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ORCHARD SPRAYING.

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INDEX.

ORCHARD SPRAYING.

D E. LEWIS.

INTRODUCTION.

This paper is written especially for those farmers and fruit growers who have not begun spraying, or who have not had success in protecting fruit from insects and disease by the application of spray materials. The outline of the work has been suggested by the questions asked in the letters which are constantly being received from fruit growers, and it has been the intention in all cases to give brief, practical information in the simplest words.

Spray materials and machinery have received especial attention. Detailed information is given in regard to mixing and testing the common orchard spray solutions, as well as the method of applying each. The important individual parts of a spraying machine are discussed with a view of explaining both their use in spraying and also the desirable and undesirable types of each. The acreage which each type of spray machine may be expected to protect is discussed also, in order to aid a grower in selecting a machine suitable to his needs.

A spraying outline is given, showing the dates and kind of material to use in protecting the fruit crop from the common orchard pests.

The small amount of space allowed for the discussion of each subject in a bulletin of this kind makes it impossible to give detailed information which will be suitable for all circumstances. It is hoped, however, that the general directions herein contained will be helpful to many, and that those having special orchard problems not discussed here will submit them to the Station for aid in solution. If insects or diseased wood or fruits are sent in for identification, the materials should be fresh and a careful description of the injury caused by each should always accompany them.

WHY SPRAYING IS NECESSARY.

Spraying has become necessary because of the great numbers of insects and plant diseases which injure the orchard trees and fruit. So numerous have these pests become and so

certain is their destructive work, that fruit buyers can hardly be induced to look over an unsprayed orchard, knowing that the fruit will be largely worthless and will not sell or keep well. This condition has not always existed. During the life of some of the earliest planted orchards of the state excellent fruit was grown without spraying, but the few insects and plant diseases then present have been allowed to multiply and increase unchecked, until now the crop is rendered almost entirely unsalable unless protected by spray.

Frequently eight or ten acres of orchard will hardly produce enough fruit for family use when a couple of dozen trees well cared for would allow a margin of profit after paying all expenses of cultivation, pruning and spraying, and supplying the family as well. The uncared-for orchard is not only an expense to its owner, but also a menace to other orchards near by. Insects and diseases multiply among the unsprayed trees and are literally sown broadcast over neighboring orchards. The result is that each year Kansas imports carloads of fruit from sections little better adapted to the growing of fruit than much of this state, while there is no market for hundreds of bushels of home-grown fruit because it is not salable. The situation will be remedied when the orchard is given the attention that it deserves, and one of the most important steps in this direction is spraying—not in a half-hearted way, but each application made at the right time, using the proper material and with absolute thoroughness.

Spray Materials and Spray Mixing.

No work done in the orchard during the entire season is of more importance and no work calls for more care and patience than the mixing of spray materials. The protection afforded by a spray correctly made of reliable materials is of the greatest value to the grower, but a carelessly made mixture or one made from poor materials may cause a serious loss. When possible to do so, one man should superintend all the mixing, and he should understand fully the importance of his work, and be well posted regarding the behavior of the different chemicals he handles.

The materials used in spray solutions are divided into two general groups; those applied to control fungous diseases are called fungicides, and those intended to control insects are known as insecticides. Either of these may be composed of one or many different materials, and it is frequently more economical to purchase these materials separately and mix them at the orchard. Such operations are discussed in the following paragraphs.

When a spray solution is diluted and ready to apply to the plant, the effective materials have been mixed with water and are held in solution or in suspension as very small particles. The object in so preparing the mixture is that, being in a dilute solution, a small amount of the effective material may be spread evenly over the surface of the plant, and upon the evaporation of the water in which it is held, the material itself is left upon the surface of leaves, fruit and twigs in a thin, even coat. A good agitator to keep the mixture well stirred is of the greatest importance.

In practice, the fungicide and insecticide are usually applied together, thus saving the cost of one application, but they will be discussed separately and separate directions given for mixing.

FUNGICIDES.

I. COPPER SULPHATE. This substance, commonly called bluestone or blue vitriol, is used in making Bordeaux mixture, or occasionally is applied during the dormant season, at the rate of 6 pounds to 50 gallons of water. It is the most effective fungicide known, but during the summer it must not be used without the addition of lime, as it has the property of causing severe burning to fruit and foliage. A stock solution is made by dissolving a known weight of the material in water. Ordinarily, two pounds of this material are used for each gallon of water. If a 50-gallon barrel is used, 100 pounds of the copper sulphate are placed in a burlap sack and suspended in the top of the water, In this way it dissolves much more rapidly than if allowed to sink to the bottom of the barrel. After all of the material has dissolved, each gallon of the water will contain two pounds of copper sulphate. By knowing this exact amount contained in each gallon, it is easy to add any required number of pounds called for in a formula by simply measuring one-

half gallon of this stock solution for each pound required. The stock solution does not deteriorate with age, but if kept a great length of time some of the water may evaporate, making the remaining solution stronger. In this event water should be added as is necessary to bring the volume up to its previous amount. It should always be well stirred before measuring out for spraying.

II. LIME. Lime is used in spray solutions chiefly for the purpose of neutralizing the acid condition caused by some other material. It combines with other materials, making a combination which sticks well and kills fungus spores or insects. Only a good grade of stone lime should be purchased for this use, as a poor lime is often responsible for severe burning. A great deal depends upon the way lime is slaked. If allowed to air-slake before it is used, or if too much water is used in slaking, a poor milk of lime containing many large particles, which appear as sediment, is formed. The lime should be placed in a barrel or vat and water added in small amounts, so that slaking proceeds slowly, but is never checked by the addition of large volumes of cold water. Care must be used to prevent burning. a hoe or shovel may be used to keep the slaking lime well stirred, thus causing it to slake evenly and thoroughly. It is best not to entirely cover the lime with water until the slaking is welI over, as to do so may check the process and result in a poor milk of lime. After the boiling, caused by the heat generated in slaking, has ceased, enough water should be added to form a thin milk of lime when the whole is well stirred. This stock solution is then measured out, as suggested for the copper sulphate. It is better to use the lime soon after slaking than to allow it to stand a great length of time. Usually it will not deteriorate during the application of a single spray, but is better if not carried from one application to another. It should be covered with water when allowed to stand.

III. BORDEAUX MIXTURE. Bordeaux mixture is a combination of the materials discussed in paragraphs I and 11. The copper sulphate and limeshould be prepared as for stock solutions and each added to one-half the total required water. These two solutions are then allowed to run together in equal quantities into the spraying tank. The formula found safest and most satisfactory generally, for use in apple orchards

of this state, is 3 pounds of copper sulphate, 4 pounds of lime and 50 gallons of water. It is ordinarily written 3-4-50.

IV. TO MAKE 3-4-50 BORDEAUX. Mixing Bordeaux need not be a difficult operation if it is to be made in sufficient quantities to warrant the erection of a mixing tower. Two tanks are placed on this tower, high enough to allow liquid to drain from them into the top of the wagon tank. Each of these tanks should hold a little more than one-half the capacity of the wagon tank. Large hose or gas pipe should be provided to conduct the contents of each of them into the wagon tank, and a valve should be provided for each, which

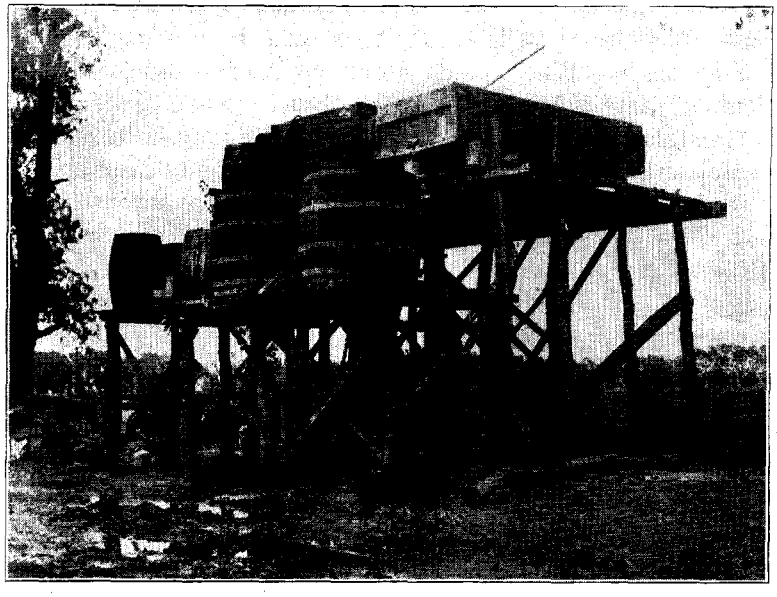

PLATE 1. Bordeaux mixing tower. When large quantities of Bordeaux are used a mixing tower is a necessity.

will enable the solution to be released at will. Hose is a little more convenient than gas pipe, as, being flexible, it requires less care in placing the wagon. Since the majority of the power sprayers have 250-gallon tanks, the operation will be described for making that amount of Bordeaux. Place seven and one-half gallons of the copper sulphate stock solution described in paragraph I (this will give 15 pounds of copper sulphate) in one of the tower tanks and add enough water to bring the entire amount to 125 gallons. If the

stock solution of lime contains two pounds of lime for each gallon of water, place 10 gallons of this solution, after stirring well, into the other tower tank, and add enough water to bring the total to 125 gallons. These two dilute solutions are then well stirred, after which the valves are both opened and they are allowed to run together into the wagon tank. In order to exclude all coarse sediment or other substances that would clog the nozzles, a brass strainer having 20-40. mesh to the inch, or two or three thicknesses of burlap, should be placed over the opening of the spray tank and the solutions strained through it. The resulting Bordeaux is sky-blue in color, and if the weighing and diluting has been correctly done it will be effective, and as safe as Bordeaux can be made. When made according to the 3-4-50 formula, plenty of lime is always in excess, but to guard against possible mistakes in weighing or measuring it may be tested with a solution of potassium ferrocyanide. Five cents' worth of this material may be obtained in crystal form from the drug store, and when dissolved in eight or ten times its bulk of water is ready for use. After the Bordeaux is made and well stirred, a cupful is dipped from the tank and a drop of the potassium ferrocyanide is added to it. If the drop turns brown when it strikes the Bordeaux, more lime must be added; but if no change occurs, the mixture may be applied without adding more lime.

It should be remembered that Bordeaux will not kill insects unless poison is added to it. Many still believe this mixture will prevent wormy apples, but this is not the case. When arsenate of lead at the rate of 2 pounds to each 50 gallons, or 10 pounds to the 250-gallon tank, is added to the Bordeaux, however, it becomes an insecticide and prevents insect injury. The greatest care should be used, not only in making Bordeaux, but also in applying it. During damp, foggy weather or during a rainy period it is very liable to cause burning of the leaves and russeting of the fruit. At such a time lime-sulphur should be substituted for Bordeaux.

V. SULPHUR. Sulphur may be obtained either as "flowers of sulphur," as light or heavy "sulphur flour," or as ground brimstone. There is little choice between the first two, provided they are equally pure. The ground brimstone is less desirable, but may be used. Either kind may be obtained in

100-pound sacks at prices varying from $1.50 to $3 a sack. Sulphur flour is ordinarily sold at a little lower price than flowers of sulphur, and ground brimstone lower than sulphur flour.

VI. MAKING LIME-SULPHUR SOLUTION. Thoroughly reliable concentrated lime-sulphur solution may be made at any time during the winter or spring and stored for summer use.

PLATE 2. A good type of kettle for use in making lime-sulphur when steam is not obtainable. When possible to use steam, better results can usually be secured.

The most satisfactory method of cooking is with steam, but an ordinary large iron kettle may be used over a fire if steam can not be obtained.

The formula used in making the concentrated solution for use in the College orchards is:

40 pounds stone lime.
80 pounds sulphur
50 gallons water.

The lime is placed in the cooking kettle or vat and started slaking. The sulphur is mixed into a thin paste with water, and added to the lime as the slaking process begins. As soon as the slaking is complete, enough water is added to bring the whole volume up to 50 gallons. This amount can be conveniently added by having previously notched a stick at the height of 50 gallons in the boiler. This stick is placed in the center of the boiling vessel and the water brought up to the notch. The mixture should boil steadily for from 45 minutes to 1 hour, according to the amount of heat used. During this boiling the solution should be held to the 50-gallon mark by adding water (preferably hot) each ten minutes. If steam is used in cooking, little water will be required, but if the solution is cooked in an open kettle over a fire, the addition of water is important. It should be stirred almost constantly to prevent caking and burning on the sides and bottom of the kettle. An old hoe is excellent for this purpose.

After the solution is cooked it should be stored in air-tight barrels, and each barrel should be filled full and stoppered tightly. It is of no advantage to allow the sediment to enter the barrel with the solution, but it will do no harm, except that it will become very hard after the solution is drawn off. When the solution is taken from the barrel and placed in the spray tank, care must be taken that all sediment which would clog the nozzles is strained out.

VII. COMMERCIAL LIME-SULPHUR. A concentrated lime-sulphur may be purchased in 50-gallon barrels from all companies manufacturing spraying materials. This solution is more expensive than the home-made concentrate when the lime-sulphur is to be used in large quantities. If a small quantity is all that is required, however, it is more economical to buy the commercial concentrate than to purchase the equipment and take the time to prepare the home-made solution. The commercial solution varies less in strength than the home-made, but each should be tested and diluted in the same manner.

VIII. DILUTION OF LIME-SULPHUR. In order to insure a certain amount of sulphur in a dilute spray solution made from concentrated lime-sulphur of different strengths, the strength of the concentrated solution should always be determined. This is obtained by determining the density of the concentrated solution by the use of a Baume hydrometer. This hy-

drometer consists of a weighted glass bulb and glass stem carrying the Baume scale from 0º to 38º. Such an instrument is indispensable, especially when home-made lime-sulphur is used. It may be obtained from companies manufacturing and selling spray materials and solutions: Bausch & Lomb Co., Rochester, N. Y.; Central Scientific Instrument Co., Chicago, Ill.; from wholesale drug and optical companies, or may be ordered through the local druggist. The cost should not exceed $1.50.

In using the hydrometer place it in the concentrated lime-sulphur solution when the temperature is about 60º F., allow it to come to rest, and read the scale at the level of the general surface of the liquid. Some of the solution will adhere to the tube, but the reading must be taken below this at the surface of the solution. The instrument may be more easily read if a full bucket of the solution is tested. Care must be taken not to allow the instrument to rest on the bottom or adhere to the sides of the bucket, and the reading must be accurate to insure the best results. Having obtained the reading of the hydrometer, a summer-spray or a dormant-spray dilution may be made by consulting the table on page 14.

Find the number in the first column which corresponds to the reading of the hydrometer. If a summer spray is to be made, the amount of the concentrated lime-sulphur for making 50 gallons is found in the second column, and the amount of water to add to it to make 50 gallons of spray is found in the third column. If the tank holds 250 gallons, multiply each of these amounts by 5; or if 200 gallons, each by 4. For example: A tank of summer spray is to be made from a concentrated lime-sulphur solution reading 24º on the Baume scale. The tank holds 250 gallons. From the table it is found that 2.4 gallons of the concentrated solution and 47.6 gallons of water are required for making 50 gallons of spray. But as the tank holds five times this amount, each of these numbers must be multiplied by 5. Twelve gallons of the lime-sulphur and 238 gallons of water will be required to make a 250-gallon tank full of spray of the proper strength. If the tank holds exactly 250 gallons, or if it is marked at this height, the lime-sulphur only need be measured, as the required amount of water is obtained by simply filling the tank after placing the lime-sulphur therein, or bringing the fluid up to the mark.

Baume reading of concentrated lime-sulphur solution.	To make 50 gallons summer spray.		To make 50 gallons dormant spray.	
	Number gallons concentrated lime-sulphur.	Number gallons of water.	Number gallons concentrated lime-sulphur.	Number gallons of water.
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

By the same use of columns four and five, a correct dormant spray may be made from any lime-sulphur concentrate testing from 15° to 35° Baume.

The effect upon fruit and foliage of lime-sulphur made and applied correctly seems to be stimulating. The leaves become dark green and the fruit appears more smooth and glossy than that from unsprayed or Bordeaux-sprayed trees, This mixture will not prevent wormy apples unless some poison is added.

Arsenate of lead is ordinarily used at the rate of 2 pounds to each 50 gallons of spray solution. Do not use Paris green, arsenate of soda or arsenite of lime with lime-sulphur.

IX. SELF-BOILED LIME-SULPHUR. Lime-sulphur is prepared for use on stone fruits by boiling the lime and sulphur together with the heat generated by the slaking lime. This makes a safe and effective fungicide when carefully made, and by adding arsenate of lead at the rate of 2 pounds to 50 gallons of the lime-sulphur, insects are also controlled. The 8-8-50 formula is most commonly used, and the solution is made as follows: For making 250 gallons, place 40 pounds of stone lime in a barrel or vat and add enough water to about half cover it. As soon as the lime begins slaking add the sulphur, which has been mixed into a thin paste with water. Mix the two thoroughly together with a hoe or other convenient tool, and continue to stir constantly while the slaking process is going on. Add water as is necessary to prevent burning, but not enough at any one time to check the slaking. The heat generated by the slaking lime will boil the mixture violently for a few moments. As soon as this violent boiling ceases, fill the barrel full of cold water and stir thoroughly. The mixture must not be allowed to stand after boiling before adding the cold water, or too much sulphur will go into solution, and injury may follow its use on stone fruits. Do not allow the boiling to continue too long, but add the cold water as soon as the slaking ceases. This mixture, after being well stirred, is strained into the spray tank through a 20-30-mesh strainer. Be careful to work all of the sulphur through the strainer, as it is the effective portion of the spray mixture. Fill the tank with water and add 10 pounds of arsenate of lead; thoroughly mix and apply to the trees. Great care must be taken in keeping the mixture well agitated, as the sediment sinks rapidly when not stirred constantly. This solution is for summer spraying of stone fruits only, the regular dormant spray being applied as for other fruits when the trees are not in leaf.

X. AMMONIACAL COPPER CARBONATE AND SOAP. A Solution of ammonia and copper carbonate is used frequently with good results, upon fruit that is nearly mature, and that would be discolored by other spray materials. The ammonia is diluted with two or three times its bulk of water, and used to dissolve the copper carbonate, after which enough water is

added to bring the whole amount up to within about 5 gallons of the total water called for in the formula. The soap is then dissolved in the remaining water and added to the copper carbonate solution. For making 50 gallons:

Copper carbonate, 6 ounces.
Strong ammonia, 3 pints.
Soap (laundry), 1 pound.
Water, 50 gallons.

Apply as a mist to ripening fruit.

INSECTICIDES.

XI. ARSENATE OF LEAD. The most reliable poison for biting insects is arsenate of lead. It may be procured commercially either in paste or powder form, or it may be made by the grower. All of the formulæ included in this bulletin are based upon the arsenate of lead in paste form, and since the paste lead arsenate contains 50 per cent of water, the dry form must be used in only one-half the quantities recommended for the paste.

There seems to be little choice between the dry and paste forms, provided each is correctly made and contains no adulterants. The dry lead is lighter, occupies less space, and is more easily kept from one season to another, in small quantities. The paste is a little more easily mixed with water and seems to stay in suspension better; however, this may be largely overcome by soaking the dry lead for a few hours previous to its use. The cost of the dry lead is usually more than double that of the paste. Arsenate of lead in paste form may be obtained in 100-pound kegs for from 8 to 12 cents per pound, and in dry form in 100-pound kegs from 18 to 27 cents per pound. A reduction is usually given in larger kegs or larger quantities.

The lead is ordinarily prepared in the same way before it is placed in the spray tank, whether in the dry or paste form. The required amount is weighed out and mixed into a smooth paste with water. It is very important to work this paste until all of the lead is held in a creamy mass, or, better still, in a thin paste. This insures a good mixture of the lead with the liquid when they are combined. After the lead is placed in the tank the agitator should be started and the whole mixture violently churned before being applied to the trees.

Arsenate of lead sticks well to the fruit and foliage and may be used with Bordeaux, lime-sulphur or water. During a very bright, hot spell, the lime-sulphur-lead may cause some burning. At such a time use Bordeaux and lead.

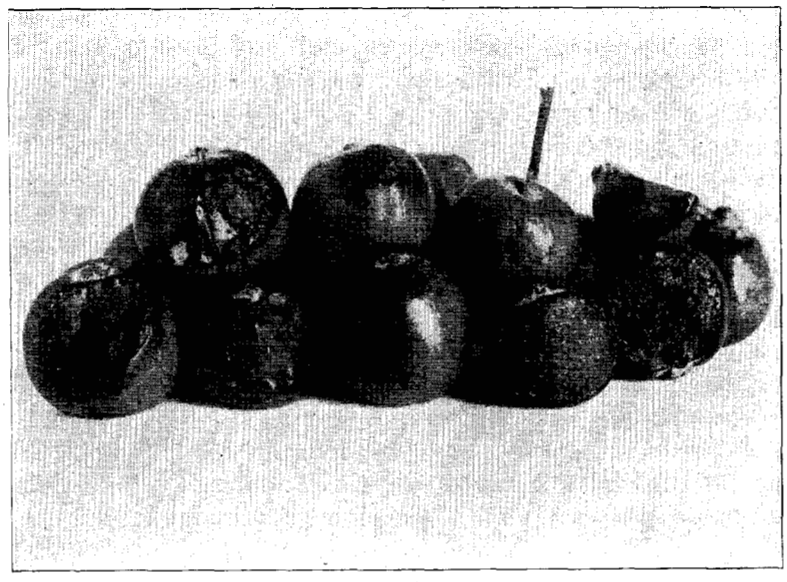

PLATE 3. Lime-sulphur-lead spray burn. Such burning takes place only during extremely bright, hot weather. At such a time Bordeaux should replace lime-sulphur.

XII. HOME-MADE ARSENATE OF LEAD. When large quantities of arsenate of lead are to be used it may be made by the grower at a little less cost than the prices quoted by dealers. Ordinarily it is best to buy the prepared lead, but the following directions have been followed by several large fruit growers, who report good control and a material saving:

14 ounces lead acetate.
5 ounces sodium arsenate.
50 gallons water or spray solution.

The lead acetate and sodium arsenate are each dissolved in a gallon or more of water, and these two solutions mixed together thoroughly. The whole mixture is then added to enough mater or spray solution to make 50 gallons, and applied.

Impurities in the materials used affect the finished product materially and are no doubt accountable for some dissatisfaction among users of the home-made lead.

XIII. PARIS GREEN. Paris green is a much less satisfactory poison than the arsenate of lead. It washes off the fruit and foliage easily and frequently causes serious burning. It is less expensive than the lead arsenate, which probably accounts for its use by a few growers. It is frequently used in controlling insects which require a large amount of poison, such as the spring cankerworm and leaf skeletonizer. It should never be applied in water without adding two or three pounds of lime to each 50 gallons. Bordeaux mixture usually contains some excess lime, so that it is less liable to burn when combined with this mixture. It should not be used with lime-sulphur. One-half pound of Paris green is used with 50 gallons of Bordeaux or water.

XIV. ARSENITE OF LIME. When commercial white arsenic and lime are boiled together an insoluble precipitate called arsenite of lime is produced.

It has been tried with varying success by orchardists, and by some is still used. There seems little reason why a reliable poison could not be made in this way, and the cost of this part of the spray solution materially reduced, provided the work mas done carefully. The common formula is:

1 pound white arsenic.
2 pounds stone lime.
2-4 gallons water.

Boil the white arsenic and the lime together for at least one-half hour. All of the arsenic must go into solution and combine with the lime, or burning may follow its use. Use at the rate of one pint to one quart to 50 gallons of water.

XV. TOBACCO. A strong solution of nicotine, very useful in fighting plant lice, may be obtained from almost any company handling spraying materials. If a solution containing 40 per cent nicotine is used it is commonly diluted to from ¾ to 1 pint in 100 gallons of water. It is useful against woolly aphis and other plant lice. Its use against leaf hoppers has not been attended with general success, owing to the difficulty of striking the hopper.

It may be used in lime sulphur or in water, and the addition of from 2 to 3 pounds of soap to each 100 gallons of the dilute spray has increased its effectiveness.

XVI. KEROSENE EMULSION. This is an old remedy for all sucking insects. It is made as follows: Dissolve ½ pound

of soap in 1 gallon of rain water by boiling. Remove from the fire and add 2 gallons of kerosene while the water is still hot. Churn violently until a thorough emulsion is obtained. This may be easily done by pumping through a bucket pump. For use, add 1 gallon of this emulsion to 10 or 12 gallons of water.

XVII. SOAPS. Common laundry soap may be used against sucking insects. Dissolve 8 pounds of soap in water by boiling, and add enough water to make 50 gallons of spray.

Whale-oil soap is also frequently used, at the rate of 1 pound to 6 or 7 gallons of water for summer spraying, and as strong as 1 or 2 pounds to 1 gallon of water for dormant spraying.

Spraying Machinery.

In order to do efficient spraying, thoroughly reliable machinery must be used. It is no longer considered economy to "get along" with an outfit which is too small or too old to do good work, simply because it is cheap. A few days delay during the important spraying time will frequently result in a loss greater than the amount required to purchase a satisfactory machine.

The size and kind of a machine best suited for an orchard would depend upon the acreage of the orchard and the size of the trees, and is discussed in paragraphs 44 to 50. Good work can be done with the best hand pumps, but they should not be employed in a large commercial orchard. In such an orchard good power sprayers are an absolute necessity.

XVIII. THE POWER. The power for pumping and compressing the spray liquid is usually obtained by hand, by traction gearing, or by the gas engine.

Hand.—Large and small hand outfits are made and are adapted to a variety of work. The largest outfits are usually provided with good leverage, making the work as light as possible. Such outfits are well adapted to the needs of a small orchard and are further discussed in paragraphs 44 and 45.

XIX. TRACTION. While a sprayer in which the power is obtained through chain or gears from the axle is fairly satisfactory for spraying farm crops which allow continuous

movement, it is not adapted to orchard work. It is impossible to do good work in the orchard without stopping at each tree, and during such a stop the pressure is rapidly exhausted. Ordinarily the distance from tree to tree is not sufficient to insure a good pressure. For orchard spraying a good large hand pump is more satisfactory than a geared or chain-drive traction sprayer.

XX. ENGINE. The largest and best sprayers are equipped with gas engines, which furnish a high, continuous pressure. Several types of engines are used, some of which are two-cycle and some four-cycle. On account of the variable load which the spraying engine must carry, a four-cycle engine is preferable, and since they are usually better understood, give better satisfaction. Air or water is used for cooling, and both have given good satisfaction. The water-cooled engine is a little less liable to injury through heating, but the best types of air-cooled engines are satisfactory if given careful attention. The engine should be as light and compact as possible, and should be of sufficient horsepower to carry its load without overworking. Usually from 1½ to 4-horsepower engines are used for spraying purposes. Instructions sent with the engine should be studied and followed, Only good oil and gasoline should be used; it is not economy to buy poor oils.

XXI. ENGINE TROUBLES. In a bulletin of this kind it is impossible to give detailed instructions in regard to the handling of an engine, but a few hints will help a careful operator to locate the trouble and find the remedy. The following is a list of the ordinary causes of an engine failing to run correctly or refusing to run at all:

1. Broken battery wires or poor connections.
2. Weak batteries or incorrect wiring.
3. Poor adjustment of the coil trembler.
4. Soot on spark plug or firing device.
5. Gasoline not turned on, or mixed with water or kerosene.
6. Dirt in pipes, preventing gas from entering cylinder.
7. Too much or too little gasoline or air.
8. Loss of compression due to leaky valves, lack of lubricating oil, broken or worn cylinder rings.
9. Soot-clogged muffler.

If the operator has studied the engine carefully when it was in proper adjustment he will be able to detect any defects

in wiring and to keep all parts clean and in good condition. The charge may at first give some bother, but he should soon learn to adjust it without difficulty by keeping in mind the following points: Black smoke from the exhaust indicates too much gasoline or too little air; a sharp explosion and a sharp or acid smell of the exhaust indicates too much air or too little gasoline; white smoke indicates too much cylinder oil. Usually when the engine is to be started after standing some time, a rich charge is obtained by placing a cover over the air inlet as the engine is cranked. The engine should be stopped by opening the switch, not by shutting off the gasoline, so that after the charge is once adjusted it need not ordinarily be changed during the summer spraying.

XXII. PUMPS. Since the pump must work against pressure, it must be of the force-pump type. All metal parts which come in contact with the spray liquid must be of brass, bronze, aluminum or some noncorroding alloy. Single-acting pumps, if but one cylinder is used, give a variable pressure. This is overcome in the duplex and triplex pumps by the use of two and three cylinders, respectively. The double-acting pump works much the same as the ordinary threshing tank pump. Liquid is forced out at each stroke of the piston and continuous pressure is obtained. Very frequently leather packing is used on the plunger, and is replaced by removing the cylinder head, just as is done in repacking the threshing tank pump. The duplex and triplex pumps are usually composed of a brass cylinder in which a close-fitting brass plunger works. The plunger should carry the packing. It is important to use the packing best suited to the particular pump being used. This packing may be obtained from the company manufacturing or selling the pump. The pump may be driven by a belt, yoke or gear. The belt drive is frequently employed if the engine used for driving the pump is to be used for other purposes during the time the sprayer is not in use. The yoke and gear drives are frequently combined, the gear alone being most used when the engine is intended for spraying only. When a belt drive is used a heavy idler should be employed to keep the belt tight.

XXIII. ESSENTIAL PARTS OF THE SPRAYER. In the following discussion the essential parts of a sprayer are taken up in the same order as followed by the spray as it enters, passes through the pump and is discharged through the nozzles.

XXIV. SUCTION STRAINER. The end of the suction hose which is placed in the liquid must be covered with screen to prevent the entrance of coarse sediment or other material which would clog the nozzles. If a screen is placed directly over the open end of the hose it does not allow enough surface for the entrance of the liquid. Various cast frames are made to fit into the end of the hose, which contain an enlarged screen surface. The strainer should be of 20-40-mesh brass screen, and the frame should be so constructed that the screen can not draw tight to the tank under suction, and at the same time allow all of the liquid to be drawn out. The shank should be long enough to accommodate two hose bands. Such a strainer is shown in figure 1, plate 4. The screen surface should be twice as large as the open end of the hose. This strainer must be cleaned frequently. Very often a clogged strainer prevents a good pressure. This is one of the first places to examine if trouble is experienced in retaining a good pressure, when the engine and pump are both working correctly.

XXV. SUCTION HOSE. The size of the suction hose varies from one to two inches, according to the capacity of the pump it is to supply. The hose should be of a good grade and non-collapsible, and be fitted at either end with two good, heavy hose bands. It should be large enough to supply the pump easily.

XXVI. VALVES. One of the most important parts of the pump is its valves. Several kinds are still found in the market, but, on account of their superiority, the ball valves are now quite generally used. They require no gasket, offer little resistance to the upward passage of liquid, act quickly, and are durable and efficient. The entire valve, seat and ball should be removable, in order that it may be replaced if worn. The ball should be large and heavy enough to drop quickly. Care must be taken in screwing the valve into place that the guides are not bent, otherwise the ball may be held down and the valve not allowed to act.

The poppet valve is still occasionally used. They ordinarily require a rubber gasket to prevent leaking, and offer more resistance to the passage of liquids through the port. They are held in place by a rod or wing guide, which too often allows them to be misplaced. One style of this kind of valve has a

beveled face, requiring no gasket. It is much the best of this type.

All valves and seats should be of hardened bronze or other durable, noncorroding material. They should be situated in places easily accessible without removing other parts of the machine. A leaky valve is easily detected by the deflection of the pressure-gauge needle.

XXVII. CYLINDER. The lining of the pump cylinder must be of such material that it will wear well and not corrode when Bordeaux or copper sulphate solution is used as a spray. Ordinarily brass or bronze alloys are used, but recently porcelain has been used by one manufacturer with good results. The metal alloy lining is frequently removable and may be replaced if worn.

XXVIII. PLUNGER. The plunger varies with the style of pump used. It carries packing in the ordinary double and single-acting pumps, but in some of the duplex and triplex types the packing surrounds the plunger, being held in place by a gland and cap. The piston rod or driving rod may be connected to a crosshead, an eccentric, or to a common crank. A heavy eccentric is most satisfactory.

XXIX. AIR CHAMBER. The purpose of the air chamber is to give space for compression, thus allowing a more steady pressure. It is located near the cylinder and connected at the bottom with the discharge pipe. As the liquid is forced out of the pump under pressure it rises in the lower part of the air chamber, compressing the air in the upper part. The air and liquid in this large space allows a much better chance for compression than if the liquid was compressed in the pipe only. The air chamber is a necessary part of an efficient spray outfit, and should be large and capable of withstanding high pressure.

XXX. PRESSURE GAUGE. No orchard sprayer is complete without a reliable gauge for indicating the compression. The ordinary steam gauge may be used, and the gauge employed is ordinarily of this type. For large power sprayers a gauge capable of indicating pressure from 400 to 500 pounds is most satisfactory. For smaller outfits a gauge reading 200 to 300 pounds is sufficient. The gauge should be connected with the discharge pipe or with the lower part of the air chamber (Fig. 2, plate 4.)

XXXI. RELIEF VALVE. The market offers several types of relief valves which have proven efficient. The purpose of this valve is to prevent the pressure from rising above a certain number of pounds, at which it may be set by the operator. A spring which holds the valve closed may be so adjusted as

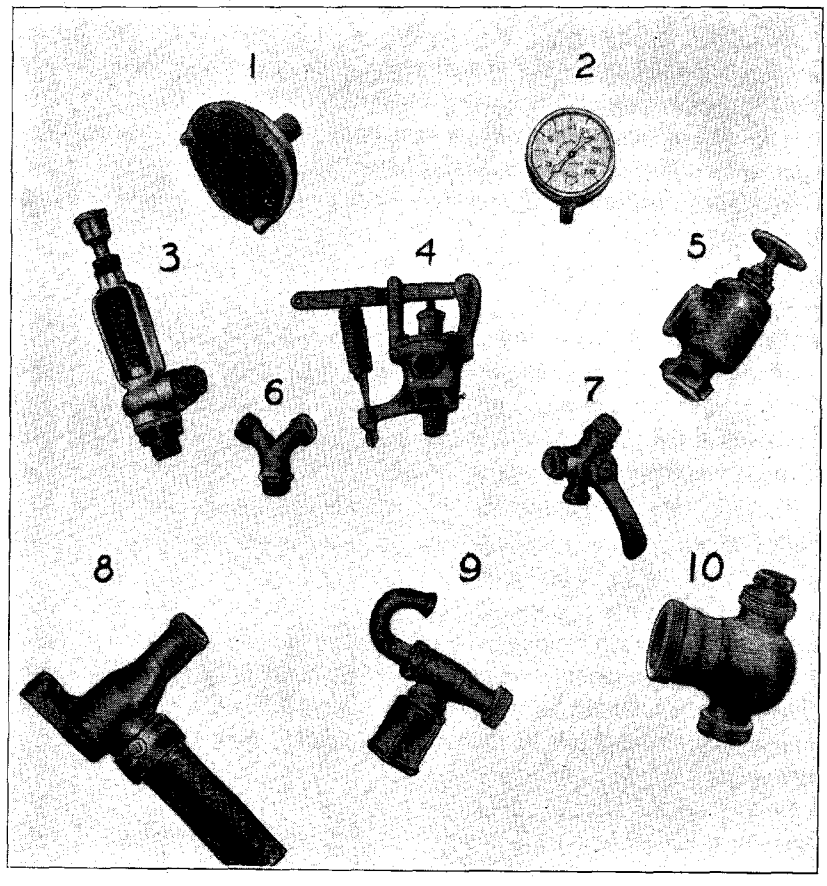

PLATE 4.

FIG. 1. Good type of suction hose strainer.
FIG. 2. One type of pressure gauge used with power sprayers.
FIGS. 3, 4, 5. Three types of relief valves.
FIGS. 6, 7. Discharge hose connections. Figure 7 is preferable.
FIGS. 8, 9, 10. Three types of tank fillers which work on the jet principle.

to allow it to open at various pressures, and when this valve opens part of the liquid flows back through it into the tank. As soon as the pressure falls to that for which the spring is set, the valve again closes and all of the liquid passes out

through the discharge hose. A good valve will regulate the pressure if one or more of the discharge hose are shut off while spraying. It is unnecessary, and harmful to the spring in the valve, to shut off all discharge hose and allow all of the liquid to pass through the relief valve when it is set for a high pressure. If the valve fails to control the pressure, remove the parts and clean thoroughly with vinegar or weak acid, and oil well. If this fails to give relief in an old valve, the seat may be worn or the spring weakened, and new parts or a new valve should replace it. (Figs. 3, 4, 5, plate 4.)

XXXII. THREE-WAY DISCHARGE COCK AND DISCHARGE Y. A discharge Y or three-way discharge cock should be attached to the discharge pipe when two leads of hose are to be used. It is much better to use the three-way cock, as by its use either hose, or both, may be shut off. Figure 7, plate 4, shows a three-way cock, and figure 6, plate 4, a discharge Y. Hose threads are provided for two openings and machine threads for the third.

XXXIII. DISCHARGE HOSE AND HOSE COUPLINGS. The discharge hose should be a good grade of from three-ply to seven-ply hose, according to the pressure which is to be carried. For hand pumps three-ply is sufficient, but for power outfits five- or seven-ply hose should be used. Hose wrapped with metal is not to be recommended. There is no economy in buying cheap hose, for it is continually bursting and giving trouble.

The hose couplings should be of the steam-fitting type, with strong connections and long shanks. The shank is usually roughened or carries rings which aid in preventing its slipping from the hose. It should be long enough to take two band hose clamps. The single-band clamp has given better service than the double type. A new device called the "Stay-On" clamp has been tried and found excellent for use with high pressure. (Figs. 12-16, plate 5.)

XXXIV. CUT-OFFS. A cut-off similar to figure 1, plate 5, should connect the discharge hose and extension rod. The lever of this shut-off should be of good length and easily turned. The type in which the valve stem is packed and the bottom closed usually gives better satisfaction than those in which the valve is beveled and drawn down by a nut at the bottom. Cut-offs shown in figures 2-5, plate 5, are not desir-

able, being either too hard to turn or do not have a large passageway for the liquid.

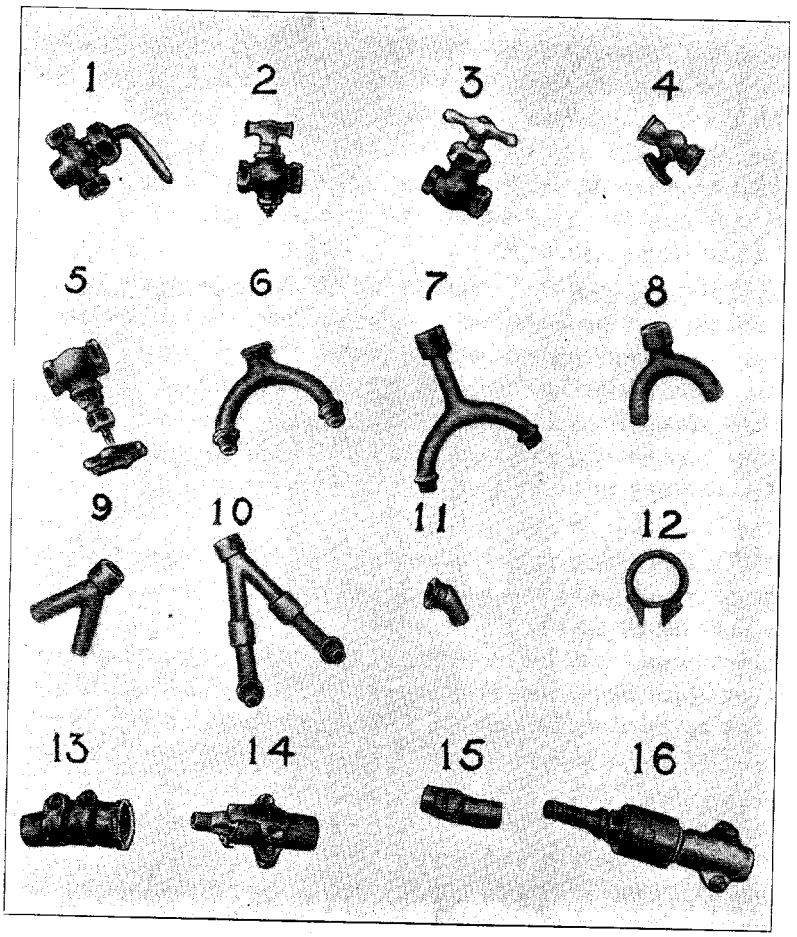

PLATE 5.

FIG. 1. An excellent type of shut-off, having good leverage and seldom giving trouble.

FIGS. 2, 3, 4, 5. Less desirable shut-offs, being either hard to operate or of too small capacity.

FIGS. 6, 7, 8, 9, 10. Nozzle U and Y connections. Figure 6 is angled, and figure 10 is provided with an excellent type of nozzle crooks.

FIG. 11. A nozzle crook having too sharp an angle.

FIGS. 12, 13, 14, 15, 16. Accessories for connecting the discharge hose to the machine. Figure 14 is an excellent new type for use with high pressure. Figure 16 shows a good type of connection for hose that is to be removed frequently.

XXXV. EXTENSION RODS. Good work can not be done in spraying trees with any outfit without extension rods of 8 to 14-foot lengths to carry the nozzles to places that could not be

reached otherwise. This rod may be simply a y4-inch gas pipe, but since such a pipe is heavy and hard to handle during an entire day, it is better to obtain a bamboo rod. Such a rod consists of a light ¼-inch brass or aluminum rod covered with bamboo. It is light and convenient, and by careful handling may be used several seasons. Threads are provided at either end for the cut-off and nozzle or nozzle Y.

XXXVI. NOZZLE Y. When two nozzles are to be used on each extension rod, a Y is used to connect them to the rod. This Y should be of a shape that will not cheek the liquid as it rushes out through the nozzle. If an ordinary straight nozzle is to be used, the Y should be angled as shown in figures 6 and 10, plate 5, to direct the spray into the tree.

XXXVII. NOZZLES. Perhaps no one part of the entire machine has caused more general discussion, or is more responsible for the effect of the spray application, than the nozzle. It is of the utmost importance to use a nozzle adapted not only to the kind of work to be done, but also to the pressure obtained with the outfit used. Some nozzles work best at one pressure and some at another, and for this reason hand pumps and engine power outfits ordinarily require different kinds of nozzles.

The nozzles included in plate 6 represent the products of several manufacturers, and a description of the kind of spray and the pressure to which each is adapted is indicated in the legend.

XXXVIII. TANK. Wooden tanks have been used almost exclusively on account of the corroding effect of certain common sprays upon metal tanks, but, by a new process, the metal tanks are now being treated to prevent corroding. The advantages of the metal tanks are numerous; they are lighter, do not dry out when not in use, are of such a shape usually as to prevent any chuck of the load, and ordinarily the cover fits tighter, preventing any loss of the spray materials by slopping over. Since such tanks have been in use only a few years, it has not been determined how long the metal is rendered noncorroding by the treatment given, and for this reason most companies are still using wood.

A round tank, or at least one having a round bottom, is best for power outfits, as agitation is more easily accomplished, and all of the solution can be drawn out of a tank of this shape.

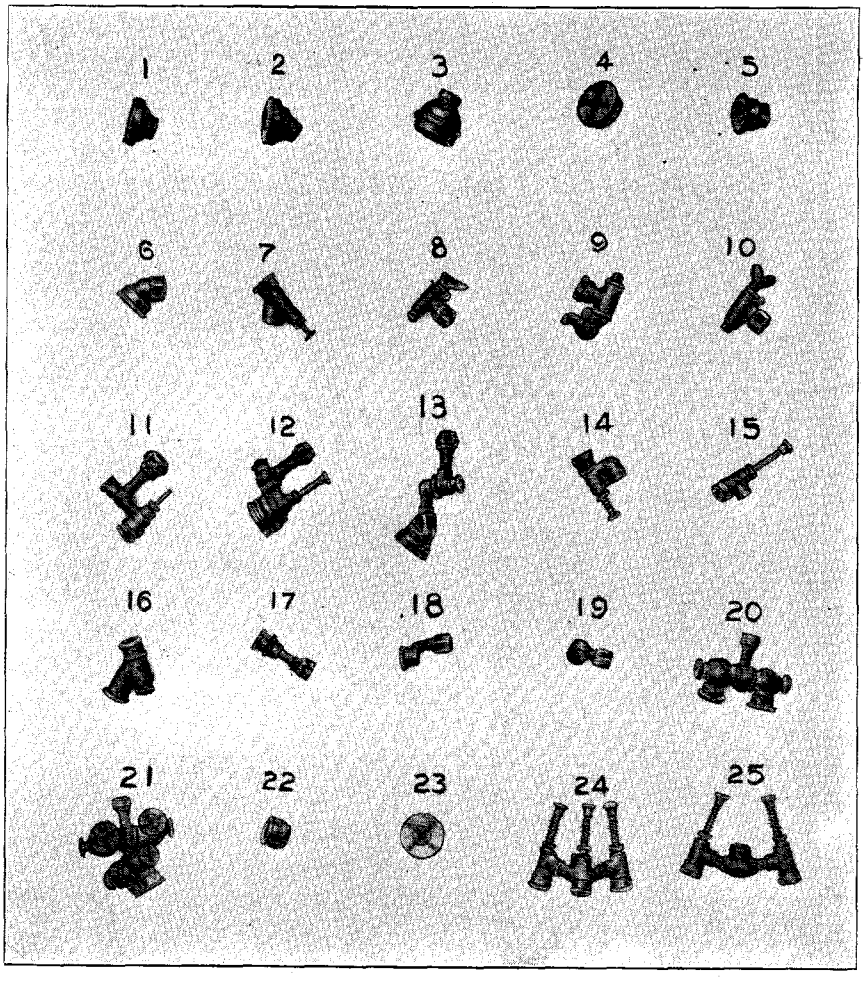

PLATE 6.

FIG. 1. Friend regular. Adapted to all regular spraying work when a pressure of 125 pounds or more is obtainable. Has discs with different sized exit apertures, giving a fine or coarse mist. An excellent nozzle. Manufactured by the Friend Manufacturing Co., Gasport, N. Y.

FIG. 2. Friend angled. Similar to figure 1 except that an angle is given which allows the directing of the spray inward and downward into the tree.

FIG. 3. E. C. Brown adjustable nozzle. Adapted to about the same pressure and work as the Friend, but more complicated and heavy. E. C. Brown Co., Rochester, N. Y.

FIG. 4. Reade & McKenna disc nozzle. Adapted to high pressure. Gives a rather coarse mist, such as is needed at the petal-fall application. Reade McKenna Co., Brooklyn, N. Y.

FIG. 5. Deming Simplex regular. Adapted to all spraying work with a light outfit. Gives fine or coarse mist by changing discs at pressures from 75 pounds up. The Deming Co., Salem, Ohio.

FIG. 6. Simplex angled. Same as figure 5 except that it is set at an angle.

FIG. 7. McCormick Vermorel. For use with medium pressure. Provided with disgorger and set at an angle. McCormick Manufacturing Co., Dayton, Ohio.

FIGS. 8, 9, 10. Bordeaux nozzles. Adjustable for use with low or high pressure. Give a flat, undesirable spray. May be obtained from any spraying company.

FIGS. 11, 12. Mistry nozzles. Adapted for use with medium pressure, at which they give a good mist. Figure 12 adjustable. Gould Manufacturing Co., Seneca Falls, N. Y.

FIG. 13. Mistry on adjustable connection. Less desirable than an angle Y. Gould Manufacturing Co., Seneca Falls, N. Y.

FIG. 14. Demorel nozzle. Similar to a Vermorel nozzle except in details of construction. Deming Co., Salem, Ohio.

FIG. 15. Vermorel. Adapted to medium pressure, and provided with disgorger. Supplied by any sprayer company.

FIG. 16. Whitewash nozzle. Useful in applying whitewash and other heavy materials.

FIG. 17. Eureka. Adapted to low or medium pressure. Disgorges by pushing against limb of tree. Deming Co., Salem, Ohio.

FIGS. 18, 19. Cyclone nozzles. Adapted to low or medium pressure. Excellent for use on hand outfits. Gould Manufacturing Co., Seneca Falls, N. Y.

FIGS. 20, 21. McCormick cluster nozzles. For use with medium or high pressure. The weight of these clusters makes them undesirable. McCormick Manufacturing Co., Dayton, Ohio.

FIG. 22. Maid of the Mist. Gives a fine spray at low pressure. Hurst Manufacturing Co., Canton, Ohio.

FIG. 23. Tiger nozzle. Adapted to medium or high pressure. Field Force Pump Co., Elmira, N. Y.

FIGS. 24, 25. Vermorel clusters. Undesirable on account of weight and the difficulty of throwing spray downward into the trees.

If a wooden tank is used it should be well bound with adjustable rods or bands and be well braced, as well as be made of the best materials. Heart cypress tanks usually have given the best satisfaction when well made. The chime, especially, must be well fitted.

XXXIX. AGITATOR. When any material is used in the spray which is held in suspension in the water, it becomes of the utmost importance that the machine be equipped with a good agitator. Ordinarily the sprays used are of this kind, and great care has been taken by manufacturers to equip power sprayers with efficient agitators. The propeller and sliding agitators are the two types mostly used, and the former is usually to be preferred. A rod containing three or four propeller blades is turned near the bottom of the tank by gearing a chain from the pump or engine. Such an agitator should run fast enough to churn the liquid thoroughly.

Paddle or sliding agitators are usually connected with the machinery and are much more efficient than hand agitation.

Hand agitators are usually employed when large tank pumps are used. Barrel pumps are equipped with paddle agitators, which are fairly efficient.

XL. TANK FILLERS. When water for spraying is obtained from creeks and ponds or from shallow wells, one of the different types of tank fillers can be used to good advantage in refilling the tank. Such a filler is especially useful if concentrated lime-sulphur is used as a spray. The concentrated solution is placed in the tank and the tank is filled directly, thus dispensing with mixing tanks. When Bordeaux is used some arrangement must be made to lift the water into the

elevated tanks, from which the spray mixture runs into the wagon tank by gravity. An ordinary threshing tank pump, or if an engine is available, a centrifugal or a rotary pump, is excellent for this purpose.

Several new devices are now being used for filling the wagon tank. They work on much the same principle as the steam jet, and, being inexpensive as well as efficient, they are fast gaining favor. A good filler should be capable of filling the tank used in from five to ten minutes. It should be durable, as light as possible, and it is best to have it attached to the sprayer, so that it is always at hand when the filling is to be done. (Figs. 8, 9, 10, plate 4.)

XLI. TOWER. Good work can not be done in spraying large trees without a tower from which the upper part of the trees may be reached. Throwing a stream of liquid into the top of the tree will not do; the nozzle must be brought near the surface being sprayed, to insure good work. During the petal-fall spray the nozzle must be carried above the parts sprayed, to insure forcing the poison into the calyx cups. This can not be done from the ground. The tower may be made of wood or metal, the important points to be considered being its strength, weight, and sufficient height to enable all parts of the tree to be reached. A guard or railing should be provided, so that the operator may give all of his attention to the handling of the extension rod without fear of falling.

XLII. TRUCK. Large power machines may be obtained with or without trucks. Frequently a low-wheeled, broad-tired truck is available for this work, and in such an event the cost of the truck might be saved. The truck sold with the sprayer may usually be employed for ordinary work when the outfit is not in use. It is important that the tires be broad and the truck strong and durable.

XLIII. CARE OF THE MACHINE—REPAIRS, ETC. The life of the machine, and especially of the engine, is very largely determined by the knowledge and care of the operator. Especially while the machine is new, all wearing parts should be very frequently oiled with a good grade of oil. The machine should be studied while in good working condition, and it should be the aim of the operator to keep it in the best condition possible. To do this it is necessary to go over each part at least once a day and see that all is in perfect adjustment. If

this plan is followed, much of the time ordinarily lost in spraying may be saved, and the machine kept in excellent condition.

At the close of each series of spray applications the machine should be thoroughly cleaned with water and housed in a closed shed. If the tank is of wood it may be left partly filled with water during the summer months, but never during freezing weather. All metal parts should be cleaned and wiped over with oil to prevent rusting, and all packing loosened and oiled. The discharge hose should be drained and hung without sharp bends.

In addition to this general care, all metal parts of the machine should receive an extra coat or two of oil when the machine is housed for the winter. The inside as well as the outside should be oiled, and all bolts requiring adjustment should be loosened and the threads oiled. All drain cocks should be left open to prevent any water from catching in any part and freezing, and it is best to cover the engine and pump with canvas or old carpet to protect them from dirt. While cleaning the machine a sharp lookout should be kept for broken or worn parts which need replacing. These parts should be ordered at once, and may be fitted at any odd times during the winter. Never wait until spraying time in the spring to order repairs; such delay frequently causes expensive waiting and heavy loss.

XLIV. BARREL PUMPS. The smallest outfit worthy of consideration for use in the orchard is the barrel pump. Several types are made, varying mostly in the placing of the parts, the kind of agitation, and the manner of fastening them to the barrel. In general this style of pump is efficient, and if provided with a good agitator may be relied upon to give a good spray when a low-pressure nozzle is used. The barrel pump is single-acting, and has a capacity, usually, of from one to four gallons per minute. The agitator should work as low in the barrel as possible and should be attached to the pump handle. Either the paddle or the churn-dash agitator is commonly used, and by one manufacturer this style of agitation is reinforced by a jet spray from the lower part of the pump, which aids in keeping all sediment in suspension. All metal parts through which the spray mixture passes should be of a noncorroding alloy. The valves should be of the ball type, and large enough

to allow the unrestricted passage of the full capacity of the cylinder.

Ordinarily one lead of hose, carrying two nozzles, will be all that the pump will supply. A nozzle of the Vermorel, Mistry or Cyclone type will give the best spray with a pump of this capacity. A pump of this type is adapted to spraying not more than four to five acres of medium-sized trees. In an orchard larger than this the larger pumps will be required for the best results. Barrel pumps may be obtained with or without the barrel, and the price varies from $10 to $25, according to the size of the pump and the kind of equipment. One lead of hose fifteen to thirty feet long, a shut-off, a bamboo or gas-pipe extension rod, nozzle Y and nozzles should accompany the pump.

XLV. LARGE HAND PUMPS OR TANK PUMPS. So great has been the demand for a hand pump of greater capacity than the barrel pump that many different types are being manufactured. Such a pump ordinarily has more than twice the capacity of the barrel pump, and, indeed, compares very favorablly with the small power sprayer in size. Much effort has been made to give the greatest capacity and compression with the least expenditure of energy, and advantage has been taken of almost every kind of mechanical leverage to accomplish this purpose. It is in this respect that the tank pumps differ most. Single- and double-acting pumps are both used. One of the most common is built very much like the ordinary threshing tank pump. Another has two upright cylinders, and works on the principle of the duplex type. Others have springs which aid in compression. A pump of this kind will ordinarily supply two leads of hose carrying two small nozzles or one large nozzle each. At a pressure of from 100 pounds to 125 pounds, the capacity

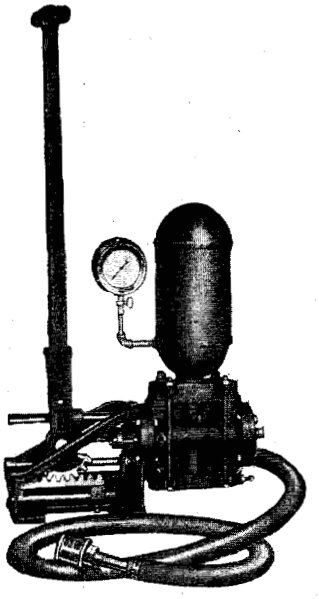

PLATE 7. A hand pump of large capacity. Such pumps are very useful in small orchards.

varies from about 4 to 7 gallons per minute. This style is intended for use in an orchard of from 5 acres or less up to not more than 15 acres. A good tank of from 150 to 250 gallons should be provided, and must be equipped with a hand agitator. The lack of mechanical agitation is one of the disagreeable features of this kind of an outfit, and, being of the utmost importance when the spray used contains much sediment, it is no doubt accountable for some of the trouble

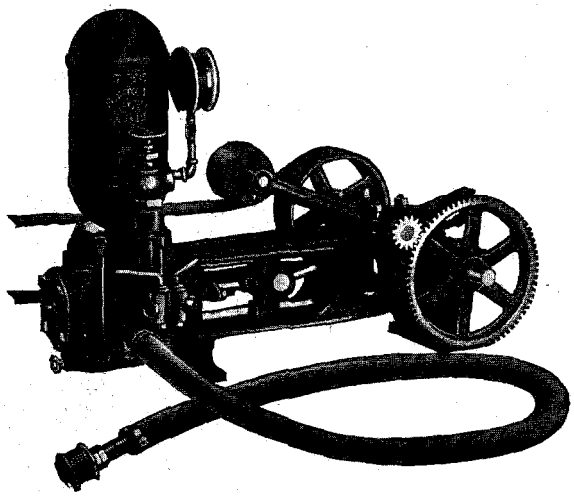

PLATE 8. A good pump for connecting with the ordinary gasoline engine in constructing a home outfit. Several companies are manufacturing a pump of the duplex or triplex type, which are well adapted for this use.

in affecting control. In order to be complete, this pump should be equipped with from 10 to 15 feet of suction hose provided with a good strainer, a pressure gauge, one or two leads (15 to 30 feet) of discharge house, extension rods, shut-offs, and nozzles. Extra packing should be obtained with the pump. Such a pump and equipment will vary in price from $30 to $50, according to size and make.

XLVI. HOME-CONSTRUCTED OUTFITS. Very frequently an outfit may be assembled by the grower which is suited to his needs, and by the use of an engine, pump, tank, or other necessary part which may be on hand, the cost is very much diminished. There are so many uses for the gasoline engine on a modern farm that it frequently happens a suitable engine is available and may be mounted on the sprayer during the

spraying season and used again for other purposes afterward. Pumps are now made by almost all companies which can be belted directly to an engine in making up this kind of an outfit, or are connected by means of a belt and jack or yoke. A two-, three- or four-horsepower engine would be of about the right size for use on an outfit of this kind. Either the horizontal, single-cylinder, double-acting pump, or the duplex or triplex types of pumps, may be obtained for this purpose. The prices vary from $50 to $80 or more. The size best suited to the work to be done, or the engine with which it is to be used, should be selected. It is usually advisable for the grower to select the type of pump with which he is best acquainted.

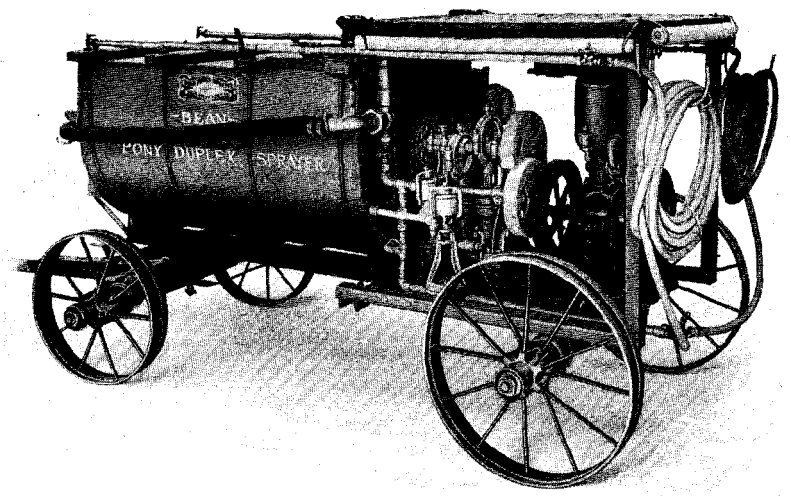

PLATE 9. A small power outfit, having about the same construction as the large sprayers, but less capacity.

The tank may be fitted with a hand agitator, or with one connected with the pump. The latter is much the better, since it gives continuous thorough agitation at all times. Hose nozzles, extension rods, cut-offs and any other accessories not obtained with the pump must be secured extra. A tower may be constructed from any light material having sufficient strength.

Some growers prefer to assemble an outfit, even though all parts are to be purchased, believing that by so doing a more serviceable machine may be obtained. Ordinarily this is not the case, and it is better to purchase the outfit complete. Minor changes usually will be made by the manufacturer to suit the purchaser.

XLVII. SMALL POWER OUTFIT. An excellent small power outfit is being made by several manufacturers which is well adapted to use in orchards of from 15 to 30 acres. These small outfits are ordinarily equipped with first-class material throughout, and the best work can be done with them, provided they are well handled and not overworked. They will ordinarily maintain a spraying pressure of from 150 to 200 pounds and have a capacity of from 4 to 8 gallons per minute. Two leads of hose, supplying one large or two small nozzles each, are ordinarily used.

The advantages of this kind of an outfit over the large hand pump are: engine power maintaining a constant pressure, mechanical agitation, requires fewer men, larger capacity, and a good tank. Better work can ordinarily be done, since the operator is supplied with a higher, constant pressure, and can give more attention to the handling of the rod. An outfit of this kind may be obtained with or without a truck, and in varying sizes, The price usually varies from about $200 to $275, according to the size of the outfit and amount and quality of the equipment.

XLVIII. LARGE POWER OUTFIT. The large outfits are intended for use in commercial orchards, and are equipped with

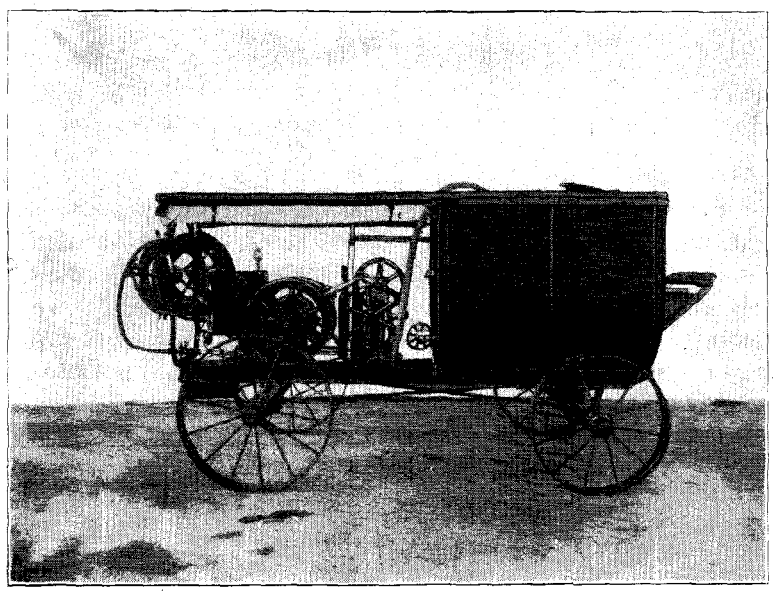

PLATE 10. Hayes power sprayer. Guaranteed by the manufacturers to carry a continuous high pressure.

all of the necessities for doing rapid, efficient work. Machines may be obtained which will maintain any pressure below 300 pounds, and with a capacity as high as 12 gallons a minute. It is important that an outfit of this type be as light as possible and still preserve its strength and power. The durability and accessibility and convenience of operation of the individual parts, as well as the capacity and weight of the machine, are items which contribute largely towards the desirability of a large outfit.

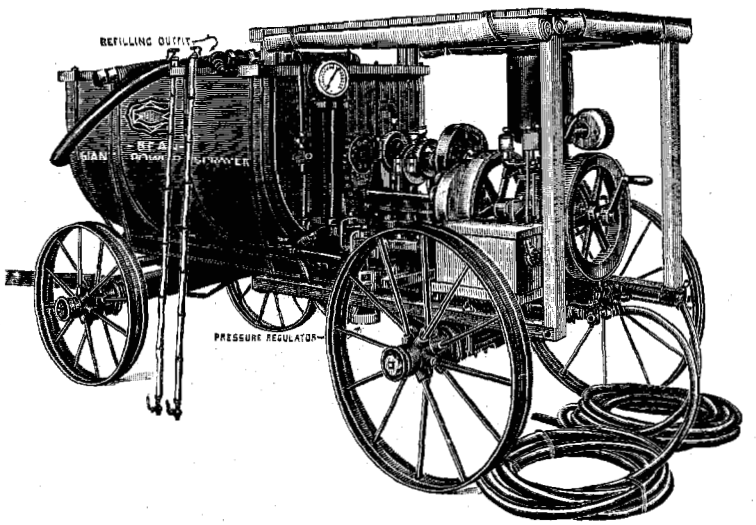

PLATE 11. Bean power sprayer. An excellent type of machine of large capacity.

A machine of this type should be capable of supplying from two to four leads of hose equipped with two nozzles each. Counting a period of six days as the maximum length of time that a single application may be applied to be most efficient, such an outfit, covering from 10 to 15 acres a day, would efficiently spray 60 to 90 acres. In order to do this, a supply wagon would be needed, so that the machine would not have to go long distances for liquid.

The largest sprayers are not so popular with growers as a medium-sized machine, one capable of supplying two leads of hose at a good pressure being a general favorite. A supply wagon holding 10 or 12 barrels may well be used with each two sprayers of this type, thus enabling the spraying to proceed almost constantly.

These large outfits, fitted with tank fillers and all of the ordinary accessories, including truck, retail at prices varying from $300 to $450. Towers ordinarily are not included, although some companies include a tower.

XLIX. COMPRESSED-AIR OUTFITS. Several attempts have been made to use compressed air for spraying purposes, a central outfit being used to charge the tanks, which must be air-tight and capable of withstanding high pressure. Such methods do not seem to have given the best results, although it seems that with proper improvements some such methods might be used. The great difficulties have been in obtaining

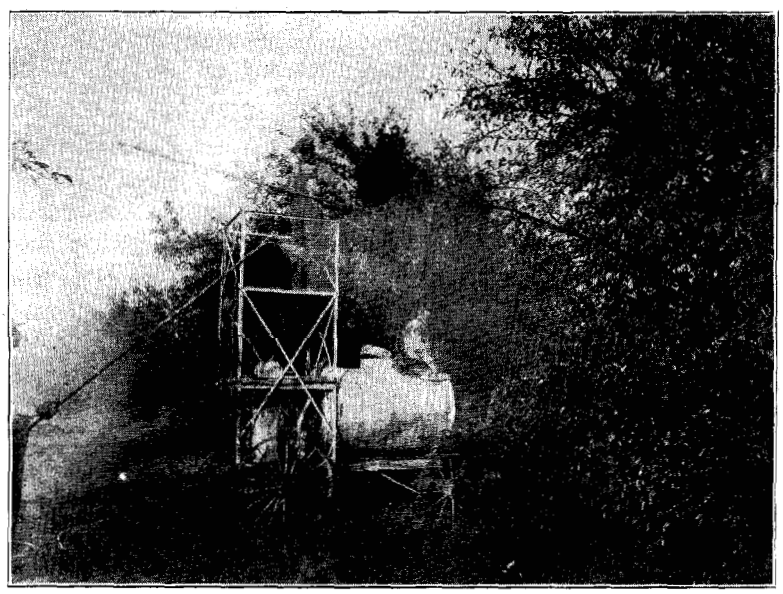

PLATE 12. One man in the tower and one on the ground can spray the trees to best advantage. Notice the angle Y, allowing the operator to direct the spray into the center of the tree.

sufficient agitation and maintaining a constant high pressure. Such a system would eliminate much of the trouble experienced with engines and pumps, and, if possible to do equally efficient work, would be less expensive than the ordinary outfits for use in a commercial orchard. At the present time no compressed-air system seems to possess all of the required essential factors.

L. DUST SPRAYING. The use of dust sprays in the College orchards has not been attended with success, even though the

applications were made at very frequent intervals. Neither insects nor fungi have been materially checked by the use of dust sprays. Sprays of this nature may have a place in protecting some crops, but certainly can not be recommended for use in Kansas orchards.

LI. APPLYING SPRAY. The manner in which a spray solution is applied has as much to do with its success in controlling insects and fungi as the kind of material used. All sprays except the petal-fall application are applied with a view of covering the part to be protected with an even, continuous coating of the solution used. The dormant spray is made with aview of coating each part of the woody portion of the plant with spray, while the summer applications are intended to cover all fruit and foliage with a protective coat. Frequently it is advisable to include the woody portion of the plant also in the summer applications, especially when San José scale or numerous cankers are present.

LII. THE DORMANT SPRAY. This spray is applied either in the fall after the leaves are off the tree, or in the spring shortly before the buds open. The spring application is preferable. Much stronger solutions may be used at this time than would be possible when the foliage is on the tree. Advantage is taken of this fact in fighting the San José scale and in killing any other insects or fungi which are present upon the tree and which may be destroyed by the solution used. The material should be delivered with a nozzle giving a spray fine enough to thoroughly coat the twigs, limbs and trunk, and with a pressure sufficient to drive it into all crevices and under loose bark. To insure success it must be applied with absolute thoroughness.

LIII. THE SUMMER SPRAY. The summer applications, except the petal-fall, should be applied with a nozzle giving a good mist with the pressure used. This means that the nozzle or the disc containing the exit aperture must be varied to suit the pressure obtainable with the machine used. As the operator passes around the tree he should see that every part is thoroughly coated. This may be more easily accomplished if the nozzles are given a constant rotary or circular movement, which insures the spray reaching the fruit or leaf from at least two angles. The speed at which the nozzle is moved mill depend upon the nozzle and pressure used, but should be

such that a maximum amount of spray material is deposited upon the part sprayed. By examining the condition of the fruit and foliage after the water has had time *to* evaporate, and comparing with the appearance of the leaves shown in plates 13, 14, and 15, the time necessary to spray each part effectively will soon be determined.

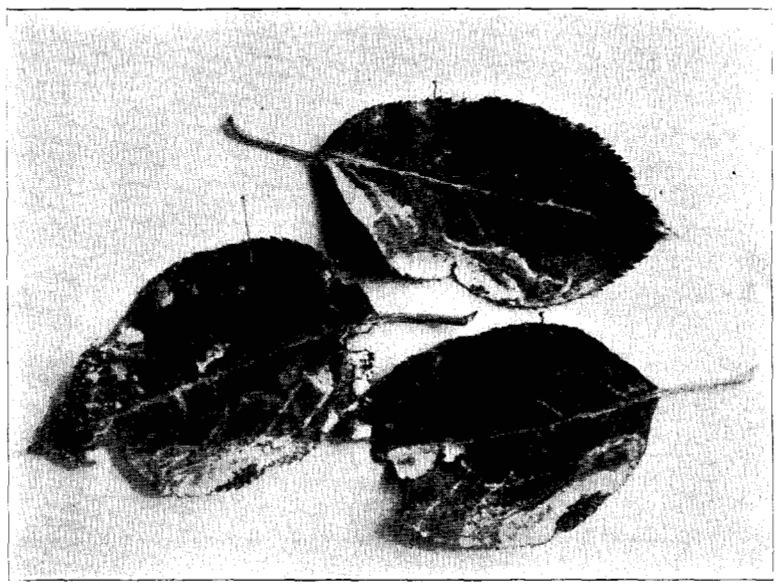

PLATE 13. Leaves showing burning following overspraying.

LIV. THE PETAL-FALL SPRAY. The object or the petal-fall spray is to fill the calyx cup full of poison. At the time of this application the calyx stands with the open part up, and the spray must be delivered from above by carrying the nozzles over the young fruit and having the nozzle or the Y bent at an angle which will deliver the spray downward. (See plates 5 and 6.) The nozzle and pressure used at this time should insure the delivery of the spray with force enough to penetrate all calyx cups. The Bordeaux nozzle is frequently recommended for use at this time, but since it delivers a flat, undesirable spray, and is wasteful of the spray material, other nozzles have been tried in the College orchard and proved as efficient, if used carefully, and have the advantage of being less wasteful. The Friend nozzle, carrying a disc with a medium-sized aperture, has been found especially effective for this work. Since this application

is the most effective single application for the control of the codling moth, it is of the greatest importance that thorough work be done.

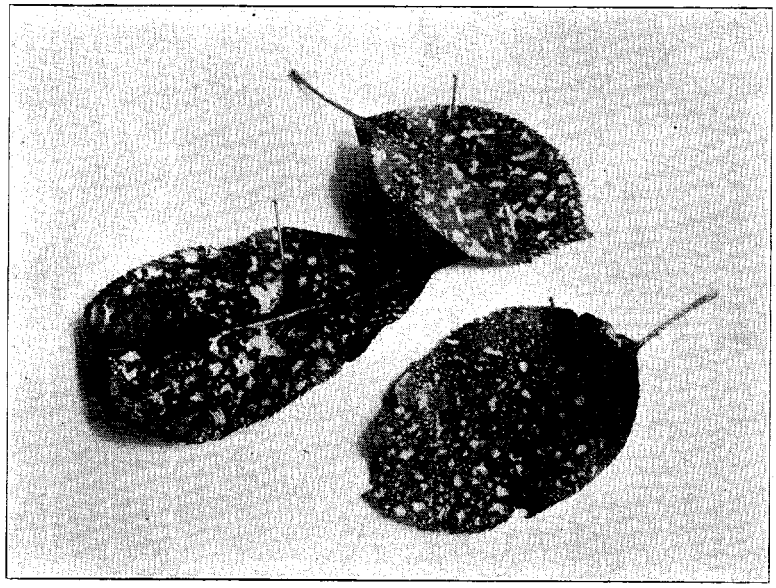

PLATE 14. Leaves sprayed with a nozzle giving a coarse mist.

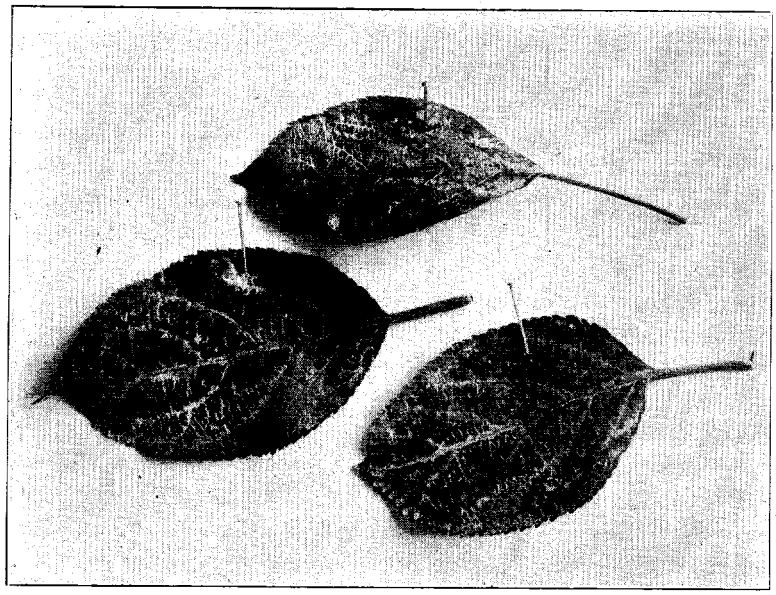

PLATE 15. Leaves showing desirable distribution of spray material.

Spray Outlines.

GENERAL SPRAY OUTLINE FOR APPLES.

	Insect or Fungi.	Spray to Use and Time of Application.
1.	*San Jose scale*	Dormant strength commercial or home-boiled lime-sulphur (6-7-8). Just before the buds swell.
2.	*Apple scab* *Plum curculio* *Spring cankerworm* *Apple rust*	Lime-sulphur, summer strength (6-7-8), plus two to four pounds arsenate of lead. When cluster buds are showing pink, but before blossoms open.
3.	*Codling moth* *Apple scab* *Black rot* *Rust*	Lime-sulphur, summer strength (6-7-8), plus two pounds of arsenate of lead. Start when petals are two-thirds off the blossoms.
4.	*Apple blotch* *Plum curculio* *Codling moth* *Black rot*	Bordeaux mixture 3-4-50 plus two pounds arsenate of lead, if the weather is dry. Three weeks after No. 3. If wet, use lime-sulphur and follow with Bordeaux as soon as dry.
5.	*Apple blotch* *Black rot* *Plum curculio* *Codling moth*	Bordeaux 3-4-50 plus two pounds arsenate of lead. Two to four weeks after No. 4.
6.	*Codling moth* *Apple blotch* *Bitter rot* *Black rot*	Bordeaux mixture 3-4-50 plus two pounds arsenate of lead. Eight to ten weeks after No. 3.
7.	*Bitter rot* *Blotch* *Codling moth*	Lime-sulphur or Bordeaux 3-4-50 plus two pounds arsenate of lead. Shortly before fruit begins to ripen.

Not all of these applications are likely to be needed in an orchard during a single season, but by determining the nature of the injury common, a schedule can be arranged from the above which is adapted to the grower's needs. Sprays No. 2, 3, 4, and 6 are those ordinarily recommended. Upon such varieties as York Imperial, Winesap, Grimes Golden and Jonathan, lime-sulphur may take the place of Bordeaux in the late sprays. Usually it is considered safer to use Bordeaux during the dry, hot weather, as lime-sulphur-lead frequently causes serious burning under such conditions.

GENERAL SPRAY OUTLINE FOR PEACHES.

Insect or Fungi.*	Spray to Use and Time of Application.
1. *Brown rot* *Leaf curl* *San Jose scale*	Lime-sulphur, dormant strength (6-7-8). If no scale is present use Bordeaux 6-6-50. Apply shortly before buds begin swelling.
2. *Curculio* *Scab* *Brown rot* *Leaf-eating insects*	Self-boiled lime-sulphur (9) plus two pounds arsenate of lead. Shortly after blooming, as shucks fall.
3. *Scab* *Curculio* *Brown rot* *Leaf spot*	Use same spray as No. 2. Apply two or three weeks after No. 2.
4. *Brown rot* *Scab*	Use same spray as No. 2. Apply as is necessary to prevent injury from brown rot. Usually applied shortly before ripening begins.

GENERAL SPRAY OUTLINE FOR CHERRIES.

Insect or Fungi.*	Spray to Use and Time of Application.
1. *Brown rot* *Curculio*	Bordeaux 3-4-50 plus two pounds arsenate of lead. Apply just before blooming.
2. *Brown rot* *Curculio* *Leaf spot*	Bordeaux 3-4-50 or self-boiled lime-sulphur plus two pounds arsenate of lead. Apply after blooms have fallen.
3. *Brown rot* *Scab* *Curculio* *Leaf spot*	Ammoniacal copper carbonate plus two pounds arsenate of lead. Apply just before fruit begins to color.
4. *Leaf spot* *Leaf-eating insects*	Apply Bordeaux and arsenate of lead as given above as necessary to control insects, etc., after fruit is picked.

* For San José scale, spray as directed in spray outline for apples.

GENERAL SPRAY OUTLINE FOR PLUMS.

Insect or Fungi.*	Spray to Use and Time of Application.
1. *Curculio* *Brown rot* *Black knot*	Bordeaux mixture 6-6-50 plus two pounds arsenate of lead. Apply shortly before blooming.
2. *Curculio* *Brown rot*	Self-boiled lime-sulphur (9) plus two pounds arsenate of lead. Apply immediately after blooming.
3. *Curculio* *Brown rot* *Scab* *Leaf spot*	Self-boiled lime-sulphur plus two pounds arsenate of lead. Apply at intervals of two to four weeks until fruit is ripening.
4. *Same as No. 3*	Use ammoniacal copper carbonate plus arsenate of lead, if necessary to spray during the ripening period. (10).

* For San José scale, spray as directed in spray outline for apples.

A List of Companies Manufacturing or Assembling Reliable Spraying Machinery and Accessories.

American Sprayer Co., Minneapolis, Minn.
Bean Manufacturing Co.. Cleveland, Ohio.
Binks Spraying Machinery Co., Chicago, Ill.
Cushnlan Sprayer Co., St. Joseph, Mo.
E. C. Brown Co., Rochester, N. Y.
Deming Co., Salem, Ohio.
Fairbanks, Morse & Co., Cleveland, Ohio.
F. E. Myers & Bro., Ashland, Ohio.
Field Force Pump Co., Elmira, N. Y.
Friend Manufacturing Co., Gasport, N. *Y.*
Goulds Manufacturing Co., Seneca Falls, N. Y.
Hardie Manufacturing Co., Hudson, Mich.
Hurst Manufacturing Co., Canton, Ohio.
International Harvester Co., Local Agencies.
John Deere Plow Co., Kansas City, Mo.
McCormick Manufacturing Co., Dayton, Ohio.
Niagara Spraying Co., Middleport, N. Y.
Spray Motor Co., Buffalo, N. Y.
The New Way Motor Co., Lansing, Mich.
W. & B. Douglas Co., Middleton, Pa.
Hayes Pump and Planter Co., Galva, Ill.

A List of Companies Manufacturing or Selling Reliable Spray Materials.

Battelle & Renwick, New York, N. Y.
Bean Spray Pump Co., Cleveland, Ohio.
Bowker Insecticide Co., Boston, Mass.
Corona Chemical Co., Milwaukee, Wis.
DeVoe & Reynolds Co., Kansas City, Mo.
Dow Chemical Co., Midland, Mich.
Grasselli Chemical Co., St. Louis, Mo.
Jas. A. Blanchard Co., Cleveland, Ohio.
Mallinckrodt Chemical Works, St. Louis, Mo.
McPike Drug Co., Kansas City, Mo.
Niagara Sprayer Co., Middleport, N. Y.
Sherwin-Williams Co., Local Dealers.
The Rex Company, Omaha, Neb.
Thomsen Chemical Co., New Brunswick, N. J., and East St. Louis, Mo.
Vreeland Chemical Co., New Brunswick, N. J.
Whitelaw Bros. Chemical Co., St. Louis, Mo.

Don'ts for Spraying.

Don't expect results if the work is not thoroughly done.

Don't think a week earlier or later than the date recommended is just as good.

Don't overspray. A continuous even coating should be left on the fruit and foliage; any material which runs off does no good.

Don't think that lime-sulphur will control apple blotch as well as Bordeaux mixture.

Don't apply Bordeaux mixture during wet weather; it is liable to russet the fruit.

Don't apply lime-sulphur and arsenate of lead during a spell of extremely hot, bright weather; it is liable to cause serious burning.

Don't try to get along with a machine which is worn out or too small to do good work; if the work is worth doing it is worth doing well.

Don't fail to clean the machine thoroughly after each spraying; it saves much trouble when the time comes for the next application.

Don't think that spraying alone will insure good fruit; pruning and cultivation are equally essential.

Don't think that spraying will pay unless the fruit is well marketed; spraying is only part of the battle.

Don't fail to apply to the Horticultural Department of the Kansas State Agricultural College when in spraying troubles.