INFORMATION ABOUT SPRAYING FOR ORCHARD INSECTS.

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IMPORTANCE OF INSECT CONTROL.

Insect control in orchards and vineyards is largely effected by spraying, and the needs of the fruit grower in the protection of his crops from the ravages of insects and fungi have been the predominating influences in the development and excellence of present-day spraying apparatus. Nowhere in the world are insecticidal operations more extensively practiced than in the United States. The money which is spent in this country each year for labor, apparatus, chemicals, etc., in insect warfare is a very large sum, amounting in the case of the codling moth to not less than $5,000,000 and an equally large sum is spent in treatments against the San Jose scale. Although spraying is without doubt the most expensive of the several orchard operations, the value of the crop is so greatly enhanced thereby that it is a comparatively small investment, the expense amounting to but a fraction of the returns directly due to the practice. Orchard spraying is, in fact, an exceedingly cheap form of insurance.

It must not be inferred, however, that spraying operations are uniformly successful; in fact, this is far from being the case. Of all orchard work, spraying is most likely to be slighted or even neglected. Numerous fruit growers have not even adopted the practice, and others are not sufficiently familiar with the details of the work to secure reasonably satisfactory results. Inadequate knowledge of the essential features of spraying has been a serious drawback to the extension of its use. Many orchardists have no standard or conception of what constitutes thorough work and are practically without knowledge of their insect foes. Under such conditions results in most cases are unsatisfactory, and in the estimation of some this has given rise to the opinion that spraying is without merit.

The term "spraying," unfortunately, has come to have a rather general meaning, and it is apparent that many fruit growers and others do not understand that the kind of spray and the manner of application depend upon the character of the insects to be controlled.
While it is entirely practicable, as will be later shown, to indicate a system of orchard spraying to control the important insects and fungous diseases, such a system must take account of the peculiarities of the troubles in question. A better understanding by orchardists of the whys and wherefores of spraying would result in a marked improvement in the vigor of orchards and the quality of the fruit, and an important saving in expense for labor and materials.

**HOW INSECTS FEED.**

A knowledge of the character of the mouth parts of insects is of importance to the fruit grower as determining the general character of sprays to be used. Broadly speaking, all insects secure their food in one of two ways—(1) by actually biting out and swallowing portions of the food material, or (2) by sucking out the juices from the interior portions of the host. While there are exceptions to this general statement, these are unimportant in the present connection.

The biting and the sucking types of mouth parts are on two quite distinct plans. In the former there are two horny, opposable jaws, working sideways, and certain accessory appendages, with which particles of the leaf, bud, fruit, or other food substances are cut out and passed on as more or less solid particles to the food canal for digestion.

This type is found in several orders of insects, as in caterpillars, or the larvæ of moths and butterflies; the grubs and adults of Coleoptera, or beetles; grasshoppers, crickets, and other Orthoptera; and sawflies, bees, etc., of the order Hymenoptera. All biting insects are subject to destruction with stomach poisons, as arsenicals. Some insects do not feed in situations where poisons may be applied, those, for instance, which feed on the interior portions of plants (apple-tree borers, the peach borer, etc.), and on the roots.

In insects having sucking mouth parts the mandibles and maxillæ are drawn out into long setæ, or bristles, which are inclosed in the greatly modified tubelike lower lip, or beak, the four setæ and beak constituting a sucking apparatus with which juices may be drawn up from plants. In feeding, the beak is placed upon the plant surface or slightly inserted. The threadlike bristles are pushed down into the plant, and by a pumping action of the fore part of the food canal the sap is readily extracted. Plant-lice, scale-insects, leaf-hoppers, the pear psylla, and the true bugs, very important enemies of the horticulturist, are sucking insects, and for their control contact sprays are used, such as corrode the body or penetrate the breathing pores (lime-sulphur wash, whale-oil and other soaps, kerosene emulsion, etc.).
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Biting and sucking insects often occur in a way to permit of their practical destruction by poisoning the air which they breathe, as with hydrocyanic-acid gas or carbon bisulphid. The fumigation of trees with hydrocyanic-acid gas, or “gassing,” is extensively practiced in California in the destruction of scale insects infesting citrus trees, and also in Florida against the white fly. Its value for similar purposes against certain deciduous-fruit insects, especially the San Jose scale, was fully tested under eastern conditions, and while practicable for smaller trees it has never been adopted to any extent for the reason that the expense of the operation in proportion to the value of the crop produced is relatively high. Deciduous and other nursery stock, however, is now regularly fumigated by most nurserymen to guard against the possible dissemination of injurious insects. Carbon bisulphid is useful against underground species, as the woolly apple aphis, grape phylloxera, etc.

SPRAYING DORMANT TREES.

The spraying of trees during winter and spring, or when they are in a dormant condition, is directed largely against scale insects, especially the San Jose or Chinese scale. There are two principal advantages in spraying at this time: (1) the absence of foliage permits of more thorough applications, and (2) the sprays may be used much stronger than during the growing season. Contact sprays are employed, as whale-oil and other soaps, kerosene and crude petroleum emulsions, miscible oils, lime-sulphur wash, etc. The prime essential is thoroughness in making applications, covering every part of the tree from top to bottom, as in general only those insects coming into actual contact with the spray are killed.

Applications may be made in late fall, as soon as most of the leaves have fallen, at favorable times during the winter when the temperature is above the freezing point, or, preferably, in the spring shortly before the buds are due to swell. Spraying in late fall and early winter is thought by some to be more effective than later, on the supposition that the scale insects are not yet entirely dormant; and the prevailing fair weather at this season and the usual slackness of work are additional reasons for fall spraying. However, the danger of injury to fruit buds and twigs, especially from the use of mineral oils and whale-oil soap, is unquestionably greater. On the whole, fall spraying has not yet come into extensive practice; although often attended with unfavorable weather conditions, the work is mostly done in the spring. In the case of lime-sulphur wash, notably better results follow spraying late in spring, to insure as large an amount of spray on the trees as possible during early summer, and thus destroy any young scales from adults which may have escaped destruction.
In fact this continued action of the wash is perhaps quite as important as its first effect.

Spraying dormant trees for the San Jose and other scales and for other insect pests has come to be a very important part of orchard work, especially in the East and also on the Pacific slope, and in general it is possible so to time this work that a single application will reach most of the troubles. Other things being equal, the insecticide having the greatest range of usefulness should be employed. Of the several dormant-tree sprays, the standard lime-sulphur wash is the one most generally used and is equally effective against many other insects which may coexist on the trees. It is an excellent fungicide, and, aside from the inconvenience experienced in its preparation and its disagreeable character, it furnishes an ideal dormant-tree spray. Abundant experience has shown it to be an effective remedy in the control of the San Jose scale under all conditions, and also for most other diaspine scales, as the cherry scale (*Aspidiotus forbesi*), the walnut scale (*Aspidiotus juglandis-regia*), the West Indian peach scale (*Diaspis pentagona*), the European fruit scale (*Diaspis ostreiformis*), and reasonably so against the oyster-shell scale (*Lepidosaphes ulmi*), and the scurfy scale (*Chionaspis furfurana*). Lecanium scales, such as the terrapin scale (*Eulecanium nigrofasciatum*) and the brown apricot scale (*Eulecanium armeniacum*), are more effectively controlled by mineral-oil sprays, though in orchards regularly treated with lime-sulphur wash these will be kept in check. One thorough treatment each year, therefore, with lime-sulphur wash will keep well under control practically all scale-insect pests of the orchard.

Prof. J. M. Aldrich has shown that the lime-sulphur wash is effective in destroying on twigs and branches the winter eggs of the aphides affecting the foliage of the apple. It has been found effective in destroying the eggs of the pear-tree psylla (*Psylla pyri*), which are deposited on the trees very early in the season by the over-wintering adults. It has long been known to be effective in destroying the pear-leaf blister-mite (*Eriophyes pyri*), which passes the winter under bud scales of pear and apple and attacks the expanding foliage in the spring. Eggs of the red spider and of clover and other mites are probably also destroyed, as well as those of various insects. In California, if applied in late spring, it has been found effective in destroying the peach twig-borer (*Anarsia lineatella*). The wash is also a valuable fungicide; if applied before the buds open, as for the San Jose scale, it effectively controls the leaf curl of the peach. Used at this time on apple it replaces the dormant treatment for apple scab, and its usefulness in the same way for pear scab is very probable.
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Against some of these troubles it must be used in spring shortly before the buds open, and is about as effective against all when used at this time. In practice, therefore, the plan should be to make one thorough application of lime-sulphur wash to orchards each spring as a general treatment for the control not only of the San Jose but of many other scale insects and other pests.

**SUMMER SPRAYING.**

By summer spraying is meant applications during the period of foliage. The work is directed principally against bud, leaf, and fruit eating insects, and an arsenical is chiefly used. Contact insecticides, exclusively used in dormant-tree spraying, are also employed in a dilute condition in the control of certain insects, as aphides, the pear psylla, leaf-hoppers, etc., but by far the largest part of summer spraying consists in the application of arsenicals, either in water or more generally in Bordeaux mixture, effecting in the latter case combination treatments for fungous and insect troubles.

Two arsenicals are chiefly used, namely, Paris green and arsenate of lead, though numerous others are available, as arsenite of lime, Scheele's green, etc. The aim is to use these about as strong as the foliage will stand without injury, though well-made arsenate of lead, a comparatively recent addition to arsenical insecticides, may be used in unnecessarily large quantities without injury to most plants. The foliage of some fruits, as apple, pear, quince, and grape, is but rarely injured by effective strengths of Paris green, and perhaps never by well-made arsenate of lead. But the foliage of stone fruits, as cherry, plum, and peach, is on the whole quite tender, and arsenicals must be employed with caution. Arsenate of lead is least likely to do harm, though repeated applications of this poison, especially to peach, may cause shot-holing and dropping of leaves and burning of the fruit.

Summer spraying is perhaps more practiced in the case of the apple than in that of any other fruit, and because of the importance of the apple its treatment deserves detailed consideration.

The principal pests to be controlled are the codling moth, the plum and apple curculios, and the lesser apple worm, which affect the fruit; and the bud moth, canker-worms, and tent caterpillars, which eat the foliage. While these several pests exhibit individual peculiarities in feeding, a system of spraying which will be effective in controlling or greatly reducing them is about as given on the page following.

*For information as to the preparation and use of Bordeaux mixture and other fungicides see Farmers' Bulletin 243, U. S. Dept. Agr., by M. B. Waite.*
SCHEME FOR SPRAYING APPLE ORCHARDS.

FIRST TREATMENT.—In orchards infested with the bud moth (*Tmetocera ocellana*), spray with arsenate of lead or Paris green just as buds are swelling.

SECOND TREATMENT.—Spray with arsenate of lead or Paris green in Bordeaux mixture when cluster buds are out, but before the blossoms open. This treatment is valuable against the bud moth, canker-worms, plum and apple curculios, tent caterpillar, etc.

THIRD TREATMENT.—As soon as the petals have fallen, spray very thoroughly with arsenate of lead or Paris green in Bordeaux mixture so as to place a dose of poison in the calyx cup of each young apple. Larvae of the codling moth, the principal cause of wormy apples, hatching some three or four weeks later, mostly enter the fruit at the blossom end, and are thus killed. This is the most important of all treatments for the codling moth and is valuable in destroying the lesser apple worm (*Enarmonia prunivora*), plum and apple curculios, canker-worms, tent caterpillars, etc.

FOURTH TREATMENT.—Three or four weeks after blossoms have fallen, use an arsenical in Bordeaux mixture, thoroughly coating the foliage and young fruit. This is valuable against the codling moth, and affords further protection against the insects above mentioned.

FIFTH TREATMENT.—An additional application of an arsenical in Bordeaux mixture is necessary, nine or ten weeks after the blossoms fall, for the second brood of the codling moth, and, in the Middle and Southern States especially, a sixth treatment is advisable two or three weeks later. In orchards not infested with the bud moth and canker-worms the first and second treatments may be omitted. The third, fourth, and fifth applications will suffice to give protection from most insect pests of the fruit and foliage, supplemented by the sixth for the territory indicated.

Stone fruits, as compared with apple, pear, grape, etc., are but little sprayed with arsenicals, mostly on account of their greater susceptibility to injury. In some of the northern States, as Pennsylvania, New York, and Michigan, and also in Canada, arsenicals are used more than in the Middle and Southern States, where the injury is more pronounced. *Domestica* or European varieties of plums, including prunes, are less injured, and there seems to be but little if any injury to these from moderate use of arsenate of lead. The peach is more sensitive; three or four applications of an arsenate of lead spray may cause much of the foliage to fall and result in the scalding and dropping of the fruit. Cherries and Japanese plums also are tender, and arsenicals must be used on these with caution.

In the case of stone fruits the principal pest to be controlled with arsenicals is the plum curculio, and the first application should be made just before the buds open. Many of the beetles are out feeding at this time and will be destroyed. A second treatment is made within a few days after the blossoms fall, and a third about ten days later. The latter treatment on peach and Japan plum, in the Middle and Southern States, is attended with increased risk. Lime should
always be used with arsenicals on stone fruits. These treatments are very effective against the curculio and result in a notable increase of first-class fruit. As this insect makes conditions very favorable for infection from brown rot, its control greatly reduces the latter. In general, only well-made arsenate of lead should be used on stone fruits, and in the case of peach only two applications should be given. The injury which results depends considerably on the character of the weather.

In the case of the grape, as in that of the apple, it is practicable to indicate a scheme of spraying which will be effective against the principal insect pests, and, if the arsenical be used in Bordeaux mixture, against important diseases as well:

**GENERAL CLASSIFICATION OF INSECTICIDES.**

As already indicated, the important insecticides may be grouped principally into three series, as follows:

**INSECTICIDES FOR BITING INSECTS (STOMACH POISONS).**—Paris green, arsenate of lead, arsenite of lead, arsenite of lime, arsenite of soda, Scheele's green, London purple, white arsenic, hellebore, dust spray.

**INSECTICIDES FOR SUCKING INSECTS (CONTACT SPRAYS).**—Lime-sulphur wash, caustic-soda-lime-sulphur wash, self-boiled lime-sulphur wash, whale-oil soap, kerosene emulsion, crude petroleum emulsion, "distillate" emulsion, tobacco decoction, pyrethrum, caustic soda, caustic potash, lime dust, carbolic-acid emulsion, sulphur spray, resin wash, etc.

**FUMIGANTS.**—Hydrocyanic-acid gas, carbon bisulphid; sulphur di-oxid, effective against all classes of insects.

**STOMACH POISONS.**

**Paris green.**—Paris green is the best known and most generally used of all arsenicals in orchard spraying, though arsenate of lead is rapidly growing in favor. Paris green is a definite chemical compound—the aceto-arsenite of copper—and when pure contains 58.65 per cent of arsenious acid, 31.29 per cent of copper oxid, and 10.06 per cent of acetic acid. The commercial article, as used in spraying, should contain 56 per cent arsenious oxid and not to exceed 4 per cent, preferably 3 per cent, soluble arsenic. If there be appreciably more than this, danger of burning foliage is greatly increased. Well-made Paris green should be of a beautiful green color, very fine and dry, free from grit, and perfectly smooth when rubbed between the fingers. This poison is sometimes adulterated, though the Paris greens on the market in this country, on the whole, average exceedingly well. Common adulterants are finely ground sand and gypsum and also common white arsenic. Pure Paris green will entirely dissolve in strong ammonia, and any sediment left over is an adulterant. Ammonia also dissolves white arsenic crystals, and where adulteration with arsenic is suspected it is best to submit samples to proper
authorities for analysis. Paris green is used on pome fruits and grapes at the rate of 1 pound to 100 or 150 gallons of Bordeaux mixture or water. When used in the latter, there should always be added the milk of lime from slaking 2 or 3 pounds of good stone lime for each 50 gallons of spray. Used in Bordeaux mixture the lime is unnecessary. Used at the rate of 1 pound to 100 gallons, there is sometimes burning of the foliage, and the weaker strengths are thus safer but less effective. Paris green should not be used on peach, cherries, or Japan plums, and only with extreme caution on other stone fruits. As this poison is heavy and rapidly sinks, adequate provision for agitation of the liquid in the spray tank should be made.

Arsenate of lead.—Arsenate of lead is coming into quite general use in orchard spraying, replacing Paris green, over which it has some advantages, although it is more expensive. The well-made product contains no free arsenic and is practically insoluble in water, and hence may be used at almost excessive strengths without injury to most foliage. It is quite adhesive and is not washed readily from the trees by rain, and on account of its finely divided condition remains in suspension much better than Paris green. It is, however, weaker than this latter, and to obtain the same arsenical equivalent three or four times more arsenate of lead must be used. This poison has been on the market for several years, and recently the number of manufacturers has considerably increased. The commercial brands are on the whole quite satisfactory, and are mostly used in preference to its home preparation. The commercial product should contain not less than 50 per cent actual arsenate of lead, and is used at the rate of 2, 3, or 4 pounds per 50 gallons of water or Bordeaux mixture. On stone fruits the lesser strength is preferable, applied in water, with the milk of lime from slaking 2 or 3 pounds of good stone lime.

Arsenate of lead may be made at home from the ingredients used in its commercial manufacture. The quantities for 50 gallons of spray, on the basis of 2 pounds of the commercial product for each 50 gallons of liquid, are: Arsenate of soda, 10 ounces; acetate of lead, 25 ounces. The two ingredients are dissolved separately in wooden or stone vessels, using about a gallon of water, preferably hot. When dissolved these are poured simultaneously into the spray tank or other vessel containing the required amount of water. The milky white precipitate which forms is the arsenate of lead, and from its fineness remains in suspension better than any other arsenical. Also, the ingredients may be dissolved and kept separately, as stock solutions, to be brought together as needed. Thus, dissolve 31 pounds 4 ounces of arsenate of soda in 50 gallons of water by suspending it in a gunny sack from near the top of the barrel; similarly treat 78 pounds 2 ounces of acetate of lead. After thorough stirring, 1 gallon of each is used for each 50 gallons of spray, thus giving the amount of poison indicated in the above formula.

The homemade arsenate of lead is somewhat cheaper than the commercial product; its preparation, however, is complicated from the fact that it is difficult to get chemicals of a known strength. The arsenate of soda especially is likely to vary in its composition, and may be adulterated with common salt. The orchardist should, therefore, obtain from the dealer a guaranty of purity of the respective ingredients and should also secure a statement showing the exact quantities of each which should be used to produce complete combination.

Arsenite of lime.—Arsenite of lime is made by combining lime and white arsenic, and the product is insoluble tricalcic arsenite. This is the cheapest of all the arsenical insecticides, and while it has never been extensively employed there is abundant evidence that it is effective, and when properly made
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It is quite safe for use on the hardier foliage, as of apples, pears, and grapes. Two methods of preparation have been recommended, as follows:

According to the Kedzie formula, boil together for fifteen to twenty minutes, or until dissolved, 1 pound white arsenic and 4 pounds sal-soda crystals (or 2 pounds of the anhydrous form) in 1 gallon of water, finally replacing any water lost by evaporation. This is the stock solution, and should be placed in a jug and properly labeled. One pint is used with each 40 or 50 gallons of Bordeaux mixture or water. When used in water there must always be added the milk of lime made from slaking 2 or 3 pounds of good stone lime, which is necessary to produce the arsenite of lime. When used in Bordeaux mixture, no additional lime is necessary in this or the following formula.

By the Taft formula, 1 pound white arsenic and 2 pounds of freshly slaked lime are boiled together for forty minutes or more in 2 gallons of water, and this furnishes sufficient poison for from 300 to 400 gallons of spray. This is not as reliable as the former, since it is difficult to tell if all the arsenic has combined with the lime. When used simply in water, milk of lime is added as in the preceding formula. It is better to make this poison up only as needed, as the arsenite of lime on standing settles into a compact mass difficult of working free in water.

Scheele's Green (Green Arsenoid).—This is the simple arsenite of copper, containing no acetic acid; it also differs from Paris green in being more finely divided, and is of a dull whitish-green color. Lacking the acetic acid, it is cheaper than Paris green. It is used as is Paris green, in Bordeaux mixture or water, and at the same strength.

White Arsenic.—With unimportant exceptions, all insect food-poisons at present used have arsenic as the active killing agent. The arsenic may be variously combined, as with copper and acetic acid in Paris green, with copper simply in Scheele's green, or with lead in arsenate of lead. White arsenic is the cheapest form of the poison, but is little used in orchard work on account of its caustic effect on foliage. A considerable proportion of white arsenic dissolves in water, penetrating and killing the plant tissues. White arsenic is sometimes used as an adulterant of Paris green and other arsenical insecticides and while raising the percentage of arsenic does so at the risk of injury to the foliage.

Arsenite of Lead.—Arsenite of lead, on account of its causticity, is but little used in orchard work. Serious injury to plants has resulted from its mistaken employment as the arsenate of lead. It is made in the same manner as the latter, using 4 pounds acetate of lead and 12 ounces arsenite of soda, which furnishes sufficient poison for 150 gallons of spray.

London Purple.—London purple is a by-product in aniline dye manufacture, the poison being in the form of arsenite of lime. The composition of London purple is quite variable, greatly interfering with its usefulness. It is a finer powder than Paris green and is used in a similar way. It is at present but little employed in orchard work.

Hellebore.—The powdered roots of white hellebore are at times recommended as a substitute for the arsenicals, especially upon fruit which is ripe or nearly so. It is applied dry, diluted with from 5 to 10 parts of flour, or in water at the rate of 1 ounce to the gallon. It acts as an internal poison to insects, but is harmless to man in the quantities recommended. Its expense prohibits its use, except on a small scale.

Dust Sprays.—These, while of variable composition, usually consist of lime dust, Paris green or other arsenical, and dry Bordeaux mixture or powdered
bluestone for fungous diseases. A formula by W. M. Scott for dry Bordeaux and lime is as follows:

"Four pounds of copper sulphate in 4 gallons of water; 4 pounds of lime in 4 gallons of water; 60 pounds of slaked lime dust. Dissolve the 4 pounds of copper sulphate in 4 gallons of water and slake 4 pounds of lime in 4 gallons of water. When cool pour the two solutions together simultaneously into a tub. Allow the resulting precipitate to settle, decant the liquid, pour the wet mass of material into a double flour bag, and squeeze out as much water as possible. Then spread out the doughlike mass in the sun to dry. After a day's drying it can easily be crumbled into an impalpable powder by crushing with a block of wood or even with the hand. This powder should be screened through a sieve of brass wire having at least 80 meshes to the inch and should then be thoroughly mixed with 60 pounds of slaked lime dust."

To this should be added about two pounds of Paris green, and very thoroughly mixed with it, making a combination fungicide and insecticide for biting insects. Dust sprays are applied to trees by air-blast machines, and owing to the rapidity with which the work may be done they effect a considerable saving in time and labor. Their use against the codling moth and other biting insects has been shown to be less effective than liquid poisons, and dry Bordeaux is notably less effective in the control of diseases than the freshly made liquid Bordeaux mixture.

**CONTACT SPRAYS.**

Contact sprays are used against sucking insects and kill by corroding the body or by stopping the breathing pores.

**SOAP WASHES.**—Ordinary soft soap and laundry soaps have long been employed against soft-bodied insects, as aphides, scale insects, etc., and certain soaps are now manufactured especially for insect work.

**WHALE-OIL SOAP.**—Whale-oil-soap wash when used on trees in foliage, as against aphides, the pear psylla, etc., is made by dissolving 1 pound of soap in 3 or 4 gallons of water, or even more dilute solutions may be effective. As a dormant-tree treatment for scale insects a strength of 2 pounds of soap to each gallon of water is necessary, and the wash should be applied hot, as at this strength it becomes difficult to spray upon cooling. Applications of soap washes are best made in spring, shortly before the buds swell, as fall and early winter treatments appear more likely to injure the fruit buds. These soaps are variable in composition and care should be exercised in their purchase. A potash fish-oil soap is preferable to one made with soda, and should contain not over 30 per cent of water. The cost of the soap wash for large-scale dormant-tree spraying is prohibitive; it is useful, however, where but a few trees are to be treated.

**LIME-SULPHUR WASH.**—This has become the main reliance in spraying scale-infested orchards, and, as elsewhere pointed out, is effective in controlling numerous other insects and is valuable for certain fungous troubles. The following formula is used only on dormant trees, as it is quite too strong for foliage:

| Stone lime | 20 pounds |
| Sulphur (flour or flowers) | 15 do |
| Water to make | 50 gallons |

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Preparation.—Heat in a cooking barrel or vessel about one-third of the total quantity of water required. When the water is hot add all the lime, and at once add all the sulphur, which previously should have been made into a thick paste with water. After the lime has slaked, about another third of the water should be added, preferably hot, and the cooking should be continued for an hour, when the final dilution may be made, using either hot or cold water, as is most convenient. The boiling due to the slaking of the lime thoroughly mixes the ingredients at the start, but subsequent stirring is necessary if the wash is cooked by direct heat in kettles. If cooked by steam, no stirring will be necessary. After the wash has been prepared it must be well strained as it is being run into the spray pump, or tank. The wash may be cooked in large kettles or preferably by steam in barrels or tanks.

SELF-BOILED LIME-SULPHUR WASH.—A wash made by the heat generated from the slaking of lime has been more or less used as a dormant-tree spray for the San Jose scale, and while a diversity of opinion prevails as to its efficiency, results on the whole have not been very satisfactory, and practically it has fallen into disuse as a winter treatment.

The recent discovery by Prof. W. M. Scott, of the Bureau of Plant Industry, of the usefulness of the self-boiled wash as a fungicide for trees in foliage, more especially the peach, has suggested, as was pointed out by him, its probable usefulness as a summer treatment for the San Jose and other scales. Thus far there has been no very satisfactory summer spray for this insect. During the summer of 1908 experiments were made by the Bureau of Entomology on scale-infested peach and apple trees, which showed that this wash, thoroughly applied, will largely free the trees from scale by preventing the settling of the newly developed “lice” and with no injury to the foliage. From two to three applications should be made, the first as the young “lice” begin to crawl in late spring and the subsequent applications at intervals of three or four weeks. The summer treatments can not be made with desired thoroughness on account of the presence of leaves, and should not be expected to replace the dormant spraying with the stronger boiled wash. But in case winter spraying was neglected or not satisfactorily accomplished, summer treatments are desirable to protect trees from injury during the growing period. These treatments, furthermore, as shown by Mr. Scott, are quite effective in preventing various fungous diseases.

The mixture that gave the most promising results was composed of 10 pounds of sulphur (flowers or flour) and 15 pounds of fresh stone lime to 50 gallons of water. This mixture may be prepared as follows:

Place the lime in a 50-gallon barrel and pour 2 or 3 gallons of cold water over it. Immediately add the sulphur and 2 or 3 gallons more of cold water. The heat from the slaking lime will boil the mixture violently for several minutes. Some stirring is necessary to prevent burning, and more water should be added if the mass gets too thick to stir; but the cooking is more effectual when the minimum quantity of water is used, usually from 6 to 8 gallons being required. When the boiling ceases dilute with cold water to make 50 gallons, stir thoroughly, and strain through a sieve of about 20 meshes to the inch in order to take out coarse particles of lime, but all the sulphur should be carefully worked through.

a For a detailed account of the lime-sulphur wash, see Yearbook, U. S. Dept. Agr., for 1906.
The mineral or petroleum oils in one form or another comprise some of the most important insecticidal agents against sucking insects, as aphides and scale insects. They are best used in emulsions, for as a rule the use of undiluted oils is attended with grave danger to plants.

KEROSENE EMULSION.—Kerosene may be emulsified with milk or soap, the latter being now more generally used. The soap emulsion is made as follows: Kerosene, 2 gallons; whale-oil or other soap, ½ pound; water, 1 gallon. The soap is finely divided and dissolved in boiling water, and after removal of vessel from fire the oil is immediately added. The whole is violently agitated while hot by thorough stirring, or preferably it should be pumped back upon itself through a force pump for from three to five minutes. After sufficient pumping the mixture will have increased considerably in bulk and assumed the color and consistency of cream. Well-made emulsions should keep indefinitely, and may thus be kept in stock to be used as needed. The spray should contain from 20 to 25 per cent of kerosene for use on dormant trees and from 6 to 12 per cent of kerosene for summer spraying.

CRUDE PETROLEUM EMULSION.—This is made as described for kerosene emulsion. The grade of oil used is known as "insecticide" oil, and should show a clear, amber color with a specific gravity of from 43 to 45° Baume. On dormant trees this emulsion should contain from 20 to 25 per cent of crude petroleum. As a summer spray the kerosene emulsion is preferable, as there is a residuum in the petroleum emulsion which upon drying may result in injury to foliage.

PURE KEROSENE TREATMENT.—Pure kerosene is used in a very limited way, more particularly in aggravated cases of San Jose scale infestation, and must be employed with caution to avoid injuring the trees. Applications should be made on bright, sunshiny days, using merely enough oil to wet the plant, ceasing to spray before the oil commences to drip to any extent. On a moist, cloudy day evaporation of the oil on the trees is slow, and the fruit buds or even the twigs and limbs may be killed.

PURE CRUDE PETROLEUM TREATMENT.—This is used in the same way as the kerosene, and the same grade of oil is used as in the crude petroleum emulsion.

OIL IN MECHANICAL EMULSION WITH WATER.—The trouble of making emulsions has led to the development by manufacturers of spray pumps designed to automatically mix in the operation of spraying, in any desired percentage, the oil and water. On the whole, pumps of this class have been found unreliable, as not discharging the percentage of oil indicated, resulting in injury to trees or ineffective results, and are now but little employed.

MISCIBLE OILS.—Under this head are to be included certain proprietary preparations, developed especially as a treatment for the San Jose scale. These consist largely of a mineral oil, rendered soluble by a small percentage of a vegetable oil, as resin oil, and an alkali. They mix readily with water and are useful where it is desired to obviate the trouble of preparing a wash, especially for the treatment of small orchards.

Miscible oils have recently been investigated by Prof. C. L. Penny and he has indicated formulas for their home preparation. There are two distinct stages in the making of a miscible oil: (1) The preparation of the emulsifier, or soap solution; (2) the mixing of the emulsifier with the petroleum oil and

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resin oil, thus producing the miscible oil. The spray proper results from a third process—diluting the miscible oil with necessary water.

Preparation of emulsifier.—In the preparation of the emulsifier an iron kettle is necessary, ranging in size from 30 to 80 gallons, or more, depending upon the scope of work to be done. A board cover should be provided and a thermometer with scale inclosed in glass and reading to 400° F. The formula for the “emulsifier” or soap solution is as follows:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Menhaden oil</td>
<td>10 gallons</td>
</tr>
<tr>
<td>Carbolic acid</td>
<td>8 do</td>
</tr>
<tr>
<td>Caustic potash</td>
<td>15 pounds</td>
</tr>
</tbody>
</table>

This is heated to 290° or 300° F. and then the following are added:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kerosene</td>
<td>2 gallons</td>
</tr>
<tr>
<td>Water</td>
<td>2 pounds</td>
</tr>
</tbody>
</table>

The kerosene is added at once after the above temperature has been reached, but the water must not be added until the mixture has cooled to at least 212° F., or below the boiling point. Otherwise, a slight explosion of steam may result. This mixture is inflammable when hot and proper precautions are necessary to prevent its igniting.

Mixing emulsifier and oils.—In the mixing of the above-described emulsifier with petroleum and other oils, no heat is required. The emulsifier may be used with kerosene or with crude petroleum with or without the addition of resin or other oils. Numerous formulas for miscible oils are given, of which the following is said to be the easiest made and most efficient as a dormant-tree spray:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soap solution</td>
<td>3½ gallons</td>
</tr>
<tr>
<td>Paraffin oil</td>
<td>40 gallons</td>
</tr>
<tr>
<td>Rosin oil</td>
<td>6 gallons</td>
</tr>
<tr>
<td>Water as required by test.</td>
<td></td>
</tr>
</tbody>
</table>

These several compounds are brought together in an open barrel or tank and all are mixed by thorough stirring, sufficient water being added to give a ready emulsion. Although heat is not needed, extreme cold, as when the temperature is around the freezing point, will prevent perfect mixing. Preferably the materials should be kept in a moderately warm room some hours before mixing.

Dilution for spraying.—For use the miscible oil is diluted with the desired amount of water by thorough stirring. From 3½ to 4½ gallons of the miscible oil are used to make 50 gallons of spray.

OTHER PREPARATIONS.

SOLUBLE SULPHUR SOLUTION.—The trouble incident to the preparation of the cooked lime-sulphur wash has also led to the introduction by manufacturers of several so-called soluble sulphur solutions, represented to contain the essentials of the boiled lime-sulphur wash, and these are coming into use as a substitute for the cooked wash. They possess distinct merit and if used of sufficient strength are reasonably satisfactory, and have a field of usefulness for the small home orchard and elsewhere.

TOBACCO SOLUTIONS.—Strong tobacco extracts or decoctions are valuable sprays against aphides, thrips, etc., and are coming into an increased use, especially against the aphides occurring on the foliage of the apple and other
plants. A proprietary tobacco extract on the market has given good results. Tobacco decoctions must be made quite strong to give an effective spray, as in the proportion of 1 pound of stems or leaves to each gallon of water.

**CAUSTIC LYE AND SODA WASHES.**—Washes made by dissolving lye or soda in water are at times employed on dormant trees against scale insects, but are less effective than the soap, oil, or lime-sulphur sprays. The caustic should be used at the rate of 1 pound to 3 or 4 gallons of water, and at this strength is very disagreeable to handle. The effect on the trees, however, is to brighten them up, and the orchardist is often misled, on this account, as to their real value in killing insects which may be present.

**SULPHUR SPRAY.**—Flowers or flour of sulphur is useful against plant mites such as the red spider, etc., and may be dusted over the trees, while wet with dew or after a shower, by means of a dusting machine. A more satisfactory means, however, is to render the sulphur soluble with caustic potash or soda. There are several formulas for the preparation of sulphur spray, the one recommended by this Bureau being as follows:

Mix 20 pounds flowers of sulphur into a thick paste with cold water and add 10 pounds pulverized 98 per cent caustic soda, by which the sulphur will be liquefied with much heat. Stir and add water to prevent burning, finally diluting with water to make 20 gallons. This is a stock solution, 2 gallons being used for each 50 gallons of spray, or even stronger without injury to the foliage.

**SPRAYING APPARATUS AND ACCESSORIES.**

The rise of spraying apparatus in the United States for orchard use dates from about 1880, but it was not until some years later that the question of its manufacture was seriously taken up. Barrel pumps were first used and they sufficed to show the possibilities of protecting crops by spraying with proper apparatus, and the demand for machinery for applying liquids to trees increased rapidly. Steam-power sprayers were apparently first used in 1894, and a gasoline outfit was used a year later. During the years of evolution of spraying machinery great improvements have been made, and many of our present-day outfits possess a high degree of efficiency. These range from small hand outfits to power apparatus, representing several different principles, and the prospective purchaser is often at a loss to know which is best to procure. The answer to the question often asked, as to which is the best spray pump, depends upon the conditions under which the machine is to be used, as the number and the size of trees, the character of ground—whether rough or smooth—intelligence of labor, accessibility of water, etc. There are, however, certain considerations which should receive attention in selecting an outfit, and there should be a better general knowledge of the principles of construction as affecting successful operation and preservation.

All pumps should have the working parts of brass or bronze or other substance which will not be corroded by the spray liquids. Brass valves are now used in the best class of pumps. Those of
Plate XVI.

Types of Spraying Apparatus.

[Fig. 1.—Bucket pumps. Fig. 2.—Knapsack pump. Figs. 3 and 4.—Barrel pumps, showing also agitators.]
Types of Spraying Apparatus: Hand-power Tank Outfits.

[Fig. 1.—A double-acting, double-cylinder horizontal pump, with one-piece plunger. Fig. 2.—Sectional view of a double, vertical cylinder pump, showing plungers, valves, waterways, etc. Fig. 3.—A double-acting, single-cylinder horizontal pump. Fig. 4.—A hydraulic, single-cylinder pump with spring arrangement to lessen work in maintaining high pressure.]
TYPES OF SPRAYING APPARATUS.

[Fig. 1.—Geared air-pressure outfit for orchard work.  Fig. 2.—Carbonic-acid gas sprayer.  Fig. 3.—Compressed-air sprayer.]
TYPES OF SPRAYING APPARATUS: GASOLINE-POWER OUTFITS.

[Fig. 1.—Illustrating a very compact arrangement of engine and pump, effecting an important saving in weight.  Fig. 2.—A water-cooled engine, with triplex pump of high-pressure capacity.]
rubber or leather are objectionable, and pumps fitted with these will be a constant source of trouble.

Single-acting pumps are mostly used for barrel and smaller outfits. In the simplest of these there is but one set of valves, the cylinder being emptied and at the same time filled by the upward or backward stroke, the plunger returning through the liquid. The cylinders are either submerged in the liquid, being near the base of the barrel or tank, or are on the outside. The former are, on the whole, preferable as, being constantly covered with liquid, the valves may be made simpler, and hence not so likely to get out of order, and priming is unnecessary. Cylinders on the outside of the tank or barrel are often in the way, but are more readily accessible in case attention is required.

With true double-acting pumps liquid is taken in and discharged at each forward and backward or up and down stroke of the lever. Such pumps have one (Pl. XVII, fig. 3) or two (Pl. XVII, figs. 1 and 2) cylinders and are vertical or horizontal, mostly the latter in the single-cylinder type. Double-acting pumps are of large capacity, suitable for hand-power tank outfits or for gasoline, and with care last for several seasons.

In hydraulic pumps (Pl. XVII, fig. 4) the pump proper is connected with a large pressure tank into which the liquid is forced, the contained air forming an elastic cushion, the immediate source of power for forming the spray.

Bucket Pumps.—This type of pump (Pl. XVI, fig. 1) is quite satisfactory where but a few small to medium-sized trees are to be treated. While somewhat inconvenient, on account of the necessity of carrying from place to place, this difficulty is not important in view of the small amount of work to be done. As a rule, sufficient hose is not supplied with bucket pumps for tree spraying. A hose 12 or 15 feet in length should be specified when ordering, and an extension rod is a distinct advantage (Pl. XX, fig. 17). Bucket pumps are suitable for applying any of the liquid sprays, as lime-sulphur wash, oil emulsions, arsenical poisons, Bordeaux mixture, etc. Several different forms are on the market, as furnished by different manufacturers. Sometimes pumps are furnished mounted on a galvanized bucket, but simply the pump can be obtained and use made of buckets or tubs already on hand. Some pumps also are fitted with clamps for fastening to the side of the bucket or other vessel. Good pressure may be developed with many of these, though usually two persons are necessary in their operation, one to pump and the other to handle the nozzle.

Knapsack Pumps.—A knapsack pump (Pl. XVI, fig. 2), as the name suggests, is carried on the back of the operator, who pumps and directs the spray at the same time. The outfit consists of a copper tank (sometimes galvanized iron is used) fitted with a small pump, with handle attached, lead of hose, extension rod and nozzle, and straps for carrying. The tank holds about 4 gallons, and all classes of spray liquids may be applied. Knapsack outfits are often fitted for use as bucket pumps, by attaching a handle to the plunger. These were much used years ago in vineyards, and are still serviceable on hillside vineyards where it is impracticable to use a larger outfit, for small orchards of
young trees, etc. In commercial work, the knapsack has largely given way to
the barrel pump, which for general work possesses many advantages. It is
difficult to get necessary power with the knapsack outfit, it is rather heavy to
carry, and especially disagreeable on account of frequent leaking around the
pump or opening, which is very objectionable to the operator.

Barrel pumps.—The barrel type of spray pump (Pl. XVI, figs. 3 and 4) is
more generally used than all others, and is especially suitable for small orchards,
as up to 10 or 12 acres. A good barrel pump will supply adequate pressure for
two leads of hose with double Vermorel or similar nozzles, and very effective
orchard spraying may be accomplished. These are of many different forms, and
there is considerable choice among the different makes. Some have the cylin-
ders on the outside and others on the inside of the barrel, and, on the whole,
the latter are preferable.

The pump is attached to the barrel either at the side or end, more commonly
in the latter way. Side attachment, however, in some particulars is preferable,
as the outfit is lower and less in the way and better agitation may be secured.
The method of fastening of pump to barrel also varies. In some cases the pump
may be removed simply by loosening a thumbscrew, catch, or similar device.
Submerged pumps—that is, with the valves near the bottom of barrel and under
the liquid—are mostly with short cylinders. These pumps are supported at the
base on a short pedestal to raise the strainer somewhat from the sediment, or
the base of pump may be raised some 8 to 12 inches from the bottom, the suc-
tion pipe, however, extending lower. Agitators are a very important part of
any pump, and there are various styles on barrel pumps, as discussed under
another heading. The barrel pump may be placed on a wagon or cart, or
fastened to a sled or drag. One man is required to pump, who can also attend
to driving, and one or two additional men, depending on whether one or two
leads of hose are attached.

Tank outfits.—In spraying on a large scale, and especially where water
must be hauled some distance, 150 to 300 gallon tanks are employed. Half-
round and rectangular tanks are made to replace the wagon bed on the trucks,
and hogshead or square tanks may be placed at one end of the wagon on a plat-
form, or in the wagon bed. Ordinary barrel pumps are used in some tank
outfits, but mostly large, hand-working, double-acting, and double-cylinder
pumps are employed, furnishing adequate pressure for two leads of hose and
double or triple nozzles (Pl. XVII, figs. 1 to 4). These pumps are mounted
on top of the tank, or on a platform at either end, and are provided with
suction hose to be inserted into the spray tank. A common defect in tank
outfits is lack of provision for adequate agitation. This point should not be
overlooked by the prospective purchaser.

Geared sprayers.—In geared sprayers horse power is used to develop the
pressure required to make the spray, the pump being operated usually by a
chain connected with a sprocket wheel on one of the wheels of the wagon or
cart. There is usually a pressure tank, the size depending upon the character
of the spraying to be done.

In the orchard sprayer illustrated in Pl. XVIII, fig. 1, there is a single pump
operated by a chain and sprocket wheel on the hind wheel of the wagon. Air is
first pumped into the pressure tank, a drive of from three to five minutes suf-
ricing to raise the pressure to from 20 to 25 pounds. The suction is then
turned on the spray liquid, and a little further driving will raise the pressure
to 80 or 100 pounds. The compression tank is large, holding about 20 gallons,
and the pressure is said to be sufficient to thoroughly spray a tree while the
wagon is standing still. Driving from tree to tree accumulates additional pressure for further spraying. A better outfit of this type has two pumps with gearing on each hind wheel, materially adding to the pressure capacity. Geared sprayers are much used in vineyard spraying, and there are different styles of these on the market. Perhaps all of them are open to the objection that sufficient pressure can not be maintained without too fast driving for effective spraying. This style of sprayer is best suited for low-growing plants, as truck crops. For orchard spraying they are less reliable as to pressure than gasoline or steam power outfits.

**Carbonic-acid gas sprayers.**—Carbonic-acid gas under pressure in drums, as in general use, is being employed as a source of power in spraying. The pressure may be maintained quite uniformly and there is little about the apparatus to get out of order. It is perhaps somewhat more expensive than the gasoline or horsepower outfits, and one must be situated so that the drums can be promptly recharged and received without delay. A supply of several drums is an advantage, avoiding possible delay in spraying at critical times. These outfits are suitable for all classes of spraying with appropriate attachments, the spray tank and drum being mounted on a wagon, cart, or sled, as conditions require. Pl. XVIII, fig. 2, illustrates the tank, drum, and connections of a carbonic-acid gas sprayer.

**Compressed-air sprayers.**—Compressed-air sprayers embody the same principle as that employed in the carbonic-acid gas sprayers, and consist usually of two equal-sized cylinders—one the air chamber and the other for the spray liquid. The tanks are mounted together on a wagon or cart, with pipe and valve connections to regulate the pressure. The air is compressed in the air tank at a central pumping station, equipped with an engine and air pump and air-storage tank, at which time also the spray tank is refilled with the spray. This form of apparatus is very simple and excellent work may be done with it. While the initial expense is considerable, owing to the necessity for equipment of engine and air pump, this is more or less compensated for by simplicity of operation, as the spraying may be attended to by one man. In some outfits proper provision is not made for agitation, and in others this is provided for by introducing the air from the compression tank in jets on the lower side of the spray tank. (See Pl. XVIII, fig. 3.)

**Steam-power outfits.**—Outfits with steam for power preceded in point of time the gasoline outfit, but, owing to constant improvements, the latter are now in more general use. Nevertheless, some orchardists prefer steam outfits and are operating them with entire success. There are essentially two kinds of steam outfits used—one employing the steam pump and the other the steam engine; the latter makes the outfit somewhat heavier, but the engine can be used for various farm purposes. The principal objection to steam outfits is their weight. Either coal, wood, or petroleum is used for fuel, and this item of expense is small. Boilers of from 1½ to 2 horsepower capacity are used, the latter preferable as giving a certain excess of power, and mostly of the upright type. The prime requisites in the successful working of steam or gasoline outfits is to keep all parts in perfect working condition by frequent examination, adjustment, and repair if necessary. The packing of piston rod of pump is a frequent source of trouble, as it quickly wears out. Care must be used in the selection of packing material and to keep it properly lubricated. The oil cups must be watched to see that they are working properly, or else hot bearings and injury may follow. All dirt should be kept excluded and only the best grade of oil employed. During cold weather warming of oil is advisable to
insure its proper flow. Frequent cleaning of boiler of sediment and cakes is necessary, and the removal of soot from flues should be attended to every two or three weeks; otherwise there is an important loss of heat. The steam pressure should be maintained as uniformly as possible, and, also, the water level in the boiler should not vary much. The same care is necessary in the successful operation of steam sprayers as for steam engines in general, and aside from their weight, these give excellent satisfaction on account of their simplicity and reliability.

Gasoline-power outfits.—Gasoline engines have during the past few years been much improved and are coming into increased use for spraying and other purposes. As now furnished, many of these are quite reliable, and by reason of lightness and the small amount of attention required during operation are preferred to the heavier steam-power sprayers. Gasoline engines are either upright or horizontal, the former, as offered for spraying, usually of the marine-engine type and on the 2-cycle plan. (See Pl. XIX, fig. 2, showing upright engine and reduction gear connection to pump.) A horizontal engine with direct connection to horizontal pump is shown in Pl. XIX, fig. 1. In the latter there is a compact arrangement of parts, effecting a saving in weight. Engines with either water or air cooled cylinders are used in spraying outfits, the latter, as dispensing with the cooling tank, being lighter. No careful comparison of the upright and horizontal and of the 2 and 4 cycle engines, as used in spraying, has been made, but both have been used successfully for several years. The prospective buyer, perhaps, can not do better than to accept the statements of firms in whom he has confidence as to the satisfactory character of their equipment.

In the operation of gasoline engines care should be taken to avoid heating of the bearings from lack of sufficient oil and too tight adjustment. In case of failure of engine to work right, the batteries should be tested for sufficient current to fire the gas; the gasoline feed should next be examined, and the sparker to see that this is not gummed up. The presence of water or dirt in the gasoline often causes trouble. Back firing—that is, explosion and a jet of flame from air inlet—may result from bad mixing of air and gas, or, if during compression, to sparking at the wrong time. Leaky valves will be sure to cause trouble and require prompt attention. Frequent examination and cleaning of valves and sparking mechanism are essential, and attention must be given to the air supply. When the air and gasoline are properly balanced, there is complete combustion and but little, if any, smoke; too much gasoline is shown by the smoke, and if there is too much air the mixture fails to explode.

Any good power pump is satisfactory, but preferably the pump should be mounted on the same base with the engine, and direct connected, or with reduction or eccentric gearing. Most power outfits are now provided with relief valves for the return to the tank of liquid when pressure becomes too high, and also some automatic means of agitation of liquid in the spray tank. Despite efforts of manufacturers to reduce the weight of gasoline sprayers this is still undesirably great. Wide-tread wheels are used on the trucks, and the front wheels should be sufficiently low to permit short turns.

Dust Sprayers.—Several machines are now made for applying insecticides and fungicides to plants in the form of a dust. Dust sprayers for orchard use have large capacity, and are operated either by hand or by gasoline engine. They comprise essentially a hopper containing the dust, and a strong fan for generating the air blast, which is conducted through a tube or chamber, into which the dust is automatically fed from the hopper, to be thus blown from the outlet tube upon the trees. In general, dust sprays as compared with liquid
SPRAYING FOR ORCHARD INSECTS. 285

Sprays are considerably less efficient for orchard insects, and have but little value against fungi. On very rough ground or where there is not available water supply their use is perhaps warranted.

Nozzles.—The spray nozzle is an exceedingly important part of any outfit, and the orchardist can not afford to fit an otherwise good spraying outfit with any but the best nozzles. During the past fifteen or twenty years many styles of these have been offered, and for the most part these are referable to the following general types or classes, some falling with more than one class, according to the particular adjustment, as shown in Plate XX.

Figure 1 illustrates the primitive and simplest form, this being an ordinary hose nozzle, adjustable to make the stream coarse or fine. The water leaves the orifice as a solid round stream, and is broken into a spray by the action of the air, and a high pressure is required. Several nozzles in one of their adjustments have this method of forming a spray, but none having this as the sole method of spray formation is now used in orchard spraying. Nozzles of this type are useful in throwing liquids into high trees, though they are quite wasteful of the spray.

In figure 2 is shown another type of nozzle, the spray being formed by the impact of two converging streams of liquid. The spray is fan-shaped and at right angles to the direction of the two converging streams. Some of these, as shown in the figure, are provided with a metal strip with different-sized orifices.

The nozzle shown in figure 3 embodies still another principle. The stream leaving the outlet, strikes against a projection or interference attached to the nozzle, thus forming the spray. With some a thin metal strip is used, a piece of rubber, or, as in the example illustrated, a wire screen.

In the Bordeaux nozzle, shown in figure 4, the spray is formed by the action of the outlet. The orifice is made larger or smaller by turning the barrel by the projecting thumbscrew, varying from coarse to fine, and when the opening is clear a solid stream is formed, thus resembling the ordinary hose nozzle of the first class. The spray is fan shape, the nozzles are readily cleared, and this type is much used where a rather coarse spray is desired, as in reaching higher trees.

Figures 5 to 7 illustrate the well-known Vermorel type of nozzle, more used than all the other forms combined. There are many styles of these, but all more or less embody the principle of giving the stream a rotary motion before it leaves the orifice. There is a chamber or barrel with an inlet on the rim, and the liquid forced into the chamber is given an inwinding rotary course, and escapes from the central orifice on the disk in the form of a conical spray. In some types the rotary motion is induced by the direction given the inlet or by a spiral spindle in the chamber. In the nozzle shown in figure 8 the stream is given a rotary motion at the entrance orifice, and rotates against the disk.

Nozzle clusters.—Two or more nozzles are often grouped together, forming a "cluster," and with adequate power permit of rapid work. By varying the angle of the respective nozzles the spray may be made to cover a greater area. Various forms of attachments are offered, as a Y, or nozzles are attached to a tubular ring (see figs. 6 and 7). For ordinary orchard spraying the double or triple Vermorel nozzle is mostly used. Coarser nozzles, as the Bordeaux, are used in spraying lime-sulphur wash, where it is desired to thoroughly drench the trees, and also in spraying for the codling moth after the petals have fallen, as furnishing force to drive the spray well into the calyx cavities.
MISCELLANEOUS ACCESSORIES.—There are several accessories to spray-pump outfits, indispensable, or of great convenience. The Y discharge and shut-off, shown in figure 9, is convenient where it is desired to shut off one or both leads of hose temporarily. This is attached to the discharge of the pump, to which the hose is fastened with ordinary couplings. Stopcocks, as shown in figures 13 and 15, are very useful at base of bamboo rods to shut off the spray when not actually in use, as in going from one tree to another. Most bamboo rods (see fig. 17) are now provided with a shut-off, in which case these become unnecessary. The orchardist should keep on hand a supply of hose clamps and couplings (figs. 12 and 14), so that any trouble with these may be promptly corrected. Provision for straining the liquid as it is brought into the tank is indispensable. A strainer commonly furnished by dealers is illustrated in figure 16. An excellent form of strainer may be made at home in the shape of a box about a foot square, without top, and the bottom of heavy hard wood with a hole bored through the center of the bottom, in which is fitted a gaspipe 1½ or 2 inches in diameter and 8 or 12 inches long. A second and lighter box, open at the top, and with an overhanging flange all around as a support, is made to fit into the larger one. The bottom of the inner box is 18 to 20 inch mesh brass wire cloth and is made so as to slope at an angle of about 30°.

In orchard spraying, extension rods are indispensable to reach the higher parts of the trees. They are of two kinds—simply small gaspipe, or bamboo canes with brass or other tubular lining. The latter are light and are more largely used (see fig. 17). Extension rods are of various lengths, as from 6 to 16 feet, and should be ordered of sufficient length to do the work required. One end is usually supplied with cut-off valve, connecting directly with the hose, and the other with the nozzle attachment. Aside from their necessity in spraying tall trees, they are generally employed as better protecting the operator from the spray.

The hose supplied with many outfits is very unsatisfactory. One-half inch, 3 or 4 ply hose is mostly used, but a desired improvement is shown in that some dealers now furnish ¾-inch hose and connections for power sprayers. The hose should have a safe excess of pressure capacity, and in any case should be capable of standing 200 pounds pressure per square inch. Some growers procure a cheap hose that will last merely through the season, buying a new supply from year to year. Others desire the best hose obtainable for use during two or more seasons. The length for working on the ground should be 25 to 50 feet, sufficient to permit spraying a tree from all sides before leaving it. The hose length for tower work may, of course, be much shorter, as 10 to 12 feet.

TOWERS.—In spraying high trees with whatever kind of outfit, as barrel, tank, gasoline, or other power, an elevated tower or platform built upon the wagon is very essential to thorough spraying. This should be from 4 to 6 feet above the level of the wagon bed, depending upon the height of the trees, the character of the ground, etc. With power sprayers, one man on the tower and two on the ground make an economical working arrangement.

TANKS.—Cypress, pine, or cedar wood makes the best tanks, the former being most durable. A coat of paint inside and out adds to their life and prevents the absorption of water, which would add to the general weight. Tanks vary from 50 to 300 gallons in capacity. If water is quite convenient, smaller tanks, as reducing weight, are advisable; but with inconvenient water supply, large tanks are preferable to obviate loss of time in hauling. Both upright and hori-
MISCELLANEOUS SPRAYING ACCESSORIES.

[Fig. 1.—Simplest type of nozzle. Figs. 2 and 3.—Other types of nozzles but little used in orchard spraying. Fig. 4.—The Bordeaux nozzle. Figs. 5, 6, and 7.—Illustrating the Vermorel type of nozzle much used in orchard work, and also illustrating nozzle clusters. Fig. 8.—A recent type of nozzle, similar to the Vermorel but of greater capacity. Fig. 9.—Cut-off. Fig. 10.—Hose clamp. Fig. 11.—Y for nozzle cluster. Fig. 12.—Hose coupling. Figs. 13 and 15.—Stopcocks. Fig. 14.—Nozzle connection. Fig. 16.—Strainer. Fig. 17.—Bamboo rod, with cut-off.]
SPRAYING FOR ORCHARD INSECTS.

Horizontal tanks are made, the former being either the barrel of 50 or the hogshead of about 100 gallons capacity. Horizontal tanks are either half-round or rectangular and may extend the entire length of the wagon or only about half this distance. The round-bottom tanks permit of short turning.

Agitators.—Practically all spray liquids rapidly settle in the spray tank upon standing, and provision must be made for agitation to insure uniform strength in the spray as applied. Careful attention should be given to this feature in any outfit. Mechanical agitators are of various kinds, referable mostly to (1) the dasher and (2) the whirling-paddle types. In the former, found mostly in barrel outfits, there is an up-and-down or lateral motion, or the lateral and vertical movements may be effected by the same agitator. These are mostly connected with the pump handle and are operated during the work of pumping (see Pl. XVI, fig. 3, showing a vertical-acting dasher type).

The second, or whirling-paddle types, are used mostly in tank outfits and are operated by hand or are connected by gearings with the wagon wheel. In power outfits an excellent arrangement is a shaft in the tank with necessary paddle wheels and connected with the engine. The liquid is given a rotary and upward movement, thoroughly mixing it.

A self-agitating, half-round tank is made by dividing it into three compartments by bulkheads, extending to within 6 or 8 inches of the bottom. The movement of the wagon in driving forces the liquid along the bottom and upward against the bulkheads and ends of the tank. Some half-round tanks are provided with a series of equally spaced paddles, fastened together above with strips, and extending along the bottom of the tank. The whole is moved back and forth horizontally by a handle on the outside.

In the jet agitator a portion of the spray liquid under pressure is returned to the spray tank, entering at the bottom. This style is but little used, except where abundant power is available, as in gasoline or steam outfits.

APPLICATION OF SPRAYS.

Successful spraying must be based upon a knowledge of the habits of the pests to be controlled. Entomologists and plant pathologists have indicated the kind of spray to be used, the times, and manner of applications, for the principal orchard and vineyard troubles; and for some crops, as apple and grape, schedules of application have been given to furnish protection against the principal insect and fungous troubles. Growers have not by any means taken proper advantage of these recommendations, and much careless and ineffective spraying is seen where better work would be expected. From a business point of view, the fruit grower can not afford to ignore the details of this highly important feature in orchard work. Apparatus should be overhauled in ample time before it is needed for use, chemicals gotten in stock, and all arrangements made, so that when the time for spraying arrives there will be no delay.

In the actual operation of spraying, account must be taken of the end desired. Thus, in dormant-tree spraying, as for the San Jose scale, every part of the tree from top to bottom should be reached. In spraying for the codling moth after the petals have fallen, the
object is to place poison in each and every calyx cup, and frequent examinations of sprayed fruit clusters should be made to see that this is being properly accomplished. In spraying for leaf-eating insects in general, a mistlike spray is desired and a general distribution over the tree must be effected. Correct spraying is really an art, and, while ideally perfect work is rarely accomplished, any orchardist by proper care can acquire a sufficient degree of proficiency to secure entirely satisfactory results.