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Preparation and Application of Fungicides.

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NOTICE AS TO BULLETINS.

The Bulletins of this Station are mailed free to citizens of Connecticut who apply for them, and to others as far as the limited editions permit.

Applications should be renewed annually before January 1st.

The matter of all the Bulletins of this Station, in so far as it is new or of permanent value, will be made part of the Annual Report of the Station Staff.

All Bulletins earlier than No. 71 and Nos. 83, 86, 93, 100, 101 and 118 are exhausted and cannot be supplied.

NOTICE AS TO SUPPLY OF STATION REPORTS.

The Station has no supply of its Annual Reports for the years 1877, 1878, 1879, 1880, 1881, 1882, 1883, 1887 and 1891.

The Annual Report of this Station, printed at State expense, is by law limited to an edition of 7,000 copies.

After exchanging with other Experiment Stations and Agricultural Journals, the Reports remaining at the disposal of the Station will be sent to citizens of Connecticut who shall seasonably apply for them, and to others as long as the supply lasts.

FORMER REPORTS WANTED.

There is frequent call for our earlier Annual Reports on the part of public Libraries, students, chemists, naturalists, and station workers.

Persons who can supply copies of Reports for any of the years above named, will be likely to find purchasers by communicating with the Director.

PREPARATION AND APPLICATION OF FUNGICIDES.

BY WM. C. STURGIS, PH.D.

The present Bulletin has been prepared with the view of meeting the constant demand for some concise and definite advice upon the methods of spraying plants to prevent diseases caused by fungi. It is not intended as a guide to the diseases themselves. That subject was treated at some length and in a popular manner in Bulletin 115 of this Station, and in our Spraying Calendar, issued in March, 1893. Both of these publications gave a list of fruits and vegetables most commonly grown, indications by which the fungous diseases which attack them may be recognized, and the course of treatment to be pursued in each case. For the determination of any particular disease therefore, the reader is referred to those publications, copies of which will be sent on application. A very much fuller list of economic plants, the fungous diseases to which they are subject and references to publications which treat of them in detail, was published in our Annual Report for 1897. This list is intended for the use of those who desire to make a careful study of the whole subject.

THE OBJECT OF SPRAYING.

Plants are sprayed with fungicides in order to *prevent* the attacks of parasitic fungi. Although sometimes spraying will check the spread of a disease after its inception, it is primarily a *means of prevention* rather than a cure. This end is attained by coating all portions of the plant with some substance fatal to fungous growth and which will therefore kill any fungous germs already present on the plant and prevent those which are carried to it later by the wind or other agencies from starting a disease.

SUBSTANCES USED AS FUNGICIDES.

The various salts of copper are all detrimental to fungous life.

Sulphate of Copper or "blue-stone" is the cheapest and most effective fungicide; it is therefore the one most commonly used. A

solution of this substance injures leaves to which it is applied; it must therefore be changed, before use, to hydrate of copper. This is done by adding white-wash to it, thus forming what is known as *Bordeaux Mixture*. This is not a solution. It forms a bluish deposit on foliage and fruit and its use is therefore to be avoided after the fruit has begun to color. Paris Green or London Purple can safely be used in connection with Bordeaux Mixture. (See p. 5.)

Another useful fungicide is *Carbonate of Copper* dissolved in *Ammonia*. The arsenites, such as Paris Green and London Purple, can not be used with this, since they are soluble in ammonia and, when in solution, are very injurious to foliage. It is a clear liquid however, is easily applied and does not spot fruit or foliage to which it is applied. It is sometimes used in cases where a fungicide must be applied to fruit shortly before harvest. (See p. 5.)

Potassium Sulphide or "Liver of Sulphur" is a salt of potash, soluble in water and forming a clear solution; it is very useful in certain cases, notably in all forms of surface mildew.

Sulphur or "Flowers of Sulphur" is also an effective remedy for mildews and similar diseases. In the field it is dusted on the plants and in the greenhouse it may be mixed with linseed oil and applied to the heating pipes.

PREPARATION OF FUNGICIDES.

Sulphate of Copper Solution.—This is prepared by dissolving one pound of sulphate of copper in 15 to 25 gallons of water. This is generally destructive to foliage and must be used while the plants are dormant. It kills lichens and mosses on the bark of trees and rids the latter of fungous germs before the growing season begins.

Bordeaux Mixture.—

Sulphate of Copper,.....	5 lbs.
Lime,	5 lbs.
Water,	45 to 50 galls.

The object to be aimed at in preparing this mixture is the rapid union of the two substances in diluted solution and the thorough mixing of the same. Therefore proceed as follows:

Dissolve 5 lbs. of sulphate of copper either by adding it to two or three gallons of hot water or by enclosing it in a coarse bag

and suspending the whole in a half-barrel of cold water so that the water just covers the sulphate.* When dissolved, dilute with cold water to 15 gallons. Slake 5 lbs. of perfectly fresh (not air-slaked) stone lime in a little water, preferably hot. When thoroughly slaked, dilute and pour it into the spraying-cask, using, if necessary, a strainer or piece of coarse bagging to strain out the coarse sediment. If the lime is of good quality and is properly slaked, there will be no lumps. Add water to make 30 galls. Pour the sulphate solution *as rapidly as possible* into the white-wash, stirring thoroughly for two or three minutes. The resulting mixture should be of a pure, deep blue color, and should settle very slowly.

If, for any reason, it is more convenient to reverse the process and pour the white-wash into the sulphate solution, this may be done with equally good results, *providing both solutions are dilute.*

Bordeaux and Paris Green.—This is a combined fungicide and insecticide prepared by mixing $\frac{1}{2}$ lb. of Paris Green to a smooth paste with a little water and adding it to every 45 or 50 galls. of Bordeaux mixture.

NOTE 1.—*Copper sulphate corrodes most kinds of metals; it must therefore be used only in copper, brass, or wooden vessels.*

NOTE 2.—Much time may be saved at the spraying season by preparing before-hand stock solutions of copper sulphate and lime, containing, in separate vessels, any number of pounds in half the number of gallons of water. One gallon of either stock solution will then contain two pounds of either copper sulphate or lime and the time consumed in weighing and dissolving will be saved. *Care must be taken to protect the stock solution of copper sulphate from evaporation by keeping it in a closed vessel, and to keep the lime protected by at least two inches of water.*

Ammonia Solution of Carbonate of Copper.—

Carbonate of Copper,	5 oz.
Ammonia (strong),	3 pts.
Water,	45 to 50 galls.

Mix the carbonate of copper to a thick paste with water. Add the ammonia slowly until the paste is dissolved, using, if neces-

* Copper sulphate dissolves much more readily when pulverized or granulated. It can be procured in this condition from The Nichols Chemical Co., 32 Liberty St., New York. (See p. 16.)

sary, a little more than the three pints. A clear, dark-blue solution results. Dilute with water to 45 or 50 galls.

NOTE 3.—*The strong, undiluted solution may be made in quantity and diluted for use as needed.*

NOTE 4.—*The arsenites (Paris Green or London Purple) can not be used with this solution.*

Potassium Sulphide.—This is used in solution. Dissolve 1 oz. of the sulphide in 3 galls. of water, and apply as a spray.

NOTE 5.—*Sulphide of potassium must not be exposed to the air. It should be kept in tightly-stoppered bottles.*

Corrosive Sublimate.—This is the bichloride of mercury and is used as a disinfectant for potato "seed" affected with scab.

Dissolve 4 oz. of corrosive sublimate in 30 galls. of water in a cask or barrel. Put the potatoes in a loosely-woven sack and immerse them in the solution for 1½ hours. Spread them out to dry, then cut and plant as usual.

NOTE 6.—*Corrosive sublimate is a fatal poison if taken internally. Do not leave the solution uncovered. Do not use the barrel for any other purpose except after a thorough rinsing with hot water. Plant or bury all treated tubers.*

NOTE 7.—*Corrosive sublimate attacks all metals; it must therefore be used in wooden vessels only.*

Formalin.—This is a 40% solution, in water, of formaldehyde gas. It is used to disinfect "seed" potatoes.

To 30 galls. of water add 1 pint of formalin. Soak the tubers in this solution for two hours, then cut and plant as usual. Formalin is apparently as efficacious as corrosive sublimate in the treatment of seed potatoes, and further possesses the advantages of being non-poisonous and of not corroding metals. Its use will doubtless supersede that of corrosive sublimate for the treatment of scabby seed-potatoes.

SPRAYING PUMPS.

The object of spraying being to apply a small quantity of a fungicide over a large surface, often at a considerable height above the ground and with the greatest possible economy of materials, time and labor, it is essential to use some form of apparatus which will deliver the liquid in a finely divided spray and with considerable force. To accomplish these ends most manufacturers of pumps now supply outfits especially adapted to

spraying. Although the initial expense of such outfits seems large, it is speedily returned in the saving in labor and materials which their use ensures.

Spraying pumps are made in various patterns and sizes according to the use for which they are intended. They may be grouped in five classes, as follows. (1) *Pail-Pumps*,—small force-pumps, provided with an air-chamber and used in connection with a pail; suitable for greenhouse work and for spraying individual plants or small areas. (2.) *Knapsack Sprayers*,—copper tanks of 4-6 gallons capacity, carried on the back of the operator and provided with small force-pumps; suitable for the spraying of vineyards and small fruits. (3) *Barrel Pumps*,—powerful force-pumps adapted for attachment to a barrel or tank; suitable for the spraying of orchards or large areas of low-growing plants. (4) *Steam Sprayers*,—very powerful pumps, driven by steam-power; expensive and adapted principally to the spraying of tall trees or to coöperative work on the part of a number of orchardists combined. (5) *Special Outfits*,—adapted to some particular purpose such as the spraying of potatoes on a large scale.

The following pumps and outfits may be safely recommended as among the best in their respective classes.

PAIL PUMPS.

These can be procured of any manufacturer of pumps. The following are good patterns.

"*Perfect Success*," made by The Deming Co., Salem, Ohio; list price, \$7.00.

"*Bordeaux*," made by The Goulds Mfg. Co., Seneca Falls, N. Y.; list price, \$9.00.

"*Aquarius*," made by Messrs. W. & B. Douglas, Middletown, Conn.; list price, \$10.50.

KNAPSACK SPRAYERS.

These are somewhat burdensome and inconvenient to use, and the special lines of work to which they are adapted can often be served equally well by the more generally useful barrel-pumps. The following patterns of knapsack sprayers are among the best.

"*Eclipse Knapsack*," outfit No. 1, made by Messrs. Morrill & Morley, Benton Harbor, Mich.; list price, \$12.00. This sprayer is illustrated in Fig. 1. It is claimed for it that, having no stuff-

ing box, it does not leak or slop over on the top of the tank, and that the pump itself is not soldered in place but can be readily

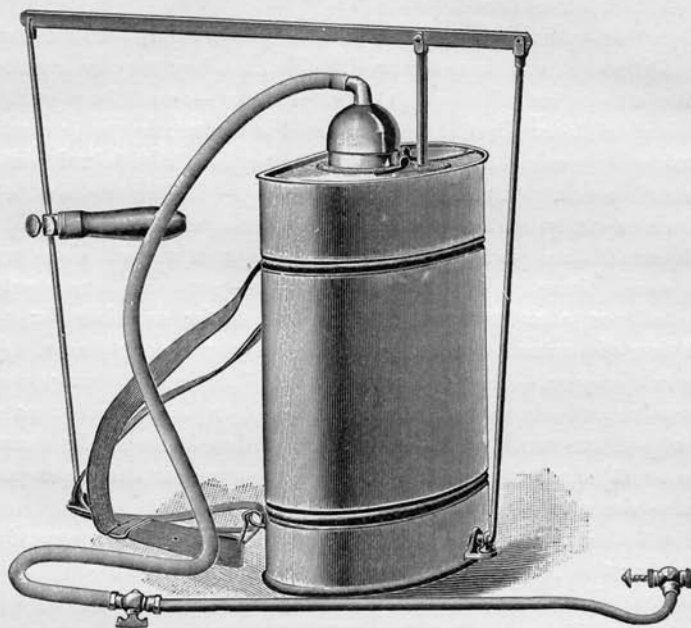


Fig. 1.

removed to be cleaned. The pump is of brass throughout, the tank is of copper, and the handle is reversible so as to be used with either hand.

Fig. 2 represents a similar sprayer known as the "*Handy*," and manufactured by The Goulds Mfg. Co., Seneca Falls, N. Y. The list price is \$15.00. The pump possesses a stuffing-box, but any leakage drips back into the tank. The pump is of brass and the tank of copper.

The Field Force Pump Co. of Lockport, N. Y., makes a knapsack sprayer known as the "*Garfield*." From the description it is apparently a first class apparatus. The pump works without a stuffing-box, and is provided with a very large air-chamber. The list price is \$10.00.

NOTE 8. *We strongly recommend prospective purchasers of spraying outfits to buy barrel-pumps in preference to knapsack sprayers in all cases where the work to be performed can be equally well done by either outfit.*

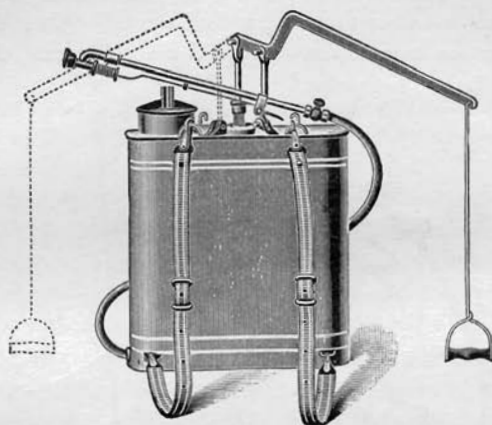


Fig. 2.

BARREL PUMPS.

For economy of time and labor, and for general utility, these pumps are unsurpassed. The following patterns are among the best; they represent the latest and best experience of practical orchardists.

The "*Eclipse*," No. 2, Model 97 (Fig. 3), is manufactured by Messrs. Morrill & Morley, Benton Harbor, Mich. This pump and the following one (Fig. 4) embody a new principle in spraying pumps, that of placing both air-chamber and cylinder within the barrel, thereby decreasing the height of the pump above the barrel. This is a distinct advantage in orchard work among low-branching trees. The active parts of the "*Eclipse*" are made of brass, the head and body of iron. There is no stuffing-box, but the plunger, a short brass cylinder, is fitted with packing. The discharge pipe passes up through the air-chamber. Both this pump and the following are provided with a mechanical agitator attached to the pump handle, which works satisfactorily.

The "*Eclipse*" is a thoroughly reliable and durable pump for use with Bordeaux mixture. The list price of the pump alone is \$10.00, but we recommend "*Outfit C*," consisting of pump, eight feet of hose, one eight-foot bamboo extension rod and double Vermorel nozzle. The bamboo extension is a bamboo pole bored out and lined with brass; it is a very great improvement upon the solid pole with hose attached which is usually recommended as a means of reaching the tops of high trees. This outfit is listed at

\$14.00. If, as is often the case, a double lead of hose is desired, with extra extension rod and double Vermorel nozzle, the makers supply it for \$4.00, list price.



Fig. 3.

Fig. 4 represents the "*Pomona*," made by The Goulds Manufacturing Co., Seneca Falls, N. Y. In all essential points this pump is similar to the "*Eclipse*." The method of construction is practically the same except in one point. In the "*Pomona*" the cylinder is rather short and is provided with a stuffing-box; the plunger acts throughout the length of the cylinder and the wear upon the different portions of the latter is thus equalized. In the "*Eclipse*" the wear comes principally near the middle of the cylinder. The list-price of the "*Pomona*," with one ten-foot lead and Vermorel nozzle, is \$12.25; with two ten-foot leads and two Vermorel nozzles, \$14.00. Any light pole can be used as an extension. The cut shows the pump mounted on the side of the

cask, but the manufacturers are prepared to furnish the same pump adapted to the end of the cask.

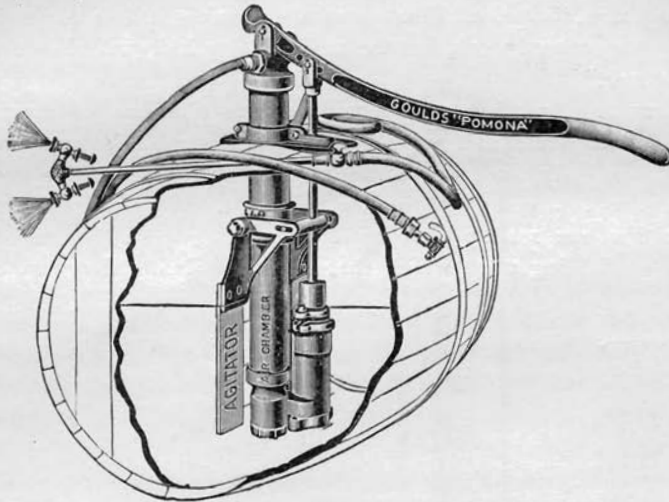


Fig. 4.

A very powerful barrel-pump is the "Advance," made by the Deming Co., Salem, Ohio. (Fig. 5.) The working parts are of



Fig. 5.

brass and are easily accessible. The air-chamber is capacious and is placed outside of the barrel. The list-price of the pump alone is

\$18.00; with one 12½ foot lead, pole connection (for attaching the nozzle to an extension pole) and single "Bordeaux" nozzle, \$4.50 extra, list-price. The same firm makes a less expensive pump for orchard work, but the model is decidedly inferior to the "Advance."

NOTE 9. Any light wagon will serve as a means of conveyance for the barrel and pump. The most desirable features are a short, low body, and a construction which will allow the front wheels to turn completely under the body. If greater height is desired it can readily be secured by erecting upon the wagon a light scaffolding upon which the man who directs the spray can

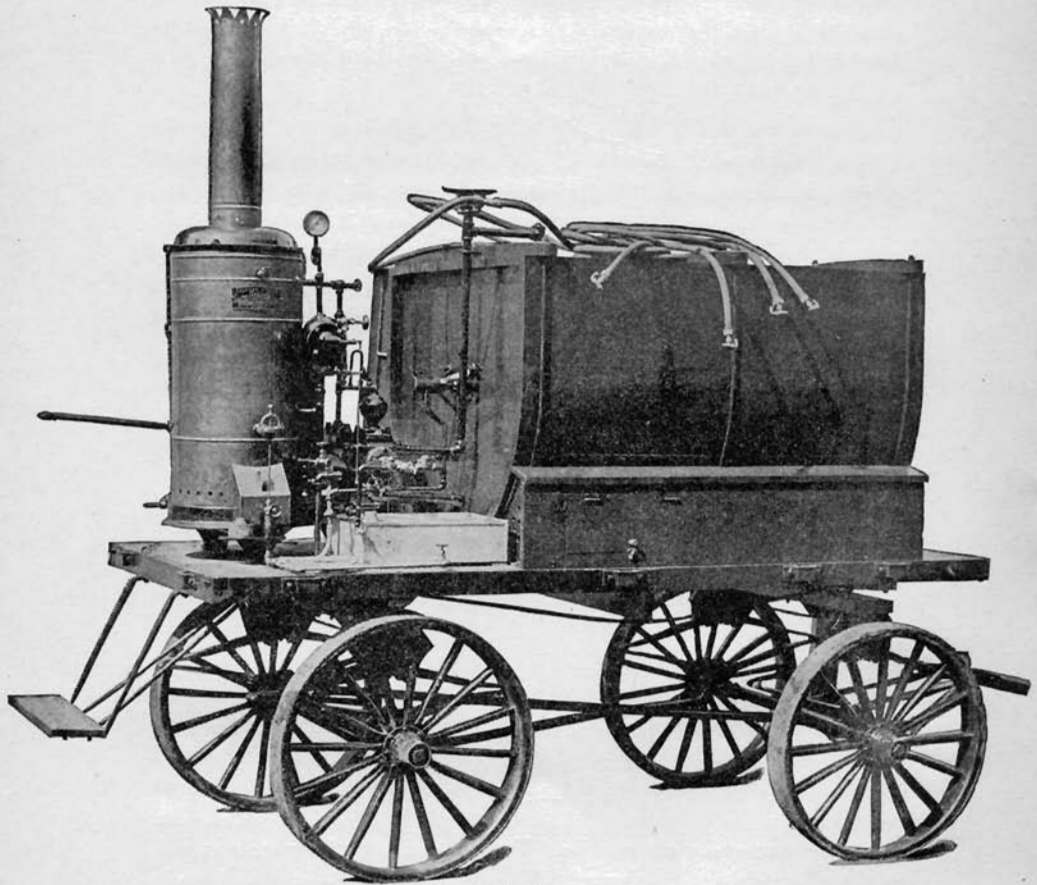


Fig 6.

stand. Usually however, with any one of the barrel pumps mentioned above, a spray can be directed into the tops of orchard trees by a man standing in an ordinary farm wagon.

STEAM SPRAYERS.

As mentioned above, a steam outfit is applicable only to very extensive, coöperative work. Moreover, the demand for such outfits is so slight that few firms manufacture them and the models have not yet been perfected.

The Field Force Pump Co., Lockport, N. Y., furnish to order a compact and apparently serviceable steam-sprayer at a list-price of \$260.00. This outfit is shown in Fig. 6. Similar outfits are described and figured in the 19th Annual Report of this Station, for 1895, pp. 210-213, and in the Year Book of the U. S. Dept. of Agriculture, for 1896, pp. 69-88.

OUTFITS FOR SPECIAL PURPOSES.

Growers of potatoes and other field crops have created a demand for some appliance which will distribute a fungicide or insecticide over several rows of plants at once or over an extended area. This demand has been met in several ways. One of the simplest appliances for this purpose is that described and

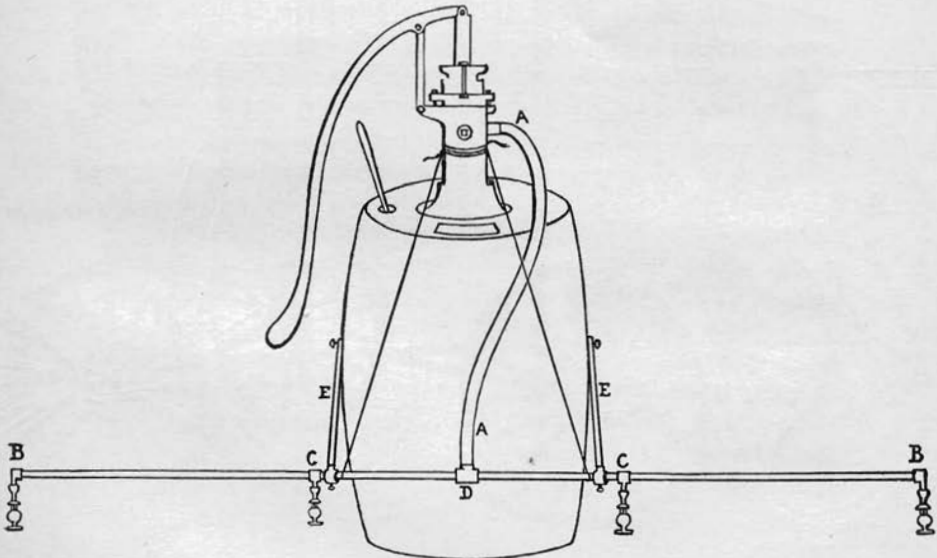


Fig. 7

figured in the 17th Annual Report of this Station, for 1893, pp. 74-77. (Fig. 7.) In this case the liquid is discharged through a hose (A) into a distributing pipe (BB) extending transversely behind the wagon and carrying a number of nozzles at intervals of three feet. This pipe may be either fastened to the barrel by arms (EE), or carried by a man walking behind the wagon. This outfit is cheap, serviceable and easily constructed.

Messrs. Morrill & Morley, of Benton Harbor, Mich., manufacture an appliance illustrated in Fig. 8. This so-called "*Universal Nozzle Rig*" is adjustable to any wagon, at any height, and the nozzles can be set at any desired angle. It is better adapted to use in connection with grapes or small fruits than with potatoes. The list-price, not including pump, is \$13.00.

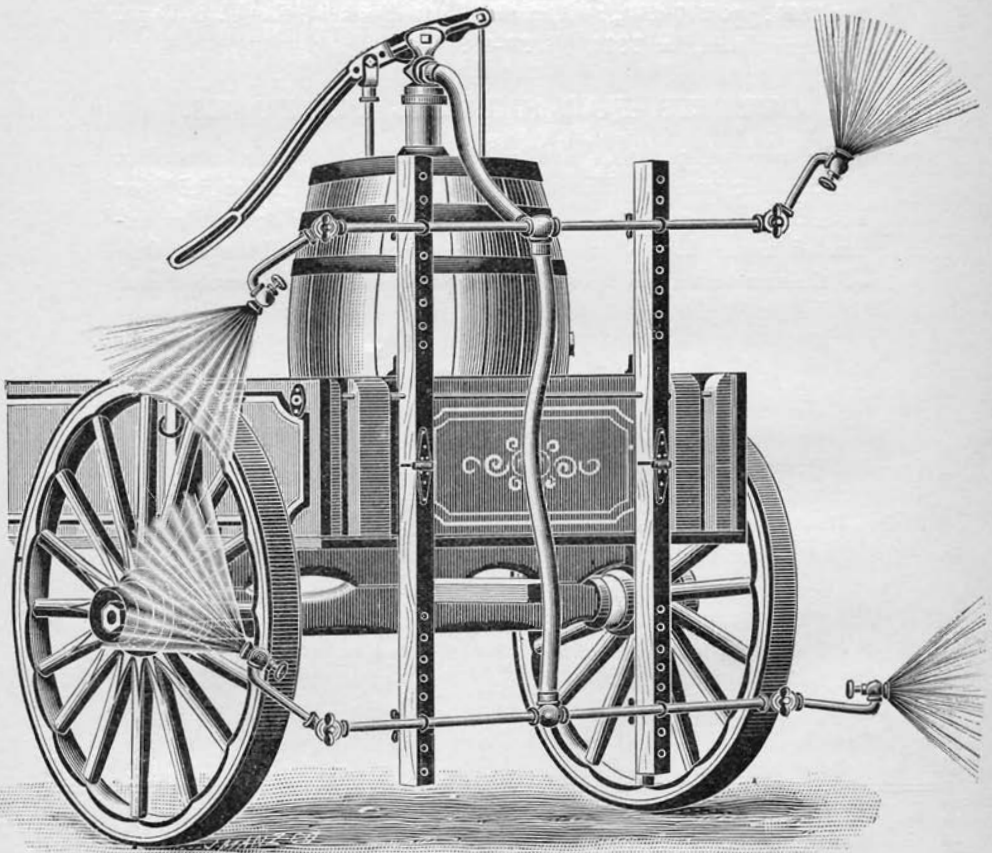


Fig. 8.

NOZZLES.

Whatever form of spraying apparatus be adopted a good nozzle is indispensable. The essential points in a good nozzle are that it must break the liquid into a fine mist-like spray and spread it evenly over as large an area as possible, and that it can be easily cleared if it becomes clogged. There are three or four nozzles which answer these requirements admirably. For use with a pump of considerable power the *McGowen Nozzle*, sold by John J. McGowen, Ithaca, N. Y., is excellent. It is easily adjusted to long or short distance work, cleans itself automatically and delivers a fine fan-shaped spray. The price is about \$1.50.

For use with an ordinary knapsack or barrel pump there is nothing better than the *Vermorel Nozzle*, Figs. 9 and 10. In this nozzle the liquid is forced through an eddy chamber and a discharge cap, forming a conical spray. The fineness of the spray may be regulated by having two or three discharge-caps and using one with a smaller or a larger aperture, according to the fineness of the spray desired.

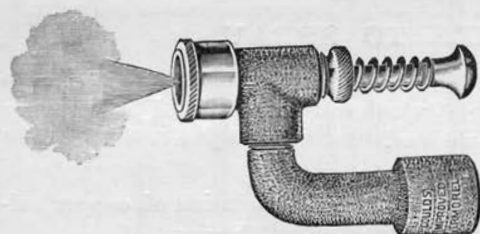


Fig. 9.



Fig. 10.

It is essential, in this form of nozzle, that there be a joint between the eddy chamber and the elbow, so that any foreign substance which may lodge in the elbow can readily be removed;* also that the piston which serves as a degorger in case the nozzle clogs, be held back by a spiral spring so as to leave the aperture free under ordinary conditions. These points are illustrated in Figs. 9 and 10, the first representing a single *Vermorel* made by The Goulds Mfg. Co., Seneca Falls, N. Y., list-price, \$1.00; the

* Another advantage, often overlooked, of the joint between the eddy chamber and the elbow is that thereby the spray may be directed at any desired angle, by merely loosening or tightening the joint.

second a double *Vermorel* made by Messrs. Morrell & Morley, Benton Harbor, Mich., list-price, \$1.00. (Single \$0.50.)

A similar nozzle is the "*Deming Vermorel*" made by the Deming Co., Salem, Ohio, list-price, \$0.80. The same firm sells another good nozzle, the "*Bordeaux*"; it is readily cleared if it becomes clogged and the fineness of the spray is under immediate control, but it throws a fan-shaped spray, which is usually less desirable than a conical spray. The list-price is \$0.80.

COST OF MATERIALS.

Lime.....	per bbl. (350 lbs.).....	\$2.25
Sulphate of Copper (in crystals).....	100 lbs.	4.50
" " " (granulated)*.....	100 lbs.....	5.00
" " " (granulated)*.....	per bbl. (450 lbs.).....	18.00
Carbonate of Copper	per lb.....	0.35
Ammonia (26°)	per lb. (1 pint).....	0.12
Sulphur (Flowers of Sulphur)	10 lbs.....	0.50
" (Flowers of Sulphur)	(1 bbl.) per lb.	0.02½
Sulphide of Potassium (Liver of Sulphur) ..	per lb.	0.22
Corrosive sublimate	per oz.....	0.12
Formalin	per lb. (1 pint).....	0.80

WHEN TO SPRAY.

Spray only in case it is evident that the plants are subject to some fungous or insect pest which can be controlled by spraying and in no less troublesome way.

Spray to prevent rather than to cure.

Spray early, beginning with the plain solution of copper sulphate (p. 4) before buds swell and growth begins.

Spray thoroughly and early for fungous pests with Bordeaux mixture (p. 4). The first two or three applications generally do the most good.

Spray late, if necessary, with the ammonia solution of copper carbonate (p. 5), in order to avoid spotting the fruit.

Spray just before the flowers open and just after the petals fall, *never* when the plants are in full bloom.

Spray once every ten days or two weeks.

Spray again after a heavy rain; a light shower will not wash Bordeaux mixture from the leaves.

SPRAY THOROUGHLY, IF AT ALL.

* For sale, at price quoted, f. o. b. in New York, by the Nichols Chemical Co., 32 Liberty St., New York. Terms, cash with order.