State of Rhode Island and Providence Plantations.

THE SAN JOSÉ SCALE

(Aspidiotus perniciosus, Comst.)

AND

METHODS OF TREATMENT.

A. E. STENE.

FIG. 1.—Female San José Scale. After Atwood. See page 24.

Joint Bulletin of the State Board of Agriculture and Extension Department of the Rhode Island College of Agriculture and Mechanic Arts.

1908.

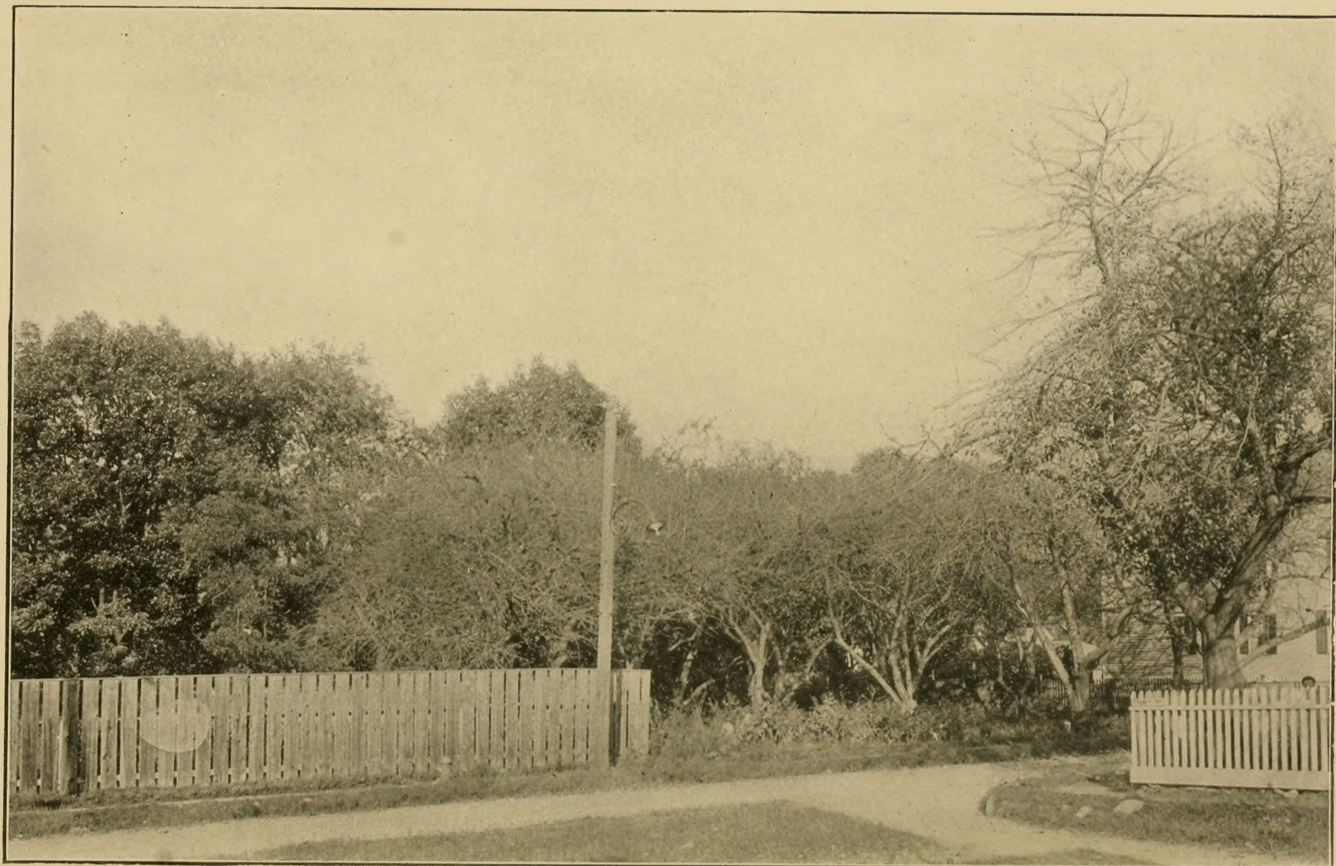

PLATE I.—Part of large orchard destroyed by scale, East Providence. Photograph taken in July, 1907.
This picture illustrates the condition of hundreds of orchards in the state.

ERRATA.

In the second paragraph on page 13, line five should read as follows: "*have fallen in the autumn, or just* **before** *they come out in the spring.*"

Note further discussion of this topic on page 64, and remember that the principal spraying for the San José Scale is given when the trees are dormant. Summer spraying with kerosene emulsion is sometimes given, but only to check the scale until effective winter treatment can be given.

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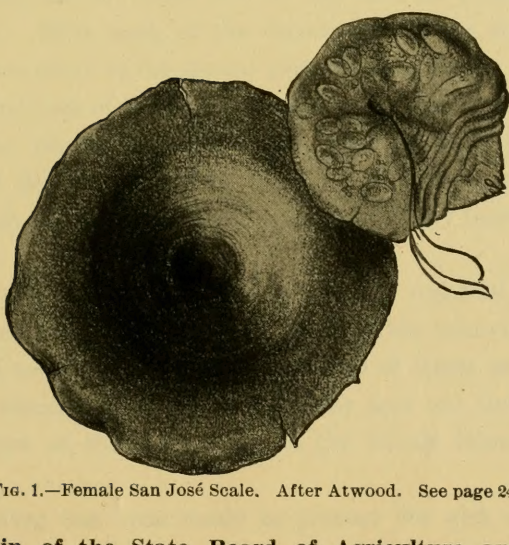

FIG. 1.—Female San José Scale. After Atwood. See page 24.

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PREFACE.

This bulletin is written in response to a very urgent demand for information on the San José scale, as evinced by the hundreds of letters which come into the office of the Extension Department of the College every year with questions regarding this insidious fruit pest and methods of destroying it or preventing its ravages.

The bulletin is divided into two parts. The first part, in large type, is in the nature of a summary, and presents briefly the essentials in formulas and directions for treatment of the scale for quick perusal and for those who do not care for a further study of the subject. With each of the statements in the summary, page references are given to the second part of the bulletin.

The second part of the bulletin takes up a fuller discussion with an endeavor to present a history and description of the scale and methods of dealing with it in the light of present knowledge and practice such as the up-to-date Twentieth Century farmer is demanding.

The bulletin contains but little original material, except such general observations as have been made on the behavior of the scale under local conditions and the tabulation of losses as shown by information obtained through the circular sent out the past autumn to the names on the mailing list of the Rhode Island Experiment Station.

An endeavor has been made to present the gist of information which seems, in the opinion of the writer, essential to a fairly complete knowledge of the scale and methods of treatment, but undoubtedly much has been left out, and if anyone wishes to pursue the subject further, he can refer to the following books and publications, from which the writer's information is largely drawn:

Economic Entomology, by Dr. John B. Smith, published by Lippincott.

Fumigation Methods, by Willis G. Johnson, published by Orange Judd Co.

Spraying of Plants, by Lodeman, published by the Macmillan Co.

Bulletins of the N. Y. State Museum at Albany, by E. P. Felt.

Bulletins by Dr. Howard and Dr. Marlatt and others of the Department of Agriculture at Washington.

Bulletins of various experiment stations in the United States, but principally those of New York, Delaware, Massachusetts, Connecticut, California, and Washington; also articles from the Rural New Yorker, Country Gentleman, and the New England Homestead.

ACKNOWLEDGMENT.

The writer is greatly indebted to the Bureau of Entomology, Department of Agriculture, at Washington, for co-operation in securing estimates of damage done by the scale; to the Rhode Island Experiment Station for the use of mailing machine in sending out circular letters; to the Federal Department of Agriculture and various experiment stations, and manufacturers of spray apparatus, for use of cuts, full credit of which is given elsewhere; and to the following persons for submitting estimates of value of fruit trees: L. G. K. Clarner, Arnold's Mills, R. I.; Cyrus Miller, Haydenville, Mass.; Prof. Craig, Cornell University: Prof. U. P. Hedrick, New York Experiment Station, Geneva; Prof. William Stuart, Vermont Experiment Station ; and Geo. T. Powell, Ghent, N. Y.

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LIST OF CUTS.

FIG. 2.—San José scale on twig, enlarged five times.
After Atwood.

SUMMARY.

Injurious insects take an enormous toll from the products of the farm, garden, and forest. It amounts to from six to eight hundred millions of dollars a year. Pages 14 to 16.

Erroneous ideas regarding the character of injurious insects and plant diseases lead to a great deal of useless expense and labor in the attempts to control them. Pages 16 to 19.

The San José scale was introduced from China into the San José Valley of California sometime previous to 1873. In 1887 it was found in the East, and since that time it has spread, principally through the transportation of nursery stock, over a large part of the United States. Pages 20 and 21.

The first intimation of its presence in Rhode Island was gotten in 1897. It is probable that it was introduced into the State a few years previous to that time. It is now found in every town in the State, and in a large majority of the orchards. Pages 21 and 22.

When only a few of the San José scale are present, the insect is difficult to detect. When a tree or shrub becomes thoroughly infested, the scale forms a grayish, scurfy coating on the bark. On rubbing the bark vigorously, a yellowish liquid appears, due to the crushing of the insects underneath the scale. On young, green wood, and on light or green-colored fruit, a reddish discoloration can be seen around each scale. A small, low-priced magnifying glass is of great aid in detecting the insect. Pages 22 and 23.

The San José scale survives the winter in the larval stage, and matures in the early spring. Unlike most of the insects that we are acquainted with, the San José scale does not lay eggs, but produces its young alive. The period of bearing young extends, for each female, over five or six weeks, and a total of from three to four hundred are produced. The young larva remains active for about a day and a half, after which it settles down and begins to secrete over itself the scale covering. The females never move again, but the males when mature appear as minute, two-winged, fly-like insects. The San José scale insect matures in about forty-five days from birth, and we have here in the North from three to four generations. Pages 23 to 26.

The host plants of the San José scale include a large number of the trees and shrubs usually grown in nurseries. Pages 27 to 31.

The enemies of the San José scale include a number of very minute, parasitic-insect enemies, and the well-known ladybird beetles. Pages 32 to 34.

The San José scale is distributed largely by means of nursery stock. For short distances it may be carried by the wind, insects, birds, and even higher animals. It may spread from tree to tree by interlacing branches. Page 34.

The loss due to the scale in the State of Rhode Island amounts, at a conservative estimate, to over two hundred thousand dollars. Pages 35 to 38.

The San José scale is changing the fruit-growing of the State. Small growers are becoming discouraged, and only those who are taking up a fight against the scale in an energetic manner have faith in the future of fruit-growing. Pages 38 to 40.

Fruit-growing is gravitating into the hands of specialists. A higher class of fruit and better prices will be the rule in the future. Page 40.

The chances of saving a tree badly infested with the San José scale depend upon its vitality primarily, but also on the determination of the grower to continue fighting the scale. Page 41.

The law of supply and demand will so regulate the price of fruit that it will cover the additional cost of spraying. Pages 41 and 42.

The present means of controlling the San José scale may be divided into two classes: First, *preventive or general orchard treatment.* Plant stock free from scale; keep it in a thrifty condition; and plant and prune so as to make the labor of subsequent spraying economical. Pages 42 to 44. Second, *spraying.* Spray thoroughly in early spring or late fall with an effective solution. Trees badly infested should be sprayed both spring and fall. The standard remedy to-day is the lime-sulfur wash, made up as follows:

Lime, fresh, unslaked	15–20 lbs.
Sulfur	15 lbs.
Water	50 gals.

Slake the lime with hot water enough to keep it well covered. Make the sulfur into a thin paste with a small quantity of hot water, and add to the lime while slaking. Stir thoroughly, and when slaking ceases, add water to make 20 or 25 gallons. Boil from 45 minutes to one hour in a kettle, or by means of steam. Strain through a wire sieve of 20 meshes to the inch into spray barrel or tank, and add water to make 50 gallons. Apply at once. Pages 44 to 56.

Excellent remedies are obtained from petroleum. Miscible, or so-called "Soluble" oils, either home-made or some of the well-prepared proprietary brands, are effective and can be recommended for those who can not use the home-made lime-sulfur wash. Pages 56 to 60.

A discussion of the comparative value of the lime-sulfur and miscible oils is given on pages 60 and 61, and a few other spray solutions used for the San José scale are mentioned on pages 61 and 62.

The time of the year to spray depends a little on the extent of the infestation and on the solution used, but principally on the convenience of the orchardist. Generally speaking, it should be given just after the leaves have fallen in the autumn, or just after they come out in the spring. (**The one absolutely important consideration in applying a spray remedy against the scale is thoroughness.**)

A good spray outfit, suitable to the kind and amount of spraying to be done should be secured. The essentials are a good pump, sufficient length of hose, an extension rod, and a good nozzle of the Vermorel type. Pages 65 to 73.

Fumigation with hydrocyanic-acid gas is useful under some conditions. As an orchard remedy it is of little value in the East. Pages 74 to 77.

As a preventive of distribution of the scale through nursery stock, fumigation is worthy of careful consideration. Pages 77 to 83.

As a remedy for the San José scale in greenhouses, hydrocyanic-acid gas is practically a specific. Pages 83 to 87.

The dipping of nursery stock is being recommended as a substitute for fumigation, and is worthy of trial. Pages 87 and 88.

INTRODUCTION.

During the last few years a careful study of injurious insects has brought out the not very pleasant, yet interesting, fact that they take an enormous toll from the annual production of crops in the United States. Dr. Marlatt, in a recent paper in one of the yearbooks of the Department of Agriculture, estimated that the annual loss to *growing* farm crops alone, due to insect depredation, amounts to about 10 per cent. of the total value of these crops. For the year in which the paper was written, the total loss due to insect injury was about five hundred millions of dollars. If we add to this the loss to forest crops and products of all kinds in storage, there was for that year a grand total of between seven hundred and fifty and eight hundred millions of dollars. And yet this does not include the total loss due to insects, for we have learned that they enter into our interests in various ways which were not known or suspected until recent times. Take, for instance, the carrying of disease by insects which results in loss of health, productive capacity, and attendant expenses, to say nothing about the frequent loss of human life.

The only reason why farmers have submitted to their part of the heavy tax without complaint, except when the enormous increase of some particular species of insect has caused an uncommonly large or total destruction of crops, is: *first,* that they have not always realized its enormity, the levy being generally made before the crop is harvested and measured; *second,* the comparative familiarity with loss due to insects and the consequent indifference; and *third,* the idea that the loss is more or less inevitable and must be accepted as a matter of course.

A study of our injurious insects has further revealed the fact that a large percentage of our worst pests are foreigners, and have gained entrance to our country through the avenues of transportation in one way or another. In a recent exhibition of the Department of Agriculture at the World's Columbian Exposition, as described by Dr. Howard in the Yearbook for 1897, 602 different species of insects, 171 of which were imported species, were shown as being more or less injurious to agricultural products. From this group were again separated out 73 which were especially injurious, and of these 30 were native, 37 imported, and 6 of doubtful origin. Among the imported ones may be mentioned the San José scale, gypsy moth, brown-tail moth, elm-leaf beetle, codling moth, cabbage worm, cotton boll weevil, oyster-shell scale, pea weevil, buffalo moth, leopard moth, asparagus beetles, and Mediterranean flour moth.

Once in this country and acclimated, which most of them become in a comparatively short time, they have found an abundant food supply and more or less freedom from the parasitic and predaceous enemies which harassed and kept them in check in their native habitats. Insects have enormous reproductive powers, and with the natural checks removed, these introduced pests have increased at an alarming rate in the case of some species, and have spread consternation in the ranks of many people who grow the crops on which these insects feed.

It is well to remember that we have not as yet all the injurious insects of foreign countries which are liable to be imported. Dr. Howard, in the article already quoted, describes a number of injurious insects from Europe, Australia, West Indies, Mexico, and other countries, which are liable to be imported at any time, and which are injurious to species of fruit raised in the United States.

A national quarantine law similar to that now carried out by the State of California, through which a thorough inspection can be made of all plants and material which are liable to bring these insects into our country, is an immediate necessity. It has been recommended to Congress on several occasions by Dr. Howard and others, but so far no steps have been taken to pass such a law. The only thing that can be done at the present time is for the inspectors of the different maritime States to keep a sharp lookout for importations of plants; and nurserymen and others who order from foreign countries can help materially by notifying the inspectors of the arrival of consignments of such plants in order that inspections may be made if necessary.

Many of the introduced insect pests just mentioned have created great havoc locally in many parts of the country, but there is perhaps no insect which has gained such wide-spread distribution throughout the whole country, and caused such large losses generally, as the San José scale. On account of its wide dissemination and detrimental work, there is an enormous amount of published information available regarding the pest, but much of this literature is of little or no interest to the average grower. Nevertheless, in order to intelligently take up the problem of dealing with the insect, he should have a thorough knowledge of its life history and the various methods of fighting it, together with the reasons for the various recommendations. This part of the bulletin will, therefore, be devoted to presenting this information as briefly and plainly as possible. There is also a little information in regard to the history of the San José scale in this country; the struggles which have been going on against it in the different sections, and especially in this State; its present status and the prospects for the future, which will be of some value in itself to the average citizen interested in the presence of the scale as an economic problem, and also as throwing light on the importance to the agriculturist of being on the lookout to prevent the introduction and dissemination of other pests which, fortunately, have not as yet reached our country.

Popular Fallacies Regarding Insects and their Control.

Not knowing the life history or character of insects, many suppose that a spray good for one kind will also be efficient for others. Having learned that certain stomach poisons, such as, Paris green, arsenate of lead, etc., are effective against potato bugs, they are surprised to find out that these are of absolutely no use for the San José scale. Still others show less knowledge of the principles of spraying in believing that any spray solution, as for example, Bordeaux mixture, should be good for the whole category of plant ills. It can not be emphasized too strongly that insects must be treated in a different way from plant diseases, and also that the species of these two classes of plant enemies vary greatly in their habits and life history, and a thorough knowledge of each is necessary in order to work intelligently in destroying or controlling them.

It is of special importance to the modern farmer to know that insects may be divided into two classes, according to the manner in which they take their food: 1. Those which chew the leaves or other parts of the plant. 2. Those which insert a beak or tube into the tissues of the plant and suck up its juices. Prominent examples of the former are various injurious beetles, such as, the potato and rose beetles, popularly termed "bugs," and their larvæ, and the caterpillars of the various butterflies and moths, such as, the cabbage butterfly, the mourning cloak butterfly, and the gypsy and brown-tail moths. As an example of the latter may be mentioned the true bugs, to which belong plant lice, scale insects, the squash bug, etc. The former can be quite readily reached in many cases with some form of stomach poison put upon the outside of the leaves or other parts of the plant on which they feed, but it is evident that the latter class, since they absorb all their food from the interior of the plant, can not be reached by any such application of poisons. It may also be added, although it is very much to be regretted that it should be necessary, that neither this class of insects nor any kind of an insect which feeds upon plant tissues can be discouraged or destroyed by any magical process of inserting or injecting chemicals into any part of the plant, or by spreading them in or on the soil for absorption by the roots. The reasons for this are self-evident on even casual reflection. The plant would be unable to take up any appreciable amount of such chemicals. If taken up, the distribution thereof would be extremely local and weakened by dilution with large quantities of sap; and finally, should such nostrums be absorbed in sufficient quantity to poison the insect, the plant itself would be poisoned and destroyed.

Coming back to a more specific consideration of the San José scale, we frequently hear of other remedies and processes of treatment which are more rational but nevertheless faulty in their composition or application, or both. For example: Common whitewash is applied by a great many to the trunk and branches of the trees with the mistaken idea that it is an efficient remedy against the scale. The application of this is faulty for two reasons: In the first place it is not sufficiently strong to destroy any but possibly the young and only partially protected scale; and secondly, because its application on the trunks and large branches only protects those parts of the tree, the infestation of which is in reality of much less importance than the infestation of the smaller branches and twigs. Another objection to this method—and it is true of the application of any solution, whatever it may be—is that no remedy against the San José scale can be put on with a paint brush or wash rag, unless the tree is very small or pruned back to the trunk and a few stubs of branches, without the application of so much labor that the cost of application will greatly exceed the value of the tree. The grower must provide himself with adequate and up-to-date apparatus suited in size to the number of trees which he will have to spray. The Twentieth Century agriculture can not succeed with antiquated methods and appliances.

Mechanical means, such as scraping the trunk and larger branches, are sometimes resorted to, but for reasons already given, such remedies are of little use. If the tree is an old one with very rough bark, scraping off the loose portions which may hide the scale underneath is valuable as preparation for subsequent thorough spraying. The only mechanical remedy which is at all efficient is the application of a sharp axe to the trunk of the tree close to the ground. To those who can not or will not have their trees thoroughly treated, it is undoubtedly the only remedy when the trees have become thoroughly infested, for so far, we have not come across a single case in the State where the scale, when once established, has ceased its work until after the tree has been destroyed, unless intelligently treated with some effective scale remedy.

THE SAN JOSÉ SCALE.

(Pronounced Săn Hō-saý.)
Aspidiotus perniciosus, Comst.

General History.

This insect was first discovered in this country in California in 1873. The term San José scale is derived from the valley of that name where it was first located. It must have been prevalent sometime previous to the year mentioned, as it was then well distributed in the section where it was found.

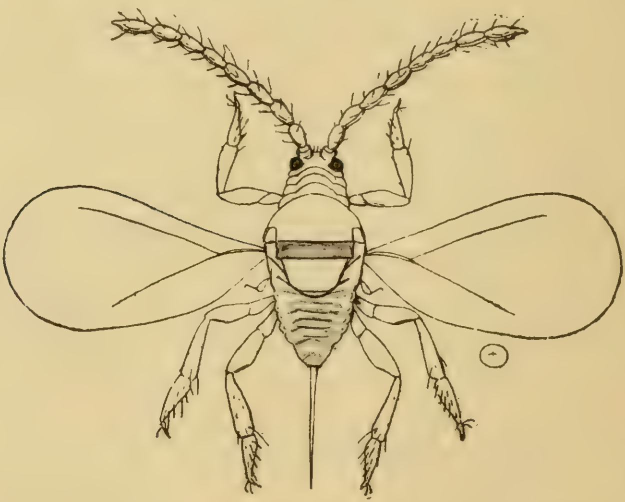

Fig. 3.—Male San José scale insect, greatly enlarged, after Howard, U. S. Dept. of Agr., Bur. of Ento., Bul. 62.

The first description of the insect was written by Professor Comstock in 1880. In recognition of its capacity for serious mischief he called it *Aspidiotus perniciosus.* The Pernicious Scale has been suggested as a common name but has not been generally accepted, and it is doubtful if another name, "The Chinese Scale," proposed by the Department of Agriculture will displace the one by which it has been known for so many years.

There has been a great deal of speculation as to where this insect originated. It was successively reported as having been introduced from Chili, Hawaiian Islands, Australia, and Japan; but recent investigations by Dr. Marlatt of Washington seem to prove quite conclusively that the original home of the San José scale is in China.

In the East the scale was first discovered in the grounds of Dr. C. H. Hedges of Charlotteville, Virginia, in 1893. The infestation was investigated, and the introduction was quite definitely traced to two New Jersey nurseries, which in 1886 or 1887, in an endeavor to secure a curculio-proof plum, had imported a number of plum trees from the San José district in California. These nurseries, probably without knowing what a serious pest they were distributing, scattered it broadcast in various localities in the Eastern United States. It soon got into other nurseries, and at the time of its discovery in 1893, as subsequent investigation proved, it had become established in a large number of different places in the various states. Since then, and until the inspection laws became generally enacted in the different states, while some of the nurseries took pains to send out only clean stock, the scale was still further disseminated into almost every state in the Union by ignorant or irresponsible nurserymen and others dealing in shrubs and trees liable to be infested.

Recent legislation has put a partial check upon the continued distribution, but the scale has now been so far scattered that all hope of ever exterminating it has gone, and all that can be done is to check its ravages and reduce the damage from it to a minimum.

History in Rhode Island.

It is difficult to trace definitely the history of the scale in Rhode Island. Professor Marlatt, in Bulletin 62 of the Bureau of Entomology, Department of Agriculture at Washington, states that up to 1898 no report of the presence of the scale had come from this State. In a bulletin by the State Board of Agriculture, written by Mr. Southwick in 1900, the author speaks of it as being of recent importation. It is probable, however, that it was known to be present as early as 1897, and to have been established sometime previous to this year. Professor Adams of the Rhode Island College states it as his recollection that the first report of the presence of the scale came to this institution from Newport in 1897, and that another was sent in soon thereafter from an estate near East Greenwich. Beginning with 1898 a large number of reports and also infested material were received at the college from various parts of the State. It was undoubtedly thoroughly established in some of the larger nurseries of the State at this time, as many growers are quite unanimous in their statements that trees which they purchased from certain nurseries near Providence from 1898 to 1900 were destroyed two or three years later by what proved to be the San José scale.

At the present time there is not a single town in the State but what is infested in one or more localities, and no plantations in which nursery stock has been set out within the last ten years are likely to be free from the pest. It is probable that four-fifths of the orchards of the State are more or less infested, and in many places the majority of the trees have been so badly injured as to necessitate their destruction.

Methods of Detecting the Scale.

When a tree or shrub first becomes infested and there are only a few scales present, detection is extremely difficult even for the experienced entomologist. To those inexperienced in the use of the magnifying glass, detection is more or less difficult until the tree becomes quite thoroughly infested, at least in places. Close observers will

FIG. 4.—Magnifying Glass.

probably notice quite readily with their naked eyes the bright yellow little insects which crawl around throughout the summer-time and autumn until frosts set in. The light-colored scales about the diameter of a common pin which have just settled down, as well as somewhat larger and darker scales about the size of a small pinhead, may perhaps also be observed against the smooth bark on young wood. When the bark becomes quite thoroughly covered with the scales it assumes a rather rough, scurfy appearance of an ashy-gray color. When rubbed with the hand, or, better, with the thumb nail, a yellowish liquid appears, due to the crushing of hundreds of insects. This liquid gives a greasy feeling to the bark where it has been rubbed. On very young wood, especially if of a bright, greenish color, the scale will be surrounded by a reddish discoloration. This is true also on fruit, and of course it shows best on green fruit and on light-colored varieties. Care must be used, however, not to confuse the red spots formed by fungous diseases, such as *Entomosporium maculatum*, with those of the scale.

If the outer bark, even though dark and showing no discoloration, be stripped off so as to disclose the inner green-colored portion, this will also be found discolored in the same way as described above, if the scale is present.

The orchardist should by all means possess and learn to use a small magnifying glass. It will help him greatly in detecting the scale. Such a one as illustrated in Figure 4 can be purchased for about fifty cents, and for all practical purposes is as good as one costing ten times this amount.

Life History.

Unlike the larger insects with which we are more familiar, the scale is ovoviviparous, that is, the young are born alive instead of developing in eggs laid by the parent. The young larvæ crawl about from twenty-four to thirty hours after birth until they find some suitable place to settle down. They then proceed to insert the long sucking tube into the bark, and a waxy secretion is exuded,

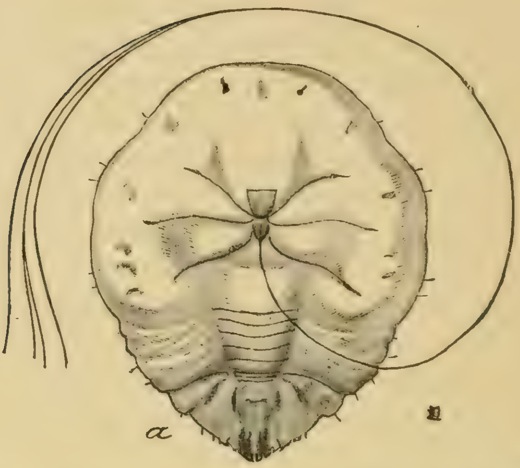

FIG. 5.—Underside of female scale insect, showing proboscis or sucking tube. Greatly enlarged. After Howard, U. S. Dept. of Agr., Bur. of Ento., Bul. 62.

from the back of the insect, which in time gradually covers the whole insect and hardens into the scale.

Soon after settling down the larva loses its legs and antennæ, and in the case of a female the insect becomes fixed and never moves from its position. The larva sheds its skin several times, and this is added to the scale covering. In about thirty days the female becomes full-grown, and in a week or so thereafter begins to bring forth young. She continues to give birth to young at the rate of nine or ten a day for about six or seven weeks.

The male scale attains maturity in about the same length of time as the female.

Owing to the fact that young are being born over such a long space of time from each female, it is difficult to ascertain the number of generations; but according to the majority of investigators, there are three or four in the North. Four hundred young is an average for each female, and the possible number of descendents for one over-wintering female is enormous and has been estimated at over three billions.

The scale winters over in the larval stage. Insects in all stages

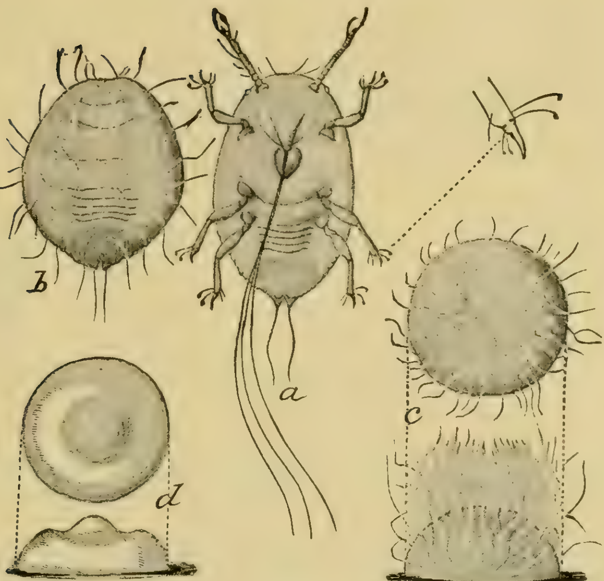

FIG. 6.—Development of the scale. *a*—Underside of larvæ showing proboscis. *b*—Back of larva with wax exuding. *c*—Further development of wax secretion. *d*—Larval scale nearly formed.
After Howard and Marlatt, U. S. Dept. of Agr., Bur. of Ento., Bul. 62.

of development, from the active crawling larvæ to the adults which have completed their life history, may be found on the tree at the beginning of winter, but probably only those larvæ which have a well developed scale survive. Probably not over one-eight to one-third survive the winters of the north.

Description of the San Jose Scale.

The San José scale, *Aspidiotus perniciosus*, Comst., belongs to the class termed "Armored Scales." In this class the scale covering is in the nature of a house for the insect, and does not form a part of its body.

FIG. 7.—Scale of male San José. Greatly enlarged.
After Atwood.

The adult female scale is about $\frac{1}{16}$ of an inch in diameter and nearly circular in outline. At or near the center of the scale is the highest point, or nipple, usually of a darker color than the rest, and this is surrounded by a concentric depressed area. Outside of this

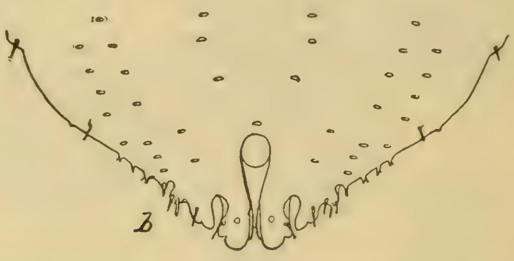

FIG. 8.—Cut showing characteristic form of anal plate of female, as seen under the microscope. After Howard, U. S. Dept. of Agr., Bur. of Ento., Bul 62.

depression the scale is marked off more or less distinctly into rings or circular areas, some of which may have a slightly lighter yellowish shade than the central nipple or the margin of the scale. In color the scale varies from white or light yellow when young to dark gray or almost black when it approaches maturity. See Figs. 1 and 6.

The male scales are smaller, more elongated or oval in shape, and flattened at the extremities, with the nipple near one end. The concentric rings are more plainly marked than in the female. See Fig. 7.

The young larvæ of both sexes are ovoid in shape and yellow in color. They have six legs, two antennæ or feelers, and a long proboscis or sucking tube folded beneath the body. After the first moult, the larvæ of both sexes lose their legs and antennæ. The female becomes more or less shapeless and resembles a flattened sack, somewhat rounded in outline. See Fig. 5. It remains fixed and changes but little in succeeding moults, while the male goes through a number of changes, finally acquiring six legs and antennæ again, and two wings, and backs out from under the scale as a minute, active, fly-like insect. See Fig. 3.

HOST PLANTS.

THE following list of host plants of the San José scale has been copied from a list by Dr. W. E. Britton, quoted in Bulletin No. 62 of the Department of Agriculture at Washington. In this list we mention only the trees and shrubs which have been observed in this State. It will be noted also that the list varies a little from that of Dr. Britton's, in that a few plants which are mentioned as "Commonly or Badly Infested" have not been found so in the investigation in this State. In a like manner, a few that are noted in the original list as "Seldom or Never Infested" have been found quite badly infested in our inspection work:

Commonly or Badly Infested.

Amelanchier canadensis. Medic. Shad-bush, Juneberry.
Cornus sanguinea. Linn. Red osier. Red-twigged dogwood.
Cratægus oxyacantha. Linn. English hawthorn.
Cratægus coccinea. Linn. Scarlet fruited hawthorn.
Cratægus crus-galli. Linn. Cockspur thorn.
Cydonia vulgaris. Pers. Common quince.
Cydonia japonica. Pers. Japanese or flowering quince.
Populus deltoides. Marsh. Carolina poplar.
Populus nigra. Linn. *var. italica Du Roi.* Lombardy poplar.
Prunus avium. Linn. Sweet cherry.
Prunus cerasifera. Ehrh. *var. atropurpurea.* Dipp. (*P. pissardi.*) Purple-leaved plum.
Prunus domestica. Linn. European plum.
Prunus japonica. Thunb. Flowering almond.
Prunus persica. Sieb. & Zucc. Peach.
Prunus triflora. Roxbg. Japanese plum.
Prunus virginiana. Linn. Chokecherry.
Pyrus communis. Linn. Pear.
Pyrus malus. Linn. Apple.

Pyrus. Sp. Crab apple.
Ribes oxyacanthoides. Linn. Gooseberry.
Ribes aureum. Pursh. Missouri or flowering currant.
Ribes rubrum. Linn. Currant.
Rosa. Sp.
Rosa rugosa. Thunb. Japanese Rose.
Salix. Sp. Willow.
Salix pentandra. Linn. Laurel-leaved willow.
Salix babylonica. Linn. Weeping willow.
Sorbus americana. Marsh. American mountain ash.
Sorbus aucuparia. Linn. European mountain ash.
Symphoricarpos racemosus. Michx. Snowberry.
Syringa vulgaris. Linn. Common lilac.
Tilia americana. Linn. American linden or basswood.
Ulmus americana. Linn. American elm.
Ulmus campestris. Smith. English or European elm.

The following, mentioned in Dr. Britton's list as being "Commonly or Badly Infested" have not been found so in our investigation work, even when standing among fruit trees which have been covered with the scale:

Akebia quinata. Decaisne.
Cratægus cordata. Soland. Washington thorn.
Fagus sylvatica. Linn. *var. purpurea* Ait. European purple-leaved beech.
Juglans sieboldiana. Maxim. Japanese walnut.
Ligustrum vulgare. Linn. Common privet.
Prunus serotina. Ehrh. Wild black cherry.
Pyrus sinensis Lindl. Sand pear, including Kieffer, and Le Conte pears.
Ribes nigrum. Linn. Black currant.
Syringa persica. Linn. Persian lilac.

The following, mentioned under the next heading of the above-mentioned list as being rarely infested, have been found quite subject to the scale:

Elæagnus longipes. Gray. Silver thorn.
Rhus cotinus. Linn. Smoke bush.

Staphylea sp. Bladder nut, which is mentioned in Dr. Britton's list as being found free from the scale, has been found badly infested in one of our nurseries.

Occasionally or Rarely Infested.

Acer saccharinum. Linn. Silver maple.
Acer saccharinum. Weir's cut-leaved.
Acer platanoides. Linn. Norway maple.
Alnus. Sp. Alder.
Cornus stolonifera. Michx. Wild red osier.
Cornus florida. Linn. Flowering dogwood.
Deutzia. Sp.
Euonymus. Sp.
Forsythia. Sp.
Hibiscus syriacus. Linn. Shrubby althea.
Morus alba. Sp. Mulberry.
Prunus cerasus. Linn. Sour cherry.
Rhodotypos kerrioides. Sieb. & Zucc.
Rubus strigosus. Michx. Red raspberry.
Sambucus. Sp. Elder.
Viburnum opulus. Linn. Cranberry tree.
Vitis. Sp. Grapes.

Æsculus hippocastanum Linn. Horse-chestnut, which is given here in the original list, has often been found among trees badly infested, and yet at no time have we discovered any San José scale on it.

The following also have never been found infested, although it should be said in regard to them that they have not been sufficiently observed by the writer to place them definitely in the immune list in this State:

Ampelopsis quinquefolia. Michx. Virginia creeper.
Betula alba. Linn. Cut-leaved white birch.
Buxus. Sp. Box.
Castanea americana. Raf. Chestnut.
Catalpa bignonioides. Walt. Common catalpa.
Celtis occidentalis. Linn. American blackberry.
Fraxinus americana. Linn. White ash.
Gleditschia triacanthos. Linn. Honey locust.

Juglans nigra. Linn. Black walnut.
Kalmia latifolia. Linn. Mountain laurel.
Ligustrum ovalifolium. Hassk. California privet.
Lonicera. Sp. Honeysuckle.
Picea alba. Link. White spruce.
Robinia. Sp. Locust.
Rubus nigrobaccus. Bailey. (*R. villosus.*) Common blackberry.
Sassafras officinale. Nees. Sassafras.
Spiraea. Sp.
Thuya occidentalis. Linn. American arbor vitæ.

NOT INFESTED.

Ailanthus glandulosa. Desf. Tree of Heaven.
Andromeda. Sp.
Aralia spinosa. Linn. Hercules' club.
Bignonia. Sp. Trumpet vine.
Calycanthus floridus. Linn. Carolina allspice, sweet-scented shrub.
Carpinus. Sp. Hornbeam.
Cedrus. Sp. Cedar.
Cephalanthus occidentalis. Linn. Buttonbush.
Clethra alnifolia. Linn. Sweep pepper bush.
Corylus. Sp. Filbert, hazelnut.
Exochorda grandiflora. Lindl. Pearlbush.
Gaylussacia. Sp. Huckleberry.
Genista tinctoria. Linn. Dyer's greenweed.
Ginkgo biloba. Linn. Maidenhair tree.
Gymnocladus canadensis. Lam. Kentucky coffee tree.
Hamamelis virginiana. Linn. Witch-hazel.
Hedera helix. Linn. English ivy.
Hicoria. Sp. Hickory.
Hydrangea (all species).
Juglans cinerea. Linn. Butternut.
Juniperus. Sp. Juniper.
Laburnum vulgare. Griseb. Golden chain.
Larix. Sp. Larch.
Liquidambar styraciflua. Linn. Sweet gum.
Liriodendron tulipifera. Linn. Tulip tree.
Magnolia (all species).
Myrica cerifera. Linn. Wax myrtle.

Nyssa sylvatica. March. Tupelo, pepperidge, black gum, sour gum.
Ostrya virginica. Wild. Hornbeam, iron wood.
Philadelphus coronarius. Linn. Mock orange, syringa.
Pinus. Sp. Pine.
Platanus occidentalis. Linn. American plane, buttonwood.
Quercus (*all species*). Oak.
Retinispora (*all species*). Japan cypress.
Rhamnus. Sp. Buckthorn.
Rhododendron. Sp.
Sciadopitys verticillata. Sieb. & Zucc. Umbrella pine.
Shepherdia. Sp.
Smilax. Sp.
Sophora japonica Linn. Japan pagoda tree.
Stephanandra flexuosa. Sieb. & Zucc.
Tamarix. Sp.
Tsuga canadensis. Carr. Common hemlock.
Vaccinium. Sp.
Wistaria. Sp.
Xanthoceras sorbifolia. Bunge.

NATURAL ENEMIES OF THE SAN JOSÉ SCALE.

Dr. L. O. Howard of the Department of Agriculture, in a recent bulletin by Dr. C. L. Marlatt, states that there are eight species of true parasitic insects which have been reared from the San José scale. These are nearly all very minute parasites which live on their host insect underneath its scale.

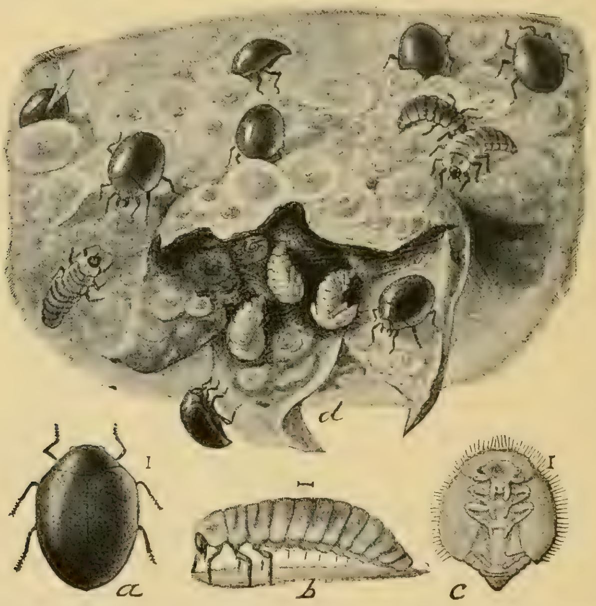

FIG. 9.—Microweisia misella preying on San José scale. *a*—Adult beetle. *b*—Larva. *c*—Pupa natural size is indicated by short line near each figure. *d*—Calyx end of apple, showing beetles and larvæ destroying the San José scale, also greatly enlarged. After Howard and Marlatt, U. S. Dept. of Agr., Bur. of Ento., Bul. 62.

It will hardly be of interest to the readers of this bulletin to give a very full resumé of Dr. Howard's account of these parasitic insects. They are not primarily San José scale parasites, but live also on other armored scales.

The writer has in a few cases picked up scale-infested twigs which unquestionably showed the work of some of these little parasites, but it is needless to say that, so far, they are not even materially checking the pest.

Rather more hope of relief is experienced from larger so-called predaceous insect enemies, chief among which are the various ladybird beetles. These are well-known predaceous enemies of plant lice, and it is known definitely that two of the species, common in the State, are feeding to some extent, at least, on the San José scale. One of these is the Twice-stabbed ladybird, *Chilocorus bivulnerus*, Muls. This is a little black, sluggish, hemispherical beetle with a bright red, or yellowish-red spot on each of the wing covers. It is about $\frac{3}{16}$ of an inch in length. In no case has this been found in very large numbers. Even on badly infested trees the writer has seldom seen more than four or five specimens.

The other ladybird, *Microweisia misella*, Lec., from which we may expect a great deal more help, is very much smaller, only about $\frac{1}{16}$ of an inch in length, similar in shape to the former, but coal-black in color. In a few cases the writer has observed these little beetles in very large numbers on scale-infested trees. The numbers of the scale, however, were so great that even though numerous, the beetles were scarcely able to appreciably check the pest.

On the discovery of the fact that the scale came originally from China, it was hoped that parasites from its native habitat might be introduced, and the Department of Agriculture imported a ladybird, *Chilocorus similis*, which is said to be its principal enemy in that country. This is a black beetle which, in its adult form, is practically indentical in shape and color with the twice-stabbed ladybird. It differs from our own species, however, in its larval stage, and also to some extent in its life history. It has failed to become sufficiently acclimated to establish itself in this country, except in a very few places, and even in these places, it is scarcely multiplying sufficiently to keep the scale in check. In time, however, this species may possibly establish itself more fully in some parts of the country, and perhaps also some of our native species will develop a larger appetite for the San José scale. It is possible, too,

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that many of the parasitic enemies to which we have made brief reference may become more active in future years.

A few fungous and other diseases which affect the scale have been studied by the Department of Agriculture and some of the experiment stations, and under favorable conditions some of them may render valuable assistance in checking the pests in sections of the country favorable to their growth.

Means of Distribution of the Scale.

Owing to the fact that the young female moves around for a very brief time and can travel only a short distance, after which it settles down never to move again, the scale can not be distributed very widely or rapidly through its own efforts. Within a very restricted radius it is undoubtedly spread slowly through the aid of other insects. The ladybird beetles, which have been spoken of as predaceous enemies of the scale, are no doubt occasionally responsible for its dissemination, as observers have frequently noted beetles of this kind with young scale larvæ upon them. Higher animals, such as, birds, squirrels, etc., probably distribute a few. In orchards, horses in cultivating or men in pruning and harvesting may aid in its distribution. The wind is perhaps responsible for carrying it short distances, and in close plantings, interlacing branches permit distribution from tree to tree. The chief means of distribution, however, to which we owe the very rapid spread throughout this country from state to state, and from one locality to another within the states, is through the transportation of nursery stock in its various forms, such as, cuttings, buds, scions, and young trees. It is deeply to be regretted that our country did not wake up to the danger of dissemination in this way when it was first discovered and pass the inspection laws which we now have to prevent its spread.

Losses Due to the Scale in Rhode Island.

Last summer an arrangement was made with the Department of Agriculture at Washington whereby it was made possible to carry on a special investigation in the ravages of the scale for this section of the country. A large number of circular letters were sent out with request for information regarding the number of fruit trees of different kinds destroyed or injured, and also certain questions regarding the distribution of the scale and proposed methods of treating it.

The results did not come up to our expectations. About seven thousand circulars were sent out and only about 550 have been received at the present time. It made it impossible to determine very accurately what the complete loss is for the whole State, but enough has been ascertained to give us some basis for further calculation.

The replies gave us a great deal of information regarding the present situation in the State, but as this is discussed elsewhere, it will not be necessary to repeat it here. The blank sent out requested information regarding the number of trees of different kinds and ages which had been destroyed or injured by the scale. It also requested that the recipients in returning the blanks should place an estimate on the value of the trees. The latter request was complied with only in very few cases, and it was therefore necessary to secure estimates in other ways. Such estimates have been very kindly furnished by a number of fruit growers and horticulturists in this and other states, and it is on these estimates that we base the calculations which will be given below. It may be said in passing that the estimates varied greatly; the value of a mature apple tree, for instance, being placed at all the way from $25 to $250. The figures which we shall use are much lower than the average value as calculated from the estimates that have been received. They are undoubtedly still too large for the average conditions in this State, and the sum total of loss as derived from them has been still further reduced to one-third.

Apples*	1 year	$1 00
"	2 and 3 years	2 00
"	4 and 5 years	3 00
"	6 and 7 years	4 00
"	8 and 9 years	6 00
"	10 and 11 years	8 00
"	12 and 13 years	10 00
"	14 and 15 years	12 00
"	16 and 17 years	15 00
"	18 and 19 years	18 00
"	20 and 21 years	22 00
"	22 years	25 00
"	26 years	30 00
"	30 years	40 00
"	35 years	50 00
"	40 years	50 00
"	45 to 60 years	50 00
"	75 years	20 00

An injured tree was valued at one-half of what an uninfested tree was worth.

According to the reports received:—

The total number of apples of all ages injured was	4,370
The total number of apples of all ages destroyed was	1,421

The total loss was approximately $60,300. Reducing this by two-thirds, gives us a total loss of $20,100,

There are in the State approximately six thousand farms, and if we assume that one-half of these have apple orchards, the number of reports is only one-sixth of the total number of farms. It should be reasonably fair, therefore, to multiply the $20,100 loss above noted by six to get the total value for the State. This would place the loss at $120,600. This sum does not take into consideration

*Age given is time after permanent planting and does not include the time that the tree has grown in the nursery.

the loss to the small grower in village and city. If such losses were counted it would probably raise the total to $160,000 or $170,000.

To get at the proportion of loss to the total value of the orchards of the State, the number of bushels of apples in 1889 and 1899, as given by the census of 1900, were added together and divided by two to get the average for the two years. This amounts to 289,401 bushels as the product of the farms of the State. Multiplying 25 cents, which should not be too high a price as the net return per bushel during the last five or six years, by the above number will give us $72,350.25 as the net income from the apple trees of the farms in the State. Assuming this to be 5 per cent. interest on the value of the apple orchards, their total value would be $361,751.25. This would indicate, then, that the loss to the apple orchards of the State amounts to about one-third of their total value.

The loss to pears, peaches, and plums, according to the reports received and calculated from estimates of value similar to those obtained for apples, amounts to:

Pears, killed, 839 trees	$8,492 70
Pears, injured, 855 trees	6,669 75
Peaches, killed, 6,484 trees	24,143 50
Peaches, injured, 667 trees	1,794 00
Plums, killed, 616 trees	1,682 25
Plums, injured, 433 trees	915 33
	$43,697 53

Assuming that the estimate here, also, being for trees reasonably well cared for, would be too high as an average for the State, and taking only one-third of the total loss, we have $14,565.84.

Orchards of these trees are not as common, of course, as apples, and it would not be fair relatively to estimate that one-half of the farms in the State have such orchards. Assuming, however, that they are found on one-third, or approximately 2,000 of the farms, the reports which have been returned are one-fourth of the total number of possible reports. Multiplying the sum which we have estimated to be the loss by four, we have a total loss of $58,263.36, which, when added to the loss in the apple orchards, gives a total loss of $178,863.52 for the orchards of the State. As with apples, many plantations of the last-named fruits are not enumerated as farms, and if we add the loss to that of apples outside of farms and this sum to the total just given, we shall have a grand total of over $200,000 as a conservative estimate of the loss to the apple, pear, peach, and plum plantations for the last six or seven years. But this is not all. If loss to other trees and to shrubs which are attacked by the scale be added, the grand total will be still greater.

These figures are, of course, only approximations, but it is probable that the loss is rather underestimated than overestimated.

To these direct losses should also be added the loss from misdirected labor in spraying, the waste of spraying materials, and the interest on the reduction in incomes from the farms due to the destruction of the orchards.

The Status of Fruit-Growing as Affected by the San Jose Scale.

Fruit-tree planting, generally speaking, is at a standstill. Old orchards are gradually disappearing, and the very lucrative business of growing orchard crops, to which some of our lands are eminently suited, is fast being destroyed, except in the case of a few up-to-date growers who have looked the San José scale problem squarely in the face, studied the situation, secured what information they could from colleges, experiment stations, and agricultural publications generally, in regard to the best methods of overcoming the difficulty, and have then set to work with a grim determination to "do or die." Such men are succeeding, and with the gradual decline of fruit-raising among their fellow growers, they are reaping a well-merited reward in greater demands for their fruit and higher prices.

It is an oft-mentioned quotation from some horticultural lecturer, that the scale is in reality a blessing in disguise, and that it is one of the greatest educators in fruit-growing. An uncharitable critic would immediately say that this lecturer must be one of those who have profited by the higher price in fruit, but there is a deal of truth in the statement, however, looking at it as it stands. The old-fashioned method of planting trees and perhaps encouraging them a little by cultivation or mulching until they begin to bear, and then expecting them to produce abundant crops of good fruit from year to year is at an end. In fact, if the truth had been realized, part of this idea was exploded long ago, even before the advent of the scale, for the fruit grown by careless methods was not often of high quality. The first-class fruit of to-day was rare. The standard of the markets was low, and people were willing to buy and use second-class fruit. Cider was more generally in demand, and a great deal of fruit could be utilized in its manufacture. People were also unaware that anything better could be expected from their trees. To these considerations in a small measure at least—and to the halo that always surrounds the good old times—and not entirely to the great increase in injurious insects and fungous diseases which usually receives all the blame—is due the fact that older people frequently say that fruit-raising has become impossible.

In place of the old-fashioned way has come a closer study of orchard work and requirements of tree growth, and partial realization, at least, of the principles of plant nutrition and of the fact that the soil is not inexhaustible in plant food, even such as is required by orchard crops. We no longer expect to gather crops of fruit, and sometimes hay or pasturage, from our orchards without adding something to feed the plants that we grow. Cultivation and fertilization for orchards are taken up precisely for the same reason that they are used for corn, potatoes, or garden crops.

The scale has been an educator in many other ways. The attention which the orchardist has been compelled to focus upon it has been reflected partly also upon other insects which have existed only in limited numbers, or whose depredations were looked upon as so much a matter of course as to escape attention.

Plant diseases have come into notice on account of their influence in checking the growth of plants or reducing the value of the crops harvested. Demand for information along these lines has grown rapidly. Agricultural colleges and experiment stations, the National Department of Agriculture, and men in actual contact with fruit-growers and fruit-growing have been quick to study the crop pests, carry on experimental work, and supply much needed information, until we now have in America, if we are to believe an eminent British plant pathologist, the largest body of knowledge regarding spraying and related methods of dealing with injurious insects and plant diseases of any country in the world.

Future Prospects.

It is undoubtedly true that general fruit-growing in Rhode Island is on the decline, and many are predicting that the San José scale will reduce the total amount of fruit produced in the future. The latter statement is to be doubted. The hit-or-miss fruit-growing by everybody is undoubtedly approaching an end, but the large fruit-grower who will study the question closely and apply the knowledge gained will continue to increase his plantations. There will be an increase in the amount of high quality fruit and a decrease in that of poorer quality. The fruit growing, gravitating into the hands of specialists, will aid in maintaining a higher price for the products of the orchard, not only from the fact that there will be less competition, but also because there will be greater care taken in the growing and marketing of these products.

The deplorable element in the present situation is the decadence of the home orchard. For a while, at least, the man who has a little land around his house will cease to plant fruit trees because it is too much trouble to keep them free from the scale. It is probable, however, that the small fruit-grower in village and city will learn some points in regard to spraying and care from the experience of the large orchardist. Dwarf trees offer a possible solution. By planting these he will be able to get quicker returns, keep the trees near the ground where he can readily treat them, and still get as large returns of good apples as in the past. In the future better public spraying will be carried on by men who know their business and do the work in a careful manner at a price which the owner of the trees can afford to pay. Probably, also, the San José scale may be approaching the height of its virulence. It is the history of nearly every imported insect that it increases in activity and numbers for some time after it is introduced, and then, as its enemies develop, it suffers a gradual decline until such a time as it shall have reached its proper balance in the economy of nature.

Chances of Saving Trees Badly Infested.

Whether to try to save a tree that is badly infested is sometimes hard to determine, except by giving it a trial. The question is, of course, can such a tree be revived into a healthy tree and brought into a bearing condition sooner than a new tree set in its place?

Much depends upon the age of the tree and the kind of fruit. Generally we may say that if a tree shows vigor, as evinced by the shoots of the season, it will often revive at a surprisingly rapid rate when pruned back and thoroughly sprayed. If the main branches are dying, the young shoots weak, and especially if the bark on the trunk begins to show lack of life and vitality, the chances for saving the tree are very uncertain. The question of whether to attempt to save a tree also depends to some extent on the grower himself. It is useless to try to save a badly infested tree unless he makes up his mind to watch the tree closely and spray thoroughly once a year for some time to come, and better, twice a year for the first year or two.

Does It Pay to Spray.

This question has been answered partially in the previous topics. Ultimately it is a question which must be answered by each man for himself. Where the owner of a few trees has to hire somebody to spray, pay him at a dollar per tree, and then gets perhaps 25 cents worth of fruit from each tree, he will naturally soon begin to think that spraying does not pay. When he learns how to do the work him self, however, in an efficient manner, it can be done for much less than the above figure, and no doubt most of the people who grow trees would be willing to keep them, even if the fruit barely pays for the expense of growing them.

So far as the large grower of trees is concerned there need be no question. The law of supply and demand will so regulate the price of fruit that a reasonable return for the expense of raising will be received. At the present time, owing very largely to the presence of the scale all over the country, fruit is quite high in price, and there are examples in our State, as well as in others, that the men who spray thoroughly are reaping a good harvest.

Aside from the destruction of the scale, other benefits which results from spraying, such as, cleaner and healthier trees, and the prevention of various plant diseases, are looked upon by many orchardists as sufficient to pay for the expense of treatment.

PRESENT MEANS OF CONTROLLING THE SAN JOSÉ SCALE.

The means of controlling the scale at the present time vary a little with conditions, but may be divided into: first, general orchard treatment; second, spraying; and third, fumigation.

General Orchard Treatment.

This includes, first of all, care in the purchasing of trees to see that the stock is not infested. As we have noted in previous discussions, the scale owes its distribution throughout the country almost entirely to dissemination on nursery stock. It is therefore of great importance: first, that no nursery stock should be purchased which does not bear a certificate showing that the nursery has been inspected by authorized inspection officers; and secondly, if there is any suspicion that the scale may be present in a nursery—and such a suspicion is warranted for more than one-half the nurseries in the East—the grower should see to it that the stock is thoroughly fumigated with hydrocyanic-acid gas, either by the nurseryman or by himself.

The old-fashioned idea of high-headed trees must also be changed. The trees should be headed low so that all parts can be conveniently and economically reached with spray remedies. The necessity for such a plan is not an unmitigated hardship, because it has been found to be more economical to have low-headed trees, not only for all kinds of spraying, but also for pruning and the harvesting of crops. When we arrive at the time to which everything now points, when thinning of all kinds of fruit will be more generally practiced, these low-headed trees will again be found most desirable. Implements are now made whereby cultivation of such trees is rendered easy, and the old argument for high-heading, namely, that the branches must be far enough above the ground so that horses can be driven under them, is no longer tenable.

The low-heading necessitates, for most of the standard longer-lived varieties, a somewhat greater distance between the trees. Where 35 feet has formerly been recommended as the maximum distance, 40 feet is now the rule. Pruning is also much more essential than it has been in the past, not only because of the greater economy of time and material in spraying when surplus wood has been removed, but also because of the need to so shape the tree that it may produce a maximum of good-sized, well-shaped, and well-colored fruit, and a minimum of second-class fruit. Hand-in-hand with this goes the need of cultivation and fertilization, which has already been mentioned. It is coming to be realized that plants, physiologically and pathologically, are subject to rules similar to those which operate in the animal kingdom. One of the most important of these rules is that a plant in a thoroughly healthy and thrifty condition will resist injury from diseases or from insect parasites in a far greater degree than one which is in a neglected condition. It is obvious, therefore, that the cultivation and feeding of the trees so as to put them in a thoroughly healthy condition is of prime importance.

Spraying.

The discussion so far may be said to deal with preventive measures, but in the case of the scale, even after the greatest care has been exercised, it is likely that the grower will still have trouble on his hands, and when the pest once gets a foothold in his orchard, the only possible remedy is the application to the trees of proper insecticides.

Brief General History of Spraying for the San Jose Scale.

The dangerous character of the San José scale was learned very soon after its discovery, and experiments in methods of treatment were at once taken up both by the State of California and the United States Department of Agriculture.

One of the first remedies tried was a lime-sulfur and salt preparation which had been used in California as a sheep dip. It was found to be quite successful and soon became a standard remedy in that State. When the scale was discovered in the East, the Department of Agriculture instituted experiments to try the efficiency of this same wash on the trees where the scale was found. For some reason or other, probably unfavorable climatic conditions, the remedy seemed to be a total failure and was abandoned for a time.

Kerosene emulsion having been successfully used as a contact insecticide for some time, attention was next turned to this and other oil preparations with a view of securing some efficient spray remedy. The kerosene emulsion, made according to the standard formula, was soon found inefficient, impracticable and too expensive, and extensive trials were made with kerosene and water and crude oil and water mechanically mixed by means of pumps especially prepared for the purpose. The general purpose of the experimentation was to determine the insecticidal value of the oil solutions, and also their effect upon the trees. It was at first supposed that an efficient remedy had been discovered in crude oil, which, when applied in sufficient strength, would generally destroy the scale. It was found, however, that the results were in many cases unsatisfactory because of the injury to and sometimes total destruction of the trees to which the remedy was applied.

Attention was again turned to the lime-sulfur wash, not only by the Department of Agriculture, but also by various experiment stations throughout the infested regions, and this time with a great deal better results.

Later a new kerosene oil remedy, prepared by mixing a hydrated lime called "Limoid" and kerosene, ready-made lime-sulfur washes, and a number of so-called "soluble," or more correctly, miscible, oil preparations have been recommended, all of which are considered more or less successful by various experiment stations and growers.

A few years ago a certain agricultural newspaper took up the discussion and announced that caustic potash was a sovereign remedy for the scale. When applied at a certain strength it was undoubtedly efficient in destroying the insect, and the success at first was such that it promised to become a universal remedy. Although it was not generally recommended by agricultural experiment stations, its success was such that many who used it were inclined to criticise the station workers for their slowness in discovering its virtues. This conservative attitude on the part of the experiment stations has, however, been amply justified in recent developments, for we no longer hear caustic potash recommended as a remedy against the scale.

History is repeating itself at the present time in that experiment stations are being criticised for not unqualifiedly recommending the use of the miscible oils. The champions of these remedies argue that the oils are much easier to prepare and apply, are fully as effective as the old-fashioned lime-sulfur wash, and but little more expensive. Two or three stations in their experiments have gotten very satisfactory results from the use of these oils and are recommending them freely. In other cases, however, the stations have not had such good results, and as the oils have not been used long enough by all kinds of growers on different kinds of trees to fully establish the effect of more or less continuous use, general recommendation has been withheld.

The Lime-Sulfur Wash.

The weight of opinion at the present time seems to be in favor of the home-made, boiled lime-sulfur wash, and since it is of considerable importance to understand the methods of preparation of this remedy, a somewhat extended discussion of it will be given.

Since the lime-sulfur wash was first used, a great many formulas for its preparation have been tried and recommended. In its early history in California it was made from lime, sulfur, and salt, and when the first experiments were conducted in the East the California formula was followed, the only variation being in the proportion of the ingredients. In Oregon an attempt was made to combine in the lime-sulfur wash greater efficiency as a fungicide, and a quantity of copper sulfate was added. In the East the disagreeable work of preparing the wash by boiling led to an attempt to find some means by which it could be prepared without this labor, and the addition of caustic potash and carbonate of soda was recommended. Recent experiments have indicated that the addition of salt is unnecessary, and that the attempt to increase its fungicidal properties by the addition of copper sulfate is detrimental. Preparations with caustic potash and soda have been found less efficient and more expensive than the boiled wash.

The following formulas will give an idea of the different ways in which the remedy has been prepared:

	Lime, lbs.	Sulfur, lbs.	Salt, lbs.	Sugar, lbs.	Caustic Soda, lbs.	Copper Sulfate, lbs.	Water, gals.	Length of time of boiling.
Original California Sheep Dip	80	100	10	20	....	....	160	....
Present California Wash	30	15	10	....	....	....	60	1–2 hrs.
Piper's Formulas	15	15	....	....	....	....	45 or 60	1 hr.
Regular Oregon Wash, 1907	50	50	....	....	....	....	150	1 hr.+
Special Lime-sulphur Wash with copper sulphate (known in East as Oregon Wash.)	50	50	....	....	....	8–10	150	1 hr.+
Illinois	15	15	15	....	....	....	50	1¼ hr.
New York (Geneva)	40	20	15	....	....	....	60	2–2½ hrs.
Lime-Sulfur-Caustic Soda	30	15	....	....	5	....	50	....
Conn. Exp. Station Wash	20	14	10	....	....	....	40	....
R. I. Bulletin 100, 1904	15	15	5–10	....	....	....	50	40–50 min.
R. I. Circulars, 1905	15–20	15	....	....	....	....	50	1 hr
U. S. Dept. of Agriculture, 1906	20	15	....	....	....	....	50	1 hr.
Chemical	13½ pure.	25	....	....	....	....	100	....

Reducing these formulas to a uniform quantity of water, say 100 gallons of complete spray solution, will indicate more easily the wide varaition in amount of lime and sulfur.

	Lime, lbs.	Sulfur, lbs.	Salt, lbs.	Sugar, lbs.	Caustic Soda, lbs.	Copper Sulfate, lbs.	Water, gals.	Time.
Original California Sheep dip..................	50	62½	6¼	12½	....	.....	100	....
Present California Wash..	50	25	16⅔	....	....	.....	100	....
Piper's Formula..........	25	25	.....	....	....	.....	100	(60)
Regular Oregon Wash, 1907	33⅓	33⅓	.....	....	....	.....	100	....
Special Lime-sulphur with copper sulphate (known in East as Oregon Wash.)	33⅓	33⅓	.....	....	....	5⅓–6⅔	100	....
Illinois Wash.............	30	30	30	....	....	.....	100	....
New York (Geneva)......	66⅔	33⅓	25	....	....	.....	100	....
Lime-Sulfur-Caustic Soda.	60	30	.....	....	10	.....	100	....
Connecticut Exp. Station.	50	35	25	....	....	.....	100	....
R. I. Bulletin, 1904......	30	30	10–20	....	....	.....	100	....
R. I. Circular, 1905.......	30–40	30	.....	....	....	.....	100	....
U. S. Dept. of Agriculture, 1900..................	40	30	.....	....	....	.....	100	....
Chemical................	13½ pure.	25	.....	....	....	.....	100	....

Careful experimental work coupled with chemical analyses during the past two or three years is gradually doing away with the diversity of formulas, and one of the simpler ones will undoubtedly be generally recommended all over the United States.

Formula for the Lime-Sulfur Wash as Generally Recommended at the Present Time.

In the light of the present knowledge regarding the lime-sulfur wash, then, we can fully recommend the mixture made according to the formula and directions which have been sent out in Bulletin No. 100 of the Rhode Island Experiment Station, with the exception that the salt may be left out if the operator so chooses.

The formula is as follows:

Stone lime, freshly burned, and of good quality	15 or 20 lbs.
Sulfur, flowers of, finely ground	15 lbs.
(Salt, if used)	10 lbs.
Water	50 gals.

The mixture may be boiled either in barrels with steam or in large iron kettles with direct application of fire. In either case the preparation should be as follows:

Slake the lime with a small quantity of boiling water, only sufficient to keep the lime well covered being used. Mix the sulfur with water into a thin paste and add it to the lime as soon as the slaking begins. In this way the heat generated by the lime is used to combine partly the lime and sulfur. Stir the mixture thoroughly, and after the slaking ceases add hot water to make 20 or 25 gallons, according to the size of the kettle or barrel. If salt is used it should be added at this time. Boil in kettles or in barrels by means of steam. If kettles are used, continue the stirring, and in any case boil from 45 to 60 minutes. Strain into spray barrel through a wire sieve with not less than twenty meshes to the inch. Make up to 50 gallons, and apply at once.

The color of the prepared mixture should be a dark orange-yellow when well stirred. If allowed to settle, the liquid at the surface should assume a dark oxblood color.

If the lime used is of good quality, so that but little sediment remains in the bottom of the kettle, 15 pounds are sufficient. Should there be any question as to its purity, however, it is best to use 20 pounds.

INGREDIENTS OF THE LIME–SULFUR WASH.

The Lime. — The lime is fresh or unslaked plasterer's lime, produced by means of heating or "burning" limestone. Pure limestone, of which white marble is the most common example, is calcium carbonate $CaCO_3$. When this is strongly heated, carbon dioxide (CO_2) is driven off, and pure lime, calcium oxide (CaO) remains.

7

The ordinary limestone from which our lime is made is seldom pure, so that the quicklime or CaO, bought on the market is usually impure. The chief impurities are sand and larger fragments of igneous rock and magnesia (MgO) derived from magnesium carbonate in the limestone.

The lime for the making of the lime-sulfur wash should be reasonably pure, and free from the above-mentioned impurities. If after a thorough boiling for an hour a great deal of sediment remains in the bottom of the kettle or other vessel in which the boiling took place, it indicates that the lime is impure, and more must be used. Good lime should not contain over 10 per cent. of impurities.

Sulfur.—This substance is found free in nature especially in volcanic regions, but also, in combination with various minerals, chiefly iron. It is mined in its free state or reduced from its ores. The former is called crystalline sulfur, and the latter is the common brimstone. Brimstone is heated in retorts which vaporize the sulfur and conduct the vapors into especially constructed condensation chambers. While the walls of the chamber are cool the sulfur vapor condenses on them in very fine particles, which are scraped off and called flowers of sulfur. Later the chamber becomes so hot as to condense the sulfur merely to a molten mass which is run out into moulds and becomes the stick sulfur of commerce. From this are made the various grades of ground and finely ground sulfur.

The flowers of sulfur were formerly recommended as being preferable for the preparation of the lime-sulfur wash, but lately the finely ground sulfur has come into use. It readily enters into combination with the lime, and is equally good so far as efficiency is concerned, It should be used exclusively, since it is usually somewhat cheaper. The crystalline sulfur has been tried, but it enters into combination more slowly and requires much longer boiling.

The *salt*, if used, is common commercial chloride of lime; and the *caustic soda* is the ordinary brand, which can be purchased quite cheaply in the market.

APPARATUS FOR PREPARING THE LIME-SULFUR WASH.

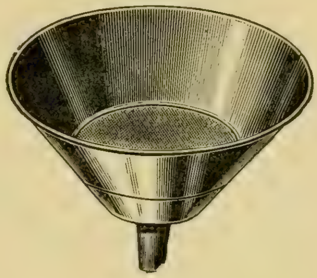


Fig. 10.—Strainer for straining spray solutions into tank.—Goulds' Mfg. Co.

Convenient apparatus for the boiling of the lime-sulfur wash is essential for its economic preparation. If to be prepared in small quantities, two sugar kettles of 25 to 30 gallons capacity, one for heating water and the other for boiling the wash, with the addition of a barrel for holding the supply of water, will serve the purpose very well. The details of such an arrangement can be easily learned from referring to Fig. 21. With this arrangement one man can readily prepare a fifty-gallon lot of the wash while three men with hand pumps are putting it on the trees. Where more than one hand pump or a power sprayer is operated, a steam boiling outfit is almost a necessity. Such outfits are illustrated in Fig. 20 and Plate XVI, Figs. 1 and 2. The essentials of the arrangement are a steam boiler and a number of ordinary kerosene barrels in the bottom of which are fixed perforated gas pipe connected with the main steam pipe for the escape of the steam. One of the barrels is used for heating water and the others for boiling the wash. The forcing of steam into the bottom of the barrels creates sufficient disturbance in the liquid so that stirring is not necessary. A main water supply from tank or hydrant conveniently located is a necessary adjunct to such an arrangement.

The platform on which the barrels stand should be high enough so that the prepared solution can be led through the outlet pipe into the spray tank or barrel by gravity. Valves should be provided for both the steam and outlet pipes of each barrel. The valve of the outlet pipes should be so constructed as not to be readily clogged. The boiler should be of 1 horse-power capacity for each barrel used.

Both of these arrangements can be used out of doors. If the boiling is done in a building, it is better to use one that is not painted, as the fumes from the sulfur escaping through the doors and windows are likely to discolor the paint around these openings.

CHEMICAL COMPOSITION OF THE LIME SULFUR WASH.

It is beyond the purpose of this bulletin to discuss at length the chemistry of the lime-sulfur wash, but inasmuch as the work which has been done by the United States Department of Agriculture, and by a number of stations, notably Massachusetts and Washington, is throwing a great deal of light upon the question of what should be the best formula, a few notes from the bulletins of the above named stations will be given:

According to Professor R. W. Thatcher of the Washington Agricultural Experiment Station, properly prepared lime-sulfur washes contain a total sulfur in chemical combination nearly equal to the amount of sulfur used. This sulfur exists in a variety of compounds, but chiefly in what are called sulfid sulfurs. These sulfid sulfurs, according to Bulletin No. 116, by Dr. Fernald of the Massachusetts Agricultural College, are of different composition, namely: Monosulfid CaS; Calcium Hydrosulfid $Ca(SH_2)$; Calcium Polysulfids CaS_3, CaS_4, CaS_5. In addition the wash contains the following sulfur and calcium compounds: Calcium Thiosulfite CaS_2O_3; Calcium Sulfite $CaSO_3$; Calcium Sulfate $CaSO_4$, Gypsum; Calcium Hydrate Ca(OH); and Calcium Carbonate $CaCO_3$, Limestone.

In connection with such chemical studies, experimenters have been led to believe that the sulfid sulfur compounds are the immediately active insecticidal agents in the wash. The thiosulfate is more slowly decomposed, and is responsible for the somewhat prolonged efficiency of the mixture. It is not yet known in what way the sulfur compounds act upon the scale, but it is thought that in the rapid decomposition of these sulfids in contact with the air, minute particles of free sulfur are liberated, and that these, either in themselves or by combination with the oxygen of the atmosphere, as sulfuric dioxide—quite well-known to us in the old-fashioned sulfur matches— in some way destroy the insect.

These chemical analyses have also given the following interesting facts regarding the composition and action of the lime-sulfur washes: The addition of copper sulfate reduces the amount of the sulfid sulfur compounds by forming an insoluble copper sulfid which is probably of little use, either as an insectcide or fungicide. The salt does not enter into any chemical combination with the lime and sulfur, and the wash is in no way influenced by the presence or absence of this substance. This emphasizes the conclusion, which has been reached in a more general way by experiments in the application of the wash, that the addition of salt is largely a useless expense.

Thatcher mentions, as a further conclusion from his analyses, that the greatest quantity of effective sulfur compounds is obtained most cheaply in some of the simpler formulas, preferably those of Professor Piper, formerly of the Washington School of Science. These are designated as Piper's 1:1:4 and 1:1:3 formulas. The formulas mean of course that 1 pound of sulfur and 1 pound of lime are used with either 3 or 4 gallons of water. Reduced to the more common way of stating them, these formulas are practically the same as the one recommended by the Illinois and various stations of the East, with the exception of the salt, and followed up to the present time by the Rhode Island College and Station: namely, 15 pounds of sulfur, 15 pounds of lime, and 50 gallons of water. In the case of Piper's formulas, it would be either 45 gallons of water or 60 gallons of water.

The chemical work has also shown that certain proprietary remedies, such as the "Rex" Lime and Sulfur compound, when fresh at least, are quite equal to the home-made mixtures in the amount of sulfid and thiosulfate compounds. With the dilution of the stock solution that is recommended by the manufacturers of the "Rex" wash, however, the amount per gallon is not as great as that in the home-made mixture, according to the 1:1:3 formula, and, consequently, it should be used somewhat stronger than recommended.

An interesting fact shown by the analysis conducted at the Massachusetts Experiment Station is that calcium carbonate, calcium sulfite, calcium sulfate, more or less inactive as insecticidal agents, and thiosulfate, are rapidly increased in quantity after the solution has been prepared, and the sulfid compounds are decreased. This seems to corroborate the general opinion that the freshly prepared wash is more effective and desirable to use than one which has been standing for some time. Quaintance, in a bulletin of the Department of Agriculture, states that the reheated wash does not differ in composition from the freshly made. Some of the sulfur is crystallized on boiling, but this will dissolve again on reheating. The writer has been unable to find any analyses of reheated washes, but other analyses show that continued boiling as well as standing after preparation increases the less-active sulfur compounds in the wash, and it would seem as if this would prove that reheated washes are not as good as the fresh. Practical experience, as already alluded to, so far as it throws any light on the subject, seems to substantiate this conclusion.

Chemical analyses have shown that the formulas which depend upon the combination of the sulfur and lime through the heat of the slaking lime only are faulty because only about 8 per cent. of the sulfur is brought into solution. Such analyses have also shown that at the end of 45 minutes of thorough boiling practically all of the sulfur has entered into chemical combination, and that nothing is gained by continuing the boiling for more than one hour. In fact, indications are that certain of the more active polysulfids change into less active thiosulfate or calcium sulfate.

The amount of lime recommended in the standard formula is nearly twice as great as that required to combine with the sulfur. The surplus lime remains as a whitewash and gives the light-yellow color to the well-stirred wash. It is useful in giving color to the wash so as to show what trees have been treated and how thoroughly the work has been done. It may possibly also aid in holding the wash on the trees until the less-active thiosulfate compound has become active. The "Chemical" formula already given in the table on page 47 is made to supply just sufficient lime for combination with the sulfur.

OTHER LIME-SULFUR REMEDIES.

The Lime-Sulfur Caustic Soda Formula.

Fresh stone lime of good quality	30 lbs.
Sulfur, finely ground or flowers	15 lbs.
Caustic soda	5 lbs.
Water	50 gals.

This wash is prepared in the same way as the boiled wash, with the exception that after the sulfur has been added 5 pounds of caustic potash is gradually put into the mixture and no boiling is done. Stir the mixture thoroughly, adding fresh hot water to make a thin paste. After the soda is dissolved, make up to the required amount of the formula and strain as in the previous mixture. When well prepared this is a fairly efficient mixture and probably equal to anything, excepting the miscible oils and the boiled lime-sulfur wash.

Hayward, in Bulletin No. 101, Bureau of Chemistry, Department of Agriculture, recommends that this wash should be prepared as follows:

Make the sulfur into a thin paste with hot water, and add the caustic soda. Stir the mixture thoroughly for fifteen minutes and add the lime. Allow the lime to slake and add more hot water, if necessary, in order to keep the lime well covered. After the slaking ceases, add fresh water to make 50 gallons.

The Self-Boiled Lime-Sulfur Wash.

The two formulas already given are now considered as the best, but the following notes on another method may be of interest.

Lime..	30 lbs
Sulfur	15 lbs.
Water	50 gals.

The preparation is the same as that for the boiled sulfur, excepting that the slaking lime is relied upon to dissolve the sulfur instead of boiling. As has already been noted under the chemistry of the lime-sulfur wash, this wash is not satisfactory.

Several proprietary remedies are sold on the market, among which are *Calcothian* and *Horicum.* There is not as yet sufficient evidence in regard to the effect of these on which to base definite conclusions.

Thatcher, in his bulletin on the lime-sulfur washes, mentions another proprietary remedy, the *Rex* lime-sulfur wash, which he considers to be very good, providing it is fairly fresh and used somewhat stronger than the manufacturers recommend.

Remedies Derived from Petroleum.

Kerosene in the standard emulsion, the formula of which need not be repeated here, was early used in an attempt to control the scale. It was found, however, that its chief value lay in its use as a summer spray to check the too rapid development of the scale. Nevertheless it was recognized that petroleum oils possessed considerable merit as contact insecticides, and efforts were made to secure a formula or method by which they could be utilized in some form. Pumps have been designed which will spray a mechanical mixture of kerosene or crude oil and water, and at one time this method was generally recommended. The New York Experiment Station has been active in the testing of various preparations containing petroleum, and the following notes in regard to the use of kerosene and crude oil have been gathered largely from the bulletins of this station.

Under favorable conditions, common kerosene of the best grades, 150° flash test, or better, and water, mechanically mixed of the strength of from 15 to 25 per cent., can be used on apples and pears in the summer time with little or no injury. On stone fruits, a mixture of this strength is frequently detrimental. Kerosene of this strength, however, is of no value against fully-formed San José scale, and can only be used, like kerosene emulsion, as a check for the recently settled young scale and the crawling larvæ.

A 40 per cent. solution of good grade kerosene can be applied to dormant pear and apple, and this mixture is fairly efficient in destroying the scale. Under favorable conditions, and when the trees are entirely dormant, pure kerosene has been used on pears and apples without any appreciable detrimental effect; but even the 40 per cent. solution above mentioned is injurious to these trees if applied after the sap starts in the spring. On the other hand, peculiarly enough, stone fruits react in an entirely different way. A mixture containing 25 per cent. of kerosene is injurious to trees of this kind during the dormant season, but much higher amounts can be used after the buds begin to swell and before the leaves come out.

All so called reduced oils or gas oils of specific gravity .837, or 35° Baumé, are unsafe at any time on any tree, while the lighter grade of specific gravity .79, 44° Baumé, or not less than 40° Baumé at 60° temperature, can be used at any time in the same way as kerosene.

The great difficulty in using these mechanical mixtures of oil and water is that no accurate pump has as yet been devised. Most of them will vary the amount of oil sprayed 5 per cent. or more on either side of the percentage fixed. Efforts have, therefore, been made to find some way of producing an emulsion of water and oil, and the following remedies have been recommended.

KEROSENE LIMOID MIXTURE.

A few years ago Professor C. P. Close recommended hydrated lime as an emulsifier. The Charles Warner Co., of Wilmington, Delaware, put out the required form of lime under the name of Limoid. The formula was as follows:

Kerosene... 1 gal.
Limoid... 4 lbs.
Water......sufficient to make the solution of the required percentage of oil.

It was claimed for this kerosene-limoid mixture that it is easily made and applied; that it colors the trees the same as the lime-sulfur wash, so that it is easy to see whether they have been well covered; that, like all oil preparations, it spreads more thoroughly over the whole surface of the bark than the lime-sulfur washes; and that it is equal in efficiency to these washes.

Experience has not wholly borne out the claims based on the early experiments, and in recent years certain other oil preparations have been recommended under the name of

MISCIBLE OILS.

Formulas for the home preparation of these have been published by the Delaware Experiment Station and by the Storrs Experiment Station of Connecticut. The following notes are taken from a recent bulletin of the latter station: (There are three parts to the process of preparing the oil according to the formulas given. Note also that the author uses the term "soluble oil" instead of miscible oil.)

Emulsifier.

Carbolic acid (crude liquid 100 per cent.) .... 2 qts.
Fish oil...2½ qts.
Caustic potash (granulated).............................. 1 lb.
Heat to 300° F., remove from fire, and immediately add:
Kerosene...3½ qts.
Water..5½ qts.

"This formula is sufficient to make 13 gallons of the complete soluble oil or 208 gallons of the spray mixture. It may be made up in any quantity and kept indefinitely. It is the most complicated part of the formula, but little difficulty will be experienced if the proper materials are used. The cooking is best done in an iron kettle. An ordinary kettle or caldron, commonly used on the farm for making soft soap, will answer the purpose. It should be equipped with a cover and so arranged that it can be readily removed from the fire, and should not be more than half filled to allow for foaming. The mixture being *inflammable* when hot, the cooking should not be done inside or near a building, unless, of course, a steam coil or jacketed kettle is used, and care should be observed in preventing the fire from blazing up around the top of the kettle. A good thermometer graduated to about 320° F. will be necessary. If the local dealers are unable to supply thermometers of this description, they may be purchased at one dollar each from Eimer & Amend, 205–211 Third Ave., New York. Five cents extra should be enclosed to cover postage."

"*The various materials should be added separately in the order named and while the whole is being stirred.* When the operation has been completed, the resultant mixture will thicken up and present, except for its darker color, somewhat the appearance of soft soap."

The Complete Soluble Oil.

Emulsifier	8 parts.
Crude petroleum	18 parts.
Rosin oil	4 parts.
Water	1 part.

"Although the soluble oil will remain in good condition for a long time, it seems advisable to prepare this, the second part of the formula, just before using."

"By securing the materials in large quantities, the soluble oil may be made for 16 to 18 cents per gallon. If diluted with fifteen parts of water, as is recommended, the spray mixture costs slightly over one cent per gallon. In view of its spreading action when applied to the tree, and from the fact that it can be sprayed with a fine nozzle, one gallon will go much farther than the same quantity of lime and sulfur."

To use this "soluble oil" stir thoroughly, and to one part of the oil take fifteen parts of water. When about to mix large quantities, it is well to test the miscibility of the oil by pouring a few drops in a glass and stirring it. If a good milky emulsion without free oil on the surface is formed, the stock solution is all right to use. It is further added, in regard to this method, that absolutely clean spraying utensils should be used. Bordeaux mixture, Paris green, or lime-sulfur are liable to spoil the emulsion.

PROPRIETARY REMEDIES FROM PETROLEUM.

Various proprietary remedies made from petroleum oils under the name of "soluble" or "miscible oils" are sold on the market. Among these are *Scalecide*, *Kil-O-Scale*, *Target-brand Scale Destroyer*, etc.

These are quite well-known, and are generally well recommended by users. Scalecide has come into prominence in this State perhaps a little more than the others, and indications are that for those who cannot prepare their own spray solutions, or who have only a small amount of spraying, it can be recommended as a safe and efficient remedy.

Comparative Value of the Lime-Sulfur Wash and Miscible Oils.

There is quite a little discussion as to the comparative value of the lime-sulfur wash and the miscible oils. It is claimed for the lime-sulfur wash that it is cheap; effective; not injurious to the trees; that it has a prolonged action; gives evidence by color of the thoroughness of spraying, which is a very important part, especially when the spraying is done by some one not the owner of the trees; if applied in the spring of the year it forms a partial protective coating over the bark which prevents the settling down of young insects that may be born early in the season; that it has been found effective against the pear tree psylla, and probably also destroys a great many eggs of plant lice; and that it is effective as a fungicide, especially against leaf curl of peaches and probably also against brown-rot of the same fruit, and possibly apple scab.

Its disadvantages are that it is laborious and difficult to make and disagreeable to apply; it must be thoroughly sprayed, for it does not spread like the oil preparations, and for this reason it is probably not so effective as the oil sprays on trees with rough bark, such as old apple and pear trees; the solution is quite corrosive and injurious to spraying apparatus, and caustic to horses and to men doing the spraying.

It is claimed for the oils that they are easy to mix and apply; that they spread well, and absolute thoroughness in covering is not so essential as with the lime-sulfur wash; that they are not hard on machinery, except perhaps the hose; and that they are quite effective, and are advantageous, especially for the small grower.

The disadvantages are that they are rather high in price, if proprietary remedies are purchased, and laborious to make, if to be be prepared at home; that they are practically colorless and do not indicate whether spraying has been thorough; that the effect is practically immediate, and there is no protection to the bark against future infestation; and that they have but little, if any, fungicidal value.

Miscellaneous Spray Solutions for the San Jose Scale.

Whale Oil Soap.

Whale oil soap	2 lbs.
Water	1 gal.

It is essential to secure a good potash soap and the following brands are recommended by the Massachusetts Experiment Station:

Good's caustic potash and whale oil soap.
Good's caustic potash and whale oil soap No. 3.
Bowker's Tree Soap.
Leggitt Brothers Anchor Brand.

The whale oil soap spray has been found by the United States Department of Agriculture to be about as efficient as the lime-sulfur wash.

It is somewhat disagreeable to handle, and when cold it is difficult to apply. The chief objection to it, however, is that it costs about eight times as much as the home-made lime-sulfur wash.

Resin Wash.

A mixture composed of the following ingredients has been used against certain kinds of soft scales in California, and is claimed by some to be of value against the San José scale:

Resin	20 lbs.
Concentrated lye	4 lbs.
Fish oil	2½ pints.
Water	100 gals.

Place the resin, lye, and oil in a kettle with sufficient water to cover to a depth of three or four inches. Boil about two hours, adding more water if necessary. Dilute with hot water up to one-third of the final quantity, and finally make up to 100 gallons. This is a stock solution.

A New Wash Proposed by the Department of Agriculture at Washington.

J. K. Hayward who has made quite an exhaustive chemical study of the lime-sulfur washes in the various combinations, proposes the following formula, which he claims is much more easily made than the solutions already mentioned and has the required amount of sulfur compounds as polysulfids and thiosulfates. While theoretically it is probably not as desirable for this climate as the lime-sulfur wash, on account of the fact that it is more easily washed off the trees by rains, nevertheless it may, on account of its simplicity, be worth a trial.

The proposed formula is as follows:

Powdered sulfur	19 lbs.
Caustic soda	10 lbs.
Water	50 gals.

A paste is made of the sulfur with about five and one-half gallons of boiling water. The caustic soda, which should be in small pieces, is then added, and the mixture is stirred occasionally for about half an hour; then 44½ gallons of water are added; the mixture is again stirred, and should then be ready for use. Should it be desired to add lime as a marker, and possibly as a means also of holding the wash on the tree, Hayward recommends that about 17½ pounds of slaked lime be added. The lime is slaked with enough water to make a thick paste, and added to the sulfur and caustic soda just before making up to 50 gallons.

A proprietary wash, sold under the name of "Con-sol," has been found by Thatcher of Washington to be a sulfur-soda wash, and probably is made in some such manner as the above mentioned.

Comparative Cost of Spray Solutions.

It is impossible to give exact cost, because the prices fluctuate from year to year, and also vary with the different places where they are sold. The following prices of ingredients and proprietary remedies are approximately correct for the present year. From these any one can figure out the cost of the various spray remedies.

Lime............$8.00 per ton, or about $1.00 per barrel of 250 lbs.
Sulfur............$2.50 to $2.60 per hundred pounds in barrel lots, F. O. B. New York.
Salt.............about 35 cents per hundred pounds.
Caustic soda......$4.50 per cwt. in 10 lb. cans.
Whale oil soap....4 cents to 5 cents per lb., by the barrel.
Kerosene.........11 cents to 13 cents a gal. by the barrel.
Crude oil.........about 12 cents a gallon.
Limoid...........$2.50 and $5.00 per hundred pounds.
Scalecide.........$1.00 a gal., or 50 cents a gal. in barrel lots.
Horicum.........$1.00 a gal., or 50 cents a gal. in barrel lots.
Kil-O-Scale.......$1.00 and $1.50, according to quantity.
Calcothian.......5 cents per gal. by the barrel.

The Time of the Year to Spray.

There has been much discussion regarding what time of the year the spraying should be done. It seems to be quite conclusively proven that fall or spring spraying is much more effective than winter spraying, probably because of greater resistive powers of the scale during the winter when entirely dormant.

A late spring application, especially with the slow-acting lime-sulfur wash, will probably not only have an immediate effect upon the scales which are reviving after the winter's rest, but will also continue to work on the scale, through the less quick-acting thiosulfate compounds, for some time after the leaves have come out.

In the fall of the year, immediately after most of the leaves have fallen, the scale is undoubtedly still in an active condition in this climate. Many young can still be seen crawling about, and the application of a spray is undoubtedly very effective. It may be reasoned that at this time of the year an oil spray would be fully as effective as a lime-sulfur wash, provided that it is applied in such a form and quantity as not to be injurious to the partially dormant trees.

There seems to be little choice, therefore, between fall and spring, except such as depends upon the kind of spray used. If the trees are badly infested they should be sprayed both in the fall and in the spring. The old idea which was published rather freely a few years ago, that a single spraying once in two or three years was sufficient to keep the insect in check, has been entirely exploded. The orchardist will have to make persistent annual attacks if he wishes to keep his trees clean, and when the trees are thoroughly covered, two applications a year are none too much.

Methods of Applying Spray Remedies.

As much depends upon the careful application as on the remedy itself. Squirting a few gallons of some patent mixture at a tree when time permits is usually time and money wasted. As noted under the discussion of the scale, it multiplies so rapidly that a very few which survive the winter and the application of the spray compounds will in the course of a summer increase to such an extent that the grower, on examining his trees in the late autumn, will probably wonder whether his spraying was of any use whatever. It is therefore absolutely essential, no matter what spray mixture is used, to cover the trees thoroughly. Paint brushes, whisk brooms, carriage-washing outfits, garden hose, and other ancient and venerable spraying outfits must be delegated to the domain of the old-fashioned gardeners. The up-to-date orchardist must secure for himself a spray outfit which will do the work according to modern principles. This does not necessarily mean that he will have to purchase expensive apparatus. There are good outfits designed for all kinds of spray work and for spraying a few trees as well as for spraying large orchards.

The second requisite for effective work is careful manipulation of the nozzle in applying the mixture. A good worker will thoroughly cover a tree without drenching it to such an extent that the liquid runs down the trunk or drips from the tips of the branches. The purpose of this is obvious. To use a familiar illustration, everyone has noticed how much more thoroughly a mist or fog will dampen the surface of trees, on the under side of the branches as well as on the upper side, and how much less thoroughly the surface will be wet after a brief but heavy shower. The mist from the nozzles being very fine, it is another obvious fact that only one side of a tree can be well sprayed if there is even a moderately strong wind blowing. In such a case no effort should be made to spray the side away from the wind. Spray with the wind, thoroughly, then watch for a day when the wind is from an opposite quarter, and spray the other side.

Spraying Apparatus.

During the last few years a great many improvements have been made in spraying machinery and appliances, and apparatus suitable and efficient for all kinds of work and for small or large plantations can now be obtained.

FIG. 11.—Compressed air knapsack sprayer.

The pump is, of course, of primary importance. The selection of one depends on the use to which it is to be put. For small gardens, and where only a few fruit trees or shrubs are to be treated, one of the various knapsack sprayers, or even a bucket pump, will serve the purpose. For orchard and shade tree spraying, a barrel pump or compressed air or gas sprayer is required; and where there is a great deal of work to be done in large commercial orchards, or even on park and shade trees, the largest forms of the above, or even gasoline or steam power sprayers are, undoubtedly, the most economical.

The essential points in a pump are that it shall be strong enough to give a pressure of from 75 to 100 pounds per square inch; that the working parts shall be simple, easily gotten at, and made of bronze, so as to work smoothly and resist corrosion as much as possible. The pump should have an efficient agitator attached and operated by the handle of the pump, or else separately. Large cast-iron chambers on barrel pumps are undesirable if attached to the top of the barrel, as they make them top-heavy and also liable to be caught and overturned by overhanging branches.

For a few bushes or very small trees, the compressed air knapsack shown in Fig. 11 will serve the purpose. This consists of a cylindrical air-tight tank of brass or galvanized iron with an air pump fixed in the center of it. The tank is filled half or two-thirds full with the spray liquid, then closed and a quantity of air is forced in. A pressure sufficient to forcibly eject the liquid can thus be produced with one or two pumpings. This form of knapsack is a much more desirable apparatus to use than the old style illustrated in Plate XIII, Fig. 2, though perhaps less durable. A bucket pump such as that illustrated in Plate XII, Fig. 2, can also be made to serve the purpose where only a few plants are to be sprayed, but when it becomes necessary to move it around, it is inconvenient and time-consuming.

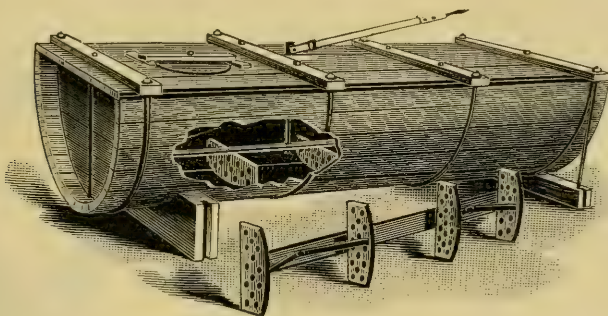


Fig. 12.—Large tank with agitator, for large hand or gasolene pump.

For gardens and small orchards, a small barrel pump such as that illustrated in Plate XI makes a very convenient and efficient outfit. For larger orchards a barrel pump such as shown in Plate XII, Fig. 1, is necessary, and if mounted on cart wheels and provided with sufficient length of hose, they can be made to do most of the work of the small sprayers as well. Such pumps are capable of furnishing pressure enough for two leads of hose, and can be used under all conditions where spraying is required. For large orchards, hand power tank pumps of types indicated in Fig. 13 and Plate XIII, Fig. 1, are used, and furnish an amount of power and efficiency excelled only by power sprayers. As already stated, large gas or air pressure or power sprayers

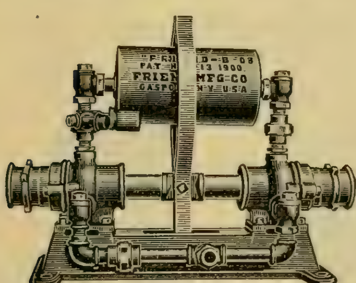


Fig. 13.—Type of double acting tank pump.

are the most convenient for very large orchards and for street and park tree spraying in large towns and cities. Plate XII, Fig. 3. Gas sprayers are on the market in which carbon dioxide gas cylinders, such as used in soda fountains, are utilized. These cylinders are attached to the air-tight spray tank in such a way that the gas can be gradually admitted and a uniform pressure maintained. (See plate XV.) Large air-pressure sprayers are similar, except that in place of the gas cylinder a compressed air tank, to be filled at a central plant, is carried.

Fig. 14.—Bamboo extension pipe, 8 to 10 feet long.

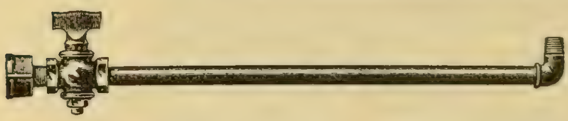


Fig. 15.—Short extension pipe for use with bucket or knapsack sprayers.

Fig. 16.—"Y" for attaching two nozzles to one lead of hose.

For the purpose of spraying kerosene or crude petroleum, many of the barrel and smaller pumps have attachments designed to introduce a given quantity of oil into the pump and to combine it mechanically with the required amount of water. Such attachments are quite effective when in working order, and save the labor of making emulsions, but they can not always be relied on to furnish the given proportions of oil and water. The use of emulsified oil is

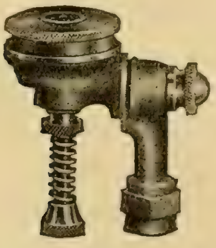


Fig. 17.—"Mistry" Vermorel nozzle.

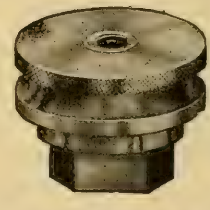


Fig. 18.—"Mistry Junior" nozzle.

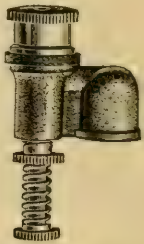


Fig. 19.—"Demorel" nozzle.

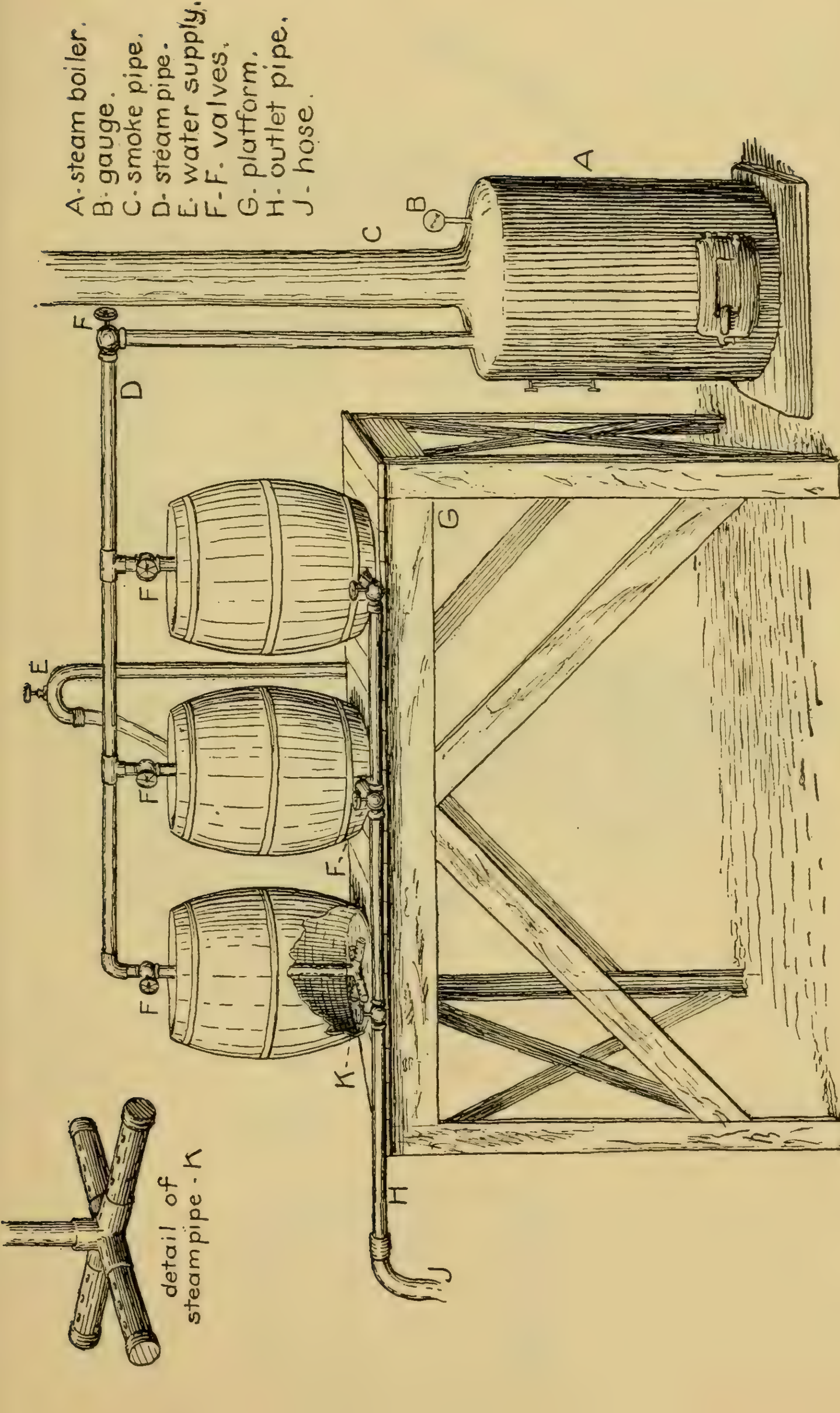


Fig. 20.—Boiling Lime-Sulfur with Steam.

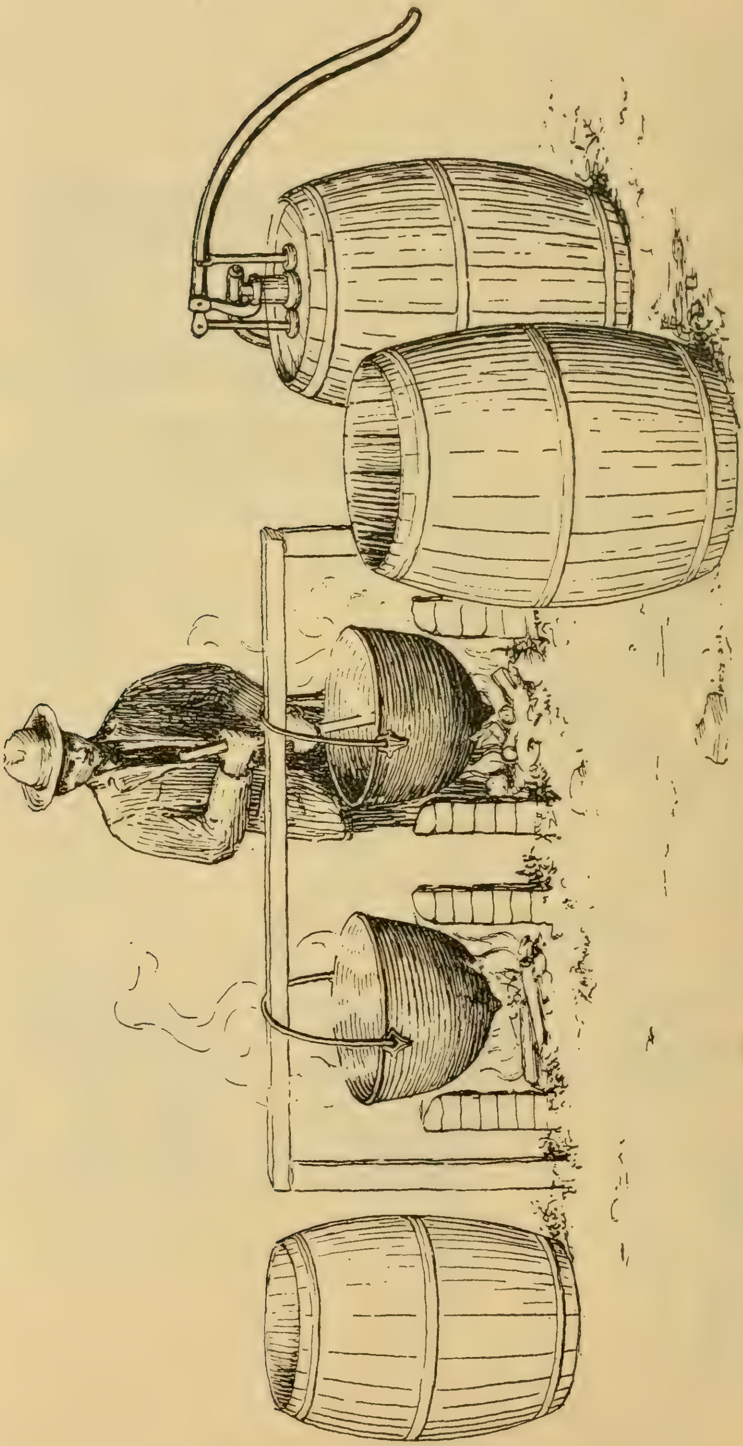


Fig. 21.—Boiling Lime-Sulfur with Kettles.

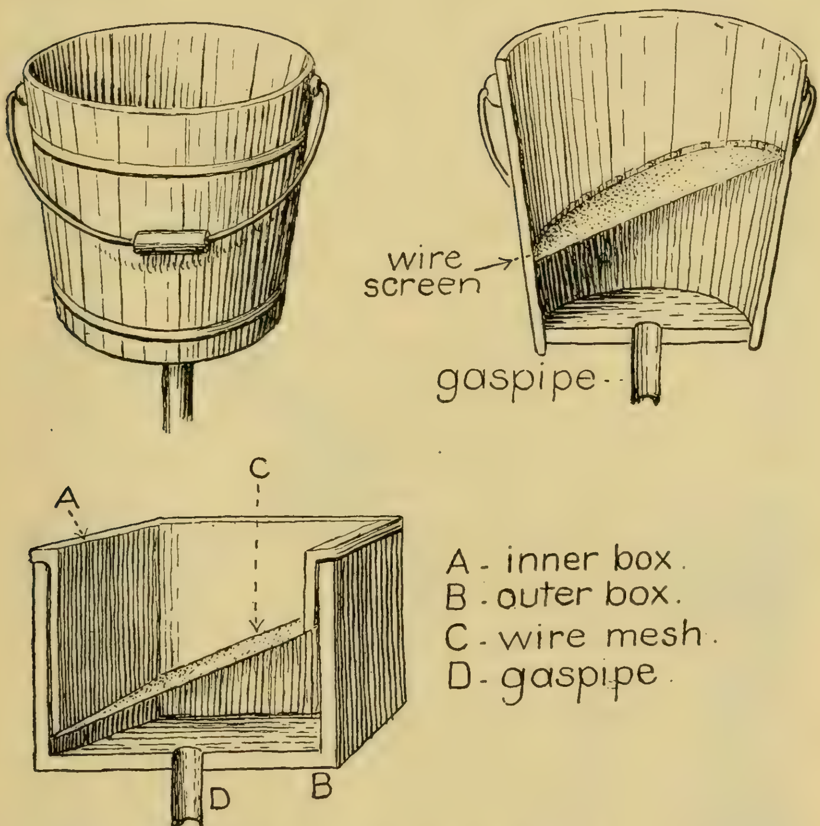


FIG. 22.—Home-made Strainers. See page 90.

therefore taking the place of mechanical mixtures, and these attachments are seldom used.

Hose of good quality, in lengths of thirty-five to fifty feet for each lead, should be provided. The short lengths usually furnished with spray outfits are of but little use. The half-inch size is amply large enough, and some prefer the three-eighths inch size. An extension pipe eight to ten feet in length is essential where orchard and shade trees are to be sprayed. An ordinary one-fourth inch iron gas pipe can be made to serve the purpose. The bamboo extension rod sold by dealers is made up of a bamboo pole in which a thin brass pipe is inserted. (Fig. 14.) These are very light, and convenient to handle, but lack in durability. Whichever form is chosen, it should have a brass stop-cock at the lower end so that the spray can be turned off at any time.

The nozzle is a very important part of any spraying outfit. While there are a great many types on the market, there are practically only two that are extensively used, viz.: the Bordeaux and the *Vermorel. The first mentioned type can be made to produce a spray graduated from a fine, fan-shaped one to a solid stream. It is used to some extent in spraying tall trees when the liquid must be forced some distance from the nozzle before it reaches the foliage. The Vermorel type gives a very fine misty spray. It is produced by forcing the liquid, while in a whirling motion, through a small orifice in the cap of the nozzle. There are a number of forms of this type. The Mistry nozzle, represented in Fig. 17, is a recent one made by the Gould Manufacturing Company. It has a very large eddy chamber into which the liquid is forced in a tangential direction, and produces a very fine spray.

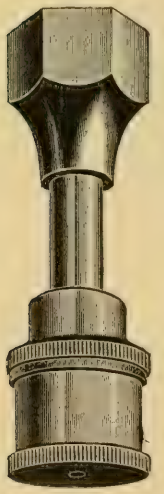


Fig. 23.—A recent form of Vermorel nozzle.

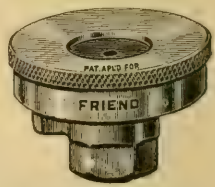


Fig. 24.—A type of Vermorel nozzle without plunger.

*See bottom of p. 89 for notes regarding use of term Vermorel.

A plunger, held back by a spring, works through this chamber and clears the orifice. The Demorel, made by the Deming Company, is of the same general shape, but the whirling motion in the liquid is produced by forcing it through a groove which encircles the plunger. (Fig. 19.) Another form, see Figs. 23 and 25, now made by the Latham & Company, and by Spramotor Company is similar to the Demorel in some respects. The whirling of the spray is produced by being forced through a groove on the outside of the plunger, but instead of having an elbow and a separate plunger, the cap is movable and can be forced back on the supply pipe to the end of which the clearing pin is attached. For ordinary spraying, the Vermorel type is to be preferred. It produces a fine, misty spray which thoroughly covers the twigs and foliage with the least amount of waste. It is necessary, however, to bring the nozzle within three or four feet of the foliage in order that the liquid may reach it. This can be accomplished by means of extension pipes already mentioned, and in addition, for very large trees, by letting the sprayers climb into the trees, or placing them on elevated platforms attached to the spray tank, or by employing ladders.

FIG. 25.—Battery of "Spramotor" Vermorel nozzles with drip guard.

With the smaller sizes of nozzles one is not always sufficient to produce the volume of spray desired, and in such cases a battery of two or more may be used as indicated in Fig. 25, where a number of "Spramotor" nozzles are arranged for attachment to one lead of hose or by the use of the "y" shown in Fig. 16.

FUMIGATION WITH HYDROCYANIC-ACID GAS.

As an insecticide this gas was first used by the United States Department of Agriculture against the cottony cushion scale on citrus trees in California. Later, when the San José scale was discovered in the east, the Department of Agriculture instructed the originator of the method, D. W. Coquillet, of the Department, to try the effect of the gas on this pest, and it has been gradually developed into a very efficient remedy, under certain conditions, not only against the scale, but also against a number of other insect pests, especially in dwelling-houses, mills, factories, and conservatories.

This bulletin being devoted to the San José scale, a discussion of the use of this gas against other insects is outside its scope. A great deal of valuable information is at hand, however, regarding its use for other insects, and the writer has applied it in greenhouse fumigation at different times with very satisfactory results. Correspondence regarding such use of the gas will be welcomed and carefully attended to at any time.

The essentials for fumigation are a gas-tight container, or covering, to confine the gas, and potassium cyanide and sulfuric acid with which to produce the gas, together with glass or stoneware vessels for mixing the chemicals.

Hydrocyanic-acid gas is formed through the decomposition of fused cyanide of potassium (K Cn) under the action of dilute sulfuric acid. The reaction is as follows:

$$2\,K\,Cn + H_2\,SO_4 = 2\,H\,Cn + K_2\,SO_4.$$

The H Cn is the *Hydrogen cyanide* or cyanic-acid, a colorless gas with the odor and taste of peach pits. It is a deadly poison to human beings as well as to the lower forms of animal life. When in water solution this gas becomes a deadly poison known as prussic acid. *The potassium cyanide* from which the gas is made is also a deadly poison to animal life. IT IS, THEREFORE, OF THE GREATEST IMPORTANCE THAT THE OPERATOR SHOULD USE EXTREME CARE IN

THE FUMIGATION WORK NOT TO INHALE THE GAS AND TO GUARD AGAINST OTHER PERSONS OR DOMESTIC ANIMALS ENTERING THE FUMIGATION HOUSES WHILE THE GAS IS STILL IN THEM. THE POTASSIUM CYANIDE MUST BE KEPT UNDER LOCK AND KEY, AND ESPECIAL CARE MUST BE USED NOT TO LET CHILDREN COME NEAR IT.

THE ACID is ordinary commercial sulfuric acid of specific gravity 1.83. It can be secured of dealers in chemicals in almost any large city.

THE GENERATORS should be either of stoneware or glass, Ordinary one-half or one-gallon crocks serve the purpose admirably. The size will depend something on the amount of chemicals to be used in the generators. Tall and narrow crocks, provided they are not too narrow to admit of the introduction of the cyanide in the paper bags, are better than wide ones because the cyanide will be more completely covered with the sulfuric acid and water.

In mixing the chemicals the water should be measured out first; then measure the sulfuric acid and pour it slowly into the water. The presence of the sulfuric acid in the water generates considerable heat, and this is desirable to increase the rapidity with which the cyanide is dissolved. Do not mix the acid and water, therefore, until the fumigation is to be performed.

When a single paper bag is used to hold the cyanide, the gas begins to generate almost immediately after placing the cyanide in the liquid. When the gas is first given off, it is accompanied by a steam, which is evolved through the great heat occasioned by the chemical action.

It is essential that the operator should lose no time in getting out of the room fumigated after all the chemicals have been combined. Those who wish to take extra precautions can rig strings by means of screw-eyes whereby the cyanide can be lowered into the jars from outside the door of the room. If this is done, place the strings and bags in position and try them on the jars before mixing the water and acid. When everything has been found to work satisfactorily, tie up the strings outside the door securely so as to prevent any accidental dropping of the cyanide into the jars. Mark the exact position of the jars; remove them and put in the water and acid. Replace the jars where they stood before, close the door, and release the string which drops the cyanide into the generator.

In purchasing the potassium cyanide, care must be used to secure the 98 per cent. pure chemical. Recent chemical analyses in one or two of the experiment stations have indicated that some of the cyanide sold on the market is only about 50 per cent. pure. It is needless to state that cyanide of this strength will only give about half the efficiency which the 98 per cent. cyanide will give, and that the formula here stated will not produce the desired results.

The size of the pieces in which the cyanide comes matters but little, if there is sufficient water and acid to cover them thoroughly.

Orchard Fumigation.

As an orchard remedy for the San José scale it is not of practical value in the East, except in the case of particularly valuable trees or small trees which can be covered with an especially constructed fumigation box, because of the great expense necessary in providing the apparatus and in covering and fumigating the trees.

The first cost of providing tents or a sufficient number of fumigation boxes to make the work economical is from $100 to $300. Experiments in New York have indicated that the total cost per tree of moderate size is from 20 cents to 50 cents.

Those who wish to use it on small trees can obtain an idea of how a practical and convenient apparatus of this kind can be constructed from plate XVII, a box which has been devised and used by the New York Experiment Station. It has been argued against such boxes that they are wasteful of gas because as much must be used for a small tree as for a large one. On the other hand, it is much more easily set up than a tent would be, and the cubic contents being known, definite quantities of gas can be generated. For large trees, tents of canvas operated by some form of derrick are necessary. In our orchards they are not practical. They wear out quickly, and are too expensive and difficult to operate.

For orchard fumigation, a quantity of cyanide half again as great as that recommended on page 78 for fumigating nursery stock must be used, because it has been found that the soil, especially if damp, will absorb quite a large part of the gas.

Those wishing to look into this matter should write to the New York and California Experiment Stations for their bulletins.

Fumigation of Nursery Stock.

The chief value to the orchardist of this gas comes from the possibility of so thoroughly destroying the scale on the nursery stock that he has to plant that he can feel assured of freedom from the scale so far as his newly planted trees are concerned, and thus save the cost of spraying for two or three years.

Quite a full description of this work was given in the writer's first report on nursery inspection, but as this bulletin is to be published as separate from the Annual Report of the Board of Agriculture, it is perhaps well to repeat the gist of what was given in the above-mentioned article. The writer has repeatedly urged, in his reports on the nursery inspection work, that the nurserymen should provide themselves with adequate fumigation houses or boxes, not only to safeguard their customers, but also to treat such stock, cions, and grafts as they may themselves purchase, should they have any suspicion that such stock may be infested with the scale. It is becoming more and more apparent from year to year that nurserymen can not be up to date unless they are in position to apply this valuable remedy against the introduction and distribution of certain injurious insects. Purchasers of nursery stock can help greatly in emphasizing the need of fumigation by demanding that nursery stock about which there is the least suspicion that it may have the San Jose scale shall be thoroughly fumigated before delivery on their premises.

The chief arguments against fumigation are, first, that it is expensive; and secondly, that it is injurious to the nursery stock.

The expense consists, of course, first, in providing the necessary box or house in which to carry on the fumigation. The cost of these, however, should not be prohibitive. The box is of comparatively low cost, and the house, while its initial cost is quite large, may nevertheless serve useful purposes as storehouse or as workhouse during the winter time to such an extent that its cost for fumigation purposes is of small account. The cost of chemicals, when bought in large quantities, is of comparatively little account.

There is yet some question as to whether fumigation is injurious to nursery stock. It is a common idea among some nurserymen that it is the case. Careful experiments in a number of experiment stations have not, however, borne out these claims, and it is the expressed opinion of many writers that injury is due to carelessness in the work. They have indeed found that there has been some loss in nursery stock fumigated, but that it is in no case greater than would ordinarily occur.

The advantages of fumigating nursery stock are that it prevents further distribution of the scale, and even in infested regions it saves spraying for two or three years if the trees are clean when set out.

APPARATUS, CHEMICALS, AND METHODS OF FUMIGATING NURSERY STOCK.

The essential apparatus for fumigating nursery stock are a gas-tight fumigation house or box, one or two earthernware crocks or glass jars, an eight or sixteen-ounce graduate for measuring acid and water, a set of scales for weighing the cyanide, and a number of small paper bags for holding the cyanide. See Plate III, Fig. 2.

The chemicals are fused potassium cyanide, 98 per cent. pure, and commercial sulfuric acid of specific gravity about 1.83.

The formula is as follows:

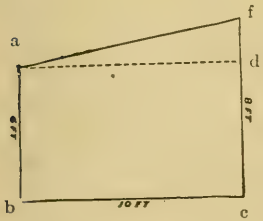
Potassium cyanide, 98 per cent. pure	1 part.
Commercial sulfuric acid	2 parts.
Water	4 parts.

In a good, tight house, two-tenths of a gram of cyanide should be used for each cubic foot of space in the house. If the house is leaky, or if it has a dirt floor, 25-100 of a gram should be used.

The cubic contents of the house and the amount of chemicals to be used should be accurately computed. As the quantity of cyanide per cubic foot is given in the metric system, and common scales give weight in avoirdupois, it is necessary to reduce the total number of grams of cyanide to ounces avoirdupois by dividing by 28.35, the number of grams in an ounce. To get the quantity of acid and water, simply double and quadruple the quantity of cyanide and measure both in glass graduate marked according to the avoirdupois table.

Examples:

To find contents of largest room in fumigation house, pictured in Plate XIX.



Height of front wall	8 feet.
Height of rear wall	6 feet.
Width of room	10 feet.
Length of room	14 feet.

$10 \times 6 = 60$, or number of sq. ft. in the area of rectangle a b c d.

$10 \times 1 = 10$, or number of sq. ft. in the area of triangle a d f.

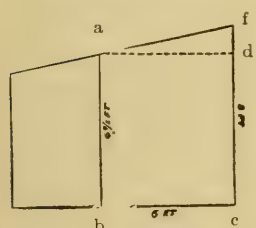
$60 + 10 = 70$, or number of sq. ft. in the area of end.

$70 \times 14 = 980$ or cu. ft. in contents of room.

$980 \times \frac{2}{10} = 196$, or number of grams potassium cyanide required.

$196 \div 28.35 =$ approximately 7, or number of ounces potassium cyanide.

To find contents of the second largest room in above plan:



$6 \times 6\frac{4}{5} = 40\frac{4}{5}$, or number of sq. ft. in the area of rectangle a b c d.

$6 \times \frac{3}{5} = 3\frac{3}{5}$, or number of sq. ft. in the area of triangle a d f.

$40\frac{4}{5} + 3\frac{3}{5} = 44\frac{2}{5}$, or number of sq. ft. in the area of end of room.

$44\frac{2}{5} \times 4 =$ approximately 178, or number of cu. ft. in contents of room.

$178 \times \frac{2}{10} = 35.6$, or number of grams potassium cyanide required.

$35.6 \div 28.35 =$approximately $1\frac{1}{4}$, or number of ounces of potassinm cyanide.

To find contents of fumigation box, pictured in Plate XVIII.

$3 \times 3\frac{1}{3} = 10$, or sq. ft. in area of end of box.
$10 \times 10 = 100$, or cubic ft. in contents.
$100 \times \frac{2}{10} = 20$, or number of grams potassium cyanide.
$20 \div 28.35 =$ approximately $\frac{5}{7}$, or numberof ounces potassium cyanide required.

THE FUMIGATION HOUSE.

The essential feature in a fumigation house or a box is to have it as nearly air-tight as possible. The cheapest construction of walls, roof, and floor is double boarding with one or two layers of tar paper between. In a house the frame and the first layer of boards should be constructed on the box plan, in such a way that strips of the paper can be applied beginning at the base of one wall and extending up and over the roof to the base of the opposite wall. Let the strips lap five or six inches. Projecting rafters or studdings, to get around which the paper has to be broken, should be avoided. If such have to be used, extra layers of paper should be placed around them so as to make the joints air-tight. This precaution, also, should be applied to doors and ventilators. It is recommended that two layers of paper be used between the boarding all around the building, including the roof and floor. The first layer of boards for the wall should be matched flooring. The second may be matched or lapped siding, placed horizontally, or boards planed on one side with weather strips, nailed vertically, as shown in Plate XIX.

The roof may be shingled, or may be built, like the wall, with planed boards and weather strips.

Partitions should be built in a similar way, but may be constructed of a cheaper grade of boards. The floor is constructed in a similar manner, placing a fair grade of flooring for the top layer.

In order that the gas may have access to all parts of trees to be fumigated, the floor should have a movable slat grating on which the stock may be laid, and which will hold it a short distance from the floor.

Doors and ventilators should be made similar to those of a refrigerator, and of double boarding, with paper between like the walls. Doors should have three, and ventilators two, hinges. They should close by means of clamps, like those of a refrigerator. Heavy felt strips should be glued to both doors and casing where they come together, as shown in section of door, in Plate XIX.

The plans as drawn may be varied in dimensions to suit each individual nurseryman's needs. The plan presented in Plate XIX is large enough for the biggest nursery in the State. The house is 8 feet high in front and 6 feet in the rear, and the larger room contains 980 cubic feet. At .2 grams per cubic foot this will take 196 grams cyanide, or approximately 7 ounces.

For tender stock this should not be exceeded; but for the bulk of fumigation work that a nurseryman has to do, 1 ounce per 100 cubic feet is in common use, or $9\frac{1}{2}$ ounces, approximately, for the room given. The small room contains 178 cubic feet, which at 2-10 grams per cubic foot would take $1\frac{1}{4}$ ounces, and at 1 ounce per 100 cubic feet would require 1⁸⁄₁₀ ounces cyanide. The small room indicated in the plan may be used for storage or workshop.

Where only small quantities of stock are to be fumigated, a box like that shown in Plate XVIII will serve the purpose very well. It is built of double boards, with paper in between. The material for the box should be as light as possible, commensurate with sufficient strength, so that it can be easily moved about. The demand for lightness, strength, and sufficient tightness can be met by constructing the inside portion of the box of $\frac{3}{4}$-inch material, and reinforcing the corners inside with heavier pieces of material to which the boards have been nailed. A double layer of tar paper should then be tacked on all around the box, and this should be covered with $\frac{1}{2}$-inch matched material such as is usually used in box making. If desired the corners can be reinforced on the outside so as to prevent the ripping off of the ends of the boards, should they strike against anything in moving. The cut will show the plan sufficiently so that a carpenter can easily construct it. It contains 100 cubic feet and will take approximately 5-7 ounce potassium cyanide, if 2-10 of a gram is used per cubic foot, or 1 ounce according to the other plan.

A few nurserymen have an oiled canvas tent which can be placed over a wagon loaded with nursery stock. The edges are weighted down and made tight by piling dirt on them. If carefully done, fumigation with such apparatus will be efficient; but it is doubtful if it is any cheaper in cost or more economical in time than the construction and use of a fumigation house as already described. A few large nurseries in other states have built fumigation houses large enough to hold a loaded wagon. Such an arrangement is no doubt economical of time, but the cost of house and fumigation is materially greater.

In addition to the house or box the only apparatus needed are one or two crocks holding about one-half gallon, an eight-ounce glass graduate for measuring acid and water, and some paper bags in which to weigh out the cyanide.

A great many formulas giving the proportion of acid and water to cyanide are in use. A common one is to take half again as much acid as cyanide, and half again as much water as acid. As the acid is quite cheap and the commercial brand is apt to vary in strength, a great many use the 1–2–4 formula, or two ounces acid and four ounces water to every ounce of cyanide. The cyanide, as already noted, should be 98 per cent. pure. The acid may be ordinary commercial sulfuric, which can be obtained of any druggist or dealer in chemicals.

Of Special Importance.

In connection with fumigation work of this kind the following points should be kept constantly in mind:

Be sure the potassium cyanide is 98 per cent. pure.

The potassium cyanide and the gases produced from it are exceedingly poisonous. The gas must not be inhaled, and the cyanide should be kept where children can not get at it. The crocks should be cleaned out after each fumigation and the residue should be buried.

Fumigate only when trees are in dormant condition.

The stock should be piled loosely and must not be packed at time of fumigation. Every part of the stock, including the roots, should be as free from dirt as possible, and especially, of course, the stems and branches should be as clean and free as possible from dirt and other covering which may prevent the gas from reaching the insects.

Stock may be fumigated if only slightly damp, but never when wet.

Never repeat the fumigation of the same stock.

A strong dose for a short time is less detrimental to the plants and more effective against the insects than a weaker dose for a longer time.

Evergreens seldom, if ever, need fumigation.

Lose no time in getting out and shutting door after cyanide has been dropped in acid.

Fumigation of Peach and Nectarine Houses for the San Jose Scale.

As a remedy for the scale in peach and nectarine houses, the experience of the writer during the past two or three years leads him to say emphatically that hydrocyanic-acid gas is a very satisfactory remedy. A number of houses of this kind have been fumigated by him or under his direction, and the outcome has been beyond expectations. One of the first was that of Mr. Philip Caswell, of Newport, and the following letter from him will indicate the results that he has had:

NEWPORT, R. I., January 10th, 1908.

MR. A. E. STENE,

R. I. Agricultural College,

Kingston, R. I.

DEAR SIR:—In reply to your favor of the 3rd inst., would say that the trees in my peach house were young stock and had not borne fruit over two seasons before you fumigated the house the first time. I don't think that the stock was infected when I imported it from England, as there had been scale on the old trees. The young stock, however, seemed to take it pretty badly, so that it showed its effects on the fruit the year previous to the fumigation.

The results of the first application of the potassium cyanide mixture were quick to be seen, apparently killing most of the scale. However, we gave the house another fumigation in about two weeks, which made all scale life extinct. Much improvement was noticed in the fruit that summer.

As a matter of precaution we now use the treatment every spring, just before the trees break, which keeps them free from the scale. I am inclined to believe that no preparation could work better than this cyanide mixture on peach trees inside a house.

Very respectfully yours,

PHILIP CASWELL.

It should be noted that, according to his letter, he himself gave the house a second fumigation a short time after the first, but this is not to be recommended. It is the experience of most users of the gas that two fumigations following closely upon each other are detrimental, and the results which the writer has had with other houses where only one fumigation has been given indicate that one each season is amply sufficient to keep the houses entirely free of the scale. In fact, if surroundings are such that the scale is not carried into the house from infested trees or shrubs outside, there should be no occasion to fumigate after the house has been thoroughly treated two or three successive years.

DIRECTIONS FOR FUMIGATING PEACH AND NECTARINE HOUSE.

The first essential is to determine accurately the contents, in cubic feet, of the house. The methods differ a little with the different kinds of houses. With an even span house, such as shown in Fig. 26, get the width of the house from A to C; the height of the wall from A to B; and the distance from the floor to the pitch from D to E; and finally, the length of the house.

If now we find the area of one end of the house in square feet and multiply this number by the number expressing the length of the house in linear feet, we shall obtain the contents in cubic feet.

Supposing the width of the house figured is 20 feet; the height of each wall 5 feet; and the height from the floor to the peak 10 feet; and the length 100 feet. The contents are ascertained by the following method:

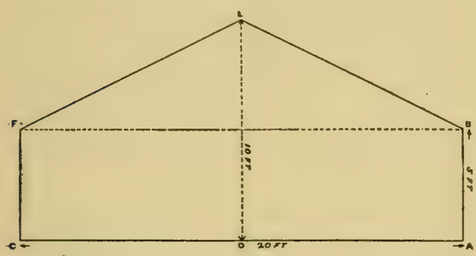


Fig. 26.

20 × 5 = 100, or number of sq. ft. in area of rectangle F B A C.

20 × 2½ = 50, or number of sq. ft. in area of triangle F E B.

100 ft. + 50 = 150, or number of sq. ft. in area of end.

150 × 100 = 15,000, or number of cubic ft. in contents of house.

If the house is a lean-to, as shown in the next illustration, Fig. 27, we must ascertain the height from A to B; the width from A to C; and the height from C to F, to find the area of one end of the house. After this is found, the example is the same as in the previous illustration, as follows:

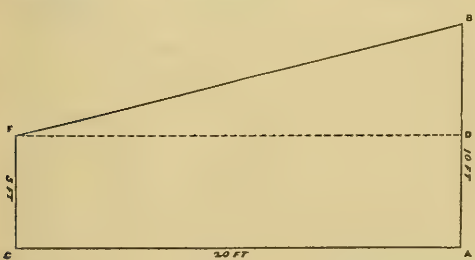


Fig. 27.

20 × 5 = 100, or area in sq. ft. of rectangle F D A C.

20 × 2½ = 50, or area in sq. ft. of triangle F B D.

100 + 50 = 150, or area of end in sq ft.

150 × 100 = 15,000, or cubic ft. in contents of house.

If the house is an uneven span as shown in the third illustration, Fig. 28, the example becomes a little more complicated. We have to have the height of both walls from A to B, and from C to F; the distance from A to D and from D to C; and the height from D to E. This will enable us to divide off the end of the house into two rectangles and two triangles; then by finding the area of each one of these, separately, and adding the results together, we will have the area of the end of the house.

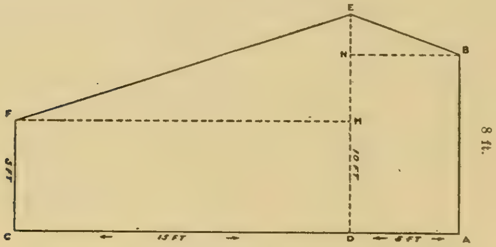


FIG. 28.

$15 \times 5 = 75$, or number of sq. feet in the area of rectangle F M D C.

$15 \times 2\frac{1}{2} = 37\frac{1}{2}$, or number of sq. ft. in the area of triangle F M E.

$5 \times 8 = 40$, or number of sq. ft. in the area of rectangle N B A D.

$5 \times 1 = 5$, or number of sq. ft. in the area of triangle B N E.

$75 + 37\frac{1}{2} + 40 + 5 = 157\frac{1}{2}$, or number of sq. ft. in the area of one end of the house.

$157\frac{1}{2} \times 100 = 15{,}750$, or number of cubic ft. in the contents of the house.

After finding the contents of the house in cubic feet, the method of ascertaining the amount of chemicals is the same as that already given for fumigating nursery stock.

THE OPERATION.

The chemicals secured, select a night when there is little or no wind, and, having previously closed up the house so far as possible, arrange one or two ventilators so that they can be opened from the outside. Close all other openings excepting one door.

If the house is a long one, two or more jars should be used, and the total quantity of chemicals divided accordingly.

Arrange the jars by suspending the cyanide over them with string, as already described, or, dispensing with this, which is perfectly safe if one uses ordinary care, place a bag beside each jar. Now turn the hose on the outside of the house so as to wet it down thoroughly. This will close up the openings in the glass of the roof to a considerable extent. Begin at the jar farthest away from the door and dropping the cyanide into it pass quickly to the next, and so on until the door is reached. Close and lock the door and wait the required length of time, which need not exceed one hour, then open the doors and ventilators and ventilate the house for a half hour or so before entering.

Usually one can allow a peach house to remain closed until the following morning. Most of the gas will have leaked out by that time, and with a little precaution of opening doors and ventilators for a short time before going in, anyone can enter and open up the house fully. After a half-hour's ventilation, it should be perfectly safe for anybody to work in.

Dipping Nursery Stock.

Fig. 29.

There has been considerable discussion in some of the agricultural papers about the advisability of dipping nursery stock, either at the nursery or at the place where it is to be planted. It is claimed for this method that it is considerably cheaper than fumigation and less harmful to the nursery stock.

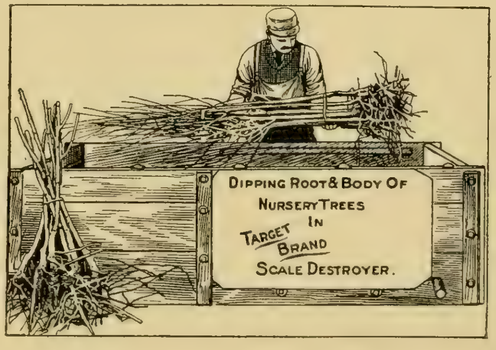


Fig. 30.

For dipping, nursery stock should be tied in *loose* bundles. It may be immersed, stem and top only, or the whole bundle roots and all, may be put into the dipping solution.

Trees should be carefully pruned before dipping and should remain in the solution for only a short time, say, one to two minutes.

The solution may be either the standard lime-sulfur wash, in somewhat greater strength perhaps than that ordinarily used for orchard trees, or one of the soluble oils.

The accompanying illustrations, Figs. 29 and 30, indicate clearly enough the apparatus needed and the method of doing the work.

There has not been enough work done on this by careful and unbiased experimenters to unqualifiedly recommend it, but evidence seems to point to the fact that it is of considerable value and should be recommended for trial by orchardists and for further work by experiment stations.

Additional Notes and Explanations Regarding Illustrations.

ACKNOWLEDGMENTS FOR USE OF CUTS.

The writer is indebted to the United States Department of Agriculture for cuts for Figs. 3, 5, 6, 8, and 9.

To the Virginia Crop Pest Commission for cuts for Figs. 1, 2, and 7, and Plate IX.

To the New York (Geneva) Experiment Station for cuts for Plate III, Fig. 1, and for Plate XVII.

To the Connecticut Experiment Station for cuts for Plate III, Fig. 2, and Plate XVI, Fig. 2.

To the Rhode Island Experiment Station for cut for Plate V.

To the American Horticultural Distributing Co. for cuts for Figs. 29 and 30.

To the Delaware Experiment Station for cut for Plate II.

To R. I. Smith, State Entomologist, Atlanta, Ga., for cut for Plate XVI, Fig. 1.

To the Wallace Machinery Co. for cuts for XIV, Figs. 1 and 2.

To the Gould Mfg. Co. for cuts for Plate XII, Figs. 1, 2, and 3; Plate XIII, Figs. 1, 3, and 4; and Figs. 10, 12, 14, 17, and 18.

To the Friend Mfg. Co. for cuts for Figs. 13 and 24.

To the Niagara Sprayer Co. for cut for Plate XV.

To the Field Force Pump Co. for cut for Fig. 11.

To the Deming Co. for cuts for Fig. 19, and Plate XIII, Fig. 2.

To the Latham Co. for cut for Fig. 23.

To the Morrill and Morley Co. for cut for Plate XI.

To the Spramotor Co. for cut for Fig. 25.

All other illustrations are original.

NOTES.

NOZZLES.—The term "Vermorel," as the name of a type, is here used for all nozzles in which the liquid is forced through the orifice of the nozzle while in a whirling motion, produced either by injection of stream into an eddy chamber in a tangential direction, or by spiral grooves. Older terms are Cyclone nozzles or Eddy Chamber nozzles.

Figures 18 and 24 indicate the latest forms of Vermorel nozzles. These have comparatively large eddy chambers, and apertures large enough to permit the passage of all particles which can go through the strainer of the pump. They do away with the plunger of the old-style Vermorel, which was designed for cleaning the orifice should it clog up.

Apparatus for Boiling the Lime-Sulfur Wash.—Figures 20 and 21 and Figures 1 and 2, Plate XVI, indicate methods of arranging apparatus for boiling the lime-sulfur wash. No further explanation is necessary except to emphasize that when the barrels are arranged on a platform this should be high enough, or arranged on a side-hill in such a way that the prepared wash can be run into the spray barrels by gravity.

Strainers.—Figure 22 indicates how home-made strainers may be constructed which will give as good results as that shown in Figure 10, though somewhat more cumbersome. The one at the top is made by tacking brass wire strainer cloth on a slant inside a common pail into the bottom of which a small piece of gaspipe has been inserted. The one illustrated below consists of an outer box about one foot square and ten inches deep, outside measurement, and a removable inner box-like frame so constructed that the strainer cloth forms a slanting bottom in it. A gaspipe forms an outlet as above. This form can be more easily cleaned than the pail.

Plate IV.—The cuts in this plate are from photographs taken in Mr. N. S. Winsor's orchard, Greenville. Figure 1 shows the excellent culture results attained by pasturing hogs in the orchard, and Figure 2 illustrates a good cover crop of rye in a pear orchard. In clean-culture method of orcharding, cultivation should cease during the first part of August and a cover crop should be sown.

Rye is excellent in many ways, but it is better to use a leguminous crop which will gather atmospheric nitrogen as well as hold the soil to prevent washing, and furnish humus.

Plate V.—This illustration is more or less typical of neglected apple trees in our State. The moss and lichens form an excellent harboring place for insects and plant diseases. The trees can be readily cleaned by the application of Bordeaux mixture or the lime-sulfur wash.

Plate VI.—The types of trees shown are characteristic. Close planting and misdirected pruning result in the first type, in which picking, as well as spraying and pruning, is laborious and expensive. The type shown in the lower picture, although not ideal, is a far better form and should be adopted by orchardists in the future.

Plate VII.—This picture explains itself. The natural tendency of most varieties of pears to assume a columnar shape has been accentuated by the pruning and environment of this tree, and the result is undesirable from the standpoint of economy in pruning, spraying, and harvesting.

Plate VIII.—This picture is from a photo taken in the orchard of Rev. Mr. Hawkins, East Greenwich. It illustrates the method of thorough pruning and careful spraying necessitated by badly infested trees.

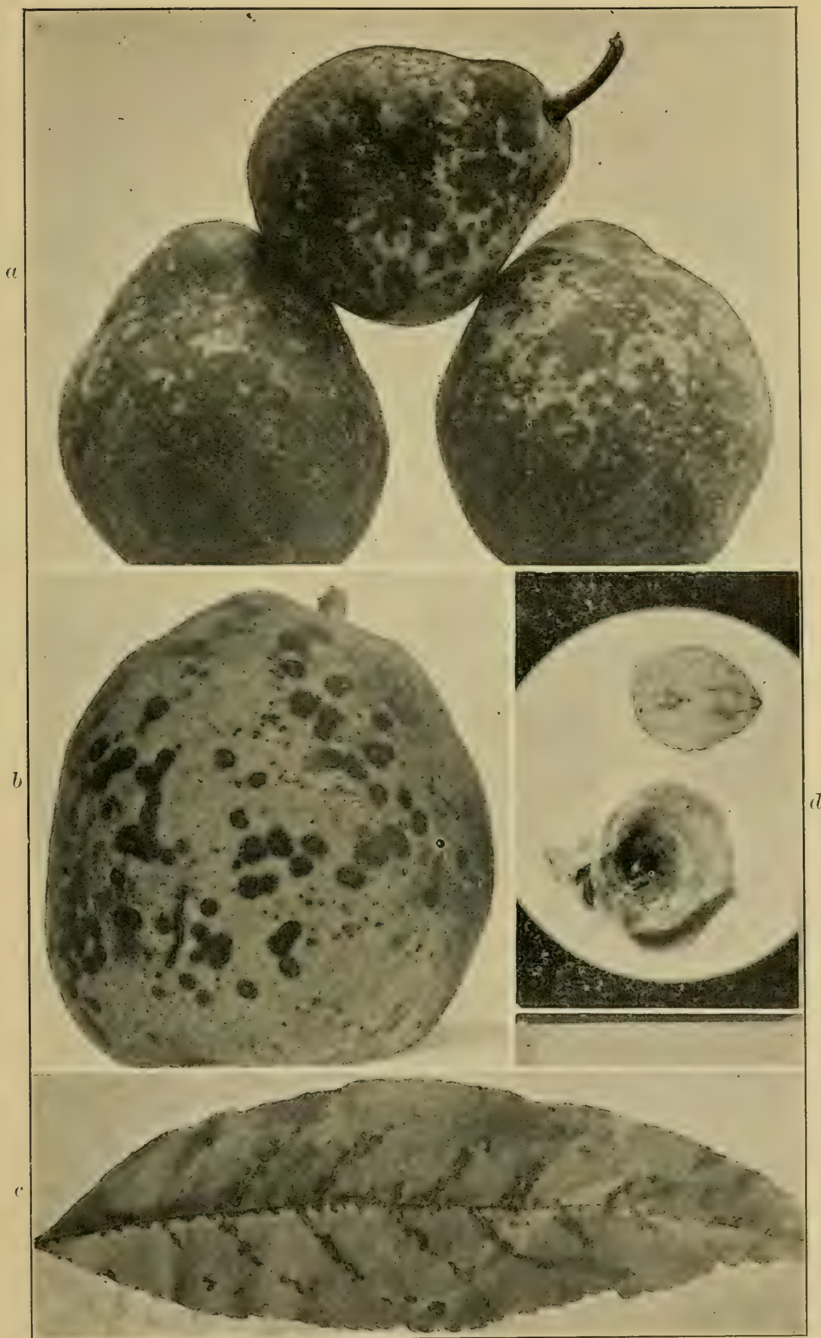


PLATE II.

(a) Kieffer pears badly infested with the San José Scale; (b) Duchess pear affected with Pear Leaf Blight (Entomosporium maculatum)—See page 23; (c) Peach leaves showing scales along the veins; (d) The underside of adult female scale, also the insect without the scale covering. From Bul. 58, Del. Exp. Sta.

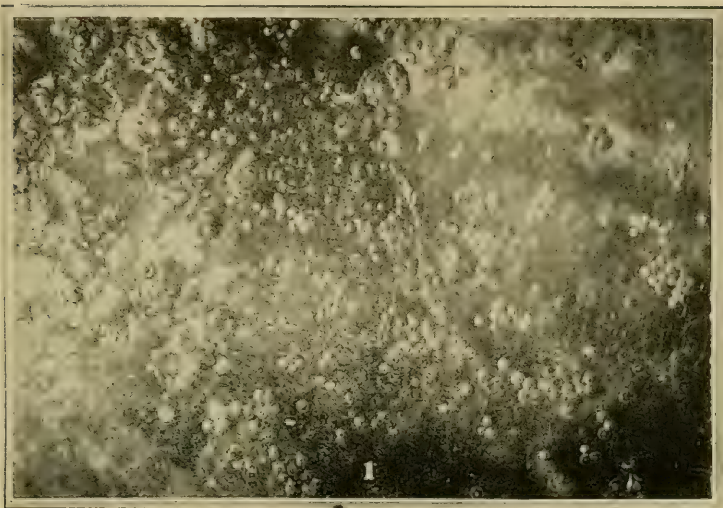


Fig. 1.—Picture of Scale on Bark slightly enlarged. After N. Y. (Geneva) Station.
For explanation see page 25.

Fig. 2.—Fumigation Utensils. After Britton, Conn. Exp. Sta
For explanation see page 78.
Plate III.

Fig. 1.

Fig. 2.

Plate IV.

Good culture in Apple and Pear Orchards. For explanation see pages 42, 43 and 90.

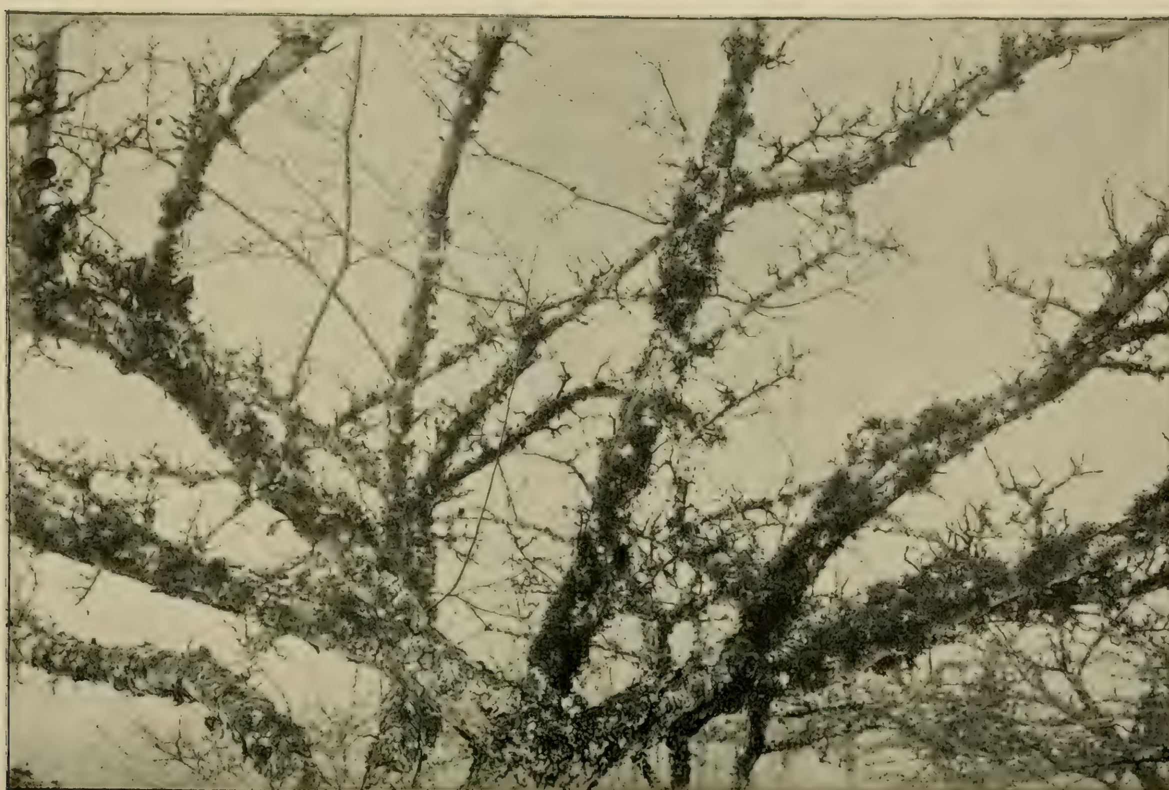


PLATE V.—Mossy Top of Apple Tree, a capital place for scale. From Bul. 83, R. I. Exp. Sta. See page 91.

PLATE VI.—High and low training of apple trees. See pages 42, 43 and 91.

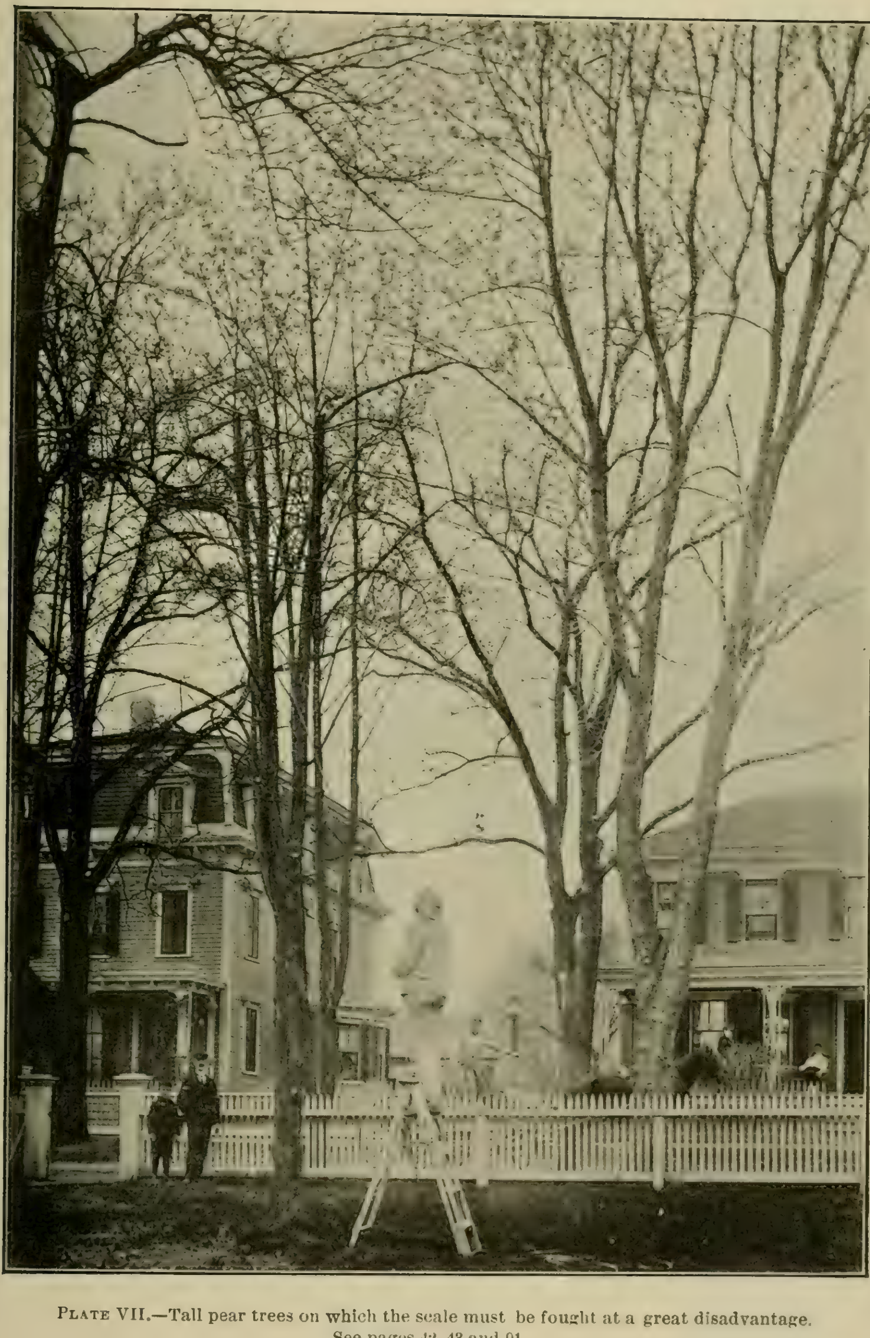


PLATE VII.—Tall pear trees on which the scale must be fought at a great disadvantage.
See pages 42, 43 and 91.

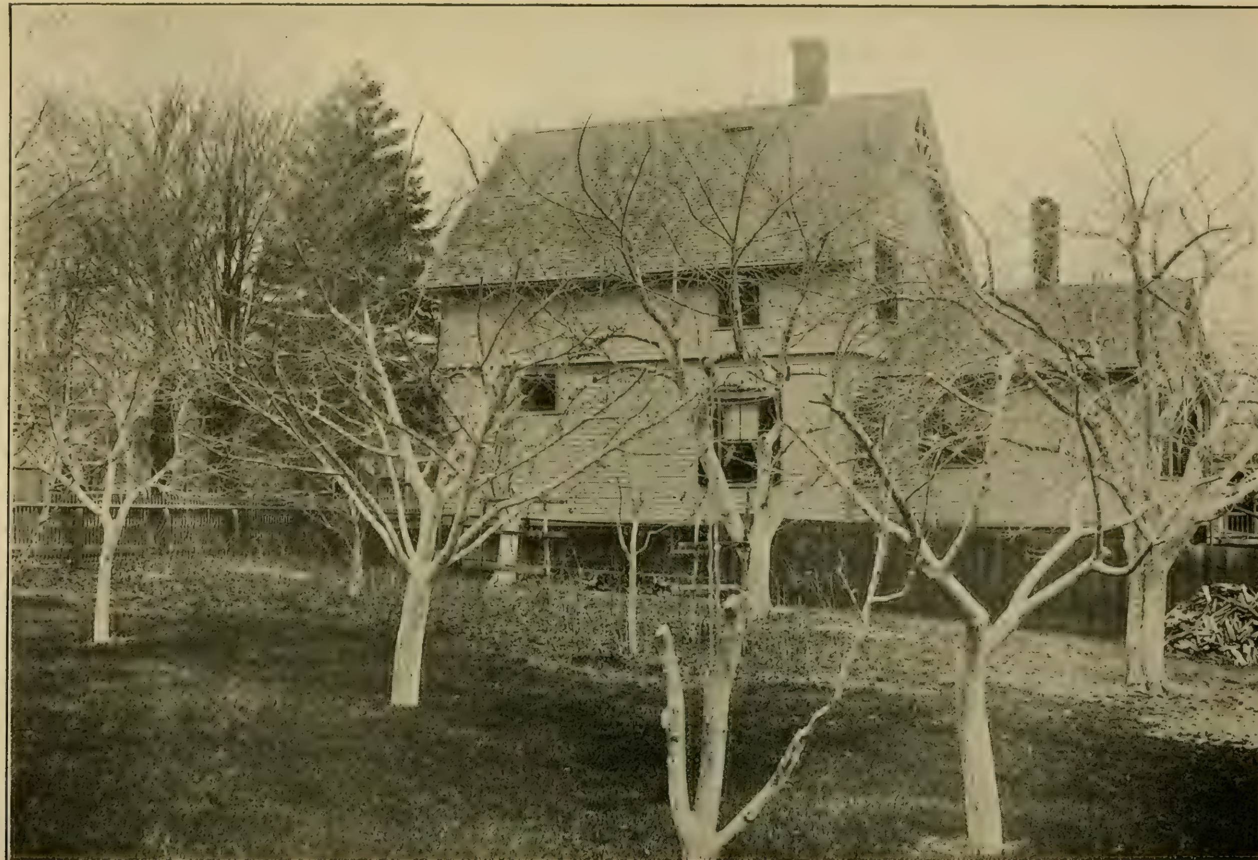


PLATE VIII.—Thorough pruning and spraying for the San José scale. See pages 43 and 91.

PLATE IX.—A Well Sprayed Orchard. Note the advantage of using the lime-sulfur wash, in that it shows clearly how well the spraying has been done. From Fifth Report of Va. Crop Pest Com.

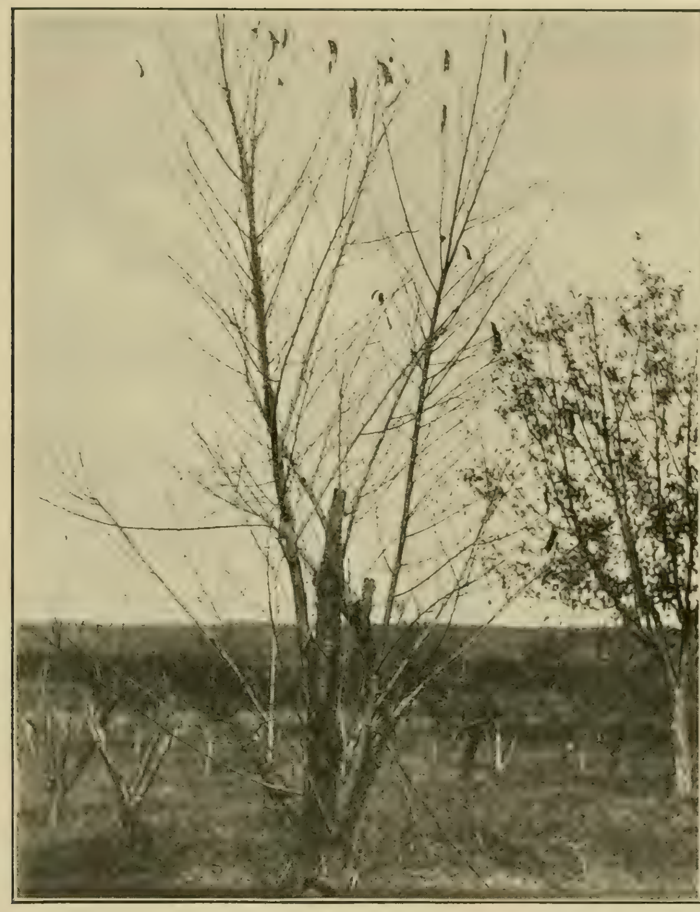


Plate X.—Peach tree badly infested with San José Scale cut back and renewed. With continued thorough spraying and a little pruning this tree would make a good bearing tree. Others shown in the backgrounds were so low in vitality when treated that they failed to revive.

PLATE XI.—Small portable barrel pump. See page 67.

FIG. 1.—Barrel pump showing agitator.

FIG. 2.—Bucket pump.

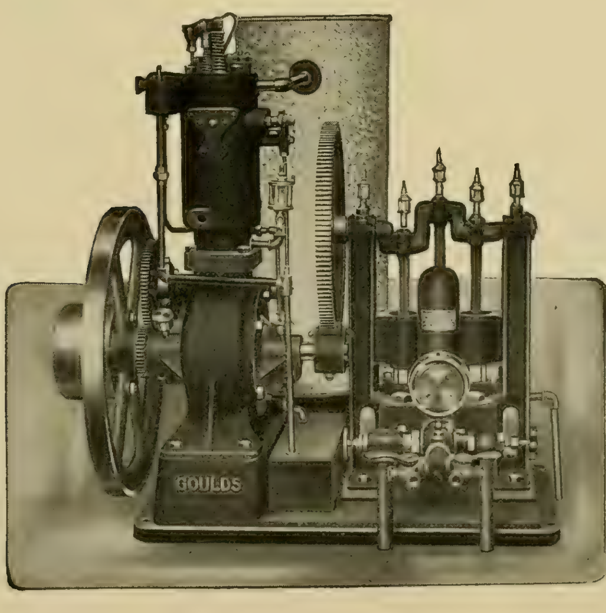


FIG. 3—Gasolene power sprayer.

PLATE XII.

For explanation and discussion see pages 67 and 68.

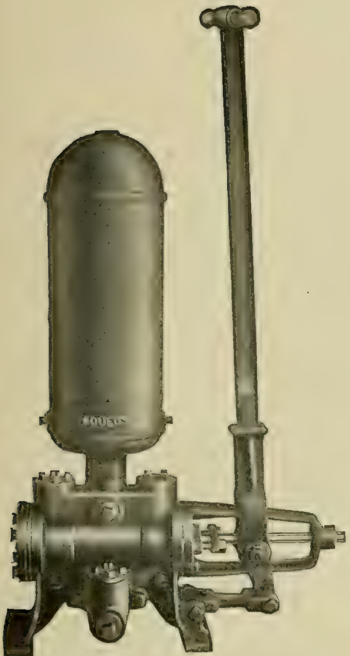


Fig. 1.—Vice-Admiral tank pump.

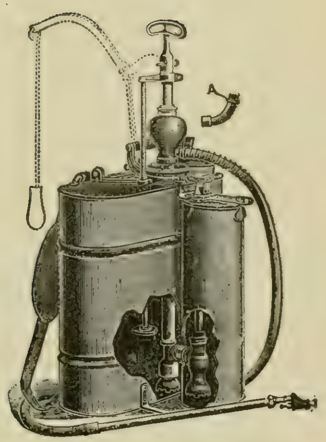


Fig. 2.—Knapsack Spray Pump. Deming Co.

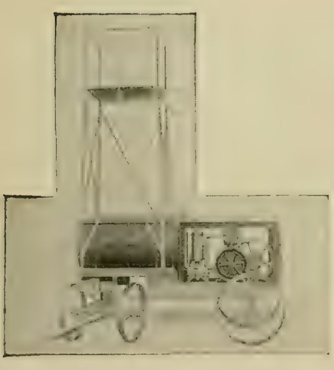


Fig. 3. — Gasolene power sprayer mounted on tank with tower.

Fig. 4.—Gasolene power sprayer in operation.

Plate XII.

For explanation and discussion see pages 66 to 73.

Fig. 1.—Invincible Mounted Sprayer—Wallace Machinery Co. The spray liquid is pumped into an airtight tank together with compressed air by pumps driven from the wheels. When machine is standing still the compressed air continues the work.

Fig. 2.—Gasolene power sprayer with air-cooled engine.

Plate XIV.

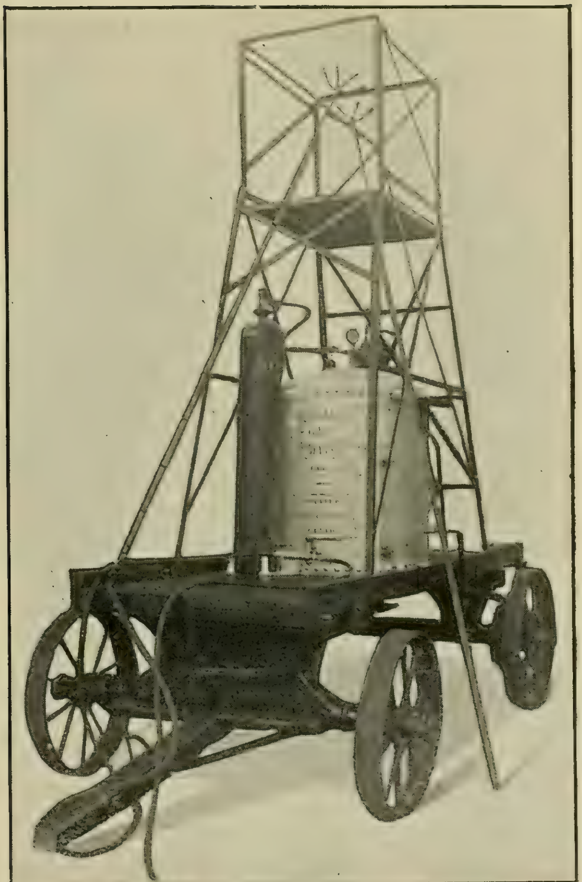


PLATE XV.

Niagara Gas Sprayer with Tower. Note the carbon dioxide gas cylinder from which power to force liquid out of large tank is derived. See page 68.

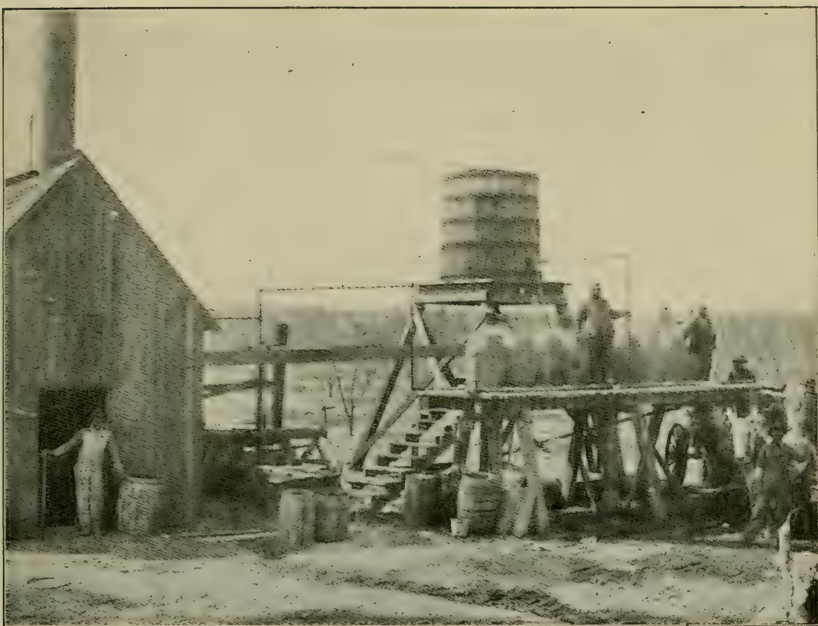


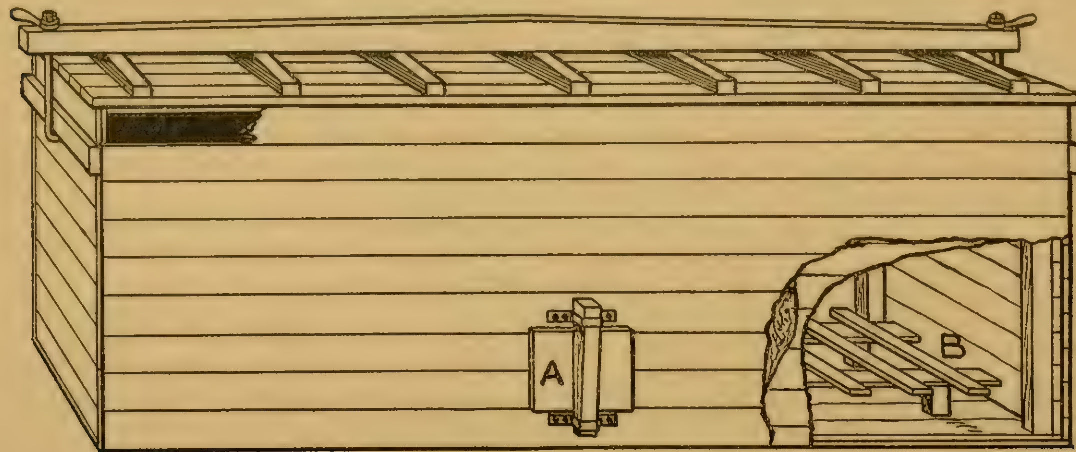
Fig. 1.—Plant for preparing lime-sulfur wash with steam.

Fig. 2.—Cooking lime-sulfur wash with steam.

Plate XVI.

For explanation see page 51.

PLATE XVII.—Hexagonal Fumigator for trees. This fumigator is made in sections and is taken apart in moving. For explanation see page 76.



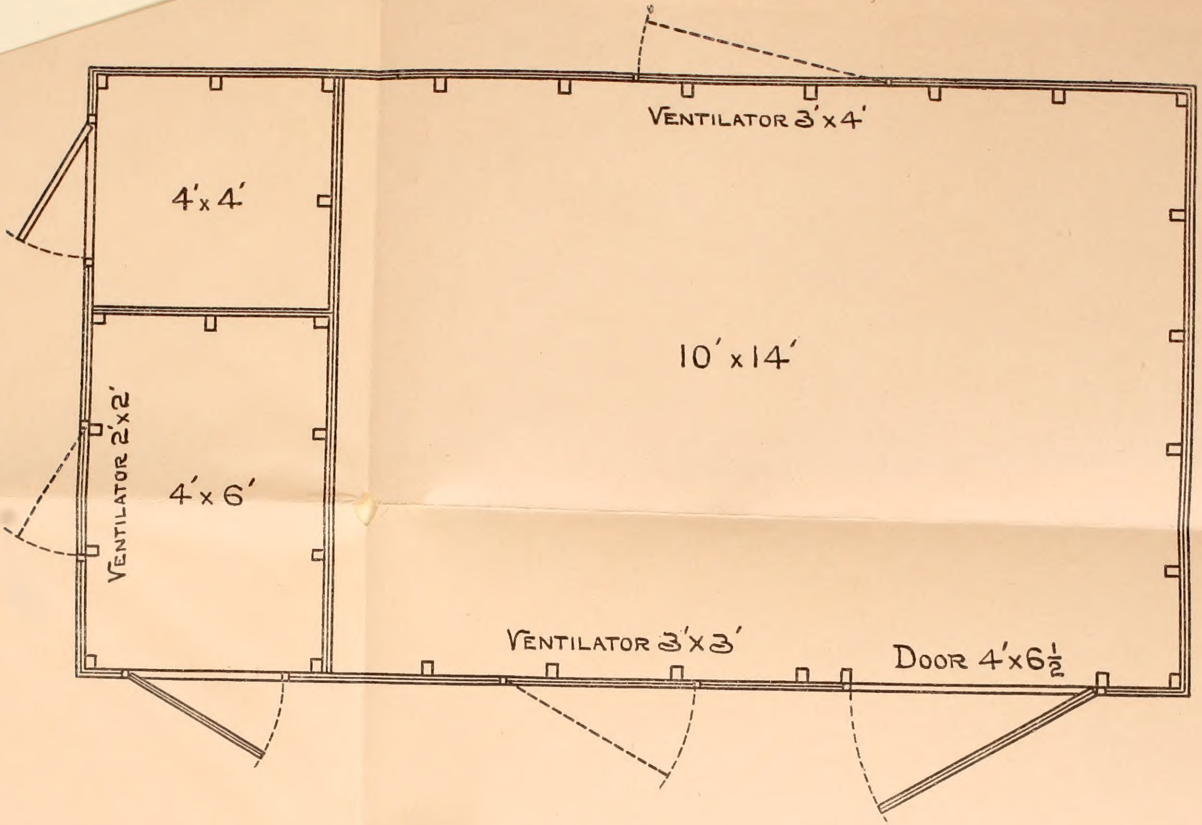
PLATE—XVIII.

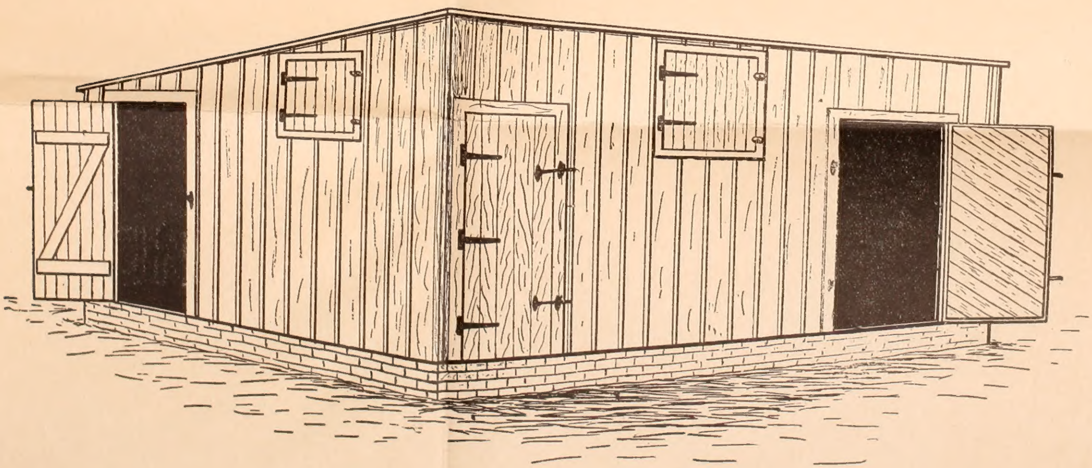
A Small door through which chemicals are introduced.

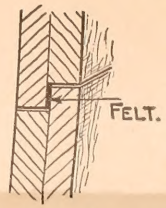
B Slat grating on which the stock is placed.

For further discussion see pages 81 and 82.

Dimensions of Box: 10 ft. long, 3 ft. high and 3½ ft wide, outside measurements.

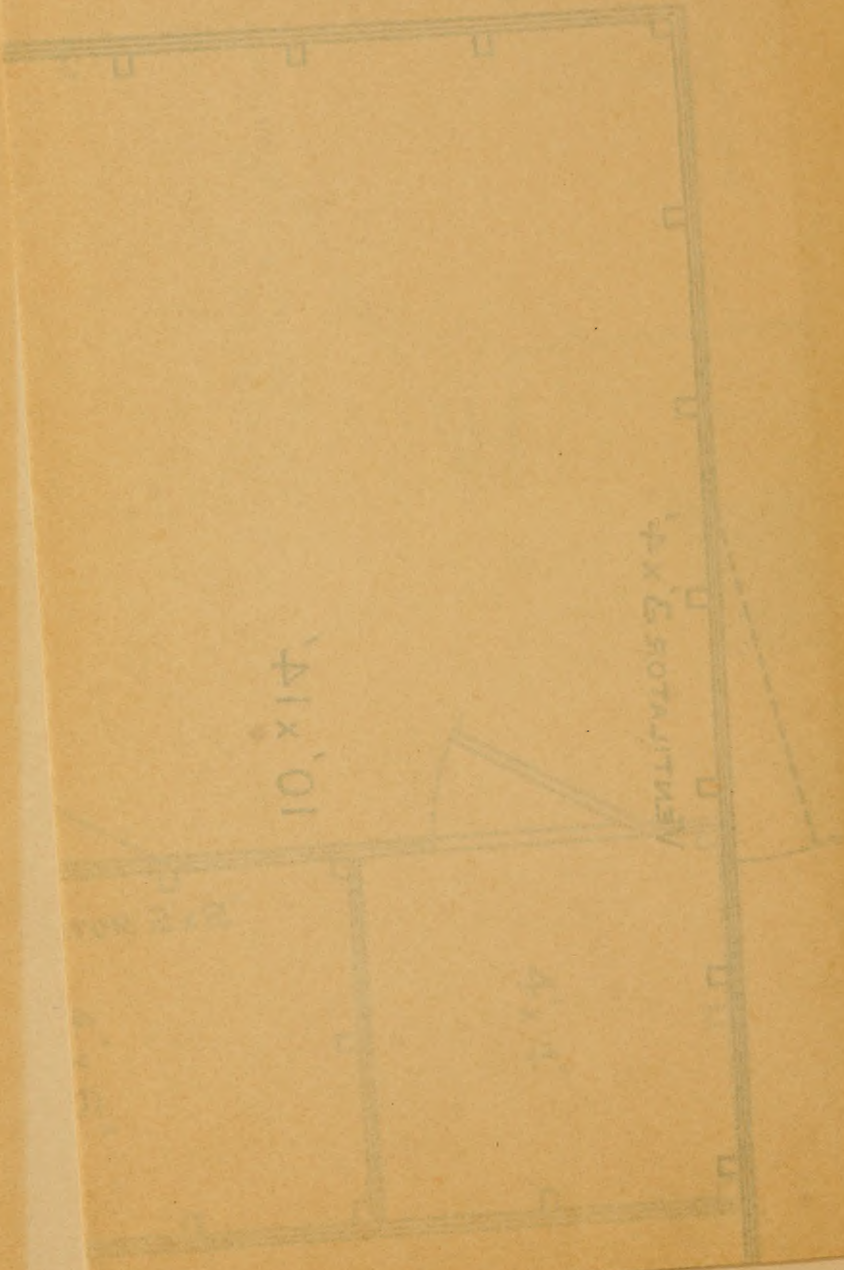






Section of Door.

Plate XIX.
For description see pages 80 and 81.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