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Stationary Spray Systems in West Virginia

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Spring in the Orchard

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SUMMARY

A plentiful water supply is essential with stationary spraying.

A power unit large enough to maintain proper pressure with some reserve is a necessity.

Elaborate housing is not necessary for successful operation. Ample protection for the equipment, however, is advisable and desirable.

Copper-bearing pipe has certain advantages for use with the stationary spray system.

Main lines vary in size from one to two inches, while laterals should not be less than ¾ inch.

An air chamber of sufficient size in the line is indispensable.

Globe valves and special cut-offs are preferred to gate valves.

Provision for drainage should be made at all low points in the line to prevent difficulties resulting from freezing.

High-pressure hose with a minimum of ½ inch in size is recommended for stationary outfits.

A definite scheme for spraying a block of trees should always be followed if no trees are to be missed.

The trend in development is toward the use of more pipe and fittings, less hose, and a one-man unit. The economy of this plan has been demonstrated. It eliminates delays in the field occasioned through the use of long hose, decreases labor costs and the difficulty of obtaining reliable help, decreases the possibility of missing trees in spraying, and speeds up the spraying operation.

The stationary spray system possesses an advantage in the number of trees it is possible to spray per man hour, as compared with portable sprayers, particularly on systems where a one-man unit is used.

Stationary spray plants are adaptable to every type of topography and are in use now in orchards where portable sprayers could be used only with the greatest difficulty.

The initial cost of the stationary system for orchards of commercial size need be no greater than the cost of complete portable spray equipment for the same orchard.

The advantages of the stationary spray system over portable sprayers in the use of labor, in power requirements, in the elimination of feed costs, in upkeep costs, and in costs of depreciation are economic factors which cannot be disregarded. The per-acre cost of spraying with stationary systems as compared with the portable method is also decidedly in favor of the stationary system.

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by F. D. CORNELL, Jr.

RADICAL CHANGE marks the attitude toward spraying during the decade just passed. No longer do orchardists ask, "Why should I spray?" but rather, "How can I spray most effectively and economically?" Studies by agricultural experiment stations have brought to light the high percentage of labor ordinarily devoted to spraying. In Maine, for example, it was found that "over four-fifths of the management charge for human labor each year was for pruning, spraying, and dusting operations," and that "over sixty percent of the management charges [for horse labor] each year was for manuring, spraying, and dusting".[1]

Any method whereby this labor charge for spraying could be reduced plainly would be reflected in the net returns. Efficiency of spraying equipment therefore is one of the essentials upon which any successful spray program must be built. Other fundamental considerations are timeliness of spray, effectiveness of spray materials, and thoroughness of application.

The use and development of a stationary spray system for orchards has created widespread interest among orchardists, who see in it a possible solution of the problem of a better means of control of orchard insects and diseases.

RESULTS OF EXPERIMENTAL STUDIES

Advantages of the stationary type of spraying as applied to California conditions are set forth in Bulletin 406 of the California Agricultural Experiment Station. This bulletin describes the individual units of the system and the method of installation. Field observations and results of field tests are also included.

On a large percentage of systems in California electric motors were used as a source of power. The effect of various factors on voltage drop was determined. Tests also showed 1- to 1½-inch mains and ¾- to 1-inch laterals to be most satisfactory. Pressure

[1]MERCHANT, C. H. AN ECONOMIC STUDY OF 93 APPLE FARMS IN OXFORD COUNTY, MAINE, 1924-1927. Maine Agricultural Experiment Station, Bul. 347, pp. 107 and 110.

ACKNOWLEDGMENT

Acknowledgment is made of the assistance of H. L. Crane, formerly associate professor of horticulture, West Virginia University, in making the preliminary survey; of the assistance of C. H. Bruce in obtaining cost records of spraying operations; of the cooperation of F. J. Schneiderhan in furnishing the data on the stationary spray plant on the University Experiment Farm; and of the hearty cooperation of the orchardists without whose assistance this study could not have been made.

tests were made with varying numbers of nozzles to determine the relation between pressure drop and the number of nozzles. Installation costs were found to range from $29.21 to $106.19 per acre, and operating costs from $5.04 to $12.69 per acre for a single application.

Bulletin 212 of the Washington Agricultural Experiment Station describes the units and arrangement of the system. In Washington, as in California, electric power is used extensively. Tests were made on the effect of pressure on atomizing and on the carrying distance of the spray. Data on installation and operating costs are given.

HISTORY OF STATIONARY SPRAYING

Although the stationary spray system was demonstrated as a practical possibility many years ago, its use in eastern orchards has come about rather recently. The idea of a pipe system of spraying was put to a practical test first by Hayward Reed of Sacramento, California, about 1909[2]. From that date until the last decade the development of this type of spray system was very gradual. The use of the stationary plant has since become popular in the western part of the United States, and large numbers of new plants are being installed each year. In the eastern states these plants have not reached such general use. Eastern orchardists, however, are giving evidence of a growing interest in this method of spraying, and an increasing number of new plants is being installed.

STATIONARY SPRAY SYSTEMS IN WEST VIRGINIA

West Virginia orchardists for years have followed the common practice of spraying with portable spray rigs. In the larger orchards several spray rigs, tank wagons, a large number of draft animals, and a large personnel are required to apply a spray. Breakdowns, delays, maintenance, housing of equipment, high feed costs, and high labor costs now cause many orchardists to consider the possibilities of the new stationary systems.

During the past nine years nine orchardists have pioneered the way in West Virginia by installing 13 separate stationary spray systems. Four of these plants were installed and used for the first time in 1929. The first users of stationary systems have gone through the experiences of trial and error in working out the details of the system for West Virginia conditions, and their contribution to our knowledge of this type of spray equipment is noteworthy.

Certain obvious features of the system commend themselves to the orchardist's consideration. Most important of these perhaps is timeliness of spray. In the pink and codling-moth sprays the time limit for effective application is short. With the stationary system these sprays can be applied at the proper time, since wet ground, which often prevents spraying with portable outfits, offers no hindrance to the stationary system.

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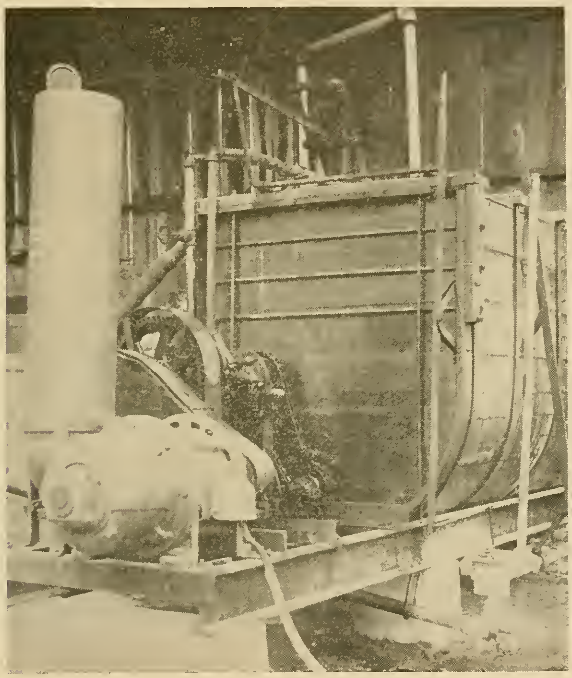
[2]Garver, H. L. The Stationary Spray Plant, Washington Agricultural Experiment Station, Bulletin 212, p. 8. 1927.

Economies suggesting themselves to the first users of stationary systems included the savings from spraying with a smaller personnel; greater crop insurance, since the spray could be applied within the proper time limits; elimination of costly draft animals; and lower maintenance costs of equipment.

The purpose of the present study is to furnish West Virginia growers with data and information regarding the details and costs of installation, the handling of the system the year round, and the efficiency and economy of the stationary system as compared with the portable system of spraying for both large and small orchards.



The stationary spray unit on the University Experiment Farm at Kearneysville

This report presents facts and recommendations as obtained from the owners themselves by personal visits during the summer of 1928 and from cost records for 1929. The recommendations are the result of extensive trials with various items of equipment pertaining to the stationary system of spraying. All of the plants studied in the survey of 1928, with one exception, had been installed for at least two spraying seasons.

Owners of the hydrant systems emphasized the necessity of a plentiful water supply. The stationary system requires much water for continuous operation and enough of this must be available to carry on the day's spraying without delay. Quickness in applying the spray and flushing the lines with water both make heavy demands on the water reserve.

The ideal location for the water supply is above the spray plant in order that water can flow to the mixing tanks by gravity. If the water is not so located, it is advisable, where at all feasible, to pump it to a tank or reservoir placed at the desired elevation, rather than to locate the plant near the source of water. The latter method would necessitate pumping the spray liquid up hill under heavy pressure. The opinion of present owners is that the force of gravity should be employed wherever possible. It is advisable too, to install pipes two to three inches in size from the supply to the mixing tanks so that the tanks can be filled quickly.

Central plant of a stationary spray system on a large orchard

LOCATION OF THE PLANT

Most of the orchards in West Virginia are, in part at least, located on well-defined slopes or on rolling land. The main plants of the stationary systems now in use in the state, with two exceptions, are located at high points in the orchards. Thus gravity pressure is brought into play with the result that lower pressures are maintained at the pumps than on level orchards. Another advantage of this plan is that pump and engine or motor are working under lower pressure and load, thus helping to insure longer life and lower maintenance costs.

One owner whose orchards are on opposite slopes has located his plant in the valley between. The pump forces the spray liquid through mains running up both slopes. This plan requires a much higher pressure at the pump than in the cases where gravity is effectively utilized. In general, it is advisable that the plant be located at a high point in the orchard in order to make use of gravity wherever possible.

THE CENTRAL PLANT

The pumping machinery is the most important part of the stationary system because its effectiveness determines in large measure the degree of success obtained from the stationary method of spraying.

The Power Unit

The engine or motor should have sufficient reserve power so that it does not have to work at full capacity at all times. The type of engine may vary greatly, but it must be capable of developing adequate power. There can be found in the plants now successfully operating, power units varying in type and make as follows: three systems operated by steam engines, the engines being used for power and the exhaust steam for cooking the lime sulphur; one Hercules 35 H. P. gasoline engine; one Ford engine; one Stearns-Knight automobile engine; one Hupmobile engine; one 10-20 International tractor; one Edwards engine capable of developing 6 H. P.; and one 7½ H. P. electric motor.

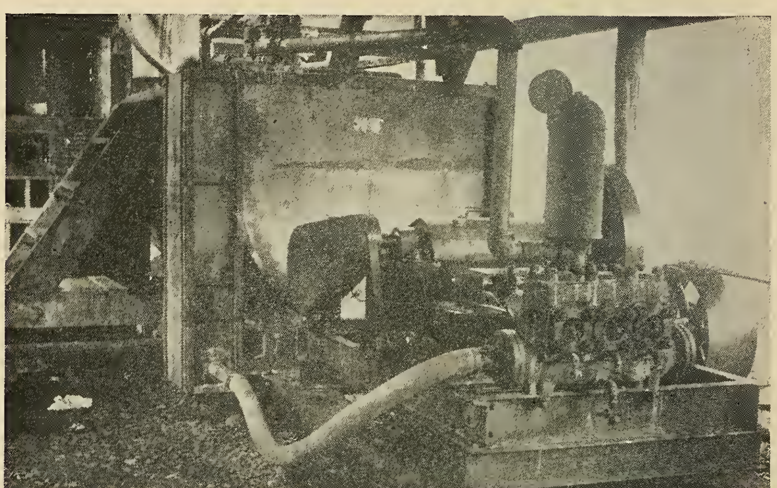
On the only system where there seemed to be much difficulty from delays and breakdowns, a 4 H. P. engine was in use. In computing the power necessary in this instance it was found that at least an 8 H. P. engine would be required for successful operation. It is evident that the power unit is a vital part of the system. In a few cases used automobile engines which had cost as little as $10 seemed to be performing satisfactorily, illustrating that adequate power can often be obtained at a low cost. The employment of such used engines, if replacement parts are readily available, may be a means of considerable saving to growers who are planning to install a hydrant system.

The first stationary spray plant using electric power was installed in the state early in 1930. Where current is available this type of motive power for stationary spray units will likely gain in popularity.

Power Transmission: In most of the systems now in use in West Virginia, power is transmitted by the use of direct gearing. On one small plant a belt is used satisfactorily. On one large plant, in which a pressure of 600 pounds is carried at the pump, power is transmitted also by a belt. Either method of power transmission seems to give satisfactory results, although the more positive gear transmission is preferred. With the electric motor, a silent chain drive is used.

On one of the systems now in use, one of the first, if not the first stationary system in the East, several pumps were tried without success. Finally a well-known concern built a pump according to specifications furnished by the owner of the system. This pump proved very satisfactory. With a few minor changes and replacements which operation proved necessary, it is still operating and shows no sign of serious depreciation after eight years of service. This pump has been improved and refined by the company, and a later model is now in use on three installations.

Most of the leading manufacturers of spray pumps, appreciating the increasing popularity of stationary spray systems, by now have developed highly satisfactory pumps.



Pump and tanks on a large stationary spray system

On the systems now operating in the state there are four Domestic Giant pumps, all of three cylinders. The first model has a 3-inch bore and a 12-inch stroke. The later model, of which three are in use, has a 4-inch bore and a 14-inch stroke. This pump is capable of delivering 80 gallons per minute under 500 pounds of pressure. Two Bean, 3-cylinder spray pumps, delivering 16 gallons per minute under 400 pounds of pressure, are giving complete satisfaction. On one plant a Myers Bulldozer pump delivering 10 to 12 gallons per minute under 300 pounds of pressure is used, and on one plant an old portable spray pump is in use. The latter is a small plant, and although made up almost entirely of cast-off equipment, is serving 60 acres of orchard efficiently. One plant uses a Friend pump and on another plant a Bean pump delivering 25 gallons per minute is used.

Since the pumps in stationary spray systems work under heavy pressures, it is important that they be securely and rigidly anchored to a solid base in order to eliminate vibration. The pump itself, in order to give long service under high pressures, must be very substantially constructed.

The pressures under which the pumps operated at the time of the survey varied from 300 to 600 pounds. The 600-pound pressure was necessary since the spray liquid was pumped up hill, a rise of nearly 400 feet. This gave a pressure at the highest point of about 290 pounds with the gun open. The average pressure carried in the stationary systems was about 400 pounds.

Relief Valves

A reliable relief valve is necessary for proper protection to the system. A relief valve which fails to function properly may cause considerable damage. In one case several of the parts of the system blew up because of failure of the relief valve to operate.*

Strainers

A strainer so constructed that the materials pass up through the screen rather than down is by far the more satisfactory. In a strainer of the upward type the material taken out by the screen tends to fall away from it and settle in the bottom, thus preventing frequent clogging of the screen.

Tanks and Agitators

Several of the tanks in use on stationary systems in West Virginia are wooden tanks taken from old portable sprayers and adapted to use in the stationary system. These are cypress tanks of 200-gallon capacity, except in one case where two such tanks have been placed end to end to make a tank of 400-gallon capacity. The tanks are all equipped with mechanical agitators driven from the pump or the engine. On two recent installations divided tanks, built especially for use with stationary systems, are in use.

On two systems concrete tanks were installed, equipped with mechanical agitators. In building a tank of this type it is important that the corners be filled in and rounded out to prevent spray materials from settling there.

It is advantageous to have the tanks so located with reference to the loading platform that materials may be unloaded from the trucks and emptied with a minimum amount of lifting. The best arrangement seems to be to have the top of the tanks on a level with the platform.

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*Not enough experimenting has been accomplished to determine definitely which type of relief valve is most reliable.

Housing

The housing of the equipment need not prove an expensive item. The essential features are that it provide protection from the weather for the working parts, and that it be arranged for the greatest ease in mixing and handling materials. Ample space should be provided for working on any part of the equipment.

THE PIPE LINE

The pipe line is a very important part of the stationary system. Experience has taught West Virginia owners much in regard to the details affecting the efficiency of the line.

Kind of Pipe

In every case in the systems studied in the survey of 1928, black iron pipe was used. Cheapness was given as the chief reason for its use. No galvanized pipe was used because the owners felt that the pipe rusts out largely from the inside and that the benefits to be derived from using galvanized pipe did not warrant the additional expense.

One owner was gradually replacing his pipe, as it became necessary, with copper-bearing iron pipe, which is now obtainable at a cost slightly higher than that of black iron. This pipe contains a small percentage of copper which tends to reduce the rate of corrosion. Two systems installed since the date of the survey have used galvanized, copper-bearing pipe throughout. Where it has been tried, it is thought that copper-bearing pipe is worth the additional expense and is a more economical pipe investment in the long run than ordinary black iron pipe.

On one system practically all of the pipe in use had been purchased second-hand. This system was installed in 1921 and most of the pipe was still in use when the survey was made. It showed little evidence of serious depreciation. The fact that satisfactory service may be obtained from used pipe opens another possibility for reducing installation costs. Obviously, if this is tried, the pipe must be in good condition.

Sizes of Pipe Used

For the main lines on the systems studied the following sizes of pipe were in use: 1-inch, 1¼-inch, 1½-inch, and 2-inch. The 2-inch mains were in use on a system where the spray liquid was pumped up hill, a total elevation of 400 feet. The large main in this case was used to reduce loss in pressure due to friction.

For laterals, all owners of stationary systems visited recommended ¾-inch pipe. There were in use for laterals at that time, however, pipes of ⅜-inch, ½-inch, and ¾-inch sizes. The owners who have used pipe as small as ⅜-inch did so at a time when there was little available information on stationary spray plants. The ⅜-inch and ½-inch sizes are slowly being replaced with ¾-inch pipe, although many laterals of these smaller sizes are still in use. The owners of stationary systems felt that for laterals, 1-inch pipe was too large and expensive, and that ½-inch pipe was too small to give the best results. All recommended that ¾-inch pipe be used for laterals.

Distribution of Mains and Laterals

Because of the topography and irregular layout of orchards in West Virginia, the location and distribution of main lines and laterals is largely an individual problem. In general, at the time of the survey, the laterals were run off the main lines about every 14 tree rows. With the systems now in use, however, this varies from four to 20 tree rows. The mains are run in such a way that the orchard may most easily be covered by the system. On systems installed during the past year more laterals were used, thus making it possible to use a much shorter lead of hose. The tendency in the newer installations is toward the use of more laterals, a shorter lead of hose, and a smaller spray crew.

Laying the Pipe Line

Pipe lines for stationary spraying in West Virginia are laid above ground. This plan hinders cultivation to some extent, and broken pipes are prone to result occasionally, but this method has been preferred to laying the pipe underground since it is cheaper, repairs can be made quickly and easily, and the lines may be laid down or taken up readily. Until recently all lines were laid on the ground. Several systems have now been installed with the pipe lines supported above ground, either by posts or by running the lines through the trees.

In laying the pipe line it is not necessary that the joints be turned up tightly, since the spray materials seal the joints sufficiently. The threads of the pipe should not be leaded in making the connections. One particular method used in attaching the laterals to the main lines seems to have merit. For example, in attaching a lateral to a 1½-inch main, a 1½-inch four-way T is used; this is bushed down to ¾ inch, then a ¾-inch valve is installed and, finally, the lateral pipe. This method of taking off the lateral reduces the friction where the lateral is attached at right angles to the line.

Unions

There should be plenty of unions in the pipe line to facilitate repair as well as taking up or putting down the lines. Ground unions should always be used in this work in order to eliminate the necessity of replacing gaskets frequently.

The Air Chamber

There should be at least one standpipe or air chamber in the line, preferably near the pump. The purpose of the air chamber is to act as an air cushion in the line, smoothing out the flow and pressure in the lines, and so to prevent jarring in the lines. Both commercially manufactured chambers and home-made ones were found in use. The home-made chambers consisted of a piece of 6-inch casing about six feet long, threaded and capped at both ends, with fittings inserted at one end to attach the chamber to the line, and a pressure gauge fitted in the top cap. In one case, where the line was exceptionally long, two air chambers were in use.

Valves

Valves have caused more trouble than any other part of the pipe line. Owners were of the opinion that gate valves were not satisfactory for hydrant spray work, although many gate valves were in use. Some men had purchased a few high-pressure valves but had found this to be an unnecessary expense. Others were using a cut-off in the lines and found it very satisfactory under test. One orchardist had been using a globe valve with removable seat. There is still some experimenting among growers with different types of valves in an effort to find one better suited to stationary spraying demands. Globe valves and special cut-offs had given the best results at the time of the survey.

One difficulty seemed to be a tendency on the part of the spray crews to close the valves too tightly. Often the result was a leaky valve. The valves tend to become corroded and must be cleaned when the spraying season is over. Where the pipe lines were taken up, one method of handling was to loosen the valves from the seat and drop all of the valves into a barrel of oil. Used crank case oil may be utilized in this manner.

On a recent installation in a neighboring state, where the lines are elevated above ground, globe valves with rising stem are used. In addition the valve is placed with the stem downward so as to eliminate the possibility of materials settling in the valve and hindering opening or closing. The rising stem shows at a glance whether the valve is open or closed. This eliminates the danger of breaking valves by applying unnecessary force when visual examination fails to indicate whether a valve is open or closed.

Care of Pipe Lines Between Sprays

The usual method followed with the stationary systems was to flush them out with clear water a few minutes before quitting time. When the hose men saw clear liquid coming from the last laterals they knew that the system had been flushed out. The pipe line, thus cleared, was left full of clean water until the next day or the next spray.

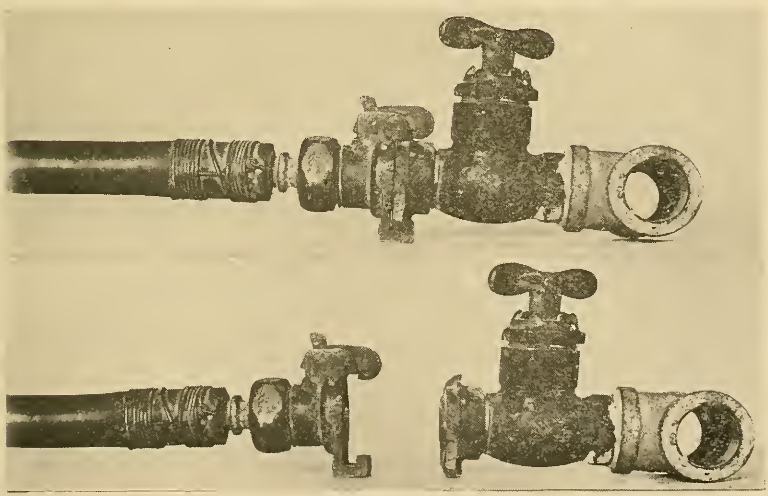
In cold weather the valves should be raised a little. If there is real danger of freezing, the lines are drained. To accomplish this, there should be a drain plug at all low points in the line.

Care of Pipe Line During the Winter

Different methods were employed in handling the pipe lines during the winter. The most common plan was to take up all laterals, after the system had been flushed out with clear water, and to store the pipe away for the winter. The valves were cared for as has been described (see page 12), and the pipe was usually piled under shelter. One owner, before storing his pipe, dropped it in a trough filled with used crank-case oil. The pipe was then removed, placed on end to drain, and finally stored under cover.

One grower took up no pipe at all. His theory was that the threads, the weakest part of the pipe, are worn out in taking up and putting down the pipe, and that, in addition, there is the labor cost. In handling his system for winter conditions, the valves were lifted off the seats and oil was squirted in the valve after the whole system had been thoroughly washed out with water and drained. The threads and all joints were painted as the pipe lay on the ground, as this was the point where corrosion would take place most rapidly. All pipe lines were then left down until ready to spray the next year. Occasionally a broken pipe resulted from cultivation or travel over it, but its replacement was not difficult or expensive. Some of the pipe handled in this way had been in use for eight years and showed little sign of serious depreciation.

All owners left main lines down all winter. One orchardist painted all mains with red paint. The painting was for preservation, and red was used instead of black so that the lines could easily be seen by those operating cultivating equipment.



A quick coupling device for use with stationary spray systems. Above, hose attached; below, hose detached. The cut-off shown has proved satisfactory for stationary spray work

HOSE AND CONNECTIONS

In all cases but one, owners of stationary spray plants were using 250-foot lengths of hose with each spray crew. The size of hose in use was ⅜- and ½-inch high-pressure hose. The length of life of the hose, from the experience of the West Virginia orchardists, was two years. There was a possibility of getting some service out of it the third season. Owners were unanimous in the opinion that nothing smaller than ½-inch hose should be used with the stationary system.

A new development on recent installations has been an increase in the number of laterals, making possible the use of 100- to 150-foot lengths of hose and a reduction in the size of the spray crew.

For repairs and connections the hose man in nearly every case carried a pair of pliers, some soft wire, and hose repair connections. Occasionally a 9-inch pipe wrench was added to this equipment. Patent hose connections were largely discarded because of troubles and delays occasioned by them. The hose in use had cost from 11 to 21 cents per foot, depending upon the number of plys. No hose reels were used in handling the hose.

As a rule very little hose trouble was encountered. In only one instance was trouble of a serious nature reported, the cause being a particularly poor quality hose.

A quick-coupling device for facilitating the speed with which the hose may be attached to and detached from the cut-off has proved very satisfactory.

SPRAY GUNS

The spray gun was in general use with stationary plants in West Virginia in 1928. Owners felt generally that there was room for considerable improvement in guns for use with these systems. All expressed a desire that a more satisfactory gun be developed for stationary spraying conditions, and requested that a study be made of spray guns and rods with a view to developing more satisfactory equipment.

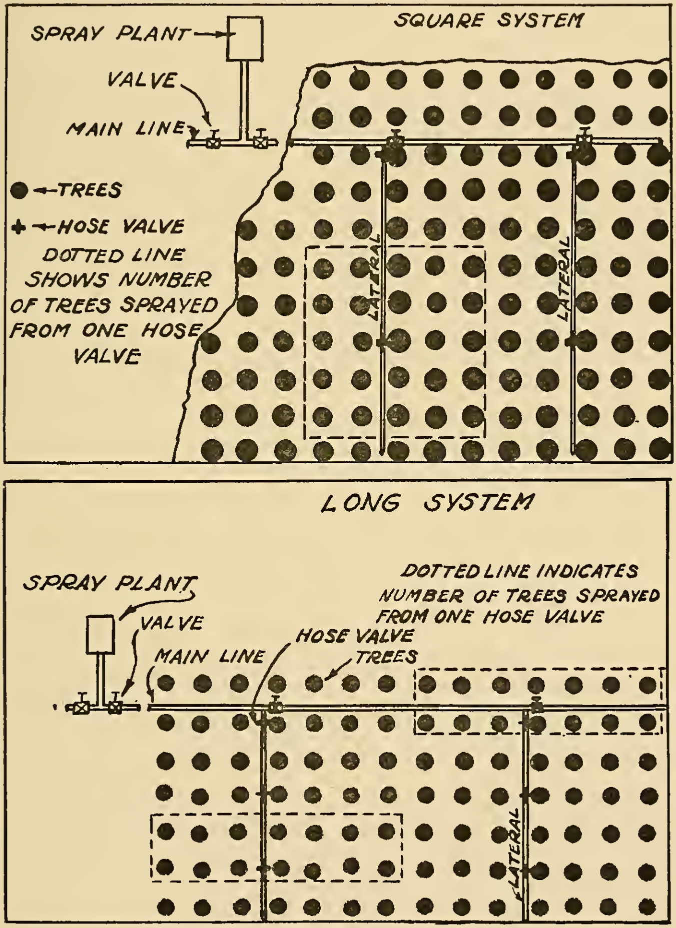
Since the survey was made, various types of rods and guns have been studied and calibrated under stationary conditions, and considerable progress has been made in discovering and developing more efficient equipment. The Virginia Agricultural Experiment Station has recently developed the Virginia nozzle and rod, which it is claimed combines some of the advantages of both the spray gun and the spray rod. Tests with this rod and with other guns and rods were made in connection with the work in stationary spraying on the University Experiment Farm in Jefferson County during the past season (1930). These results are incorporated in pages 27 and 28.

ORGANIZATION OF THE SPRAY CREW

In every case but one, the owners of stationary systems in West Virginia at the time of the survey were using three men in each spray crew: two hose men and one man with the gun. In using 250-foot lengths of hose there seemed to be difficulty in cutting down the size of the crew. One man, however, used a scheme by which two men could handle the work instead of three.

The trend is toward a plan where one man comprises the spray unit instead of three as noted. This scheme is in effect on several installations and seems to be meeting with considerable success. On one plant in the state the length of the leads of hose has been reduced to 100 feet and the size of the crew to one man.

The most common arrangement of spacing the laterals and valves in 1928 was such that a block of 56 trees could be sprayed from

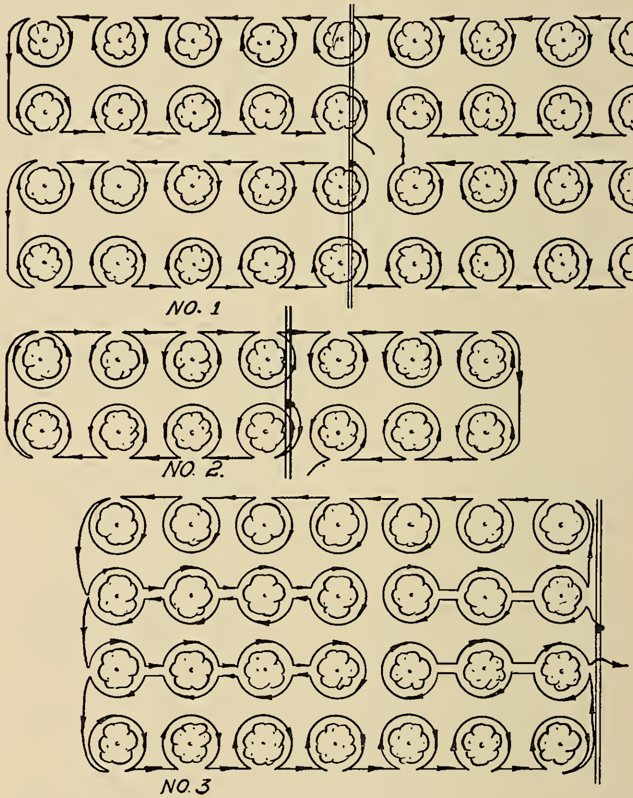


Methods used in piping orchards

one valve. The orchardists visited reported that each crew sprayed an average of about 400 trees per day. Most of the orchardists had the same crews spray the same block of trees throughout the season. In this way they could check on those who were doing careful work, and fix the responsibility for careless work.

In spraying, all followed the practice of first having the man with the gun get beneath the tree next to the trunk and spray around on the inside, gradually working toward the top. The man then stepped out and walked around the tree, spraying it completely on the outside.

An advantage possessed by the stationary system over the use of portable spray rigs is that the crews in the field are actually spraying about 90 percent of the time. With portable outfits much time is spent in travel and refilling, thus cutting down the actual spraying time per crew.



Systems followed in spraying trees

Some definite scheme for spraying the trees should be followed; in fact, some system is essential if no trees are to be missed. In No. 3 (above) is shown the scheme followed by the grower who used two men in his crew. From the diagram it may be seen that the hose man does not have to drag more than four tree-rows' length of hose at one time. The operation outlined is repeated on the opposite side of the lateral. Other plans for laying out the pipe lines and for spraying blocks of trees are suggested by the diagrams on pages 15 and 16.

ADVANTAGES OF STATIONARY SPRAY SYSTEMS

The advantages of the stationary plant over portable spray rigs, as given by owners of the systems, are:

1. The tree is the unit in this system of spraying.
2. Only one good machinist is needed with this system compared with one for each portable outfit.
3. It is easier to approach a desirable degree of standardization of repair parts.
4. There is much less wear and tear on stationary machinery than on machinery which is hauled over rough ground.
5. Lubricating and adjusting of machinery are more easily cared for.
6. The stationary system makes it possible to spray regardless of the wetness of the soil or of the topography. This makes it possible to apply the spray when most effective. The stationary system can be used with success in orchards where the topography is such that portable spray rigs could not be used at all.
7. Wind does not interfere nearly so much as when spraying with portable rigs.
8. Thorough spraying can be done more quickly than with the portable outfits. The number of trees sprayed per unit of man power is larger than with the portable system.
9. The economy of the system was stressed as a great advantage. Installation and operation of the system are as cheap and sometimes cheaper than outfitting with complete portable equipment. The stationary system does not require the wintering of draft animals.
10. The stationary system may be considered a permanent improvement.
11. The stationary system does not injure cover crops or knock off or bruise fruit as do portable rigs.

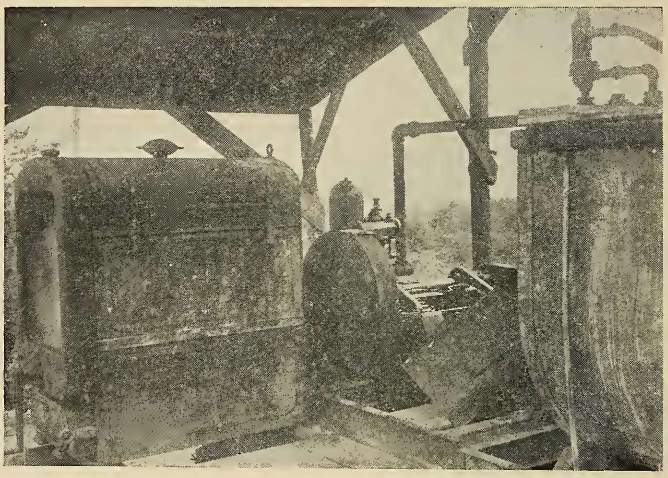
DISADVANTAGES OF STATIONARY SPRAY SYSTEMS

The users of stationary systems were very enthusiastic about them and could think of only a few points which could be listed as serious difficulties or disadvantages. The chief disadvantage, and the only one which all growers recognized as such, is given first place in the following list:

1. Any breakdown or tie-up in the system during spraying is rather costly. Much time is lost when men have to be changed from spraying to some other job while repairs are being made.
2. Pipe lines on the ground are prone to be injured by cultivation in the orchard, or by travel over the lines.
3. The cost of changing from the portable to the stationary system of spraying was mentioned by some as a possible disadvantage. This may often prove to be an advantage. Usually the change from portable to stationary methods is made when it is a choice of either purchasing more portable spray rigs or installing the stationary system. In many instances the stationary system, under these circumstances, could be installed for less than the portable rigs and equipment would cost.

THE COST OF SPRAYING WITH STATIONARY PLANTS

It was impossible at the time of the survey to obtain detailed information regarding the costs of spraying with the stationary plants, since none of the owners of such systems had kept detailed records. Consequently, cost records were kept on all of the systems for the 1929 season. The following cost data are taken from these records.



Engine, pump, and tanks on a spray system covering 285 acres

Installation Costs

The first question one asks in considering the stationary spray plant is, "How much does it cost?" Data on plants in operation indicate that there may be considerable variation in the cost of installation.

One owner with 250 acres of orchard, including 12,133 trees, installed his entire equipment for stationary spraying at a cost of $5000. The orchard is so steep that spraying with portable spray rigs would be extremely difficult. The owner estimated that to equip the orchard for portable spraying would cost about $12,000. A smaller stationary plant, serving 40 acres of orchard, was installed complete for slightly less than $1000. A third plant, installed on a 285-acre orchard, cost $2,785.50. Table 1 shows the costs of installing several stationary spray plants on different sizes of orchards.

The costs of installation as given in Table 1 include all items, namely: pump, storage and mixing tanks, power unit, building, hose, pipe, fittings, connections, labor of installation, etc. Plainly the cost of installation per acre varies considerably. Orchard No. 1, although requiring 2-inch mains, uses 250 feet of hose, thus cutting the cost of laterals somewhat. On orchard No. 2 nearly all of the pipe installed was purchased as used pipe. The cost of housing for the equipment also was comparatively low. It will be noted that the cost of installation on orchard No. 5 was relatively high for the reason that much more pipe was used in this system in order to cut down the size of the spray crew and the length of the leads of hose. Also the construction of new sheds and concrete reservoirs, and the use of copper-bearing pipe throughout, added to the cost.

TABLE 1.—*Cost of installation of seven stationary spray systems in West Virginia*

Orchard number	Installation cost	Number of acres in orchard	Cost per acre
1	$5,000.00	250	$20.00
2	2,785.50	285	9.77
3	998.10	40	24.95
4	3,109.43	98	31.73
5	9,080.34	175	51.88
6	4,557.87	209	21.77
7	4,327.73	70	61.84

TABLE 2.—*Comparison of installation costs of stationary spray systems on three orchards*

Cost items	Orchard number 4 (98 acres)	Orchard number 5 (175 acres)	Orchard number 6 (209 acres)
Variations in pipe line costs			
Pipe	$1274.00	$4934.02	$1955.59
Valves and fittings	463.00	732.02	373.20
Cost per acre	17.72	32.37	11.14
Other items of cost varying with conditions			
Pump	$ 400.00	$ 800.00	$ 550.00
Engine	125.00	*	29.70
Tanks	175.00	60.00	*
Hose and hose connections	80.00	183.39	135.85
Guns or rods	24.00	44.10	8.50
Labor	494.43	849.99	929.65
Building materials for tanks, etc.	*	460.84	532.01
Cost per acre	13.24	13.70	10.45

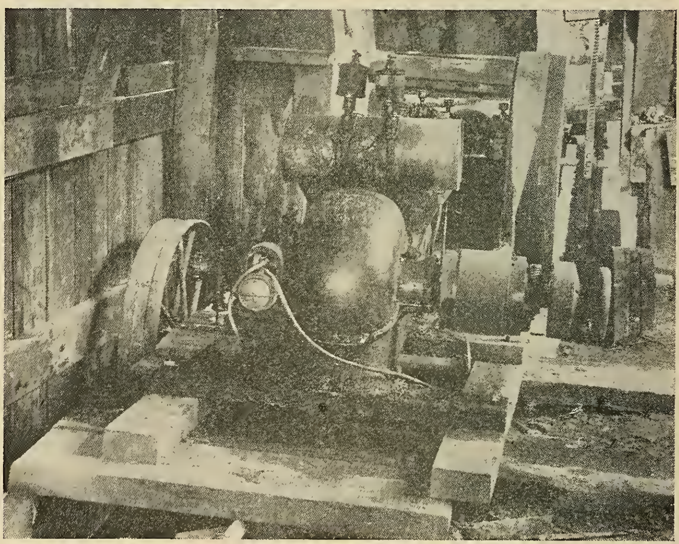
*Used equipment already on hand.

An itemized comparison of the chief items of cost on three systems shows wherein costs of installation may vary. (See Table 2.)

Growers are now realizing the value of installing more laterals, which reduces the labor costs of spraying, as well as the difficulty of obtaining reliable help. Where spray crews can be reduced from two men to one with an investment of approximately $1800 for pipe, as would be possible in one orchard, seven men could be used in the field instead of 14 as at present. The saving would be $21 a day for each day's spraying. On other orchards where three-men crews are used, even more pronounced savings might be effected. This is why plants installed recently show relatively higher pipe costs.

Another factor affecting costs is the rate at which effective spraying can be done. Not the number of trees sprayed per day, but the degree of thoroughness, is a determining factor.

There is no question that just as thorough spraying can be done with portable outfits as with the stationary system. The question is not "Can as thorough spraying be done?" but "Is it done?" The labor obtainable for orchard work is at best often unreliable. It is easier to find six to ten dependable men than twice that number. Here the stationary system possesses an advantage. Besides, in the stationary method of spraying, the man with the gun does not have to adjust his operations to the speed of a team or tractor; neither does he spend time hanging on to keep from being jolted off as a rig passes over rough ground. With the stationary system the tree can be made the unit, and the man with the gun is his own pace-maker.



A plant made largely from cast-off equipment

In a compilation of actual records of 330 days of spraying with several stationary plants the average number of trees sprayed per crew per day was found to be 385. A few of the crews were two-man crews, but the majority were three-man crews. The number of trees sprayed per crew per day ranged from 110 to 1180, depending upon conditions and the age of the trees. From records of 15 days of spraying seven- and eight-year-old trees, it was found that an average of 810 trees were sprayed per 3-man crew per day. These figures concern plants where 250-foot leads of hose were used.

TABLE 3.—*Man hours and labor cost in spraying orchards equipped with stationary spray systems*, 1929.

Orchard number	Acres in orchard	Spraying crews		Manager or foreman		Labor at central plant		Extra labor		Totals		Cost per acre
		Man hours	Cost	Man hours	Cost	Man hours	Cost	Man hours	Cost	Man hours	Cost	
1	250	2440	$717.60	135	$ 64.80	194	$ 63.00	169	$144.48	2938	$989.88	$3.92
2	285	1954	431.22	90	36.00	158	44.40	...	......	2202	511.62	1.79
4*	98	569	142.25	...	......	...	......	...	......	569	142.25	1.45
6*	209	1952	439.20	...	......	...	......	...	......	1952	439.20	2.10
8	60	348	53.95	...	......	67	19.20	100	26.00	515	99.15	1.65
9	265	1956	442.48	200	70.00	348	132.05	887	208.98	3391	853.51	3.22
10	‘235	2752	665.64	155	102.20	284	50.20	...	23.22	3191	841.26	3.58
11*	90	1257	329.35	...	......	...	......	...	......	1257	329.35	3.66

*On orchards 4, 6, and 11, labor costs as obtained were given as one total; consequently they could not be itemized.

TABLE 7.—*Spraying costs on ten orchards using portable sprayers*, 1929

Farm number	Spray labor	Spray machine expense†	Spray material	Total cost to spray	Total man hours	Total horse hours	Total tractor hours	Total number of trees	Total gallons	Gallons per man hour	Total gallons per tree	Number of sprays	Total cost per tree	Cost per tree per spray	Cost per acre
21	$ 85.70	$ 33.40	$ 68.67	$ 187.77	318	238	...	587	8,100	25.4	13.8	6	$.319	$.0533	$12.76
22	189.61	99.07	461.15	749.83	524	692	...	1,800	36,000	68.7	20.0	7	.416	.0595	16.64
23	113.13	40.64	127.90	281.67	437	222	115	1,070	13,600	31.1	12.71	4	.263	.065	10.52
24	109.45	40.70	96.45	246.60	308	228	...	500	11,750	38.1	23.5	5	.493	.098	19.72
25	467.97	147.51	567.36	1,182.84	1,335	1,173	...	3,047	77,350	57.9	25.3	7	.388	.055	15.52
26	298.25	......	752.35	1,050.60	579	481½	61	5,500	90,550	156.4	18.3	5	*	*	*
27	636.02	......	747.66	1,383.68	1,304	690	255	*	95,880	73.4	*	5	*	*	*
28	714.26	409.70	632.35	1,756.31	2,231	1,933	...	*	103,350	46.3	*	8	*	*	*
29	448.83	300.25	862.86	1,611.94	1,245	1,500	10	*	102,300	82.1	*	4	*	*	*
30	226.34	......	472.95	739.29	706	295	115	*	38,700	54.8	*	7	*	*	*

*Data not available.
†Includes depreciation.

Labor Costs With Stationary Spray Systems

Where the charge for labor—an important factor in spraying operations—comprises so large a percentage of cost of man labor as in orchard management, any reduction in this item has a direct bearing on the net returns. Although there has been material reduction in the number of men and the amount of equipment necessary to apply a spray, as a result of using stationary systems, there are possibilities for further reductions in labor requirements. This already is being demonstrated in the most recent installations.

Table 3 shows the man hours required and the cost of labor for the season needed to apply the various sprays in orchards equipped with stationary plants. This includes labor of crews, extra men, help at the central station, foreman, etc.; in fact, all labor items.

The labor shown in Table 3 is for the entire orchard for all sprays for the season. From three to five sprays were applied, but in some cases the complete number of sprays was not applied to all trees. In Table 4 can be seen the total number of trees which these hours of man labor sprayed during the season.

Table 4.—*Quantities of spray materials used during the spraying season on orchards equipped with stationary spray systems*

Orchard number	Size of orchard	Total gallons spray materials used	Total number of trees sprayed	Cost of spray materials	Average gallons per tree per spray
1	250	240,500	31,195	$ *	7.71
2	285	120,751	35,460	*	3.41
4	98	83,600	*	226.22	*
6	209	123,200	*	696.82	*
8	60	15,200	3,121	264.74	4.87
9	265	125,700	31,578	1,354.25	3.98
10	235	78,000	24,085	*	3.24
11	90	62,400	17,532	305.52	3.56

*Data not available.

Table 5.—*Cost and amount of fuel used in spraying with stationary spray systems*

Orchard number	Acres in orchard	Total hours pump was operated	Gasoline		Oil		Coal	
			Gallons	Cost*	Quarts	Cost	Amount	Cost
1	250	194	335	$73.70*	25	$ 6.25		
2	285	158	279	61.38	49	12.25		
6	209	275	226	31.64	44	11.00		
8	60	67	40	8.50	7	1.75		
9	265	175	...	......	..	.....	10 tons	$45.00
10	235	284	125	31.07	49	12.25		
11	90	151	201	44.22*	46	11.50		

*Estimated cost.

Quantities of Materials Used

The quantity and cost of the spray materials used is the second most important factor entering into spraying costs. Table 4 shows the size of orchard, the quantity of spray materials used, and the total number of trees sprayed, together with the cost of spray materials at the time these data were available.

The average quantity of spray materials applied per tree per spray is not a reliable measure of the thoroughness of the spraying operation. Much depends upon such factors as the age and size of the tree and the nature of the pruning. Without complete information on these factors, the quantity of materials applied per tree per spray can serve merely as an index.

COST OF OPERATING EQUIPMENT EXCLUSIVE OF LABOR

The cost of fuel and oil in operating the spraying systems is shown in Table 5. The repair costs obtained were so slight as to make them negligible. The labor costs in making repairs, therefore, were added to labor costs charged to spraying. Costs of repair replacements were an insignificant item.

PER ACRE COSTS OF SPRAYING WITH STATIONARY SPRAY SYSTEMS

Table 6 shows a summary of the costs of spraying with stationary systems. On not all of the systems were complete cost data available. The costs shown for orchard Nos. 6, 8, 9, and 11, however, indicate the range in costs per acre for the season. A comparison of these costs with the costs per acre for portable spray rigs shown in Table 7 indicates a decided advantage in favor of the stationary system. Such a per-acre saving in cost on a large orchard would soon pay for the investment in a stationary system. (See pages 21 and 23.)

TABLE 6.—*Summary of costs of spraying from stationary spray systems, showing cost per acre where complete data were obtainable,* 1929

Orchard number	Size of orchard	Total labor costs	Total costs of spraying materials	Total costs for fuel and oil	Total cost	Cost per acre†
1	250	$989.88	$ *	$79.95	$ *	$ *
2	285	511.62	*	73.63	*	*
4	98	142.25	226.22	*	*	*
6	209	439.20	696.82	42.64	1178.66	5.63
8	60	99.15	264.74	10.25	374.14	6.24
9	265	853.51	1354.25	45.00	2252.76	8.50
10	235	841.26	*	43.32	*	*
11	90	329.35	305.52	55.72	690.59	7.67

*Complete data not available.
†No charges for depreciation included.

DELAYS

From the records it would appear that the stationary spray system has greatly minimized mechanical difficulties. As an example of causes of delay at the central station, the following are taken from the records kept on a 250-acre orchard for one season:

7 minutes—out of gasoline; 20 minutes—repair leaks in tanks; 15 minutes—belt out of line; 1 hour—adjusting spark on tractor; 1 hour—broken bolt on packing gland; 2 hours—cleaning pipes; 5 hours—cleaning pipes.

On another plant installed in an orchard of comparable size only one hour's delay was charged against the equipment at the central station, and that was caused by dirt in the carburetor.

In the field with the spray crews the chief cause for delays centered about the hose. In the majority of the cases where delays were recorded by the crews, such hindrances were due to bad or broken hose. In only one or two cases was there any delay due to bursted pipe lines.

SPRAYING WITH PORTABLE SPRAYERS

Because records on stationary plants and on orchards equipped with portable sprayers are available for only one spraying season, little attempt has been made to draw conclusions as to the economic efficiency of the two methods of spraying.

The data presented in Table 7 show the costs of spraying on ten orchards equipped with portable sprayers for the 1929 season.

There is considerable variation in the number of gallons of spray applied per man hour, as shown in Table 5. This is further indicated by data obtained on other orchards for shorter periods during the same spraying season. Table 8 shows the number of gallons of spray materials applied per man hour for short periods of spraying on seven orchards equipped with portable spray rigs.

TABLE 8.—*Spraying with portable spray rigs under varying conditions*

Orchard number	Man hours of spraying	Total gallons applied	Gallons per man hour	Kind of equipment used	Number of men
14	103	7,200	69.9	Liqui-duster	2
15	288	21,600	75.0	2 - 300 gal. sprayers	8
16	78	5,100	65.4	1 - 200 gal. sprayer	2
17	36	4,050	112.5	1 - 150 gal. sprayer	1
18	120	11,700	97.5	1 - 300 gal. sprayer	3
19	139	8,350	60.1	2 - 300 gal. sprayers	3
20	220	10,600	48.2	1 - 200 gal. sprayer 1 - 300 gal. sprayer	4

That such variations can and do exist in the quantities of materials that can be applied per hour of man labor indicates that there is room for considerable increase in the efficiency of the spraying operation, largely through improved equipment and better management.

ADAPTABILITY OF THE STATIONARY SPRAYING SYSTEM

Since pumps, engines and motors, pipe, and valves are obtainable in units and sizes to meet almost any need, it would appear that the stationary system is adaptable to almost any set of conditions.

Under some circumstances it has been found possible to combine the stationary and portable methods of spraying by piping the more inaccessible parts of the orchard and using the portable outfit as the pumping station. It is then used as a portable outfit in sections of the orchard where there is no pipe.

THE STATIONARY SPRAY SYSTEM ON THE UNIVERSITY EXPERIMENT FARM AT KEARNEYSVILLE*

During the early months of 1930 the State purchased a 158-acre farm near Kearneysville, Jefferson County, centrally located in the leading fruit-producing region of West Virginia. The farm, known as the University Experiment Farm, was acquired in order that research work on orchard and crops problems confronting the farmers might be carried on under conditions typical of that section of the state.

The first work undertaken at this branch station was the installation of a stationary spray system. Although the system at present serves only 15 acres of orchard, it will eventually be used to spray about 80 acres. A 7½-H. P. electric motor is used for motive power. Thus far this system is the only electrically driven stationary spray plant in the state.

One 600-gallon, two-compartment redwood tank is used in this system. The tank is equipped with special agitators in order to insure the desired degree of agitation. A Super-Giant Bean pump with 3-inch cylinders, having a capacity of 25 gallons per minute, and equipped with an extra large air chamber, is used. The tank, pump, and motor are all mounted on steel sills and are rigidly anchored to a concrete foundation. A silent chain drive is used between the motor and the pump.

The present pipe line consists of 1-inch mains and ¾-inch laterals. The ground on which the lines are laid is fairly level, and pipe larger than one inch was not necessary for the main lines. All of the pipe in use on the system is galvanized, copper-bearing pipe. All of the lines at present are laid on the ground. Thirty-five hundred feet of ¾-inch pipe and 700 feet of 1-inch pipe are used. The laterals are so spaced that it is possible to use a one-man unit. The leads of hose in use are 100 feet long and are easily handled by one man, except when surface growth is extremely thick. The hose is ½-inch, high-pressure hose with special quickly detachable couplings as shown in the figure on page 13.

During the 1930 season six sprays were applied to the 448 trees comprising the present orchard. This required a total of 128 man hours of labor. Because the system was not installed in time, the delayed dormant spray was applied with a portable sprayer, requiring three men and a total of 40 man hours. The remaining five sprays were applied with the stationary system, requiring a total of 88 man hours and 37½ machine hours, as compared with 40 man hours and 25 machine hours for the first spray.

A total of 16,800 gallons of spray was applied to 2688 trees, or 6.25 gallons per tree per spray. The pressures used in spraying varied

*Data were obtained from F. J. Schneiderhan, associate plant pathologist, West Virginia Agricultural Experiment Station.

from 400 to 450 pounds, with most of the spraying being done at 425 pounds. The trees ranged in size as follows: 118 25-year-old trees, 200 ten years old, and 130 six years old.

Table 9 gives the record of the operation of the experimental plant for the 1930 season.

The system was operated during the season a total of 37½ hours. Spraying was delayed 2¾ hours during the entire period for the following causes:

30 minutes—clogged nozzles due to scale from new pipes during first spray.

15 minutes—new spray gun broke and was replaced.

2 hours —replaced defective pressure-release valve.

TABLE 9.—*Record of operation of experimental stationary spray system,* 1930

Name of spray	Total number of men	Total man hours	Average rate per hour	Total pump hours	Number of tanks of spray	Total gallons	Number of men on guns	Pounds pressure	Number of men at plant	Extra men
Delayed* dormant	3	40	.30	25	9½	2800	2	400	None	1
Pink	2	14	.30	7	4	2400	2	425	None	None
Petal fall	2	15	.30	7½	4+	2500	2	425	None	None
Three weeks	2	15	.30	7½	4+	2500	2	450	None	None
Five weeks	3	22	.30	7½	5½	3300	2	425	1	None
Mid-summer	2	22	.30	8	5½	3300	2	425	None	None

*Portable sprayer used.

The average consumption of electricity per spray application was 68 K. W. hours, which at 7½ cents per K. W. H. amounted to $5.10 per spray application. This charge is high and not representative because of the small orchard to be sprayed and because only two men did all of the work. The power cost would have been identical even though five men had sprayed during the same period, since the power used was very largely that of maintaining pressure over a given period. It is obvious that five or six spray men could have worked during the same time in which only two worked. The 25-gallon-per-minute pump was not working at full capacity at any time during the spray season because it was found unnecessary to do so in this small orchard of only 15 acres, which could be sprayed by two men in approximately 7½ hours.*

The purpose of installing the stationary plant of this capacity for such a small orchard was to anticipate the eventual spraying needs when new acreage would be planted, and chiefly also to give

*The spraying was largely of an experimental nature, requiring frequent change of materials and flushing of the system after each material was tried. It is apparent that the labor and cost data are not applicable to ordinary orchard spraying conditions and they are not presented in this bulletin for such purposes.

the apple growers of West Virginia an opportunity to inspect the very latest in stationary spray equipment. This particular outfit is, therefore, of the nature of a model experimental unit which will be changed and will have new equipment added from time to time.

SPRAY GUNS AND RODS FOR USE WITH STATIONARY SPRAY SYSTEMS†

The spray gun is used more extensively with stationary systems in West Virginia than the spray rod. The gun in the hands of an experienced spray man is a very satisfactory implement. Difficulties in operation lie in the fact that the type of spray cone varies as the operator manipulates the cut-off. When a gun is used wide open the result is not spraying, but squirting.

While many orchardists believe that the spray gun has a longer effective drive than the rod, the data in Table 10 indicate otherwise. The improved spray rod which was developed by W. S. Hough of the Virginia Agricultural Experiment Station* satisfies the need of equipment for stationary outfits. This rod has been improved by several commercial concerns. Advantages of improved rods over the spray gun are: the type of spray cone is constant and cannot be altered as in a spray gun; the effective spray drive is longer, thus enabling the operator to spray taller trees from the ground; the spray rod is less liable to misuse and damage than the gun.

Several makes of improved spray rods were tried with the stationary system at the University Experiment Farm during the spray season of 1930. All proved to be satisfactory. For trees averaging 15 feet in height a 6-foot rod was used, while a 9-foot rod was found adequate for the tallest trees in the orchard, some of them 35 feet in height. The nozzles on these rods can be regulated so that any pitch can be obtained. This pitch results in back pressure which exerts a lifting effect and makes handling much easier.

With a one-man unit for each lead of hose the spray man first sprayed upward and outward while standing close to the butt of the tree. The spraying was completed by circling the tree from the outside. When considerable wind was blowing it was found possible to spray most of the tops of trees by taking one or two positions on the windward side and permitting the wind to carry the spray through the top of the tree.

The data in Table 10 show the distance of effective spray drive and the capacity in gallons per minute of different spray implements tested at the University Experiment Farm. By effective spray drive is meant the distance from the gun or rod orifice at which the leaves are turned and sprayed on both surfaces.

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†Prepared by F. J. SCHNEIDERHAN.

*HOUGH, W. S. ORCHARD SPRAYING AND SPRAY EQUIPMENT. Va. Agr. Expt. Sta. Bul 260, 1928.

The effective spray drive of the two single guns was considerably less than that of the 3- and 4-nozzle rods. Furthermore, the capacity of these single guns is very much less than that of the rods. The 8-nozzle Bean rod is too large for use in an average orchard. This rod has a limited use in hillside orchards when the wind carries the spray down the rows of trees, but when it is used from the ground on small trees, drenching is very likely to follow. The Friend gun has about the same spray drive as the Friend 3-nozzle rod, but since the rod can be of 9- or 12-foot length, it is apparent that it has a greater range than the gun and, in addition, more capacity.

TABLE 10.—*Length of effective spray drive and capacity of different spray implements used at a pressure of* 500 *pounds with a pump capacity of* 25 *gallons per minute on the stationary spray system at the University Experiment Farm,* 1930

Type of spray implement	Spray drive	Capacity per minute
Bean 2-nozzle rod, 2-hole whirl disk	3 feet	3½ gallons
Bean 3-nozzle rod, 6-hole whirl disk	14 feet	6½ gallons
Bean 4-nozzle rod, 6-hole whirl disk	17½ feet	7½ gallons
Bean 8-nozzle rod, 6-hole whirl disk	25 feet	18 gallons
Bean gun	9½ feet	3¾ gallons
Friend 3-nozzle rod, 6-hole whirl disk	12½ feet	5½ gallons
Friend 4-nozzle rod, 6-hole whirl disk	16 feet	7¼ gallons
Friend gun	9½ feet	3¾ gallons
Hardy 4-nozzle rod, 6-hole whirl disk	19 feet	11 gallons
Boyce double gun	21 feet	9 gallons

The Friend 4-nozzle rod has a longer spray drive and greater capacity than the Friend gun. The Hardy 4-nozzle rod, made of duraluminum, proved to be the most satisfactory implement used in this test and in actual orchard spraying at the University Experiment Farm. This rod is very light, has an excellent cut-off, and a greater spray drive and capacity than any of the improved rods tested thus far. The Boyce double gun, according to the data, is much superior to the single gun from the standpoint of spray drive and capacity. A double gun in the hands of an experienced operator is an effective implement when used with a stationary spray system.

In spite of its 21-foot drive it is apparent that every 4-nozzle, 9-foot rod in this test would enable the operator to spray taller trees than with the double gun by reason of the shortness of the latter. As far as visual inspection permitted, the fineness of the spray from all these implements was kept constant during the test.

If the owners of stationary spray outfits would investigate some of the improved spray rods now on the market and compare their effectiveness with that of the spray guns, the result would probably be a more general use of the rod. The gun in the hands of a good spray man can be used effectively on trees up to a height of 20-25 feet, but the rods of various lengths can also be used for trees of that size and in addition, they are more effective for the tallest trees and are less liable to abuse.