SPRAYING MACHINERY ACCESSORIES

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BULLETIN

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SPRAYING MACHINERY ACCESSORIES

By W. H. GOODWIN*

In taking up the subject of the accessories of spraying-machinery, the author realizes that during the last five years many changes have been made in the construction and design of spray pumps. From the chaos of models which appeared on the market a few years ago, certain types of machines are surviving the test of practical use and the accessories are being altered to meet modern conditions. The devising of new spray mixtures always makes necessary some alteration in machines and equipment, due to the peculiarities of the spraying compound. To-day the fruit-growers are just beginning to realize the value of high pressure for spraying, and, to meet this requirement, the machines must be made strong without adding excessive weight, and the accessories must likewise be altered, or new ones devised to meet this change in conditions.

The author has operated many of the important makes of spraying machines and has used in practical work most of the accessories spoken of in this publication. Many people have bought the poorly equipped outfits which some manufacturers persist in furnishing, and have found out after a year or two of experience in spraying orchards, that the equipment was of an inadequate and undesirable kind. The reason why so many orchard owners are averse to spraying their orchards became very evident to the author, after a careful inspection of the customary equipment furnished with the barrel sprayers made by a number of different manufacturers. To assist those unacquainted with spraying equipment in choosing the most practical kind of accessories, is the mission of this publication.

*Illustrations prepared by W. P. Beeching, Jr. from models and sections furnished by the author.

The accessories are taken up in their order of sequence, beginning with the preparation of the spray and following the liquid through its course until it is delivered on the trees. Before the liquid is poured into the tank it must always be strained, unless one is looking for trouble.

STRAINERS

Tank strainers, of the sloping-screen type, clog if the liquid is not poured on the upper end of the screen and allowed to wash the sediment to the lower end. A modification of the Stewart strainer, in which the liquid passes upwards through the screen from below, combined with the essential feature of the sloping-screen type, is shown in Fig. 1. This type of strainer will not overflow under ordinary conditions, will not clog readily, and will usually drain out completely. It possesses all the advantages of the Stewart strainer with the additional value of the sloping-screen type of tank strainer. The screen should be of heavy brass cloth and have at least 14 wires to the inch. Wire cloth having more than 24 meshes to the inch is not strong enough to withstand the rough usage, and the fine mesh fills up with sediment and is hard to clean. A strainer of some kind is usually placed on the suction pipe or suction hose, but some machines are equipped with a metal box or well, attached permanently to the bottom of the supply tank. This type permits the tank to be drained completely and a simple, easily cleaned strainer is enclosed in the well. These are furnished with only a few makes of machines. The usual types are shown in Figs. 2 and 3.

Fig. 2 and similar types always leave an inch or two of liquid in the tank and seemingly have no advantage over the type shown in Fig. 3. The latter almost completely drains the tank and seldom clogs if it is at least four inches in diameter. These strainers should always be made of brass or some metal which is not corroded by any of the spray liquids. The iron strainers often seen on barrel pumps are entirely too small, and rarely last more than two or three seasons, even if the machine receives normal care. The screen on the suction pipe strainer should be readily replaceable in case it is damaged in any way.

SUCTION HOSE OR PIPE

The wire-lined suction hose, which is furnished with machines requiring such a connection, should be of the very best quality. One and one-fourth inch pipe connections, although not flexible, nor as easily changed as the same diameter suction hose, possess the advantage of not becoming leaky, are not affected by the oil sprays, and cost very little when their replacement becomes necessary.

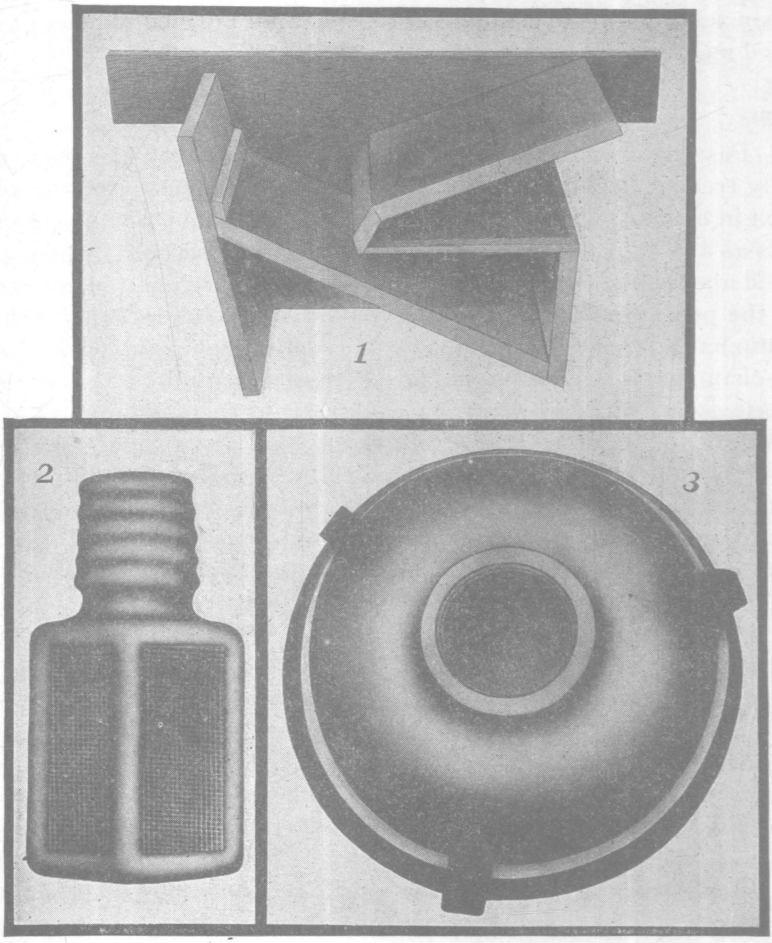

Plate I. (1) A homemade tank strainer of large capacity, having all of the advantages of the sloping-screen and Stewart strainers.

(2) This kind of strainer will always leave several inches of solution in the tank.

(3) A brass strainer with an easily replaceable brass screen of large area. A strong, durable accessory which permits practically the complete emptying of the tank by means of the suction hose.

However, a suction hose permits the washing out of the pump without washing the tank, and it is usually long enough to be placed in the storage tank when using a tank filler. Plain hose will collapse when the pump is operated, hence, it cannot be used in place of wire-lined suction hose.

AIR CHAMBERS

Passing over the subject of spray pumps, which has been quite fully treated in Bulletin 216, the air chamber, in most cases, comes next in order. The air chamber serves a two-fold purpose; first, it acts as a storage for the liquid under pressure; secondly, the air confined above the stored liquid is a resilient body which tends to equalize the pressure when there is a sudden influx of liquid. When a pump has a large capacity per stroke, and is equipped with a small air chamber, it is not unusual to see the indicator on the pressure gauge swing through a range of fifteen to forty pounds at every stroke of the pump. The strain upon hose and connections is extremely severe, and the shock upon the closing valve is comparable to the blow from a hammer, when the pump is operated under these conditions. The capacity of the air chamber on power outfits should be at least one-half as great as the amount of liquid the pump delivers per minute when it is operated at normal speed. Hand and barrel pumps should have air chambers which hold at least as much as the amount of liquid displaced by the plunger per minute, while twice this size is better and is not too large. Traction machines need an air chamber having about twice the capacity of the pump in gallons per minute. The air chamber usually forms part of the pump, but most of the traction sprayers and a few of the hand and power machines have it separate. The better types of air chambers are made as light as possible consistent with the strength required, and some provision is made for agitation when the chamber is of large capacity.

PRESSURE GAUGES

The pressure gauge is the index which makes possible careful and exact spraying when the remainder of the accessories are normally good. The operators of hand and barrel pumps are especially liable to over-estimate the pressure they obtain while spraying. With hand or barrel sprayers, few operators realize how much the pressure varies, or how much it depends upon the degree of weariness the operator feels toward the end of the day. The work varies in thoroughness, and the spray in quality, whenever the pressure is allowed to run down below the normal working amount.

RELIEF VALVES

Power and traction spraying machines must be equipped with a relief valve or pressure regulator in order to avoid accidents. The poppet types of relief valves, ordinarily furnished with power outfits, are not suitable for use on spraying machines where the spraying mixture contains grit and solid matter. When the valve is raised by the pressure of the liquid, it usually closes with a particle of sediment lodged between the broad face of the valve and its seat. This allows the spraying liquid to escape through the narrow opening at high speed, carrying with it particles of solid matter which soon channel or cut the face of the valve, and it becomes leaky and inefficient. If this type of relief valve had been designed especially for catching and retaining sediment, it could not serve the purpose better.

The ball relief valve has a narrow seat and the ball turns, giving a much greater surface with a shape which obviates any serious wear. When a relief valve having a small ball is used, it is of small capacity and of little value, as it will not take care of the overflow when both leads of hose are shut off.

A plunger type of relief valve which appeared on the market recently, is very sensitive to pressure variation and apparently has all of the requisites of durability. When the pressure becomes great enough to overcome the force of a spring, the plunger is raised, uncovering a row of holes in the wall of the sleeve, through which the liquid escapes back into the tank. Fig. 4 gives a detailed view of its construction.

Several forms of pressure regulators, on some power and traction machines, automatically throw the pump out of gear, saving power and obviating trouble and danger when all of the pump's capacity is not utilized. This also effects a great saving in wear and prevents breaking the machine or straining it unnecessarily. Another form of regulator, which is placed on the suction pipe, shuts off the supply when the pressure becomes sufficient to raise the plunger against the spring. This allows the engine to run free, excepting for the vacuum created by the pump in pulling against a reduced opening or shut-off suction pipe, the expenditure of power and the wear of the machine being greatly lessened by this little device.

A special type of pressure regulator, which is placed between the pump and the air chamber, is operated by the liquid, under pressure, raising a diaphram against the spring regulator. The rod attached to the diaphram lifts the ball in the lower valve box, and the upper valve closes automatically. This retains the pressure in the air chamber and allows the liquid supplied by the pump to pass

under the lower valve into the tank. When the pressure in the air chamber is lowered, the lower valve closes and the upper valve is opened by the solution which is again forced into the air chamber. Fig. 5 shows the appearance of this regulator, which is large and heavy in comparison with the relief valves, but it is much superior to any of the other pressure-regulating devices for power sprayers.

TANK FILLERS

Several forms of tank fillers, weighing from 40 to 200 lbs., were furnished with power sprayers of different makes several years ago. The lightest kind were rotary pumps which were of large capacity, but these pumps are not long-lived, as they must be run at high speed, and often pump water which is full of grit from ditches or ponds.

The jet pump or ejector types of tank fillers are supplanting most of the other kinds, as they have no moving parts to wear out or get out of order, and at the same time are light and convenient. They are operated by the pressure stream from the spray pump, which is forced through a reduced opening into a proportionally larger diameter pipe. The expansion of the jet of water creates a vacuum below the jet and lifts water in amounts proportional to the pressure and to the abundance of the supply. The height to which water can be raised depends upon the pressure furnished by the pump, and the height of the jet pump above the source of supply. If it is necessary to raise the water to greater heights than the ordinary suction hose permits, place the jet pump nearer to, or in the water to be raised. None of the fillers will raise water successfully by suction much higher than eighteen feet, but those placed in the water will lift it considerably higher than this, depending entirely upon the pressure of the supply to the jet stream. Three different types of tank fillers are shown in the illustrations. Fig. 6 is an ejector which may be used with steam or water; by connecting it up in a vertical position and turning on the pressure the water is raised. It is like Fig.7 in that it depends almost entirely upon the vacuum created by the jet to raise the water. Fig. 8 shows a type which, when dropped into the supply, lifts the column of water above the pressure jet. Each type has desirable features, and the choice of kind must depend largely upon individual taste. When operated under 200 lbs. pressure, they will raise from twenty to forty gallons per minute, depending upon the size of the jet pump and how high the water must be lifted.

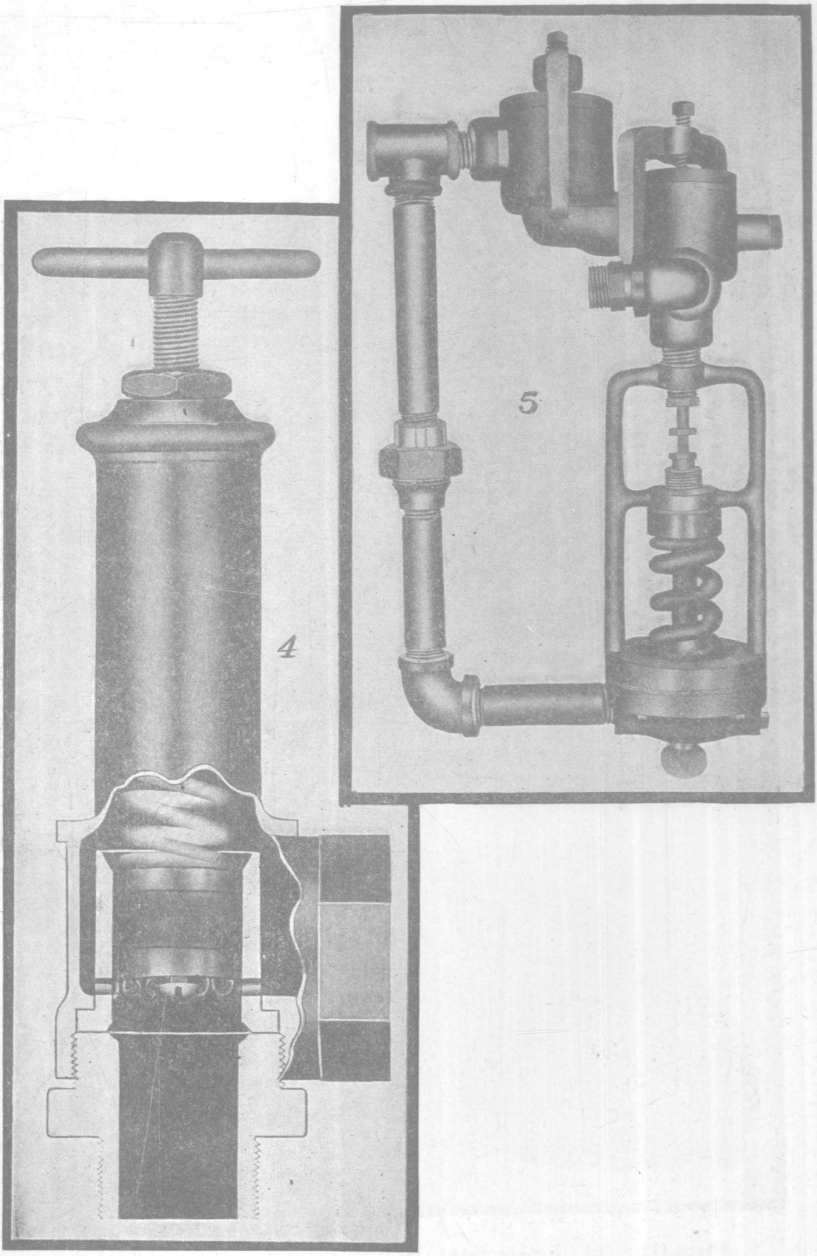

Plate II. (4) A simple plunger type relief valve which is very sensitive to pressure variation and has all of the apparent requisites of durability.

(5) A pressure regulator of a novel type which effects a great saving in power, prevents unnecessary wear, is positive in action, and has readily accessible parts.

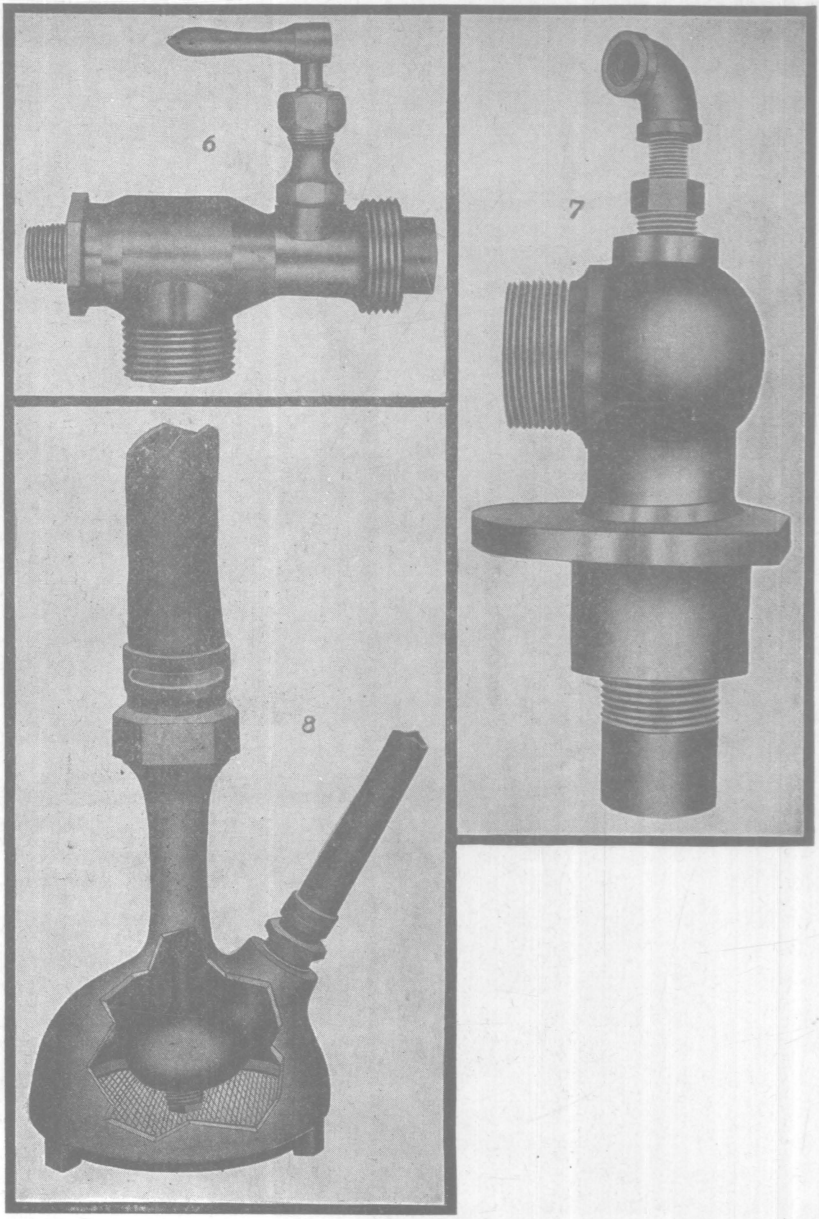

Plate III. (6) An ejector or jet pump of extremely small size but of large capacity. A simple piece of apparatus which lessens the labor of filling the sprayer tank, especially on power outfits.

(7) A tank filler which is so designed that it can be attached permanently to the sprayer tank.

(8) A tank filler which lifts the water above the high pressure jet stream. A convenient tank filler which can be left at the filling station.

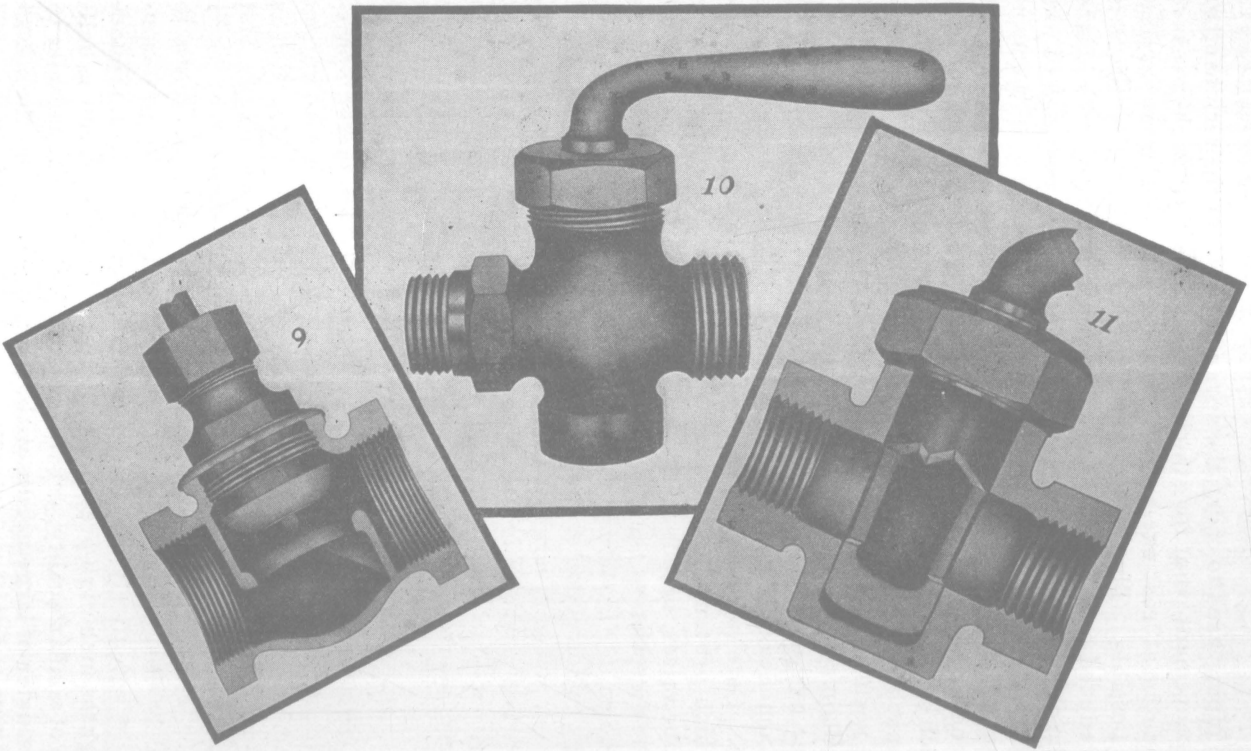

Plate IV. (9) A sectional view of a globe valve, showing the abrupt changes of direction the liquid must make and the broad faces of the valve and its seat where sediment is caught when the valve is closed.

(10) A simply constructed large leakless cutoff.

(11) A sectional view of a leakless rod cutoff, showing the comparatively large, straight passage-ways.

PIPING AND CUTOFFS

The piping used to carry the spray liquid from the air chamber to some convenient point for attachment of the leads of high-pressure hose should be at least one-half inch in diameter and make as few turns as possible. The pressure of the spray liquid at the nozzle is greatly reduced by friction of the solution against the walls of the pipe if the changes of direction are frequent, and if the size of the orifices through which it passes are small. The cut-off, at the point of attachment of the hose-lead, permits the shutting-off of one lead of hose whenever desired, and this takes unnecessary strain off the hose which is not in use. The three-way cut-offs, ordinarily furnished with machines, are always being turned in the wrong direction, with the result that some one is frequently drenched with spray-liquid. Plain cut-offs are superior to the globe valves. (See Fig. 9). The latter usually change the direction of flow very abruptly, and soon become leaky, besides requiring a lot of time to shut off the hose-lead. Gate valves are apt to become partially clogged with sediment, which prevents their closing properly, but they are superior to the globe valves, because they are of large capacity and do not change the direction of the flow of the liquid. The simple, leakless cut-off, shown in Fig. 10, is positive in action, easily operated, does not change the direction of the flow of the liquid, is readily adjusted or repacked, and is of large capacity. A sectional view of the leakless rod cut-off is shown in Fig. 11, giving an idea of the simplicity of its construction. Just under the cap-nut is a packing gland which allows any slack in the valve to be taken up, and also prevents any leakage.

HOSE, HOSE-CONNECTIONS AND HOSE-BANDS

The high pressures used in spraying with modern power spraying machines make the use of strong, heavy-walled hose imperative. Half-inch high-pressure hose of five, six, or seven-ply construction is generally used for this purpose. The heavier grades usually last enough longer, except where oil sprays are used, to warrant their purchase. Three-quarter inch hose, having sufficient strength to withstand 200 lbs. pressure, is not practical to use, as it is too cumbersome, being entirely too heavy for the operator to drag around. Three-eighths inch high-pressure hose costs almost as much as half-inch hose of similar quality, yet it does not have sufficient capacity to supply a cluster of large nozzles without greatly reducing the nozzle-pressure of the spray solution. The hose connections for this size of hose have much smaller openings than the half-inch connections, which partially accounts for the reduction of pressure at the nozzle-cap. The lead of hose to the operator on the ground should be at

least thirty-five feet long, but the lead to the tower can be as short as twelve feet without hampering the operator in handling the spray rod. Barrel pumps or large hand pumps will seldom successfully supply more than one lead of hose at a satisfactory working pressure; but two nozzles can be used on the spray rod, when one nozzle does not utilize more than half of the capacity of the pump. Figs. 12, 13, 14 and 15 show a number of the various styles of hose connections; the double-length kinds, permitting the use of two hose-bands, are the only ones which should be used. A connection having a hexagonal nut of the form shown in Fig 14 is superior to the round, coupling type, Fig. 13. The flange or a corresponding section of the male hose connection should be hexagonal, as in Fig. 15, so that an ordinary wrench can be used to turn it, and when the connection at the base of the extension rod has one-fourth inch pipe-thread as in Figs .15 and 16, the reducer of the type shown in Fig. 17 is not needed.

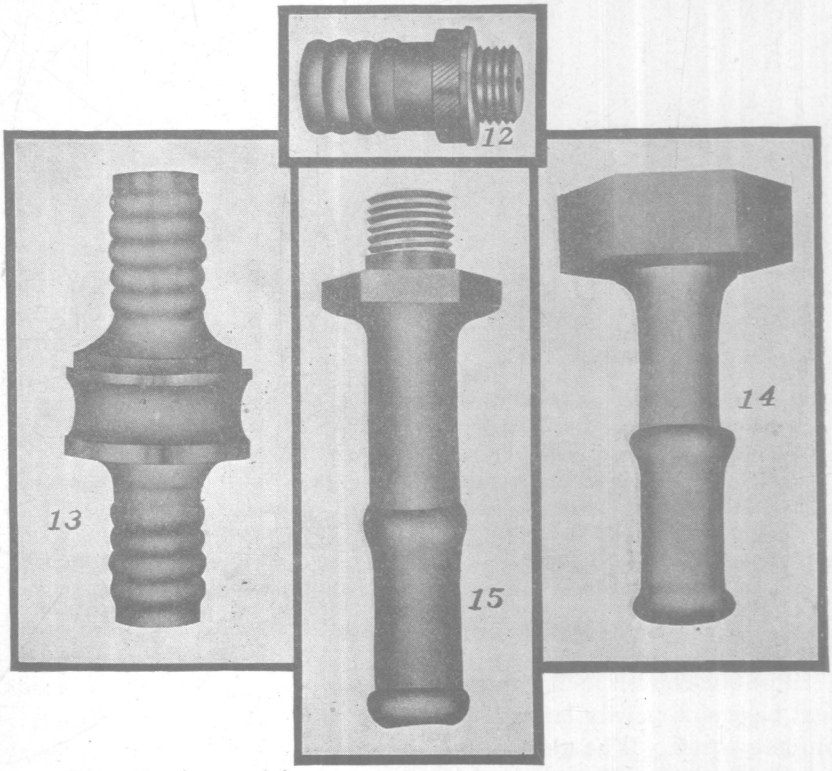

Plate V. (12 and 13) Single-length hose connections with round nut. The kind every practical spraying outfit *should not have.*

(14 and 15) Double-length one-fourth inch pipe-thread male and standard female hose connections, permitting the use of two hose bands of the Sherman type. These have a hexagonal flange and hexagonal nut so they can be adjusted with an ordinary wrench.

The Sherman hose-band, shown in Fig. 18, is much superior to a wire or narrow galvanized iron band, and is the kind that is almost universally used. "Never-slip" clamps, like those shown in Fig. 19, are so built that the hose cannot be pulled off of the connection by pressure. The hooks on the clamp extend over the flange on the connection and supplement the clamp on the hose in preventing it from slipping off of the connection. For power sprayers this style of clamp and connection is superior to any other kind, as it is impossible to blow the hose off of the connection by high pressure.

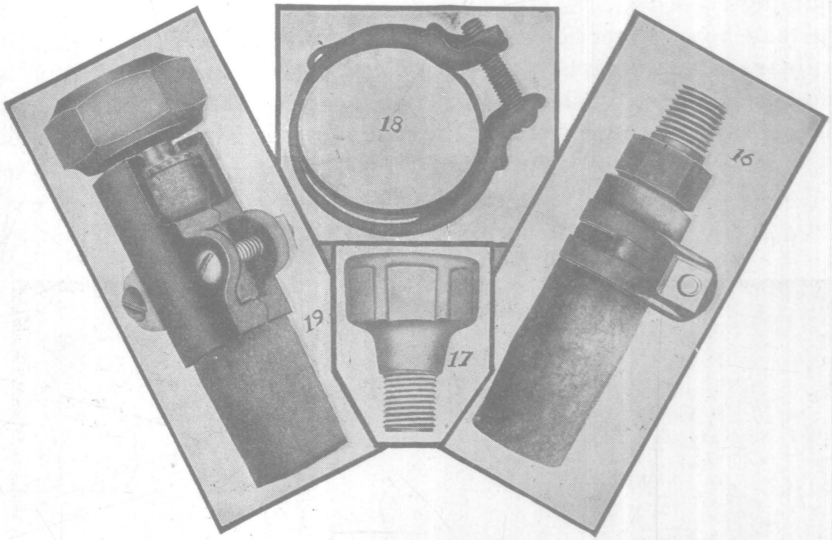

Plate VI. (16) A one-fourth pipe-thread male hose connection with a hexagonal section and held by a single Sherman hose-band. This connection is long enough to permit the use of two hose-bands.

(17) A reducer which becomes unnecessary when a one-fourth threaded connection is used instead of a standard male hose connection.

(18) A Sherman hose-band.

(19) A Never Slip hose-clamp and a double-length connection in position. The hexagonal nut is superior to the round kind often furnished.

ROD CUTOFFS

The one-fourth inch cut-offs, used at the base of the spray-rods, must have sufficiently large openings so that the flow of the liquid is not obstructed. The globe valve shown in Fig. 20 has fair capacity, but changes the direction of the flow of the liquid too often at very sharp angles, also it closes slowly and soon becomes leaky. Fig. 21 has some similar faults, but serves the purpose better for small sprayers, as it acts quickly in cutting off the spray. The cut-off shown in

Fig. 22 is of very small capacity and soon becomes leaky. A ball cut-off, which was tested for several seasons, did not prove entirely satisfactory, as it was a little clumsy and cumbersome. The gate valve cannot be closed quickly, although the ways are large. The leakless cut-off shown in Fig. 23 is simple, easily operated, and is positive in action. The ways are large, permitting the flow of the spray liquid without changing its direction, and if it becomes leaky, it is easily repacked. The use of this little accessory prevents, each season, the wasting of enough spraying mixture to pay for it many times.

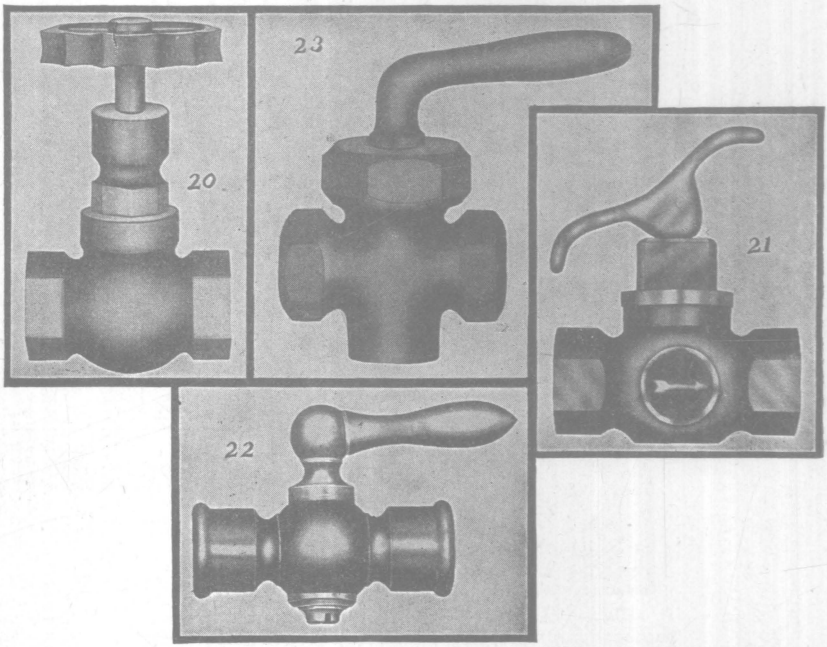

Plate VII. (20) A one-fourth globe valve. (21) A small capacity one-fourth inch spring cutoff with ways similar to the globe valve. (22) A one-fourth inch steam cutoff of small capacity. (23) A one-fourth inch leakless rod cutoff which is simple in construction, positive in action, and of a practical size.

SPRAY RODS

Extension rods are necessary for spraying large trees, since most of the modern spray nozzles produce a fine mist spray which has very little carrying power. For small orchards a section of one-fourth inch iron pipe serves the purpose very well, if the rods needed are not over six or eight feet in length. Longer lengths of one-fourth inch iron pipe are hard to handle on account of their weight, and they often break off in the threads. Rods made of brass pipe are too flexible, when made of light tubing, and too heavy, if made of strong tubing large enough in diameter to obviate flexibility.

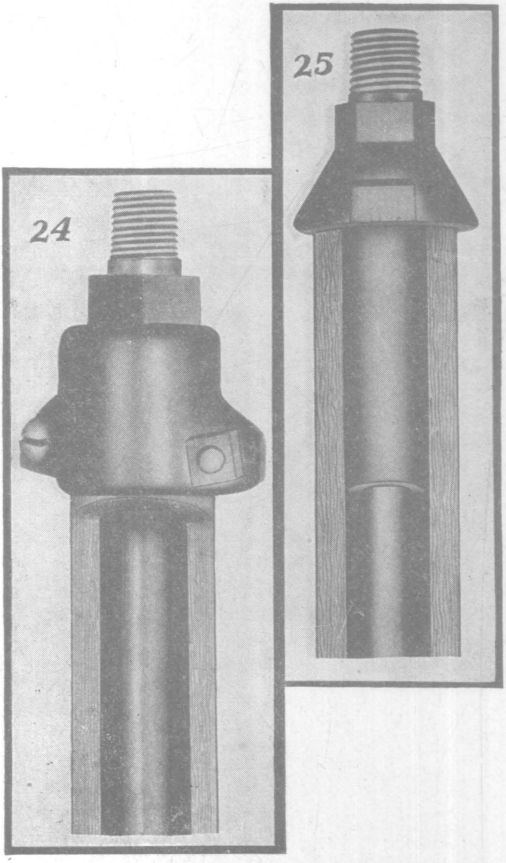

Plate VIII. (24) A section of an aluminum-lined bamboo spray rod with a thimble extending over the outside of the bamboo casing.

(25) A section of an aluminum-lined bamboo spray rod with the long brass thimbles fitting closely inside the bamboo, and clamping it tightly endwise between the cup-shaped caps of the thimbles. The hexagonal and square sections permit the use of an ordinary wrench in tightening the connections.

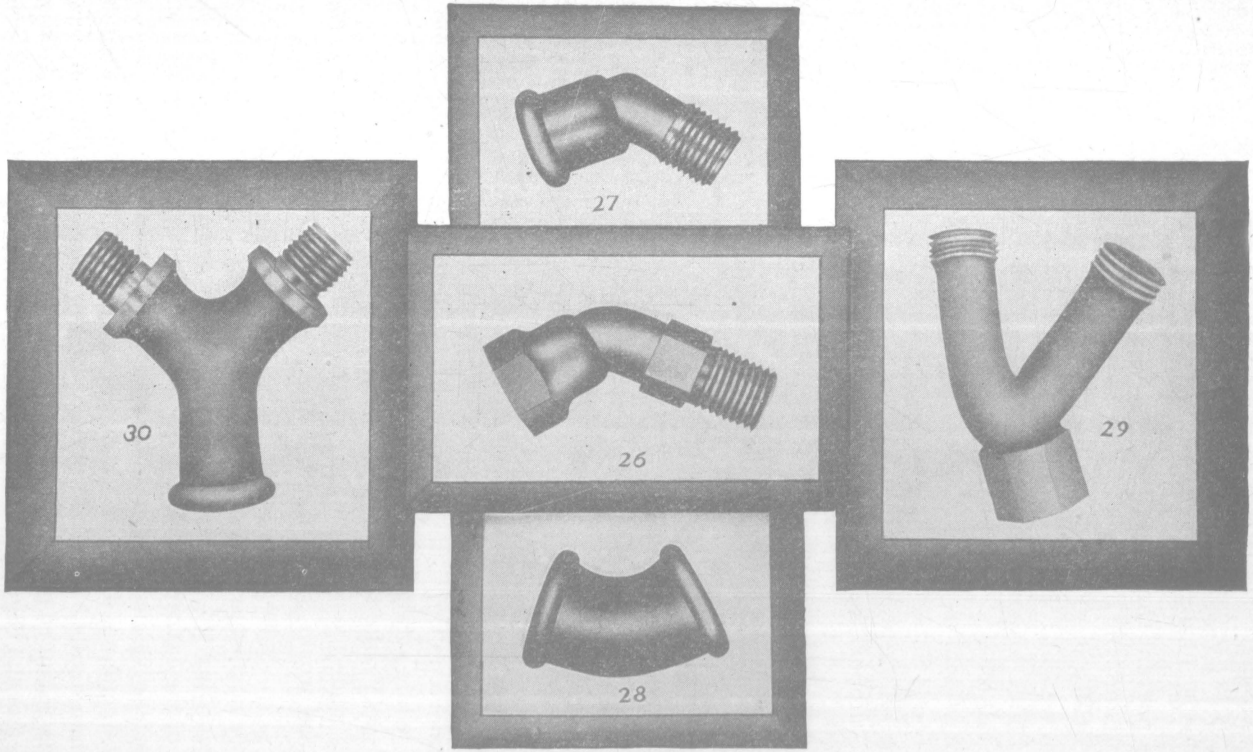

Plate IX. (26) A one-fourth inch brass angle L, having a hexagonal section at the base and also one near the top. A better type than either of the others. (27) A one-fourth inch brass angle L, with round base and top which requires a pipe wrench to hold it. (28) A one-fourth inch cast iron L, which requires a one-fourth inch pipe nipple before a nozzle can be attached. It is heavy and soon becomes corroded. (29) An angle Y, having branches diverging properly, and angled so that straight-based nozzles can be used. (30) A straight Y, with the nozzle branches too divergent for use in practical spraying.

Extension rods made of bamboo and lined with brass or aluminum pipe are light, strong, and large enough in diameter to be handled conveniently without unduly tiring the operator. The base and top should be constructed like rod-ends shown in Figs. 24 or 25, for these thimbles prevent the accidental breaking of the rod at the juncture of the fitting and the lining pipe. Aluminum-lined rods of this type are practically as strong as the brass-lined ones, and they are much lighter in weight. Bamboo rods ten feet long are usually the most practical ones, although twelve-foot rods are not too heavy nor too long for tall trees. The plain, thimbled bamboo rods, with wired ends, are seldom as durable as the kinds mentioned previously, as the bamboo is liable to split, and the rod ends are more readily broken off. The lining-pipe and thimbles get loose and turn around in the bamboo support, and there is no satisfactory way to remedy the defect.

ANGLE ELLS AND Y'S

Angle ells, like those shown in Fig. 26, with base and top made hexagonal, are more convenient than either the round style, Fig. 27, or the cast iron angle, Fig. 28, which requires a pipe nipple in one end before a nozzle can be attached. These angle connections are used to change the direction of the spray by making the straight-based nozzle, used alone or on the plain Y's, almost face the perpendicular when the extension rod is held in the position for spraying. Angle Y's can be used in place of the angle ell or of the plain Y. When more than one nozzle is used on a rod, straight nozzles should be used, as the angle-base nozzles have to be forced into position. When turned on tight, angle-base nozzles rarely stand in the correct position, while straight nozzles are always standing right when used on an angle-Y, like that shown in Fig. 29. Fig. 30 has the nozzle branches made too divergent to be satisfactory and cannot be used in practical work.

NOZZLES

Spray nozzles are readily divided into four classes, when separated according to the different shapes of spray they form, but on account of the extreme variation or intermediate forms of spray which some nozzles give, it seems the better plan not to class them as hollow cone, solid cone, solid stream, and flat or fan-shaped types of spray nozzles. When divided into classes according to their construction, several fairly balanced groups are formed, which are known as Disc, (Fig. 31), Vermorel, (Figs. 32 and 33), Modified Vermorel, (Figs. 34 and 35), Self Cleaner, (Fig. 36), Cap, Bordeaux, Cyclone, and Solid Stream nozzles. This classification follows the trend of names with which we are more familiar, and these give some idea regarding construction.

Different nozzles are suited to different work, and, as their efficiency sometimes depends upon the amount of pressure used, care must be taken not to select a nozzle which will be unsuited to the machine with which it is to be used. Some nozzles are of very large capacity and should not be used with pumps whose capacity per minute is less than that of the nozzle. The Disc nozzles are larger in capacity than most of the Vermorel or Self Cleaner types; more compact, lighter in weight, less liable to clog, and do not have any projecting parts to catch over limbs and make trouble. Although Disc nozzles have been on the market for only a few years, they are rapidly superceding the older and more common types.

Most of the Vermorel and Self Cleaner nozzles are of small capacity, largely because the small orfices through which the liquid must pass, and the abrupt changes of direction which it must make, reduce its speed and nullify the effects which should be obtained if no hindrance was present. The Bordeaux nozzles, strongly advocated by many western orchardists, usually make a flat, fan-shaped spray which is coarse and much heavier in the center of the fan than at the edges. These are also of large capacity and can be adjusted to throw a solid stream of liquid.

Cap nozzles of small capacity are suitable for bucket pumps and small hand sprayers. They are often miniature types of Disc nozzles. Those of large capacity are preferable to the Vermorels. Solid Stream nozzles are best suited for spraying tall trees, and, because of their extremely large capacity, cannot be used with any of the smaller power machines. This observation applies especially to the Worthley nozzle, which has been developed for use in spraying for the control of the gypsy and brown tail moths in Massachusetts.

A few types of nozzles which can hardly be given any definite place are included in the appended tables. These tables do not include all of the different kinds of spray nozzles sold in Ohio, but they include most of the important makes. The illustrations show the difference in the construction of some of the common nozzles, giving the defects and good points of the several kinds. It is a fault common to many of the hollow cone spray nozzles to throw the bulk of the spray in one-half of the circle. In the case of Disc nozzles this may be prevented by increasing the number and the size of the openings in the directing disc which is just below the whirl chamber. The angle of the spray may be changed by increasing the depth of the whirl chamber and the carrying power of the spray will be increased accordingly if the supply of spray liquid is adequate. The appended tables, giving various data in the different columns, have listed in the first and second columns the trade names of the nozzles and the names of the makers or manufacturers selling them.

Plate X. (31) Disc nozzle. The simple straight-based Disc nozzle, showing the gradual change of direction of flow of the liquid and the large openings permissible with this type of nozzle.

(32) A variable modified Vermorel nozzle. The head of the degorger, which is threaded and fits loosely in the threaded barrel, may be shifted in position to form a hollow cone spray when above the supply orifice, and a solid stream when below this opening. Packing under the nut prevents leakage around the degorger stem.

(33) A modified Vermorel nozzle in which the whirl is imparted to the liquid in the whirl chamber by the spiral on the head of the degorger. A packing nut prevents leakage around the stem of the degorger. *Note the number of changes of direction of flow, the abrupt angles and narrow orifices through which the liquid must pass in becoming a spray in all of the Vermorel nozzles in comparison with the passage ways of the simple Disc nozzle.*

(34) A Vermorel nozzle. The outside appearance gives very little idea of the inner construction. Note the shape and projecting parts which catch over limbs.

(35) A sectional view of a true Vermorel nozzle. The head of the nozzle may be set at an angle by turning it around on the threaded stem. The liquid enters the whirl chamber through a hole at one side of the chamber which gives it the whirling motion around the needle of the degorger. Packing under the nut prevents any leaking around the needle stems and the spring holds the needle back leaving the way to the hole in the cap unobstructed.

(36) A sectional view of a Self Cleaner nozzle showing the narrow passage-ways and the needle which cleans the hole in the cap when the head of the nozzle is pushed back.

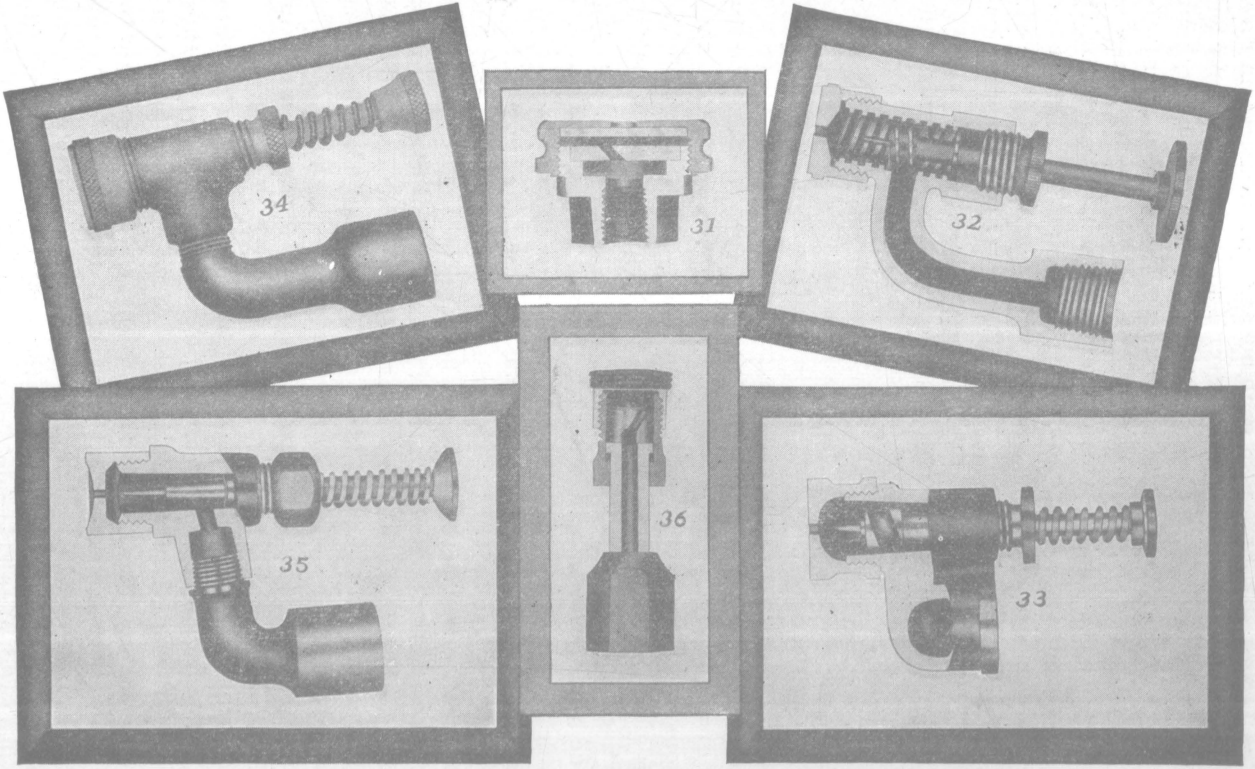

Plate X.

The weight in ounces of each nozzle is given in column three. Weight is an important item when several nozzles are used on a Y on a long extension rod. The fourth, sixth, and seventh columns give an idea of the size of each kind of nozzle, the measurements being given in inches and hundredth parts of an inch. Columns six and seven give related data which govern somewhat the length of the spray which is given in column ten. In column ten are given the greatest distances from the nozzles to which spray can be carried and still remain practically effective. The depth of the whirl chamber and its proportion to the diameter have much to do with the width of the angle of the spray. The size, shape, angle, and number of supply holes in the directing disc also affect the spray obtained. The diameter of the hole in the cap or disc has much to do with the capacity of the nozzle, but the figures in column five are not an absolute index to the capacities obtained in columns eight and nine. In the latter, the capacities are given in gallons per hour, and may be divided by sixty to obtain the capacity in gallons per minute. Column eleven gives the kind of spray formed, but there are some slight variations which are recorded in column fourteen, as shown by the testing machine. Columns twelve and thirteen indicate the material that is used in making the nozzle.

The lack of care in machining the parts of the nozzle is often responsible for some of the discrepancies which are shown by the testing machine. When the hole in the cap has a burred edge or is not perfectly centered, one-half of the ring of spray is usually heavier than the other half. Burred edges on the holes of the directing disc are also the cause of unevenness in the ring of spray. In case of the steel discs, imperfect centering was frequent, sometimes because the hole was not drilled exactly in the center, and again because discs, correctly drilled, were so loosely fitted into their retaining caps that the holes slipped out of center when the discs were clamped into place.

Nozzles having a wide-angle spray require that the operator keep the nozzle close to the object that is being sprayed, while those giving a narrow angle spray usually require the operator to keep the nozzle some distance from the tree being sprayed in order to allow the spray to break up and cover the same area as a nozzle of the former class. Disc nozzles which throw an even, well distributed, broad ring of spray, with broken spray in the center of the circle, and which also have enough carrying power to the spray to permit the operator to hold the nozzle some distance from the tree, are especially desirable. The maximum of efficiency in the Disc nozzles is to be found in those which most nearly give a solid circle of spray.

Likewise, of the variable Disc types, the best patterns will be found in those which are capable of most nearly making a perfect ring of spray, though, of course, such types are also designed to grade their discharge from the perfect ring through the hollow cone to the long driving stream. A few of the true Vermorel nozzles gave well distributed rings of spray. Most of the modified Vermorel nozzles throw the bulk of the spray in one-half of the circle, there being only one exception, and this one gives a narrow, even ring of spray. Only one nozzle of the Self Cleaner type gave an even ring of spray. The Cap nozzles were, with one exception, superior to most of the Vermorels, both in distribution of the spray and in capacity. The Cyclone nozzles are of little value, unless used in clusters. Many of the nozzles which do not distribute the spray evenly in the circle, can be used successfully in clusters. When thus massed together, good results are obtained, but they should not be used singly.

ACKNOWLEDGEMENTS

To the spraying machinery companies who so kindly furnished sample nozzles and accessories for testing and for illustrating purposes, and to Prof. H. A. Gossard for his kindly suggestions and criticism, I desire to express my thanks.

DISC NOZZLES

Name	Maker	Wt. oz.	Diam. cap inches	Hole in cap or disc inches	Diam. whirl chamber inches	Depth whirl chamber inches	Capac. 100 lbs. pressure	Capac. 200 lbs. pressure	Length of spray ft.	Type of spray	Material: Cap or disc	Material: Body of nozzle	Shape of spray thrown by the nozzle as shown by the testing machine
Whirlpool	Bean Spray Pump Co.	2.5	1 43	.046 .055 .070 .081 .099	.5	25	31 38 60 94 118	43 55 96 135 174	12-15	Hollow cone	Steel	Brass	An even broad ring of spray with some broken fine spray in the center of the circle.
Excelall	Binks Mfg. Co.	2.4	1.25	.098 .125	.75	.22	60 82	79 105	7	Hollow cone	Steel	Brass	An even ring of spray.
Atomic	E. C. Brown Co.	4.6 or 2 0	1.5	.042 .063 .073 .078	.93	.155	19 43 56 60	26 60 71 82	8-11	Hollow cone	Galvanized steel	Brass or alum.	One-half of the ring of spray heavier than the other half.
Champion Variable Spray	Champion Mfg. Co.	7.7	1.7	.078 .093 .111	.87	.125	62-75 128-157	96-119 184 232	10-25	Hollow cone to long solid cone	Steel	Brass	A perfectly even ring of spray to a solid circular mass.
Masso Spray	Crown Specialty Co.	2.4	1.12	.076 .099	.6	.125	70 114	105 158	11	Solid cone or hollow cone	Steel	Brass	A circular mass of spray with heavy spots or a fairly even ring of spray.
Aluminum Whirl	Cushman Power Sprayer Co.	2.5	1.53	.078	.84	.093	48 65	73-100	9-15	Hollow cone to solid stream	Steel	Alum.	One-half of the ring of spray very heavy, other half very light.
Simplex	The Deming Co.	2.5	1.22	.078	.6	.155	62	84	10	Hollow cone	Steel	Alum. or brass	A ring of spray with heavy spots in several portions of the ring.
Tiger	Field Force Pump Co.	3.	1.5	.063 .078	.78	.093	32 43	47 64	8	Hollow cone	Steel	Brass	A ring of spray with one-half heavy and the other half very light.

DISC NOZZLES—Continued.

Name	Maker	Wt. oz.	Diam. cap inches	Hole in cap or disc inches	Diam. whirl chamber inches	Depth whirl chamber inches	Capac. 100 lbs. pressure	Capac. 200 lbs. pressure	Length of spray ft.	Type of spray	Material: Cap or disc	Material: Body of nozzle	Shape of spray thrown by the nozzle as shown by the testing machine
Friend	Friend Mfg. Co.	3.	1 6	.078 .103	.97	.125	60 79	75 112	8	Hollow cone	Steel	Brass or alum.	A perfectly even ring of spray.
*Mistry, Jr.	The Goulds Mfg. Co.	2.9	1.37	046 .093	.87	.093	19 49	24 65	8	Hollow cone	Steel	Brass	A ring of spray with heavier spots at intervals in the ring.
Vapo	The Hardie Mfg. Co.	3.5	1.4	081 093 .106	·78	.093	34 51 68	70 85 105	8	Hollow cone	Steel	Brass	A ring of spray with heavier spots at intervals in the ring.
Hilo	The Hardie Mfg. Co.		1.5	.116	.8	.125	86-	105-225	7-20	Hollow cone to solid stream	Steel	Brass	A fairly even ring of spray.
Power	F. E. Myers & Bro.	2.3	1.18	.093	.5	.093	94	124	9	Hollow cone	Steel	Brass	A ring of spray with very heavy spots at intervals and with some broken spray in the center of the circle.
Scientific	Niagara Sprayer Co.	1.8	1.43	.063 .093 .125	.5	.218	45 86 122	66 114 176	12	Hollow cone	Steel	Alum.	A perfectly even broad ring of spray.
Spramotor	The Spramotor Co.	2.8	1.37	.089	.81	.093	56	73	8	Hollow cone	Steel	Brass	A ring of spray with heavy spots at intervals in the ring.
Winkle	George J. Winkle	2.6	1.31	.063 093	.81	.062	32 56	45 77	8	Hollow cone	Steel	Brass	A ring of spray with several slightly heavier spots at intervals in the ring.

*A new Mistry, Jr. nozzle made of Aluminum, weighs but one ounce, and has a slightly greater capacity than the one listed.

VERMOREL NOZZLES

Name	Maker	Wt. oz.	Diam. cap inches	Hole in cap or disc inches	Diam. whirl chamber inches	Depth whirl chamber inches	Capac. 100 lbs. pressure	Capac. 200 lbs. pressure	Length of spray ft.	Type of spray	Material: Cap or disc	Material: Body of nozzle	Shape of spray thrown by the nozzle as shown by the testing machine
Vermorel	Barnes Mfg. Co	3.5	.62	.041 / .067	.34	.43	21 / 30	30 / 45	6	Hollow cone	Brass	Brass	One-half of the ring of spray slightly heavier than the other half.
Vermorel	Bean Spray Pump Co.	3.37	.78	.059 / .078	.31	.25	30 / 47	39 / 64	8	Hollow cone	Steel	Brass	A ring of spray with one-half heavier than the other half.
Vermorel	The E. C. Brown Co.	3.7	.75	.063	.28	.75	51	71	8	Hollow cone	Galv. Steel	Brass	Almost a solid circle of spray but having one-half heavier than the other.
Dewspray	The E C. Brown Co.	5.5	1.15	.052	.78	.31	30	52	6	Hollow cone	Brass	Brass	A broken ring of spray with heavy spots.
Small Mistry	The Goulds Mfg. Co.	4.8	.81	.046	.46	.68	27	35	5	Hollow cone	Steel	Brass	One-half of the ring of spray heavier than the other half.
Vermorel	The Goulds Mfg. Co	3.9	.75	.046	.34	.62	26	34	7	Hollow cone	Brass	Brass	One-half of the ring of spray heavier than the other half.
Vermorel	H. L. Hurst Mfg. Co.	2.1	.87	.07	.43	.4	38	52	7	Hollow cone	Brass	Brass	One-half of the ring of spray heavier than the other half.
Vermorel	Morrill & Morley	3.6	.75	.043 / .055	.34	.93	24 / 45	36 / 66	6	Hollow cone	Brass	Brass	A fairly well distributed ring of spray with heavier spots and with some broken spray in the central area.
Vermorel	Field Force Pump Co.	3.	.75	.046 / .063	.4	.75	34 / 51	41 / 65	9	Hollow cone	Brass	Brass	One-half of the ring of spray heavy, the other half very light.

MODIFIED VERMOREL NOZZLES

Name	Maker	Wt. oz.	Diam. cap inches	Hole in cap or disc inches	Diam. whirl chamber inches	Depth whirl chamber inches	Capac. 100 lbs. pressure	Capac. 200 lbs. pressure	Length of spray ft.	Type of spray	Material: Cap or disc.	Material: Body of nozzle	Shape of spray thrown by the nozzle as shown by the testing machine
Vermorel	The Deming Co.	3.6	.75	.063 / .093	.40	.43	32 / 49	43 / 62	8	Hollow cone	Brass	Brass	An even, narrow ring of spray.
Demorel	The Deming Co.	2.7	.75	.063 / .093	.4	.43	41 / 54	47 / 70	8	Hollow cone	Brass	Brass	Only one-half of a ring of spray, crescent shaped in appearance.
Vermorel	McCormick Mfg. Co	2.8	.96	.063	.22	.75	54	75	9	Hollow cone	Brass	Brass	One-half of the ring of spray heavier than the opposite half.
Graduating Vermorel	F. E. Myers & Bro.	3.8	.75	.081	.34	10-62	45-86	56-124	6-14	Hollow cone to Solid stream	Brass	Brass	One-half of the ring of spray heavy and the opposite half light when these nozzles are adjusted to throw a hollow cone spray.
Myers graduating Vermorel	F. E. Myers & Bro	3.4	.75	.081	.34	10-75	38-98	48-112	6-14		Brass	Brass	
Vermorel	F. E. Myers & Bro	3.8	.75	.081	.4	.28	35	47	6	Hollow cone	Brass	Brass	One-half of the ring of spray heavy and the other half very light.
Myers Vermorel	F. E. Myers & Bro.	3.5	.75	.081	.4	.31	36	48	6	Hollow cone	Brass	Brass	One-half of the ring of spray heavy and the other half very light.
Vermorel	Spramotor Co.	3.1	.61	.063	.34	.25	20	30	5	Hollow cone	Brass	Brass	Heavy spots in one-half of the ring of spray.

SELF CLEANER NOZZLES

Name	Maker	Wt. oz.	Diam. cap inches	Hole in cap or disc inches	Diam. whirl chamber inches	Depth whirl chamber inches	Capac. 100 lbs. pressure	Capac. 200 lbs. pressure	Length of spray ft.	Type of spray	Material: Cap or disc	Material: Body of nozzle	Shape of spray thrown by the nozzle as shown by the testing machine
Best	Bean Spray Pump Co.	1.8	.78	.046	.43	.28	30	41	8	Hollow cone	Steel	Brass	A ring of spray with one-half much heavier than the other half of the ring.
Power	Bean Spray Pump Co.	2.5	1 22	.052 / .070	.47	.15	36 / 60	52 / 84	11		Steel	Brass	An irregular circular mass, heaviest in the center.
Eureka	The Deming Co.	1.8	.75	.07 / .093	.04	.34	26 / 54	41 / 65	8	Hollow cone	Brass	Brass	A ring of spray with one-half heavier than the other.
Vapor Mist	Field Force Pump Co.	2.4	.75	.04 / .063	.47	.25	22 / 45	26 / 60	9	Hollow cone	Brass	Brass	One-half of the ring of spray heavier than the other half.
Maid of the Mist	H. L. Hurst Mfg. Co.	1.7	1.	.081	.84	.093	45	60	9	Hollow cone	Brass	Brass	An almost even broad ring of spray.
Latham	Latham & Co.	2.	.68	.07	.37	.37	28	37	7	Hollow cone	Brass	Brass	A ring of spray varying from extremely light on one side to extremely heavy on the opposite side.
Power	F. E. Myers & Bro.	4.9	1.18	.098	.5	.12	52	75	7	Hollow cone	Steel	Brass	A ring of spray with one-half much heavier than the other half.
Comet	Nesbar Nozzle Co.	1.5	.72	.063	.31	.12	23	30	6	Hollow cone	Steel	Brass	A ring of spray with one-half heavy and the other half extremely light.
Spramotor	Spramotor Co	1.7	.62	063	.37	.15	27	43	6	Hollow cone	Brass	Brass	One half of the ring of spray slightly heavier than the other half.

BORDEAUX NOZZLES

Name	Maker	Wt oz.	Diam. supply hole in.	Capac. per hour 100 lbs. pressure	Capac. per hour 200 lbs. pressure	Constructive material	Shape of spray	Length of spray		Shape of spray thrown by the nozzle as shown by the testing machine
								Fan-shaped	Straight stream	
Clipper	Bean Spray Pump Co.	4.5	.111	165	248	Brass	Fan-shaped or straight stream	12	27	A very heavy bar of spray almost even throughout its length.
Bordeaux	Crown Specialty Co.	3.2	.093	106	146	Brass	"	10	25	A bar of spray with a heavy center and ragged thin ends.
Bordeaux	The Deming Co.	4.1	.104	146	206	Brass	"	12	20	A bar of spray with a heavy center and light thin ends.
Seneca	The Goulds Mfg. Co.	2.9	.096	112	165	Brass	"	11	20	A bar of spray with a heavy center and light thin ends.
Blizzard	Hardie Mfg. Co.	1.8	.106	125	165	Brass with steel cap	"	9	20	Crescent-shaped with a heavy center and ragged ends.
Caswell	Latham & Co.	2.5	.067	60	101	Brass with steel cap	"	9	12	A bar of spray with a heavy center and light ends.
Bordeaux	F. E. Myers & Bro.	4.6	.110	150	200	Brass	"	12	22	A bar of spray with a heavy center and light ends.
Myers Bordeaux	F. E. Myers Bro.	4.0	.073	67	98	Brass	"	10	16	A bar of spray with a heavy center and light ends.
Bordeaux	The Spramotor Co.	4.4	.093	119	159	Brass	"	10	22	A bar of spray with a heavy center and light ends.

CAP NOZZLES

Name	Maker	Wt. oz.	Diam. of cap inches	Hole in cap or disc inches	Diam. whirl chamber inches	Depth whirl chamber inches	Capac. 100 lbs. pressure	Capac. 200 lbs. pressure	Length of spray ft.	Type of spray	Material: Cap or disc	Material: Body of nozzle	Shape of spray
Auto Pop	E. C. Brown Co.	1.	75	063	.50	.09	..	.	..	Hollow cone	Brass	Brass	A ring of spray with one side slightly heavier and broken spray in the center of the circle.
Barnes	Barnes Mfg Co.	.7	72	.063	.43	.08	41	54	8	Hollow cone	Brass	Brass	A fairly even ring of spray.
Acme	The Deming Co	1.	.72	.089	.50	.15	56	75	10	Hollow cone	Brass	Brass	An even ring of spray.
Progress	McCormick Mfg. Co.	1.7	.93	.063	.62	.12	41	58	9	Hollow cone	Brass	Brass	A ring of spray fairly even with broken light spray in the center.
Star	McCormick Mfg. Co	.9	.6	04	.34	.06	9	13	4	Hollow cone	Brass	Brass	
Imperial	F. E. Myers & Bro.	.7	.75	.086	.4	.15	64	86	8	Hollow cone	Brass	Brass	A ring of spray heavier on one side with broken fine spray in the central part.
Lenox	Goulds Mfg. Co.	4.4	.81	.063	.5	.25	41	58	8	Hollow cone	Steel	Brass	One-half of the ring of spray slightly heavier than the other half.
Cyclone nozzles													
Side Cyclone	Bean Spray Pump Co.	1.4	.78	.059	.31	.31	19	34	6	Hollow cone	Steel	Brass	A ring of spray with one-half very heavy and the other half very light.
Sulphur	Bean Spray Pump Co.	1.4	.78	.059	.31	.31	19	34					
Duplex	McCormick Mfg. Co.	8.5	1.	.063	.53	.25	25	32	8	Hollow cone	Brass	Brass	Heavy half ring with very light opposite half.
Cyclone	F. E. Myers & Bro.	2.2	.75	.046	.31	.31	19	34	7	Hollow cone	Brass	Brass	One-half ring of spray very heavy, other half very light.
Side Cyclone	F. E. Myers & Bro.	1.7	.75	.046	.31	.31	19	34	7	Hollow cone	Brass	Brass	One-half ring of spray very heavy, other half very light.

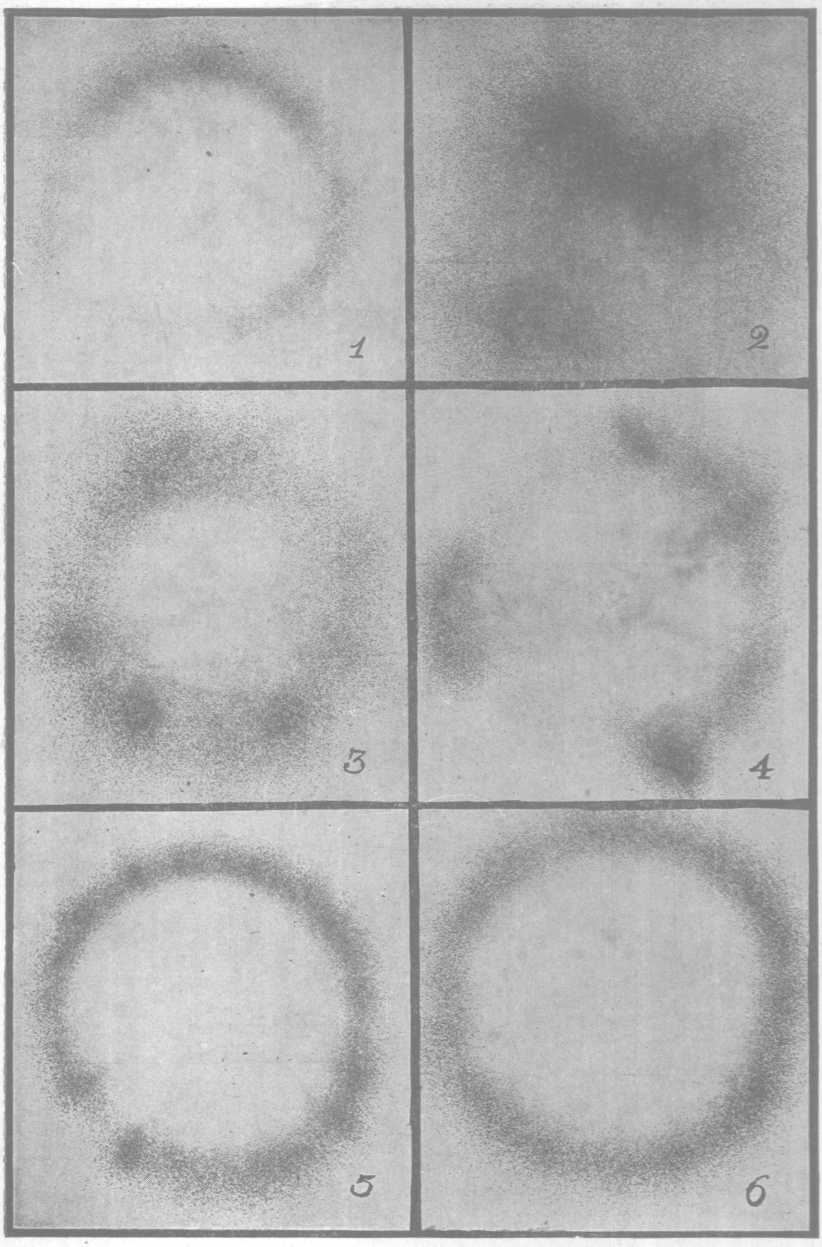

Plate XI. Test sheet showing the distribution of the spray by different makes of nozzles when placed on the nozzle testing machine. (1) Tiger. (2) Massospray. (3) Whirlpool. (4) Simplex. (5) Scientific. (6) Friend.

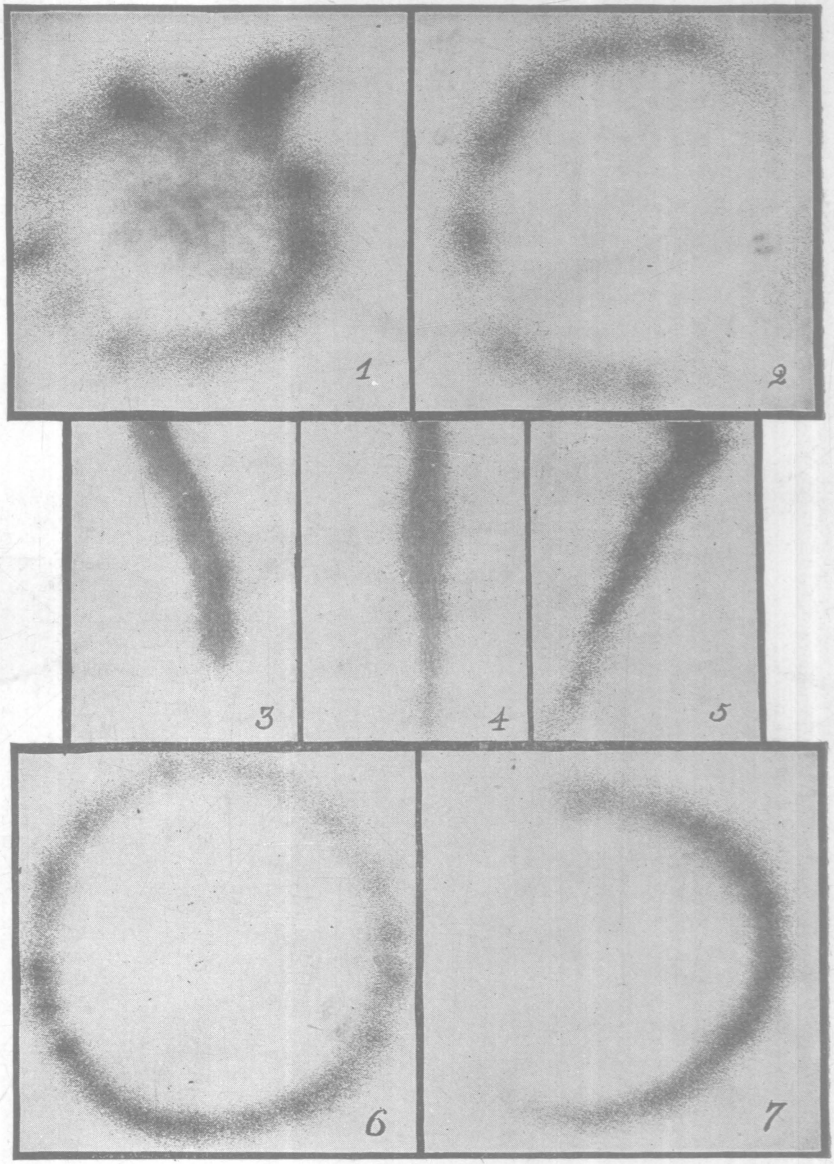

Plate XII. Test sheet showing the distribution of the spray by different makes of nozzles when placed on the nozzle testing machine. (1) Morrill and Morleys' Vermorel. (2) Myers' Graduating Vermorel. (3) Clipper. (4) Myers' Bordeaux. (5) Blizzard. (6) Deming Vermorel. (7) Demorel.