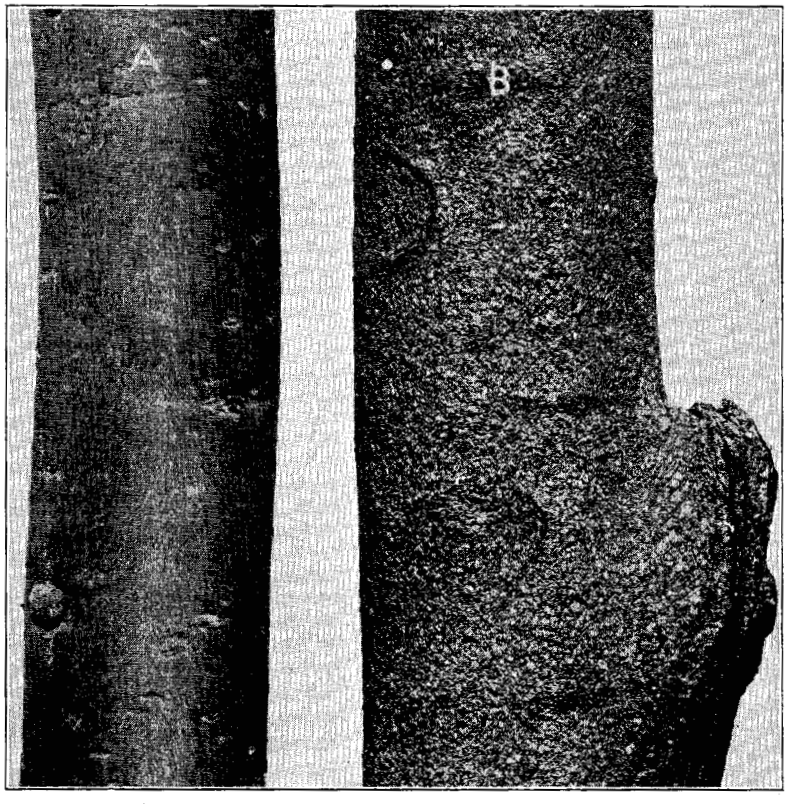
SEPTEMBER, 1916 BULLETIN NO. 214

AGRICULTURAL EXPERIMENT STATION.

KANSAS STATE AGRICULTURAL COLLEGE.

THE SAN JOSÉ SCALE

(*Aspidiotus perniciosus* Comstock)



San José scale. Noninfested (*A*) and infested (*B*) apple wood. (After Dean.)

MANHATTAN, KANSAS

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SUMMARY.

The original home of the San José scale is in China. It was brought to California in the early seventies and was first found in Kansas in 1906.

The San José scale may destroy the producing power of any orchard it infests. Natural conditions can not be expected to hold it in check, but it can be kept under complete subjugation by careful inspection and treatment of trees before setting out and by timely spraying with proper materials and methods.

Orchardists should satisfy themselves that the trees or shrubs they buy are free of scale. If there is any doubt the plants should be fumigated or dipped previous to setting out.

The most practical way to control the San José scale in infested plantings is by spraying. Spraying is beneficial, not only in controlling the scale, but also because it controls other insects and diseases and so promotes the general health of the trees.

The most satisfactory material for spraying is lime-sulphur. This may be prepared at home or bought ready for use. The commercial product is more uniform than the home-made, it is more convenient, saves time and labor, and is almost as cheap.

Miscible oils have been extensively used, but they are not recommended where lime-sulphur can be obtained, as there is much more danger of injury to the trees.

The secret of success in spraying for San José scale is good material and thoroughness. The latter requires good machinery.

A bucket or knapsack sprayer may be used where only a few shrubs or trees are to be sprayed. For orchards, a barrel pump, a double-acting tank pump or a power sprayer may be used, depending on the size of the orchard.

The best type of power sprayer is the gasoline sprayer, since with it a high and continuous pressure may be obtained, which is very essential in securing good results.

In selecting a sprayer the fittings and accessories should be given special attention.

THE SAN JOSÉ SCALE*

(Aspidiotus perniciosus Comstock.)

By LEONARD M. PEAIRS AND JOSEPH H. MERRILL.

The fruit grower of Kansas, whether his planting consists of one peach tree in the back yard of a city lot or of a thousand acres of apple trees, should be interested in the San José scale; and it is with the hope of awakening his interest that this bulletin is written.

While the scale has been present in Kansas for several years, in restricted areas, it has not received the widespread attention that its possibilities for doing injury to the fruit-growing interests of the state warrant. It is hoped that this bulletin may call attention to its importance and furnish in concrete form all the information necessary for its recognition and treatment. The discussion includes (1) a brief and concise history of the scale in the United States and in Kansas; (2) a discussion of its life history; (3) the extent of its distribution and injury; (4) an outline of preventive measures; (5) directions for the control of the scale in infested orchards; and (6) a discussion of materials and methods for spraying.

HISTORY AND DISTRIBUTION.

The original home of the San José scale is in the hill region of China to the mountains that separate China proper from Mongolia and Manchuria. In that region it attacks, among other plants, the flowering Chinese peach, and it is thought that a Mr. Lick, of San José, Cal., who imported some of these plants in the early seventies, brought the scale with them into this country. It soon became quite generally distributed in that part of California, and spread in all directions over the states west of the Rocky Mountains, and even into British Columbia. In 1886 or 1887 two New Jersey nurserymen brought some Japanese plum stock from San José, Cal., to secure, if possible,

* Since March 1, 1912, Professor Peairs has been professor of entomology in the University of West Virginia. The original manuscript for this article was prepared while he was connected with the Kansas State Agricultural College. Its publication was delayed for several years. Meanwhile Dr. J. H. Merrill, who was appointed to fill the place made vacant by the resignation of Professor Peairs, accumulated additional data relative to the San José scale in Kansas. It seemed advisable to incorporate this data, and with the consent of Professor Peairs, the entire manuscript was revised by Doctor Merrill.

a curculio-proof variety of plum. This stock was infested with the scale, and since the dangerous character of this insect was unknown, it spread unnoticed and unchecked for several years, in the meantime being transported to several states along the Atlantic coast. In the early nineties, when the scale forced itself into general notice, it was too late to exterminate it, and even the problem of control looked uncertain for a time. From the nurseries, which inevitably became infested, the scale has been carried into, and established in, almost every state in the Union.

History of the Scale in Kansas.

Serious infestation of the scale was first found in Kansas in 1906, but had undoubtedly been present some years previous to that date. At that time there was no law in Kansas providing for inspection of orchards or for any means of controlling the insect. The legislature of 1907 enacted a law, which was amended and strengthened by the legislature of 1909, giving the state entomologists power to inspect orchards and have infested plantings cut out or properly treated, and to conduct experiments to find better methods of control. The law also authorized the treatment of infested plantings against the owner's will if necessary for the protection of the fruit-growing interests in general, By virtue of this law all nurseries within the state are subjected to a rigid examination.

Practically all infested plantings in the state have been treated in some manner and all infested areas have actually been reduced in size. While it is highly improbable that the scale will ever be entirely eradicated, this law has made it possible to so control the scale that there is little likelihood of its spreading, The loss at the present time amounts to but little more than the cost of spraying, which is counterbalanced by the beneficial effect on the general health of the trees.

HABITS AND LIFE HISTORY.

The San José scale is a flat, scale-like object, bearing at its center a little point or tubercle surrounded by a depressed ring. Beneath this protective covering may be found the insect itself, which is a small, lemon-yellow, soft-bodied object. The female scale is nearly circular, but the male is more elongated. They range in size from a tiny point to an ordinary

pin-head. These insects suck the sap from infested plants, and when sufficiently abundant cause their death.

The San José scale passes the winter in a dormant condition as a half- to three-fourths grown insect. In the spring they begin to suck the sap from the tree as soon as it starts to flow, and increase in size until they become full grown. The female now begins to give birth to young at the rate of about nine or ten per day and continues to do so for about six weeks. An overlapping of generations occurs because the young begin to reproduce at least a week before the mother ceases to do so. This overlapping makes it difficult to trace the number of generations, but four seems to be the usual number for Kansas. The rate of increase is so rapid that if none of the progeny of one female were destroyed they would amount to over three billion in a single season. The young scales which emerge from beneath the mother scale resemble little specks of yellow corn meal., They are oval in shape, have six legs and one pair of antennæ. After crawling about for several hours they sink their whiplash-like tongue into the growing layer of bark, fruit or leaves, and begin to suck the sap. In a few hours they begin to secrete a mass of white, cottony and waxy fibers, which soon mat together, forming the scale-like covering over the insect. At first this covering is whitish in color and circular, with a

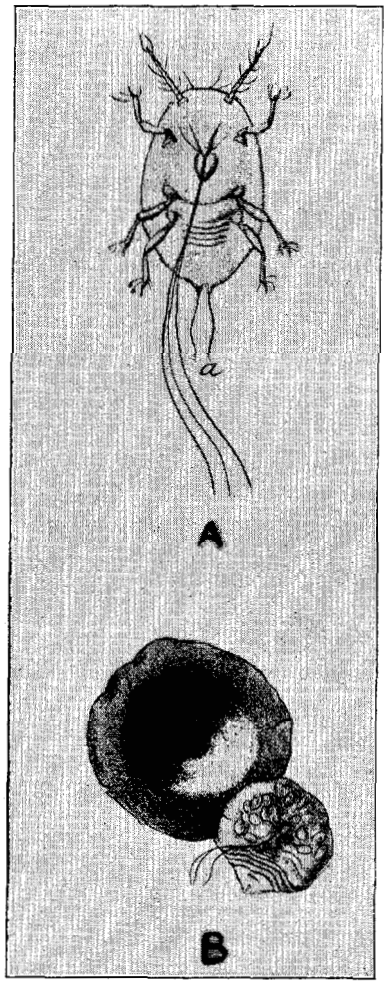

FIG. 1. The young (*A*) and the mature (*B*) San José scale insects. The small oval objects inside the body of the mature insect are young scales that are not yet born.

small point in the center. In from two to three weeks it becomes almost black, and later turns to a dusty gray. At the first molt the females lose their eyes, while both sexes lose their legs and antennae. The males have large purple eyes, and after two more molts gradually develop into delicate two-winged, orange-colored insects. The females remain flattened and circular, and after molting a second time, mate with the males.

METHODS OF DISTRIBUTION.

The scale can pass from plant to plant only during the brief period when it is a free-crawling object. This dispersal may be accomplished in several ways: (1) by crawling from tree to tree upon interlacing branches; (2) strong gusts of wind may carry the young short distances to other trees; or (3) they may crawl upon the feet and bodies of other animals, mainly birds and insects, and be carried considerable distances. The rate of mortality for the two last cases is high. The chance is very slight of scales being carried from tree to tree by persons working in the orchards or by horses and cattle. Only when orchards are very close together is there a possibility of infestation by means of wind. Birds and insects are the most common carriers of scale to uninfested orchards in the same neighborhood.

Scale is transported for great distances only through nursery stock which has become infested. Although most nurseries are annually inspected, there is still danger of getting infested stock from nurseries in scale-infested regions.

Nature and Extent of Injury.

All scale insects injure plants in the same way; that is, by sucking the sap and depriving the plant tissues of their food, or, in other words, by starving them. There is also a certain physiological effect from materials secreted by the scales into the plants, but this is of minor importance, as is shown by the fact that a tree not too badly weakened by loss of food will recover when the scale is killed.

The San José scale is found on the trunks, branches, leaves, and fruit. On the fruit it ordinarily causes small reddish discolorations, which seriously detract from its market value. The scales are frequently found clustered around the calyx end of the fruit. Oftentimes they may be found on the fruit when it is practically impossible to find them on the tree.

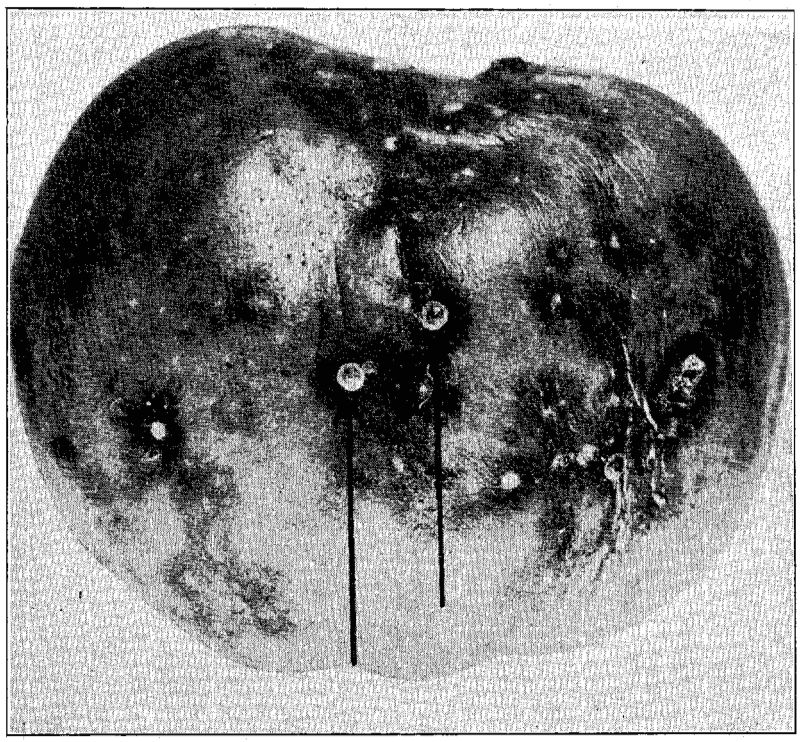

FIG. 2. Apple infested with San José scale. (After Dean.)

The extent of injury is unlimited when the conditions are favorable for the scale's development. In one or two seasons after infestation the tree may become incrusted, and in one or two more either die or become permanently worthless. What is true of the tree is true of an entire orchard, and what can occur in one orchard may occur in every orchard in a community, a county, or an entire state, given, as stated before, conditions favorable for the development and spread of the scale.

HOST PLANTS.

San José scale may attack many different kinds of trees, shrubs, vines, and ornamentals, but it is primarily a pest of fruit trees, peach trees being most liable to serious infestation. The Duchess and Bartlett pears are often seriously infested, while the Kieffer is apparently immune. The Blue Damson plum is more susceptible than other varieties of plums,

some of which are almost free from attack. Nearly all apples may be infested, but there is a marked difference in the susceptibility of different varieties, the Ben Davis and Yellow Transparent being more liable than many of the common ones. Small crabapple trees are liable to severe injury. Currant bushes are often badly injured or killed, especially the black currant. The sweet cherry may be infested, but the sour cherry is practically immune. Osage orange hedges about an orchard are a menace, for they are sometimes seriously infested and may always afford an excellent breeding place for the scale, Grapevines are ordinarily not attacked, but may be when grown

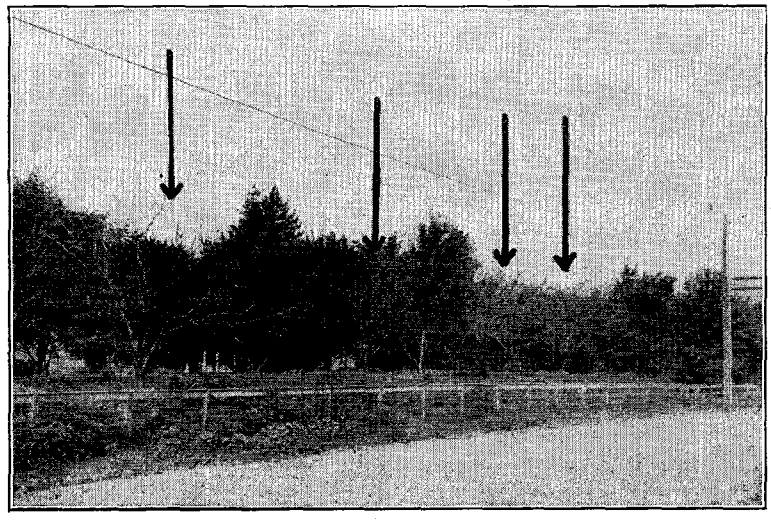

FIG. 3. *Peach trees killed by San José scale.* (After Dean.)

adjacent to seriously infested trees. Several varieties of roses and the flowering quince are the ornamentals commonly infested. The mountain ash is liable to heavy infestation and is a menace when grown adjacent to fruit trees or among ornamentals. Common shade and forest trees and many ornamentals are so seldom attacked that they may be called accidental host plants. To this class belong elm, maple, honey locust, cottonwood, willow, lilac, snowball, and syringa.

There are many varieties of plants which would never be attacked, except as grown under or near badly infested trees, when a few scales may appear upon them; for instance, we

have found it on smartweed, horse ragweed, rhubarb, and the blades of corn.

The following list of host plants was prepared by Prof. Geo. A. Dean, department of entomology, Kansas State Agricultural College, and applies especially to those trees and shrubs most commonly grown in Kansas :

(1) Trees and shrubs that are badly infested : Peach, pear, currant, plum (Wild Goose excepted), mountain ash, Osage orange, apple, crabapple, rose (some species), quince, japonica (Japanese quince), sweet cherry, spiraea, and Juneberry *(Amelanchier).*

(2) Trees and shrubs that may be badly infested but are very seldom so infested: Elm (young trees), maple (young trees), hawthorn *(Cratægus),* willow, cottonwood, poplar, lilac, flowering almond, grape, and snowball *(Viburnum).*

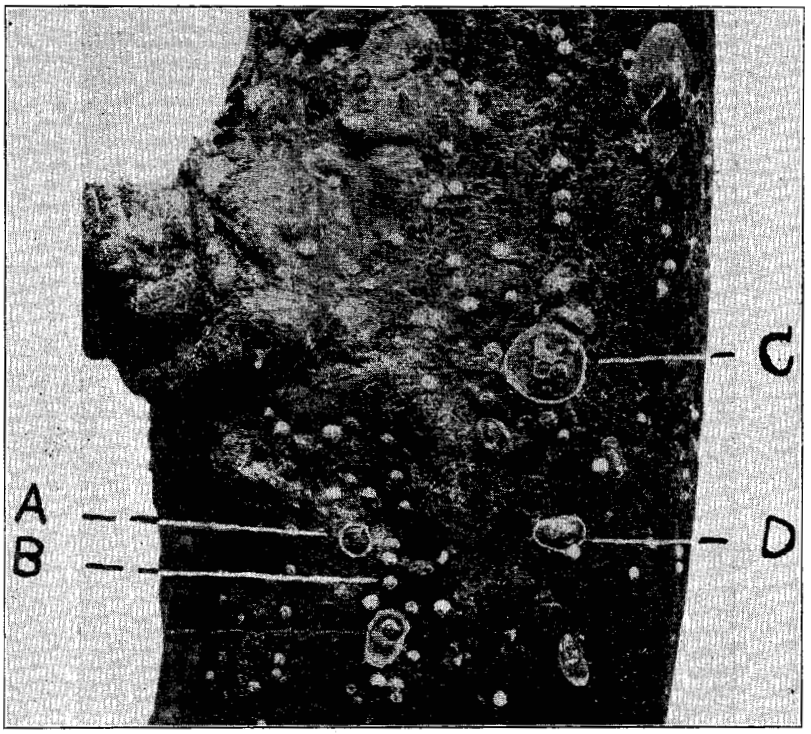

FIG. 4. Mountain ash infested with San José scale. (*A*) Half-grown scale (this is the stage in which the species pass the winter); (*B*) young scale which has just made its scale covering; (*C*) full-grown female scale; (*D*) male scale. (After Dean.)

(3) Trees and shrubs that are occasionally infested but not injured: Ash (white, green and black), bittersweet, blackberry, box elder, catalpa, elderberry, elm, gooseberry, hackberry, honey locust, black locust, mulberry, raspberry maple, rose (most species) sumac, Virginia creeper, black walnut, and honeysuckle *(Lonicera fragrantissima)*.

(4) Fruit trees that are practically immune, but upon which a few scales have been found on a very few occasions: Kieffer pear, sour cherry, and Wild Goose plum.

(5) Trees and shrubs that have never been found infested in the United States: Tree of heaven *(Ailanthus)*, arbor vitae, bald cypress *(Taxodium)*, Boston ivy *(Ampelopsis)*, butternut (white walnut), sycamore, cedar, hazelnut *(Corylus)*, fir *(Abies)*, hickory, honeysuckle (most species), ironwood *(Ostrya)*, hydrangea (all species), redbud *(Cercis)*, juniper, Kentucky coffee tree *(Gymnocladus)*, maidenhair tree *(Gingko)*, syringa (mock orange) *(Philadelphus* sp.), oak (all species), pawpaw, pine (all species), prickly ash *(Xanthozylum)*, privet (California privet) *(Ligustrum)*, spruce *(Picea)*, trumpet creeper *(Tecoma radicans)*, trumpet vine *(Bignonia)*, and tulip tree.

(6) Plants accidentally infested when growing under badly infested trees: Horse ragweed, smartweed, blades of corn, and rhubarb.

CONTROL OF THE SCALE.

Climatic conditions are doubtless effective in controlling the scale in Kansas. While many seasons are extremely favorable for its growth, there are others which are quite the reverse. Severe winter weather, with temperature ranging from 10° to 20° below zero, F., coming suddenly after mild autumn weather will kill large numbers. We have not, however, found any single planting where all the scale has been killed. Very cold rains and sleet, forming an icy coating on twigs, followed by freezing weather, will kill many scales. Extremely hot and dry periods of long duration are unfavorable to the insect. Especially is this true where the soil and roads are very dusty. A coating of dust interferes greatly with the young crawling males, causing many to perish.

The carriers of the scale may be, and usually are, destroyers as well, consequently only a small percentage of young are carried to suitable food plants. Many fall to the ground and

die, Some lodge on plants not suitable for food, as weeds and crops growing in or near the orchard. These may feed and live for a few days, but will not thrive or reproduce, and will perish in the fall when these plants, which for the most part are annuals, die. The inability of the San José scale to move from tree to tree and from orchard to orchard of its own volition is its greatest handicap.

The foregoing explains why the scale has not entirely overrun the fruit-growing regions of the country, and why it may be controlled by artificial means. It shows, also, how it may happen that some orchards adjacent to bad infestations may remain free for several years, as it is entirely a matter of chance when infestation takes place. The laws of chance, however, will not permit us to rely on any planting remaining long clean in an infested district. The limitations these and other factors impose on its dissemination are more than equalized by the rapidity with which the scale reproduces, which is greater than almost any insect of economic importance.

Parasites, Predaceous Insects and Diseases.

Natural enemies play an important part in keeping down the scale, but are not to be considered as a substitute for practical measures of control. In its native home the scale is kept under subjugation by the Asiatic ladybird *(Chilocorus simulis* Rossi). This has been introduced into America from China by the Bureau of Entomology, United States Department of Agriculture. It has never become sufficiently well acclimated or has not multiplied rapidly enough to be of practical value. Many of our native ladybirds feed upon San José scale, but since their taste for it is an acquired one, they do not give it the undivided attention necessary to render them important factors in its control, The most active of these beetles are the twice-stabbed ladybirds *(Chilocolus bivulnerus* Muls.) and a very small black species *(Microweisea misella* Lec.). Both the adults and the larvæ of the ladybirds feed upon the scale.

True parasites of the order Hymenoptera have, as a rule, failed to make themselves an appreciable factor in scale control. Many species, both American and Asiatic, have been studied in the hope that one might be found which would prove of value. One, *Prospaltella perniciosi* Tower, has done very

efficient work in parasitizing the San José scale in Massachusetts. The period of the life history of this parasite so closely coincides with that of the scale that it has done valuable work in checking the increase of the latter. Dr. L. O. Howard* has listed the following species bred from the San José scale: *Aphelinus fuscipennis* How., A. *mytilaspidis* Le B., *Aspidiotiphagus citrinus* How., *Anaphes gracilis* How., *Physcus varicornius* How., *Prospalta aurantii* How., *Alberus clisiocampæ* Ashm., and *Rhopoideus citrinus* How. Other species have since been observed by various workers.

The parasites, in the adult stage, are very minute, four-winged insects. They lay their eggs on the bodies of the scales, which hatch into small whitish grub-like objects that work their way into the bodies of the hosts and feed upon the body substance. When full grown they emerge through the scale covering, producing tiny circular holes.

Some small birds of the orchard feed upon San José scale at times, but so far as is known, none make it a steady diet.

The San José, as well as many other scale insects, is subject to the attacks of fungi. Among these the most promising is one found in Florida, Georgia and other Gulf states, called *Sphærostible coccophila.* This has been imported and tested in Kansas, as well as other states in the same latitude, but all reports seem to indicate that its destructive power is largely lost in our climate on account of the lack of moisture, which is essential to its development. Consideration of the natural enemies of the scale leads us to the conclusion that we must look to artificial methods if we hope to eliminate it as an injurious factor in fruit production.

Prevention of Infestation.

The prospective planter of trees which are susceptible to attack by San José scale will do well to obtain his trees from localities known to be free from scale and from nurseries which have never been infested. When possible he should take pains to ascertain that the owner of the nursery is reliable, that up-to-date inspection is practiced, and that careful inspection is made by the authorities of the state in which the stock is grown, He should find out from his own state officials just what the

* Bulletin 62, Bureau of Entomology.

certificate of inspection from the state in question is worth. It is also well to insist that the nurseryman send only trees grown in his own plantings and not stock bought elsewhere to fill orders. When the nursery is situated in or near an infested district the buyer of stock should insist on a certificate of fumigation as well as inspection. Better still, he should arrange to fumigate or dip all stock himself before planting. Such a course would reduce the danger of infestation to a minimum.

FUMIGATION.

If fumigation is to be practiced it must, be carefully and thoroughly done. An air-tight box or house must be available, the size depending upon the quantity of stock it is desired to treat at one time. The one essential in the construction of the box or room is that it be air-tight. Hydrocyanic-acid gas, generated by the use of potassium or sodium cyanide and sulphuric acid, is used. The potassium cyanide should be at least 98 per cent pure and the sodium cyanide should be 133 per cent pure and guaranteed fresh. The acid must be of specific gravity of at least 1.83. The formula for each 100 cubic feet of space is as follows:

Potassium cyanide	1 oz.
Sulphuric acid	1 oz. (fluid).
Water	3 oz. (fluid).

It is almost impossible to obtain potassium cyanide for fumigating purposes. Sodium cyanide may be substituted, in which case the formula for each 100 cubic feet would be as follows:

Sodium cyanide	1 oz.
Commercial sulphuric acid	1½ oz.
Water	3 oz.

The cyanide should be broken into lumps not larger than walnuts and placed in a small unglazed paper bag. The water should be poured into an earthenware jar or crock which will hold several times the volume of the acid and water combined. The acid is poured into the water slowly, and at the same time gently agitated by rocking the jar. The jar is next placed near the center of the fumigating chamber, which has previously been *filled (not packed)* with trees. The bag containing the cyanide is dropped into the jar, the door quickly closed and securely fastened, and the whole left from forty-five to sixty

minutes; then opened and allowed to air for fifteen or twenty minutes, when the trees may be removed. *Extreme caution is necessary in all these operations,* as all the materials are dangerous. Cyanide should be handled with gloves as it is poisonous, not only when taken internally but also when it comes in contact with open wounds or sores on the hands. The acid will produce dangerous burns on the skin and will ruin any clothing with which it comes in contact. *The gas generated is one of the most deadly poisons known, and care must be taken not to inhale any of it.* However, careful workmen who appreciate the nature of the materials and handle them accordingly need have no fear, as records of accidents from nursery stock fumigation are extremely rare. Fumigation, properly conducted, will positively kill all the scales on the trees and will not injure the trees, in spite of the prejudice against it among some fruit growers.

DIPPING.

Numerous experiments by different stations have shown that dipping in proper materials will kill any scales that may be on the stock at the time, and will not injure the trees if all conditions be absolutely right. Dipping is not, however, as safe and certain as fumigation, for several reasons; but for the benefit of those who may wish to experiment with it a short discussion of methods is here given. The kind of dippingtank or vat must depend to some extent upon individual preference and the number of trees to be dipped. Nurserymen often construct large tanks in which great numbers of trees may be dipped in a short time. Any tank or trough in which a half dozen or more trees may be treated at once will suffice for those who grow but few trees.

The solution used is in general the same as that for spraying, but is usually more concentrated. Lime-sulphur, the miscible oils, and kerosene emulsion have all been tested. Experiments are not conclusive enough to recommend any one of these substances above the others, but the lime-sulphur is probably the safest and is as effective as any. Commercial brands should be diluted at the rate of one part of lime-sulphur to from seven to ten of water.

The trees should be immersed for about a minute and then drained on a sloping platform, on which the trees may be placed with the tops downward. Roots must not be dipped or

they may be injured. The crowns, however, to two or three inches below where the surface of the ground has reached, should be immersed, as scale in nurseries is often most plentiful just at and below the surface. A small amount of the dip on the larger roots will do no harm. It should be remembered that trees to be dipped with safety must be in a perfectly dormant condition.

When miscible oils are used they are ordinarily diluted the same as for spraying; that is, about one part of oil to fifteen parts of water. Kerosene emulsion is diluted one part emulsion to from five to ten parts of water.

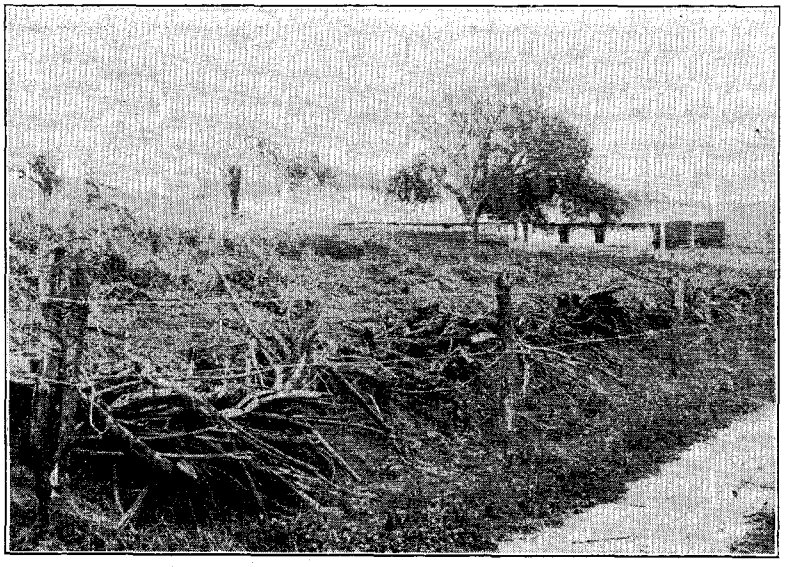

FIG. 5. The proper treatment for San José scale infested osage orange hedges. (After Dean.)

Treatment of Infested Plantings.

The only way to free an infested planting beyond possibility of doubt is to destroy every tree on which scale can be found and all trees in the immediate vicinity. Such drastic measures are recommended only when very few infested trees are found and when the infestation is evidently of recent origin, and for trees which have become so severely injured that their vitality has been reduced and there is no probability of recovery even should the scales be killed. In the latter case it is advisable, as a rule, to remove only the trees which are in the condition

described, and to spray all others in the same planting. Trees removed should either be grubbed out below the surface of the ground, or the stumps kept free from sprouts for a season.

Often the limbs of trees, especially peach trees, will be badly injured, or even dead, while the trunks are sound. In this case it is a good practice to prune heavily, cutting out all dead wood, or even to "dehorn" the trees; that is, to cut off all branches at a height of six or eight feet from the ground and allow the stubs to form an entirely new top. This entails the loss of one season's crop, but gives practically a new tree. The principal objection to this treatment is that the new branches will not bear the weight of a heavy crop as well as the original ones.

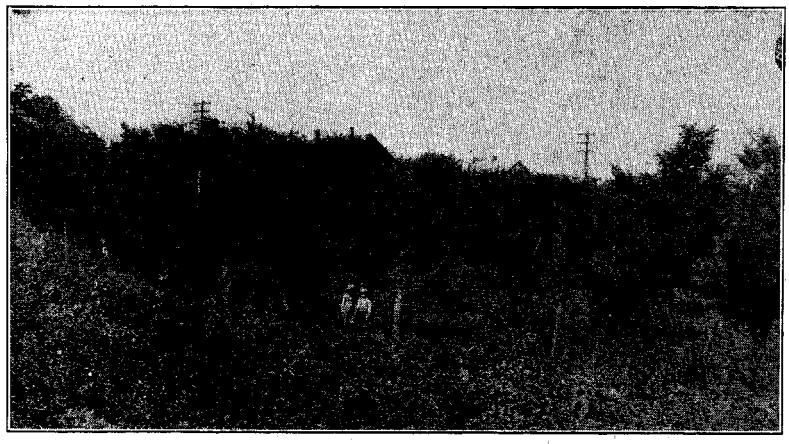

FIG. 6. The proper treatment for a badly infested peach orchard. Trees have been cut back, sprayed, and are making a good growth the following summer. (After Dean.)

Nevertheless, many peach growers follow this practice when their trees begin to get old, even though they have never had scale on them. Pruning and "dehorning" should be followed by thorough spraying, and in any case the regular pruning should be done before spraying, for the sake of economy of material and the opportunity it affords for more thorough spraying,

SPRAYING.

The universally accepted method for scale control in general is spraying. All the other control measures so far considered merely lead up to this and are accessory to it. It has been found that spraying with proper materials at the right time, if done thoroughly once a year, or in many cases every

two or three years, will keep the scale under control and prevent its doing damage either to the trees or the crop. Hence, spraying has become an accepted part of the routine in commercial fruit plantings where scale is prevalent, even when it is not continued for the control of other insects throughout the season. In fact, some writers have gone so far as to declare the scale a blessing in disguise, as it has forced many growers to provide themselves with spraying machinery, which has led to their taking up spraying for other insects and plant diseases, with the result that the increased quantity and better quality of fruit have more than repaid all costs of machinery, labor, and materials.

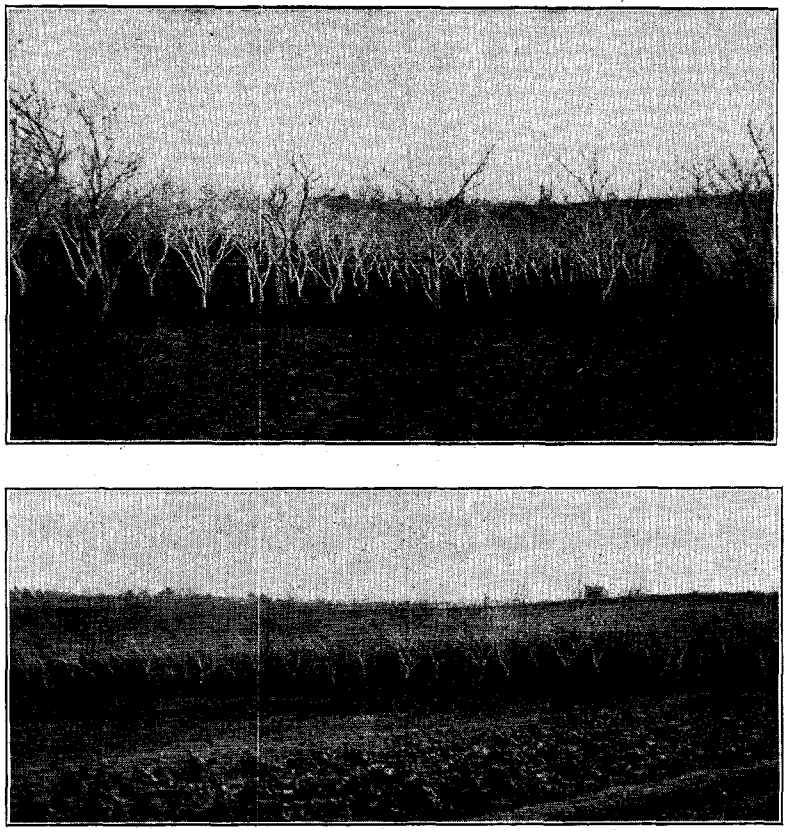

FIG. 7. The proper treatment for slightly infested orchards—properly sprayed with lime-sulphur wash. (After Dean.)

Dormant Spray.

The dormant spray may be applied after the leaves are off the tree in the fall and before the buds open in the spring. The solutions which are used at this time are much stronger than could be safely used after the foliage appears. As already mentioned, the scale prefers the tender growing portions of the tree to the older ones. These portions are the ones which are most apt to be slighted in the spraying. Furthermore, as this dormant spray is a contact spray and consequently kills only those insects which it hits, absolute thoroughness is essential in its application. A nozzle should be used which will deliver a spray fine enough completely to cover the trunk, limbs and twigs; at the same time sufficient pressure should be used to drive it into all the cracks and crevices.

Materials.

Many different substances have been tried for spraying San José scale. The materials which are now considered standard are lime and sulphur mixture, either homemade or commercial, and the so-called "miscible" oils; that is, oils which have been treated in such a manner that they mix freely with water. Other materials which have been used in the past, but have for the most part been discarded in favor of the above, include caustic soda, whale oil, soap, pure kerosene, kerosene emulsion, kerosene and water, various mixtures of resin with caustic soda and fish oils, many different petroleum products, and many patent so-called scale destroyers.

Commercial lime-sulphur. Undoubtedly the most widely used material to-day is commercial lime-sulphur. This is manufactured by many different companies. The commercial product has several distinct advantages over that made at home and has proved to be just as effective as the former. The increased demand for it has enabled manufacturers to reduce the price so that it is now almost as cheap as the homemade. In addition to this, the conditions under which it is manufactured permit the production of a more uniform grade than can be made by the ordinary methods on the farm. It is far more convenient and saves time and labor.

Most brands of commercial lime-sulphur should be diluted at the rate of one gallon lime-sulphur to nine gallons of water. This is effective when the lime-sulphur gives a hydrometer

reading of from 32° to 33° Beaumé.* Any one using large quantities of lime-sulphur should procure a hydrometer and test each barrel. When the density is less than 32°, less than nine gallons of water should be used for each gallon of spray, as indicated in the table. Standard brands can be relied upon to give a satisfactory test if they have not been severely frozen.

The disadvantages of using the commercial product are (1) slightly increased cost, and (2) the fact that it does not whiten the trees as does the home-prepared. The following table prepared by Prof. D. E. Lewis, of the horticultural department, gives the proper dilutions to be made for each Beaumé reading:

Beaume reading of concentrated lime-sulphur solution.	To make 50 gallons of summer spray.		To make 50 gallons of dormant spray.	
	Concentrated lime-sulphur.	Water.	Concentrated lime-sulphur.	Water.
	Gal.	*Gal.*	*Gal.*	*Gal.*
35	1.3	48.7	5.1	44.9
34	1.4	48.6	5.3	44.7
33	1.5	48.5	5.5	44.5
32	1.5	48.5	5.8	44.2
31	1.6	48.4	6.0	44.0
30	1.7	48.3	6.4	43.6
29	1.8	48.2	6.7	43.3
28	1.9	48.1	7.1	42.9
27	2.0	48.0	7.4	42.6
26	2.1	47.9	7.9	42.1
25	2.2	47.8	8.4	41.6
24	2.4	47.6	8.9	41.1
23	2.5	47.5	9.5	40.5
22	2.7	47.3	10.2	39.8
21	2.8	47.2	11.0	39.0
20	3.1	46.9	11.7	38.3
19	3.4	46.6	12.5	37.5
18	3.6	46.4	13.3	36.7
17	3.8	46.2	14.2	35.8
16	4.1	45.9	15.3	34.7
15	4.4	45.6	16.5	33.5

Home-cooked lime-sulphur. The formula for home-cooked lime-sulphur recommended by different experimenters varies somewhat. One which has proved satisfactory is as follows:

Stone lime	22 lb.
Flour of sulphur	17 lb.
Water	50 gal.

* The hydrometer is an instrument for measuring the density of liquids. One may be procured through any druggist or lens company. It should have the Beaumé scale, from which direct readings may be taken.

The material may be cooked in an open kettle over a fire, or by steam from a boiler. In either case the method of procedure is as follows: Put twenty gallons of water into the kettle or barrel, heat this to the boiling point, then add the lime. The sulphur should be previously mixed with enough water to form a thin paste free from lumps, and should be added to the lime while it is slaking. Stir the mixture constantly and allow it to boil for about fifty minutes. At the end of this time it should be a clear liquid of a light amber-brown color, usually lighter if cooked by steam than when cooked in an open kettle. Certain kinds of lime affect the color of the fully cooked product, giving it a greenish or greenish-yellow cast. This mixture should next be diluted to fifty gallons and used at once. One of the greatest objections to the use of this formula is that the product must be used immediately. A concentrated lime-sulphur solution may be prepared at home, however, which may be stored as well as the commercial solutions. This may be prepared as follows:

Stone lime	40 lb.
Sulphur	80 lb.
Water	60 gal.

The lime should be as free from magnesium as possible. The ordinary ground sulphur is the cheapest and is just as satisfactory as the flour of sulphur. This should be made in a kettle if cooked over a fire, or in a barrel if steam is used. The lime should be placed in a container and started slaking. The sulphur should be made into a thin paste, with water and added to the lime when slaking is well started, and the whole thoroughly stirred. Fifty gallons of water should be added, and more as necessary to maintain this amount throughout the whole operation. It should be kept well stirred and boiled steadily until all the sulphur is dissolved, which usually requires from forty-five to sixty minutes. When the boiling is finished the concentrate should be put into barrels, and may then be stored away. If the barrels are not completely filled the surface of the concentrate should be covered with oil to exclude the air. Any oil which does not take fire at the boiling point of water or does not injure the tree may be used. By consulting the dilution table and taking the Beaumé reading the proper amount of water to be added may easily be determined.

Miscible oils. Miscible oils have been used extensively as insecticides, but their use is ordinarily attended with so much danger to the trees that it is not recommended where lime-sulphur can be obtained.

The advantages of oils are: (1) they will cover more surface, gallon for gallon, than lime-sulphur; (2) they spread over the tree better, rendering thorough spraying more easy; (3) they will reach the scale on the small pubescent or "fuzzy" twigs of apple trees, where it is difficult to make the lime-sulphur adhere; and (4) they have no injurious effect on machinery, or upon the skin and clothing. They will, however, damage rubber hose more than will lime-sulphur. On the whole, the use of lime-sulphur is advised on account of its cheapness and availability, less danger of injury to the trees, and also because of its value as a fungicide, especially when used late in the spring just before the buds open.

Methods and Machinery.

The secret of success in spraying for San José scale is good materials and thoroughness. This fact may be appreciated when it is considered that any material, to be able to kill the scale, must actually come in contact with it. Since scales may frequently be more or less protected by irregularities of the bark or projecting leaf buds, the spray must be applied with considerable force and from all sides of the tree.

SPRAYING APPARATUS.

The kind of pump to be selected depends upon the number of trees to be treated. If only a few trees or shrubs are to be sprayed it can be done with either a bucket pump or a knapsack sprayer. Either of these will develop pressure enough to insure a good spray. Neither has a large capacity, however, consequently are frequently in need of refilling. If the planting consists of several trees it will be best to invest in a good barrel pump. There are several pumps of this type on the market, and most of them are satisfactory. There are, however, a few points in selecting such a pump which should be considered. Because so many corrosive materials are used in spraying the working parts should be of brass. All the valves and packing should be of simple construction and readily accessible. A good-sized air chamber is necessary to insure a

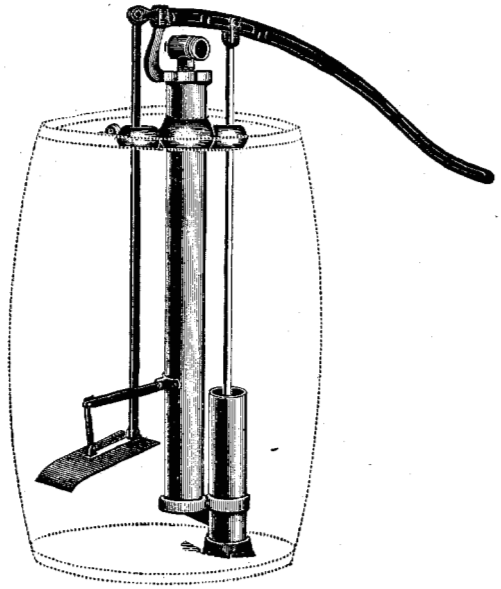

FIG. 8. A good type of barrel sprayer.

uniform pressure, and a gauge to show the amount of this pressure is a necessity. There should be a good agitator to keep the solution well mixed and a strainer at the bottom of the pump to prevent the nozzles from becoming clogged with particles of dirt. This pump should be placed on the side of the barrel rather than on the end as is often the custom. By placing it on the side it will more completely remove the contents of the barrel and the center of gravity will be lowered, thus reducing the danger of tipping over; also the whole outfit will be lower and can be more easily driven under trees.

Where the plantings are too large to be handled with a barrel sprayer and yet not large enough to warrant the purchase of a power sprayer, a double-acting tank pump may be used. Such a pump will maintain a good pressure and much larger quantities of liquid may be taken into the orchard at one time. This is a great advantage where the orchard is some distance from the water supply.

POWER SPRAYERS.

Traction sprayer. The power which compresses the air of a raction sprayer is obtained from the axle by means of a sprocket wheel and chain. In order to keep an even pressure

it is necessary to keep the sprayer in continuous operation, but in order to do good spraying a stop must be made at each tree. This can not be done with a traction sprayer without losing the pressure. It has been suggested that by spraying every other tree, or by driving around the one to be sprayed, sufficient pressure may be maintained, but in actual orchard practice this has not proved to be practical; hence traction sprayers are used but little.

Gas sprayer. Gas sprayers are provided with a tube of carbonic-acid gas, which when connected with the tank forces out

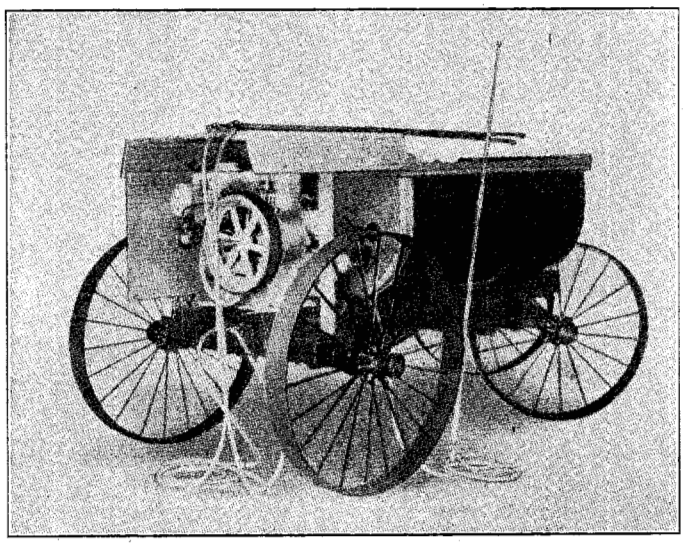

FIG. 9. A good type of power sprayer.

the spray. The advantages of this type are that fewer men are required to operate it and it is much lighter than a gasoline power sprayer. The objections are that the cost of the gas is high, it is hard to obtain, the inside of the tank tends to coat and peel off in flakes which clog the nozzles, and it can not be used with the lime-sulphur sprays.

Compressed-air sprayer. This type of sprayer has the same advantages and most of the disadvantages of the preceding type.

Gasoline sprayer. The gasoline sprayer is by far the most efficient that has yet been devised. There are several different makes on the market, and most of them are good. With a gaso-

line sprayer a high and continuous pressure may be developed, which is distinctly advantageous. In purchasing such a sprayer it is well to secure one that is capable of doing a little more work than is really necessary. This is much better than trying to make a small machine exceed its capacity. Unexpected troubles are very likely to appear, and if one is equipped with a full-capacity machine there is still an opportunity to finish the spraying at the proper time. This is very important, since in all summer spraying there are but a few days in which the work may be done, and spraying after the proper time has elapsed is wasted time and expense.

The fittings and accessories are fully as important as the engine and pump, and probably cause more trouble. If two leads of hose are to be used at the pump, a good "three-way" valve should be provided, so that either one or both leads may be cut off at will. The hose should be of the very best quality, fully guaranteed to stand a 300-pound pressure for an entire season. It may even be secured with a guarantee good for two seasons' work, and first-class hose, with proper care, should last two seasons.

The hose connections should be of the long shanked style, the shank being not less than three inches long and clamped so that there will be no possibility of its pulling out of the hose. The type illustrated in Fig. 10 has proved highly satisfactory.

Spray poles may be of iron pipe, usually one-fourth-inch size, or brass-, iron-, or aluminum-lined bamboo rods. If the latter, they should have the metal lining screwed into the connections—*not soldered,* as the latter pull apart easily. The ends of the bamboo pole should be protected with a substantial metal ferrule. The lower end of the pole should invariably have a stopcock between it and the hose connection, so that the rodman may cut off the supply to his nozzle in case of clogging without having to depend upon the operator at the supply. The most satisfactory nozzle used at this station is a "Friend," and preferably the "Friend angle." Others of the same type do very satisfactory work. These have largely superseded the old standard "Vermorel" type and are much more convenient. It will pay the prospective buyer of sprayers to insist on this style of nozzle.

All connections should be kept perfectly tight, so that there will be no leaking, as leaky apparatus causes more trouble to

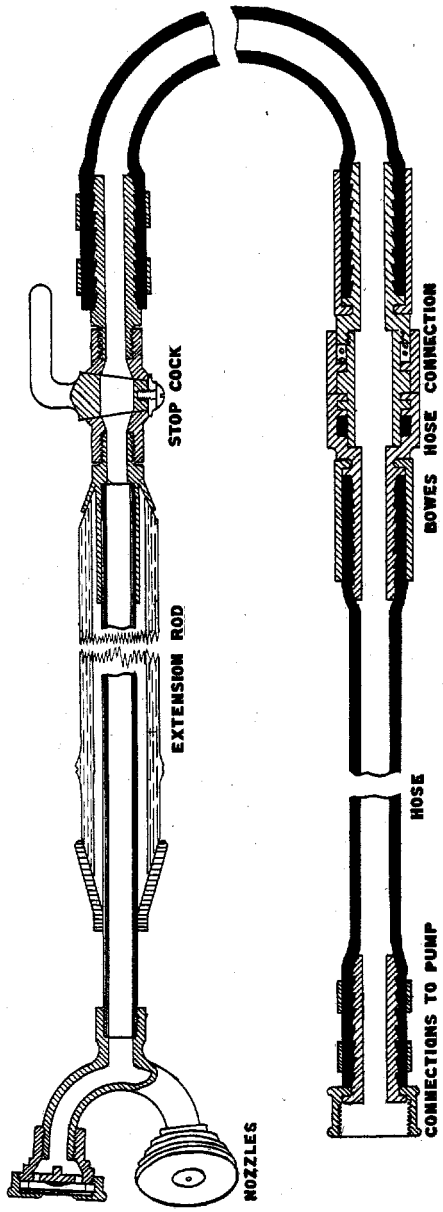

FIG. 10. A good type of hose connections, hose, extension rod and nozzles.

the workmen than any other imperfection of apparatus and renders a naturally disagreeable task doubly so. A few extra dollars spent on first-class fixtures will be well spent and may prevent much dissatisfaction among the workmen.

The size of the aperture in the interchangeable discs depends upon the pressure and the character of spray it is desired to produce. The smaller the hole in the disc the finer will be the spray.

If lime-sulphur is used it should not be forgotten that it has a caustic action on the skin and is injurious to clothing. It will also ruin painted surfaces. It causes considerable smarting and pain to the eyes and mucous membranes, but will not injure them permanently if no greater quantity than would be blown from the nozzles is encountered. Vaseline rubbed on the hands and face before starting to work will prevent much of the smarting, and even ordinary machine oil on the hands is some protection. Good waterproof leather gloves and a broad-brimmed hat afford additional protection.

Hose leads long enough to enable the driver and outfit to avoid the flying spray should be used. From thirty-five to fifty feet, and in some cases more, should be used for each lead. When, as is often the case, portions of the orchard are too rough to be driven over by the sprayer these may be reached from the nearest point by using extra lengths of hose, or, if necessary, by coupling all leads together. The horses and harness should be protected by covers.

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