzle that gives a fine spray. The greatest disadvantage of this nozzle is that the caps wear out very quickly and often need replacing once or twice each season. The lime and sulphur mixture, when forced in a thin stream under great pressure against the cap, will soon wear and enlarge the opening on any of these nozzles. If the caps could be made of hard steel instead of brass they would last much longer. Some growers praise the "Mistry" highly, while others prefer the double Vermorel. The Spramotor Co. has originated a nozzle fitted with hard steel disks, through which the openings are made. These disks can be replaced easily and while we have not yet given these nozzles a practical trial in the orchard, they appear to work nicely and throw an excellent spray. One man who makes a business of spraying trees informs me that the Spramotor is the best nozzle that he can find for his work. The nozzles of the "Bordeaux" and "Seneca" type give a fan-shaped spray, are heavy and not readily cleaned after being set, and the handles are hook-shaped and get caught in the branches. For these reasons they are not well adapted to orchard work. These nozzles are all shown on plate IV. *a.*

*Strainer and Funnel.*

We have found a home-made strainer the most satisfactory, as the ready-made strainers are not of the proper size or shape for practical use. The strainer and funnel that we have adopted consists of a common wooden pail with the bottom reinforced and a piece of one and one-half inch iron gas-pipe screwed through it. About half-way up on the inside of the pail is tacked a circular piece of iron wire cloth, having at least 20 meshes per inch. A finer strainer is not needed and only hinders the work, as the men must wait for the liquid to go through. This kind of a strainer is always convenient, will hold a pailful at a time, and there is more straining surface than if the wire was placed at the bottom. It is shown on plate IV. *b*. The materials for such a strainer cost not more than fifty cents, and the wire cloth can be obtained from the wire stores in New Haven and Hartford.

## SUMMARY.

1. This station conducted spraying experiments in Bridgeport, New Haven, Westville, Wallingford, Southington and Milford during the past season, to kill the San José scale-insect. Over 4,000 trees were treated. Nearly 800 were sprayed in December and the remainder in March and April. Fifteen different formulas were used in the preparation of the materials; mixtures of lime and sulphur were used chiefly.

2. The winter injury to trees was very serious, many orchards being permanently damaged. This makes it impracticable to express in exact figures in all cases the results of these experiments. Fifty per cent. of the San José scale-insects were also destroyed by the winter in many localities.

3. Fall or early winter spraying gave good results, both where the boiled and unboiled lime and sulphur mixtures were used, and will doubtless soon be practiced by fruit-growers.

4. The boiled mixture of lime and sulphur, using as much or a little more lime than sulphur, is probably as effective and as inexpensive as any mixture for ordinary orchard work. Of the mixtures made without boiling, the potassium sulphide and lime is excellent for a few small trees or shrubs, but is rather expensive for spraying large trees; the lime, sulphur and sodium sulphide mixture is a promising one, worthy of further trial, and giving good results in these experiments. Lime and sodium sulphide make a mixture that is less efficient than those just mentioned, nearly as caustic in its action as caustic soda, and workmen need protection in handling it. At present sodium sulphide (fused), though inexpensive, is not put up in a convenient form for orchard use.

5. Caustic soda as used in these tests did not give as good results as most of the other mixtures. Its caustic action makes it hard to handle and the hands and faces of the men should be protected.

6. Probably 100,000 fruit trees in Connecticut orchards and gardens were sprayed with the lime and sulphur mixtures during the Spring of 1904. The results were generally satisfactory.

7. A satisfactory spraying outfit consists of hand pump in barrel mounted on drag or wagon and fitted with two lines of half-inch hose at least 25 feet long, extension rods and nozzles, as described in the foregoing pages.



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