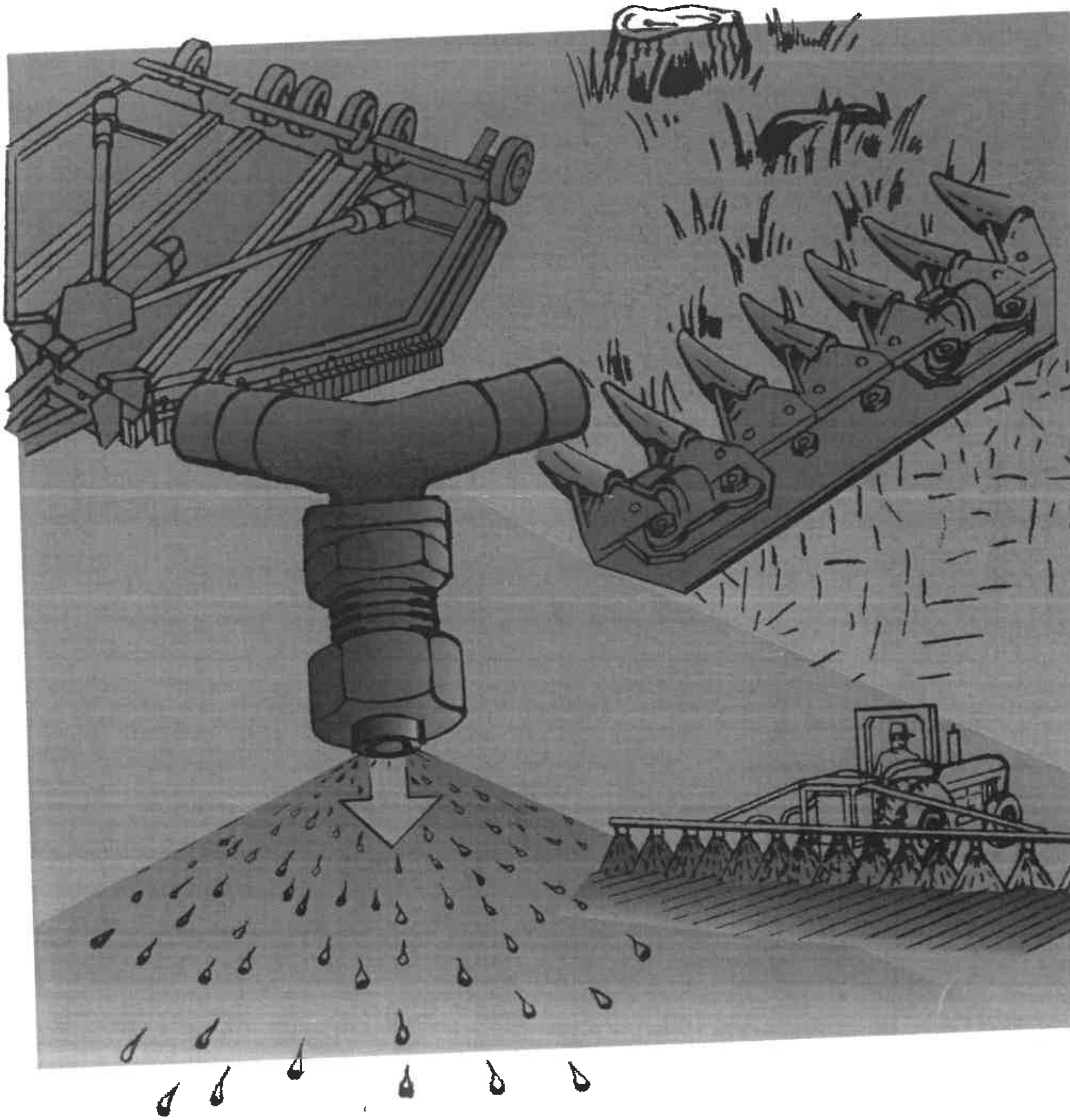
# MOWERS AND SPRAYERS

A basic guide to the operation, care, maintenance, adjustments and repair of different types of mowers and sprayers



FUNDAMENTALS OF SERVICE

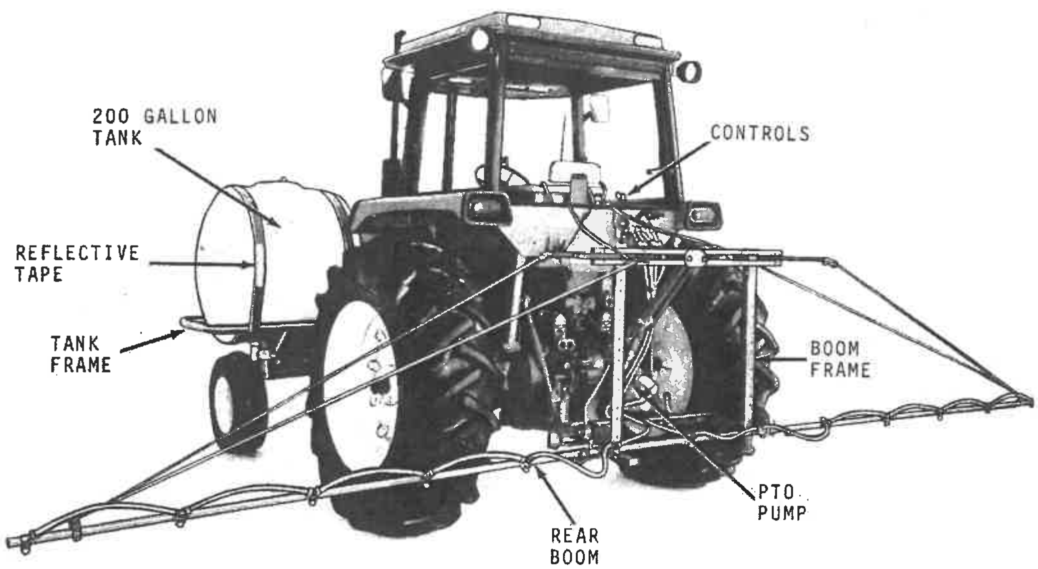



Fig. 1 — Sprayer With Rear-Mounted Boom On A Tractor

## INTRODUCTION

Low-pressure sprayers apply chemicals to control weeds, insects, and diseases in field crops, ornamentals, turf, fruits, vegetables, etc. The effective and accurate application of the chemicals requires that the sprayer be correctly operated and maintained. Improper application of chemicals can be very costly, both economically and environmentally.

Sprayers are available in many models, and may be tractor-mounted, truck-mounted, pull-type, or self-propelled. All low-pressure sprayers have several basic components: a tank, a pump, an agitation system, a flow-control system, and a distribution system.

In this section we will examine the operation, calibration and maintenance of these basic components. All of these factors are important to insure that the sprayer operates efficiently.

Beg.

## SOLUTION FLOW

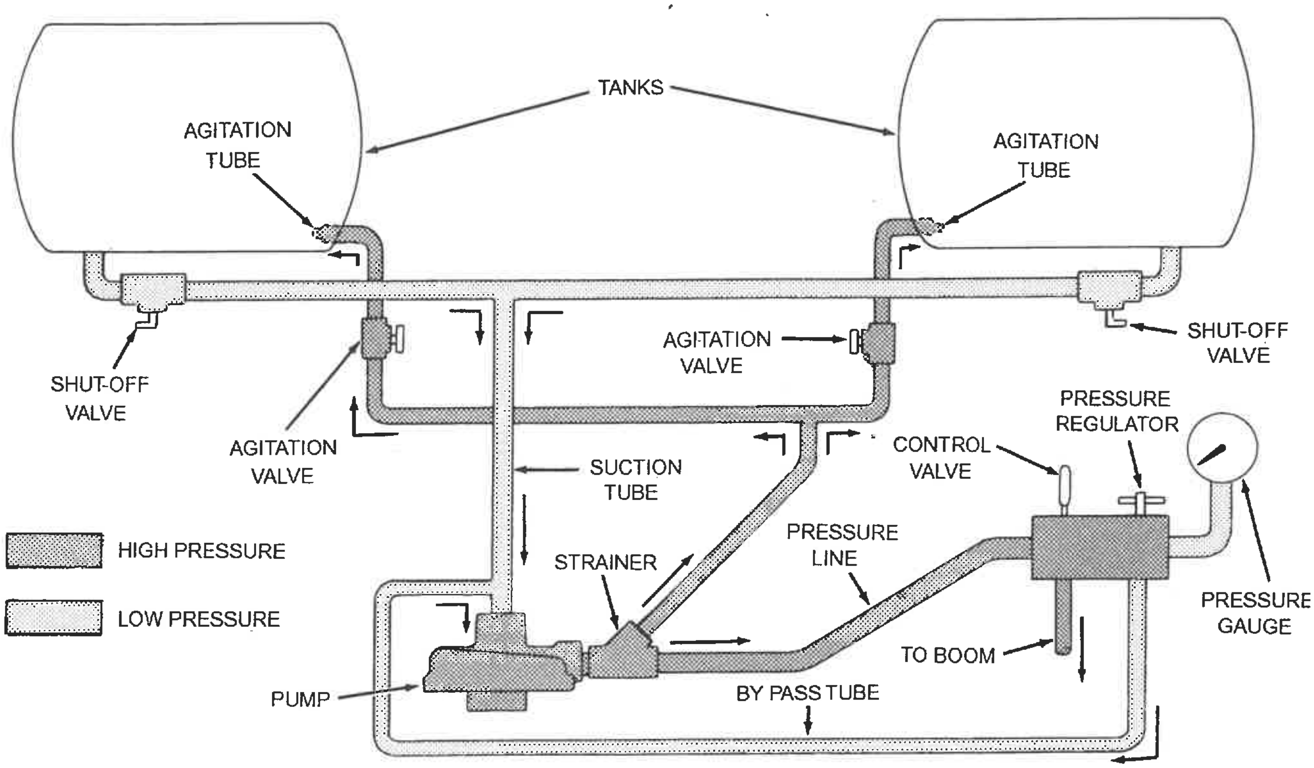



Fig. 2 — Flow Diagram For Sprayer With PTO Driven Pump

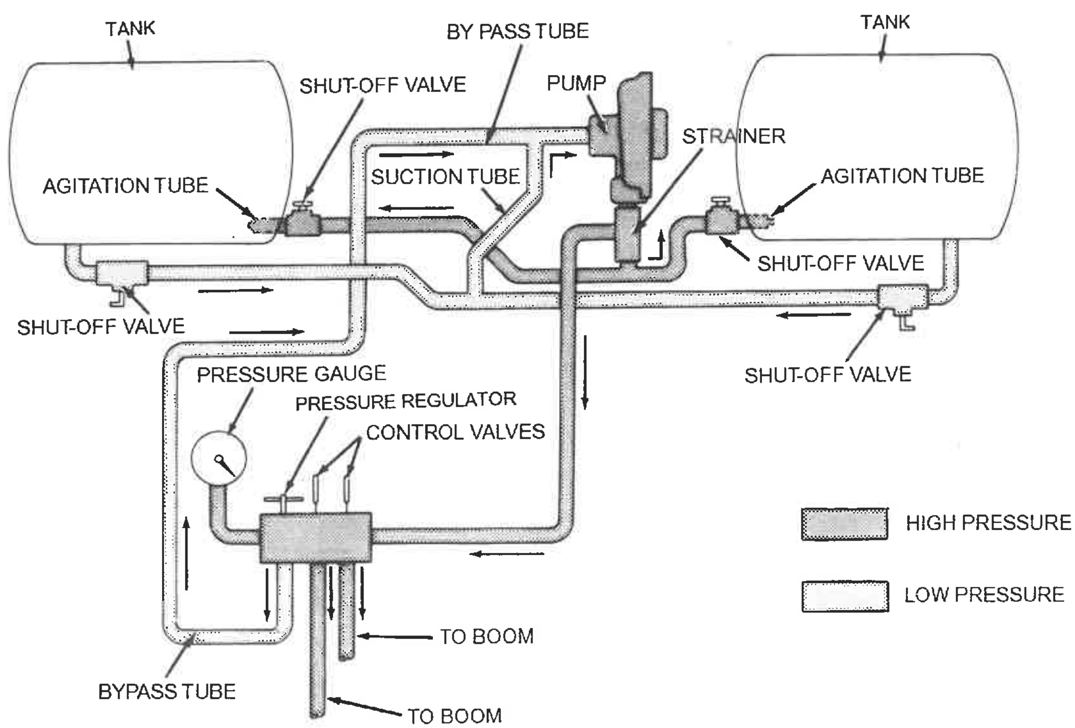



Fig. 3 — Flow Diagram For Sprayer With Hydraulic Motor Driven Pump

Although there are many different sprayer designs, the solution flow is basically the same. A typical flow diagram for a sprayer utilizing a pto driven pump and a single-section control valve is shown in Fig. 2. A typical flow diagram for a sprayer utilizing a hydraulic motor driven pump and a dual-section control valve is shown in Fig. 3.

Normally, the spray solution is gravity fed from the *solution tank* through a *shut-off valve* to the pump inlet. The *pump* must provide the necessary flow rate at the desired pressure to supply the gallons per minute (liters per minute) required by the nozzles and the tank agitator.

The spray solution is first pumped through a *strainer-diverter* where the impurities are removed before they can reach the precision parts of the sprayer. At this point, some of the solution goes back to the sprayer tanks through the *agitation tube* to keep the spray solution evenly dispersed in the tanks.

The remainder of the spray solution travels to the flow control system. The flow control system consists of a pressure regulator, a pressure gauge, and one or more solution control valves.

The *pressure regulator* maintains a constant pressure in the system. Some of the solution will pass through the pressure regulator and flow back to the pump inlet through the *bypass tube* and repeat the flow process.

The *pressure gauge* provides constant pressure readings of the spray solution.

The *solution control valve* provides instantaneous delivery or shut-off of the spray solution to the sprayer nozzles on a boom or handgun.

The sprayer distribution system normally consists of the boom, the nozzles, and the hoses and fittings necessary to connect the nozzles to the flow control system.

The *boom* serves as the mounting for the sprayer noz zles. The *sprayer nozzles* atomize the spray solutio into droplets and disperse the droplets in a specific pattern for proper impact with the surface on which the chemical solution is to be applied.

## SPRAYER PARTS

Most sprayers have the following basic parts:

- **Sprayer tanks**
- **Sprayer pumps**
- **Strainers**
- **Agitation systems**
- **Pressure regulator and solution controls**
- **Spraying nozzles**

## SPRAYER TANKS

The sprayer tank or tanks holds the spray solution. The tank can be constructed of any of several corrosion-resistant materials, depending on the nature of the spray solution to be used and the length of service needed.

Stainless steel tanks are strong, durable, and resistant to corrosion, but usually cost more initially. Galvanized tanks are inexpensive, but they tend to corrode when used with some spray solutions. Aluminum tanks are durable and moderate in price, but they also will react with some spray solutions, resulting in rapid corrosion.

Fiberglass and plastic tanks are widely used on all types of sprayers. They are relatively inexpensive and resistant to chemical reactions, but tanks made of these materials are more subject to breakage than metal tanks are.

## SPRAYER PUMPS

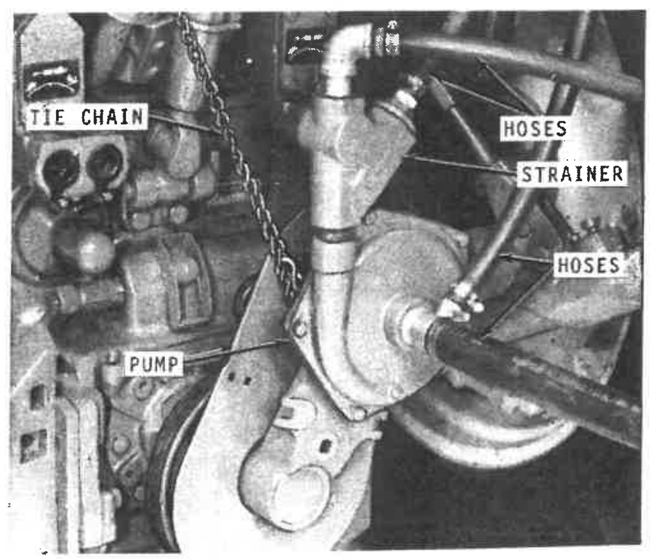



Fig. 4 — A PTO Driven Centrifugal Pump

Most sprayers are designed to operate at relatively low pressure, 10–80 psi (69–551 kPa), and are normally equipped with relatively inexpensive pumps such as the centrifugal pump or the roller pump (Fig. 4).

Some sprayers used to apply insecticides and fungicides at high pressures are equipped with the more elaborate and expensive piston pump. A newer type of pump described as a turbine pump also is available. Gear pumps, flexible impeller pumps, and diaphragm pumps are used less frequently.

The pump may be belt driven, hydraulic motor driven, PTO driven, or direct coupled to an electric motor or a gasoline engine, depending on the sprayer model. Some sprayers incorporate an electrically actuated clutch in the pump drive system.

Centrifugal And Turbine Pumps

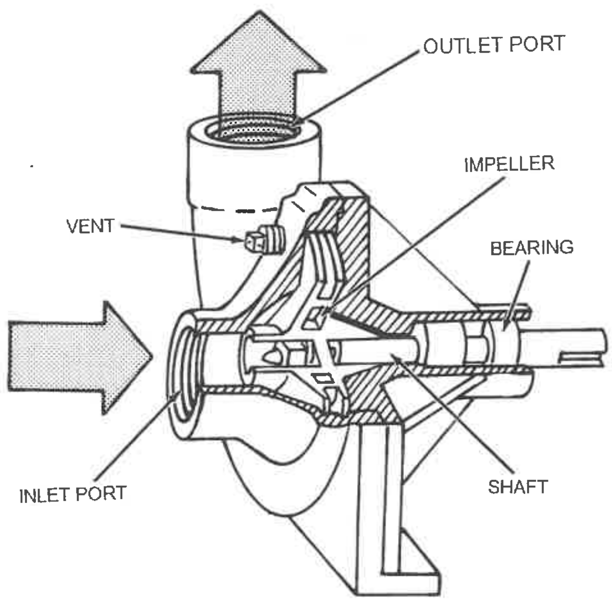



Fig. 5 — Centrifugal Pump

The centrifugal pump is popular on sprayers because of its reasonable cost, simplicity, and durability. It can readily handle wettable powders and abrasive materials.

*Centrifugal pumps* develop pressure as a result of centrifugal force (Fig. 5). The spray solution enters the pump through the center of a rotating impeller. The solution is thrown outward, radially, to the outer edge of the pump housing, and is forced out the pump outlet.

Centrifugal pumps can produce high volume output, but the maximum pressure that can be developed is about 75 psi (517 kPa). The output volume drops off rapidly when the outlet pressure is above approximately 40 psi (275 kPa). A sprayer equipped with a centrifugal pump could be used without a pressure regulator because shutting off the delivery system does not damage the pump or result in the drastic changes in pressure common with some other types of pumps.

Since centrifugal pumps are not self-priming, they should be mounted below the supply tank to aid in priming. The inlet of a centrifugal pump should never be restricted. A partially clogged suction strainer, a collapsed or kinked suction line, or a suction line with insufficient capacity will result in a loss of pressure control and possible damage to the pump.

The capacity of centrifugal pumps varies directly with the impeller speed, which is normally 1200 to 3500 rpm. When operating a centrifugal pump from the tractor PTO shaft, the need to operate at high impeller speeds requires an extra belt and pulley system or a gear system for attaining the proper pump operating speed.

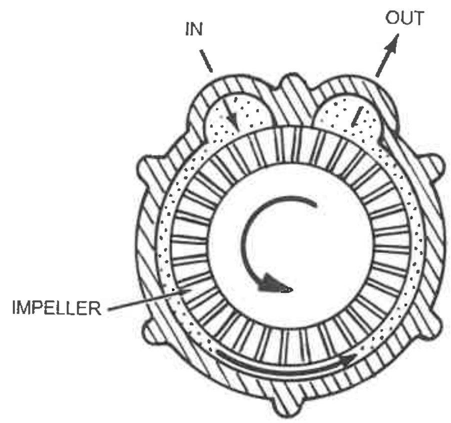



Fig. 6 — Turbine Pump

*Turbine pumps* are also available for use on low-pressure sprayers. These pumps are similar to centrifugal pumps except that the spray solution is both picked up and delivered at the outer edge of the pump housing (Fig. 6).

The turbine pump has the high volume and low pressure characteristics of the centrifugal pump, but unlike the centrifugal pump, it operates efficiently at lower speeds. The pump will operate directly from a 1000 rpm PTO shaft or with a step-up speed mechanism from a 540 rpm PTO shaft.

*Roller pumps* are popular because of their low initial cost, compact size, and efficient operation at tractor power take-off speeds. The roller pump is capable of

Roller Pumps

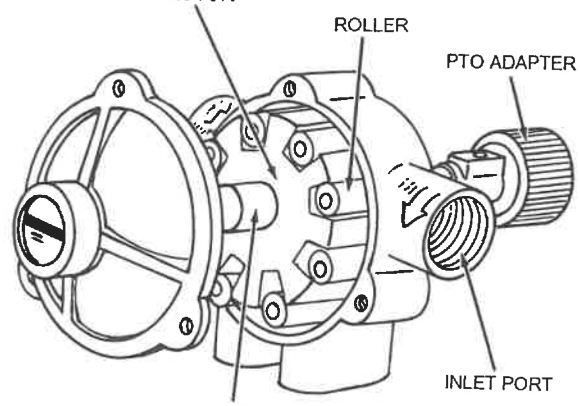



Fig. 7 — Roller Pump

generating higher pressures, up to 300 psi (2068 kPa), than the centrifugal pump.

The roller pump has loose rollers fitted into slots in an impeller that is mounted off-center in the pump housing (Fig. 7). The rotating impeller forces the rollers to follow the wall of the pump housing. As the rollers pass the pump inlet, the spaces around the rollers enlarge and are filled with spray solution. When the rollers approach the pump outlet, the spaces become smaller and the fluid is forced through the outlet.

Piston Pumps

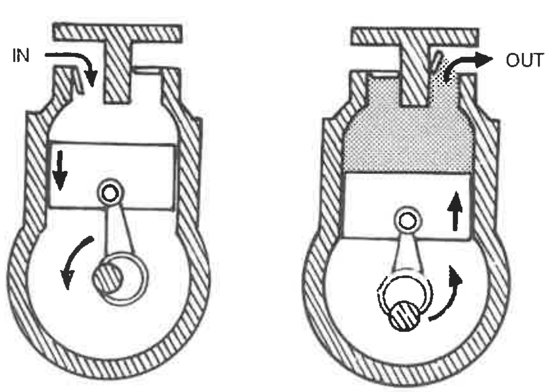



Fig. 8 — Piston Pump

Sprayers that operate at high pressures are equipped with a *piston pump.* They are designed to handle all chemicals and to develop pressures up to 800 psi (5515 kPa).

The piston pump operates on the principle that as the piston recedes in the cylinder, a negative pressure results which opens a poppet valve and allows the spray solution to be pulled into the cylinder (Fig. 8). The liquid is then forced out of the cylinder through another poppet valve that is opened by the positive pressure created as the piston advances in the cylinder.

Piston pumps can be driven by an electric motor or a hydraulic motor or they can be ground wheel driven. Because piston pumps are positive displacement pumps that deliver an exact volume of spray each time the piston makes a cycle, they can be used as metering devices when actuated by a ground driven wheel. The pump output will be directly proportional to the speed of the ground driven wheel to insure that the amount of chemical delivered per acre (hectare) is constant even though the ground speed of the sprayer rig may vary considerably.

STRAINERS

Three types of *strainers* are commonly used on sprayers: tank-filler strainers, line strainers, and nozzle strainers.

Coarse strainers located in the tank-filler opening prevent debris from entering the tank as it is being filled.

Suction-line strainers are used between the tank and the roller pump or piston pump to prevent rust, scale, or other material from damaging the pump (Fig. 9). Suction-line strainers are generally not needed to protect a centrifugal pump except against large pieces of foreign material.

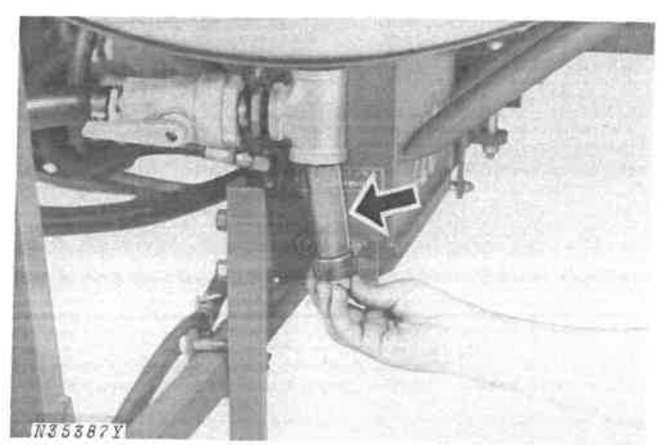



Fig. 9 — Suction-Line Strainer

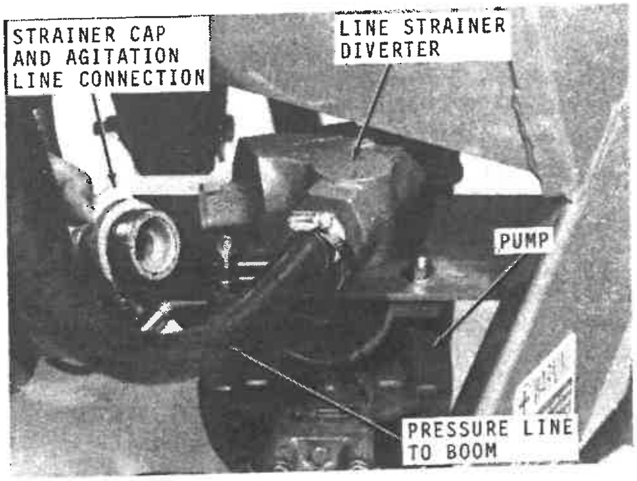



Fig. 10 — Strainer-Diverter

A strainer-diverter (Fig. 10) is normally located on the pressure side of the pump to perform two functions: (1) to strain the solution being pumped to the boom to protect the spray nozzles and (2) to redirect some of the solution back to the tank through the agitation line to keep the spray mixture evenly dispersed in the tank.

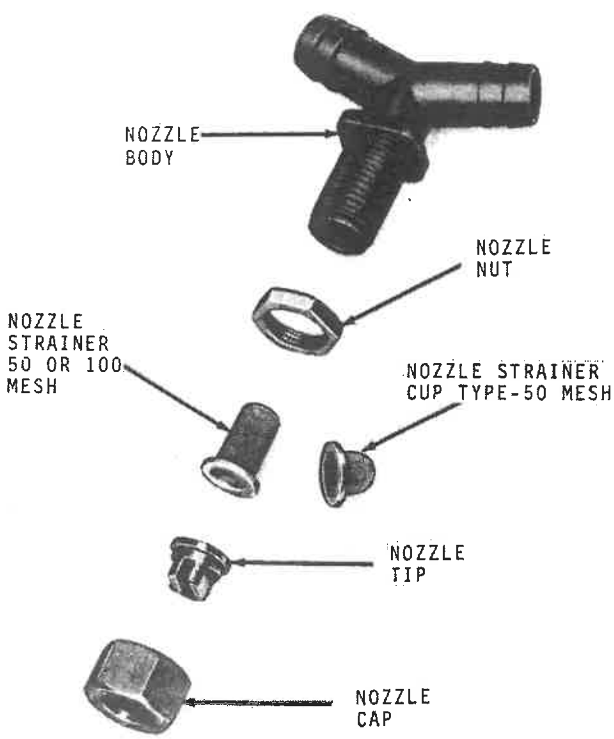



Fig. 11 — Typical Sprayer Nozzle Assembly

Most nozzles must have a strainer of the proper size to stop any particle that may plug the nozzle tip orifice (Fig. 11). These strainers vary in size, depending upon the size of the nozzle tip used, but they are commonly 50 or 100 mesh. In general, 100 mesh strainers are recommended for most nozzles with a flow rate below 0.2 gallons (0.75 L) per minute, and 50 mesh strainers are for nozzles with a flow rate between 0.2 gallons (0.75 L) and 1 gallon (3.785 L) per minute.

## AGITATION SYSTEMS

Agitation requirements depend largely upon the formulation of the chemical solution being applied. Soluble liquids and powders do not require special agitation once they are in solution, but wettable powders and emulsions will usually separate if they are not agitated by some means. Either mechanical paddles or hydraulic jets can be used to agitate the spray solution.

*Hydraulic agitation* is most commonly used on low-pressure sprayers. A portion of the pump output is returned to the tank through the agitation tube and discharged under pressure into the tank through holes in a pipe running the entire length of the tank or through special agitator nozzles. The amount of flow needed for agitation depends upon the chemical used, as well as the size and shape of the tank.

## PRESSURE REGULATOR AND SOLUTION CONTROLS

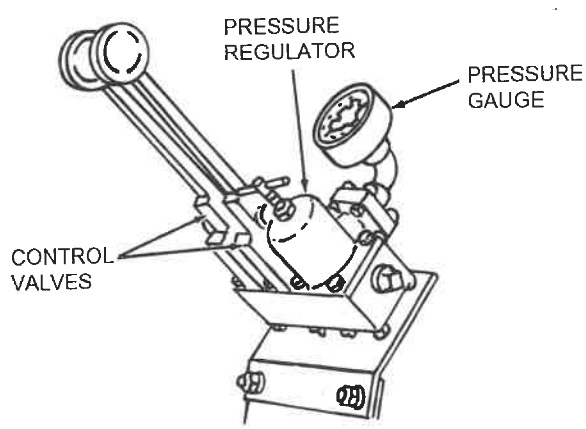



Fig. 12 — Pressure Regulator And Solution Control Valves

The flow of spray solution to the sprayer nozzles is controlled and regulated by the solution control system. All solution control systems are similar. Although the mounting and number of the standard and optional controls may vary, the control system always consists of a pressure regulator, one or more solution control valves, and a pressure gauge (Fig. 12).


Litho in U.S.A.

The *solution control valve* controls the flow of the spray solution to the spray boom. There may be one, two, or three solution control valves used, depending on the number of hoses to the boom. Opening the valves permits the spray solution to flow to the boom nozzles, and closing the valves shuts off the flow to the boom.

The *pressure regulator* controls and maintains the solution pressure to the spray nozzles. The pressure to the nozzles is one of the factors in determining the rate of chemical application.

The operating pressure may be changed by turning the regulator valve handle to obtain the desired pressure to the nozzles. At a high pressure setting, most of the spray solution will flow through the control valve to the nozzles. At a low pressure setting, much of the spray solution will pass through the pressure regulator valve and flow back to the pump inlet through the bypass tube and repeat the flow process.

The *pressure gauge* is always an independent unit. It may be mounted directly on the control valve manifold or to a fitting installed in the control cluster piping.

The pressure gauge shows the amount of pressure of the solution as set by the regulator. The importance of a good pressure gauge cannot be overemphasized. Because the nozzles are designed to operate within certain pressure limits, the pressure gauge must be used for calibrating and while operating in the field.

## SPRAYING NOZZLES

The *spraying nozzles* (Fig. 13) are a very important part of the chemical application. They can apply an accurate amount of liquid over a large area.

The nozzles help determine the amount of spray delivered, the spray pattern, the uniformity of the applied spray, the distribution of the chemical on the target, and the amount of drift.

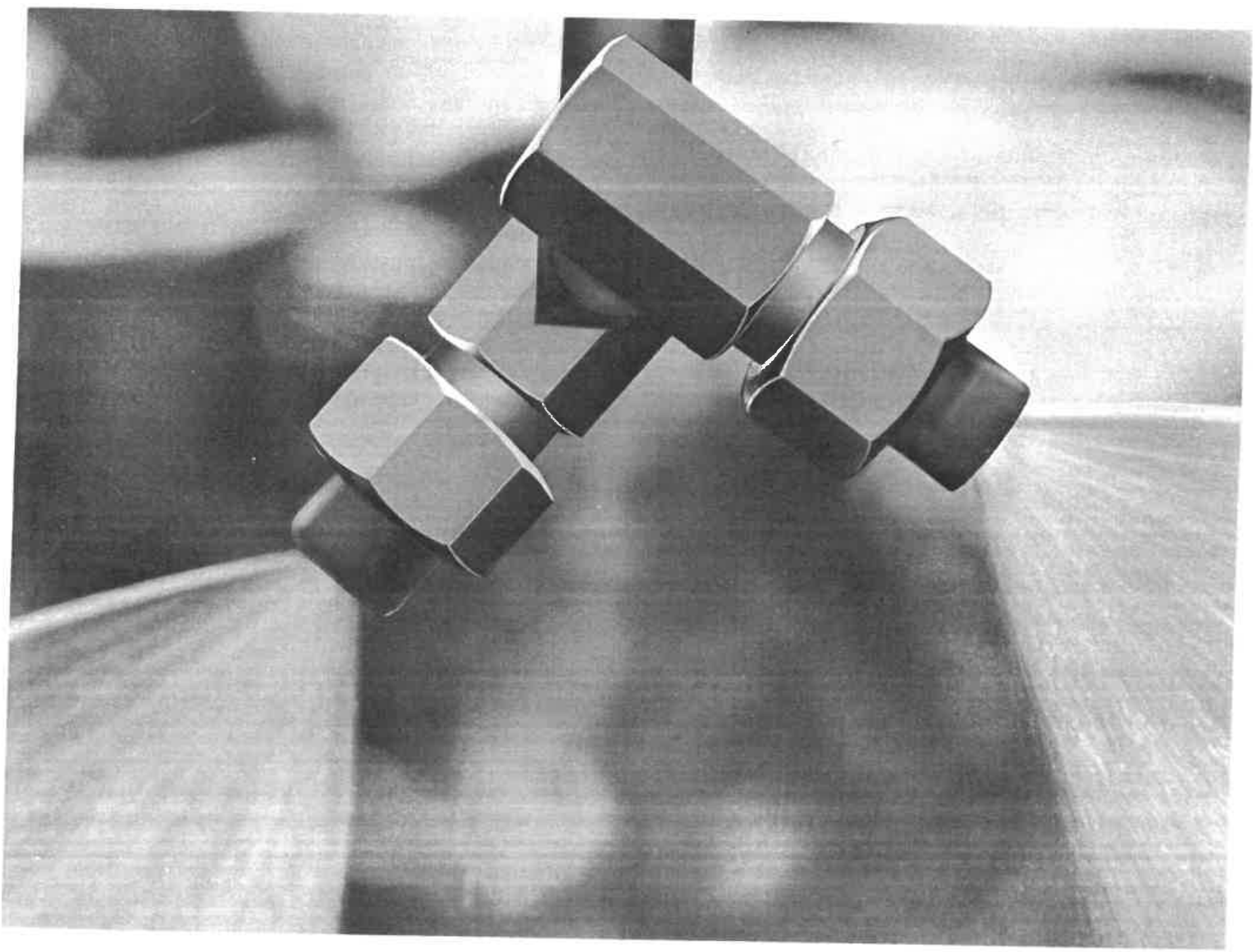


Fig. 13 — Spraying Nozzles At Work



Litho in U.S.A.

To do this, a nozzle must atomize a liquid into small droplets. Then it must spray these droplets in a specific pattern at a particular flow rate.

The nozzle does four basic jobs:

1. **Meters liquids at a certain flow rate.**
2. **Atomizes liquids into droplets.**
3. **Disperses the droplets in a specific pattern.**
4. **Propels the droplets for proper impact.**

Let's examine these four jobs in terms of nozzle *flow* rate and *atomization.*

## FLOW RATE

The nozzle flow rate is chiefly controlled by the size of the orifice in the nozzle tip. Within limits, however, the system pressure and the solution density and viscosity also affect the flow rate.

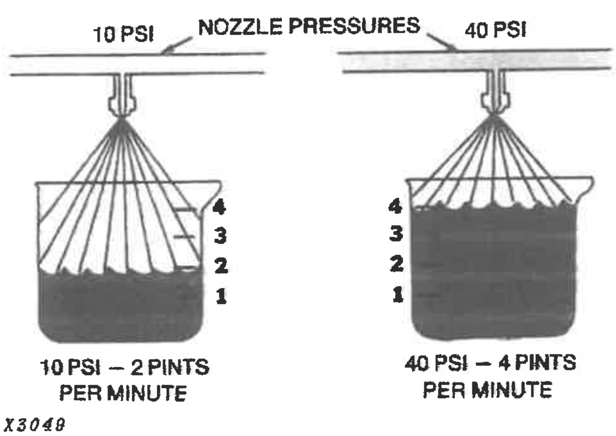



Fig. 14 — Flow Rate Is In Proportion To Pressure

With most nozzles, flow rate is in proportion to pressure. **The higher the pressure, the higher the flow rate.**

To double the flow rate, the pressure must be increased four times (Fig. 14). Conversely, to decrease the flow rate by half, the pressure must be reduced to one-fourth of the original pressure.

Most nozzles are designed for optimum performance at specific pressures, however, and the range of adjustment is relatively narrow. Line pressures too high or too low will affect the formation of spray droplets and create variations in the spray pattern.

Density and viscosity of the fluid can affect the flow rate in different ways. Under some conditions the flow rate will actually increase with more viscosity. Usually, however, **the more dense and viscous the liquid, the lower the flow rate.**

## ATOMIZATION

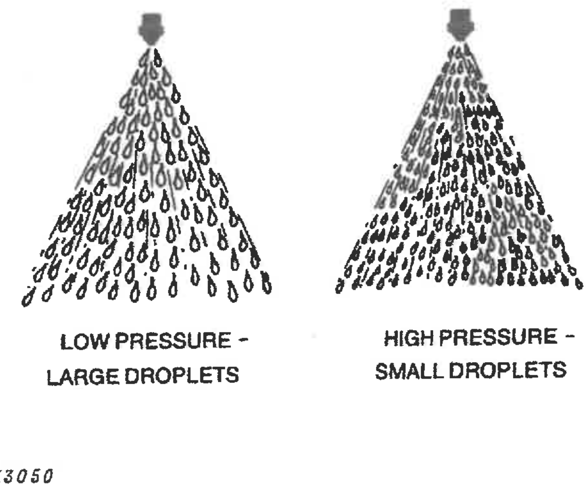



Fig. 15 — Droplet Size Decreases As Pressure Increases

Atomization is the liquid break-up caused by the tearing action of air. As the liquid exits from the nozzle, it is in unstable sheets or jets, which collapse into tiny droplets. Usually the finer droplets are toward the inside of the spray pattern, while the larger droplets are at the outer edge.

The size of droplets is affected by nozzle rating, pressure, viscosity, and surface tension.

**As pressure is increased, the droplet size decreases for a finer spray** (Fig. 15). A limit is eventually reached where more pressure has little effect on finer atomization.

**With more viscous or dense fluids, larger droplets occur.** Usually higher pressures are required to break up the liquid into the desired spray.

While surface tension does not affect atomization as much as viscosity, this tension can be difficult to break up if the liquid is denser. Another liquid of the same viscosity but with less surface tension can be atomized more easily.

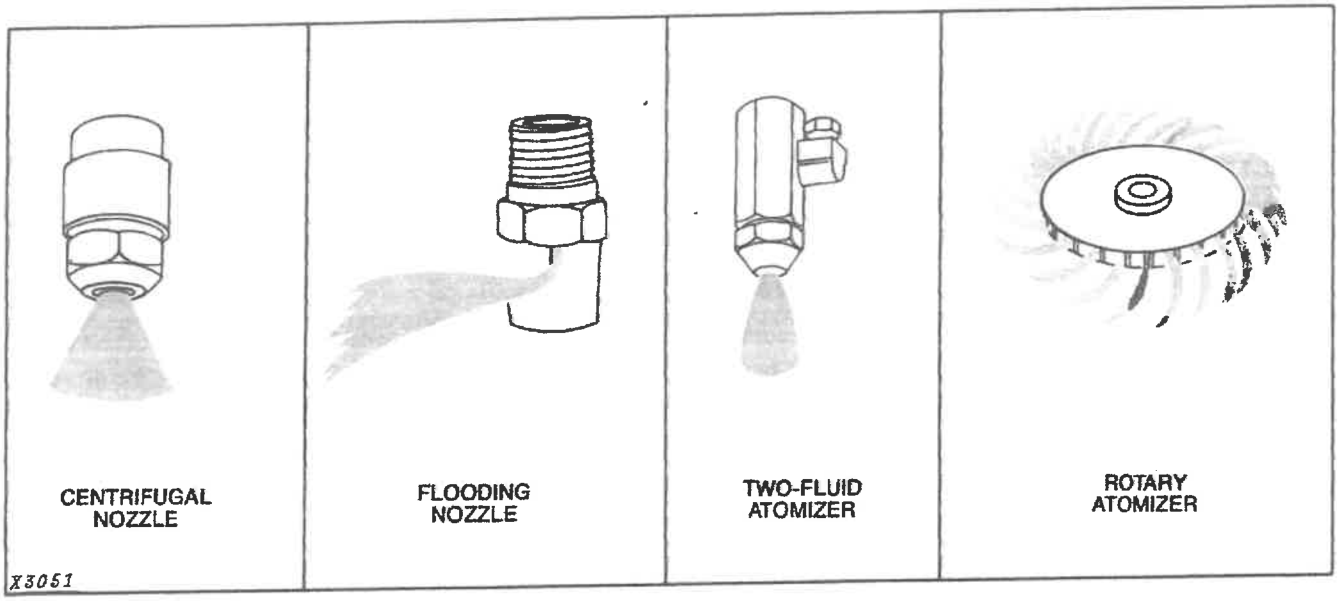



Fig. 16 — Common Types Of Nozzles

In some spray applications, such as insecticides, a finer droplet size is required in order to obtain good spray impact and coverage of the plant. But with greater atomization, the spray is more susceptible to wind drift. **Therefore, protective clothing and a respirator must be worn by the operator.**

Larger droplets are generally recommended for spraying herbicides. Tips with larger orifices such as flooding tips and lower operating pressures 15 to 50 psi (100 to 345 kPa) will give larger droplets and reduce harmful spray drift.

## TYPES OF NOZZLES

Spraying nozzles are made in several designs. Each design atomizes fluids in a specific way to meet the job requirements.

The common types of nozzles are:

- **Centrifugal nozzles**
- **Flooding nozzles**
- **Two-fluid atomizers**
- **Rotary atomizers**

CENTRIFUGAL NOZZLES are most common (Fig. 16). They are made with a wide range of spray angles, spray patterns, and capacities.

FLOODING NOZZLES produce a spray in the shape of a fan or sheet (Fig. 16). They may also be called "fan-spray" nozzles.

TWO-FLUID ATOMIZERS can produce very fine droplets and will handle dense fluids. However, they require more pressure than other nozzles.

ROTARY ATOMIZERS use centrifugal force generated by a spinning nozzle rather than hydraulic pressure to produce spray droplets in a 360 degree spray pattern.

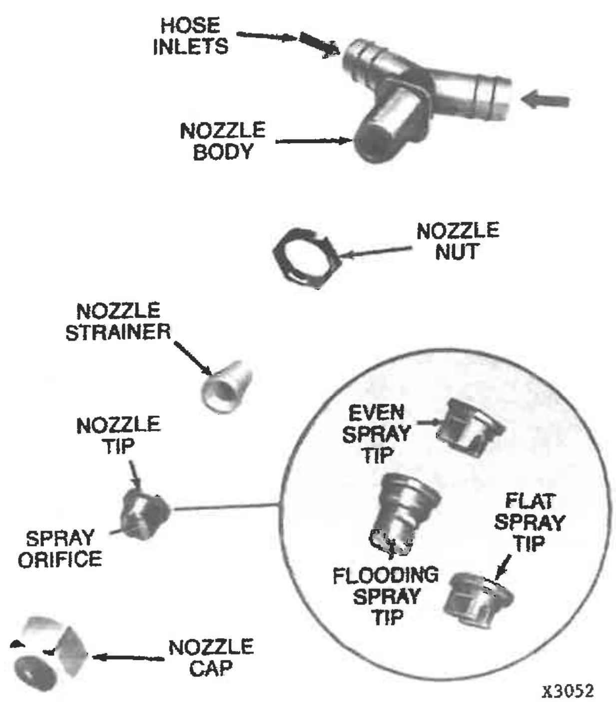



Fig. 17 — Typical Spraying Nozzle Assembly

## PARTS OF A NOZZLE

Nozzles have four basic components (Fig. 17).

- **Body**
- **Strainer**
- **Tip**
- **Cap**

Let's look at each part in detail.

### NOZZLE BODY AND CAP

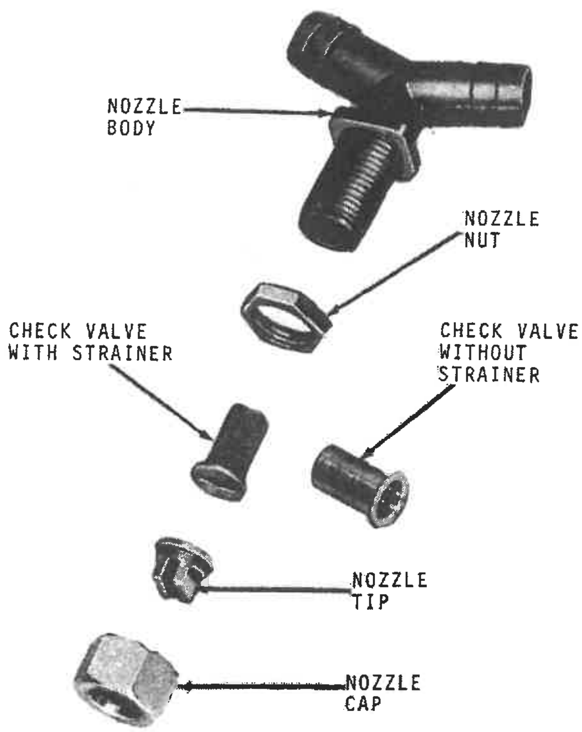



Fig. 18 — Nozzle And Check Valve Assembly

Nozzle bodies and caps are usually made of brass, aluminum, stainless steel, zinc-plated steel, or nylon (Fig. 18). These bodies and caps are designed to accept several different tips that spray various patterns (see Fig. 17). The cap holds the nozzle tip and strainer in place in the nozzle body.

Usually the nozzle body is attached to a dry boom or a wet boom.

On a dry boom, the nozzle bodies are clamped to the boom and the nozzles are supplied with fluid by hoses (Fig. 19).

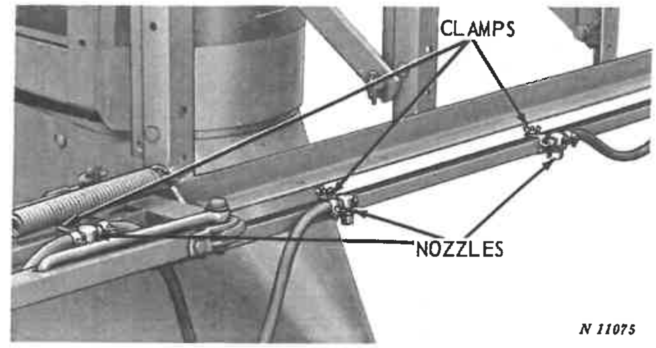



Fig. 19 — Nozzles Clamped To Dry Boom

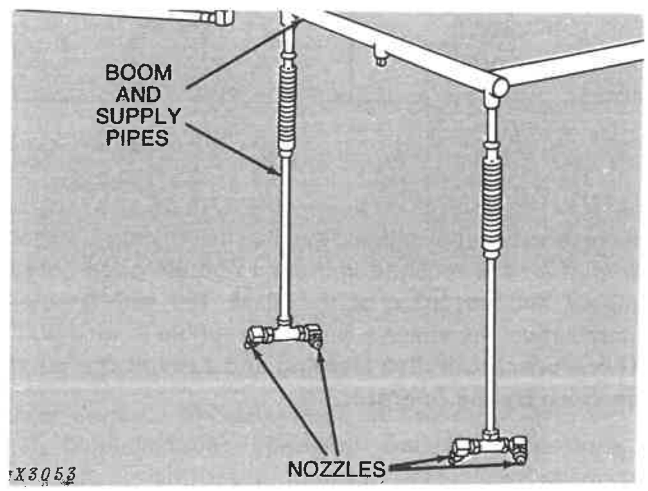



Fig. 20 — Nozzles Installed In A Wet Boom

On a wet boom, the nozzles are attached to a pipe which carries the fluid to each nozzle while functioning as part of the boom structure (Fig. 20).

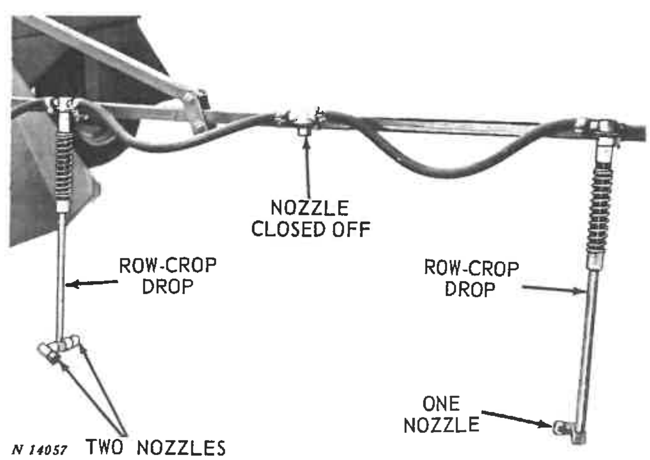



Fig. 21 — Swivel Nozzles On Row-Crop Drops

Another kind of nozzle body is the *swivel type.* Swivel bodies are attached to the lower end of a row-crop drop (Fig. 21). This allows more accurate placing of spray for use after the crop has emerged, such as for insecticide spraying of the plants. A double swivel nozzle is used between the rows to direct the spray in both directions while a single swivel nozzle is used at the outer ends of the boom.

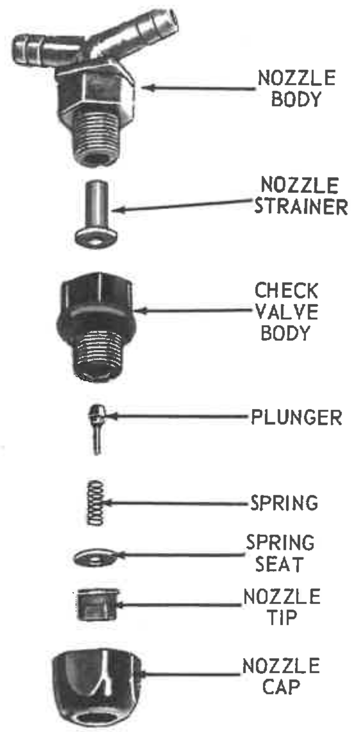



Fig. 22 — Plunger-Type Nozzle Check Valve

In some spraying operations, it is nice to have a quick shut-off at each nozzle so the nozzles won't drip at row ends or grass waterways. Check valves can be placed in the nozzle body (Fig. 18 and Fig. 22) to stop the flow.

When the line pressure drops below a certain low pressure, the valve automatically shuts off all flow. There are three valves used to do this: the ball-type (Fig. 18), the plunger-type (Fig. 22), and the diaphragm-type check valve.

The plunger and diaphragm check valves are contained in their own body and attach to the nozzle body. However, the ball check valve can be used in place of the tip strainer.

## NOZZLE STRAINERS

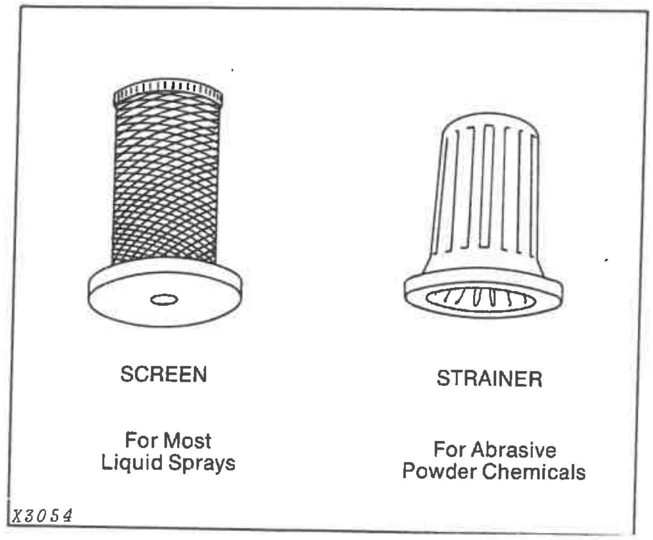



Fig. 23 — Nozzle Strainers

Nozzle screens or strainers (Fig. 23) provide the last screening of foreign material in the spraying system. This helps to prevent clogging at the nozzle tip.

On most *screens,* the screen material is stainless steel with mesh sizes of 50, 100, or 200 openings per linear inch (0.25 mm). The screen assembly is normally cylindrical and fits inside most nozzle bodies. This type of nozzle screen is used more with liquid-concentrate chemicals. When using powder chemicals, which are abrasive, a slotted *strainer* should be used (Fig. 23, right). These strainers have a larger mesh size equivalent to 16, 25, or 50 mesh.

When selecting a nozzle screen, choose the screen which has a mesh opening just a little *smaller* than the orifice in the nozzle tip. The smaller or finer the mesh, the more likely it is to clog.

A *clean* screen or strainer is vital for efficient and accurate distribution of the spray material. They should be checked and cleaned often. If not, erratic spray patterns, improper metering and delivery, or complete clogging of the nozzle will occur.

### NOZZLE TIPS AND SPRAY PATTERNS

Centrifugal and flooding nozzles have tips which provide five basic spray patterns (Fig. 24).

The centrifugal pressure nozzle produces a hollow or solid cone spray pattern. The flooding nozzle produces

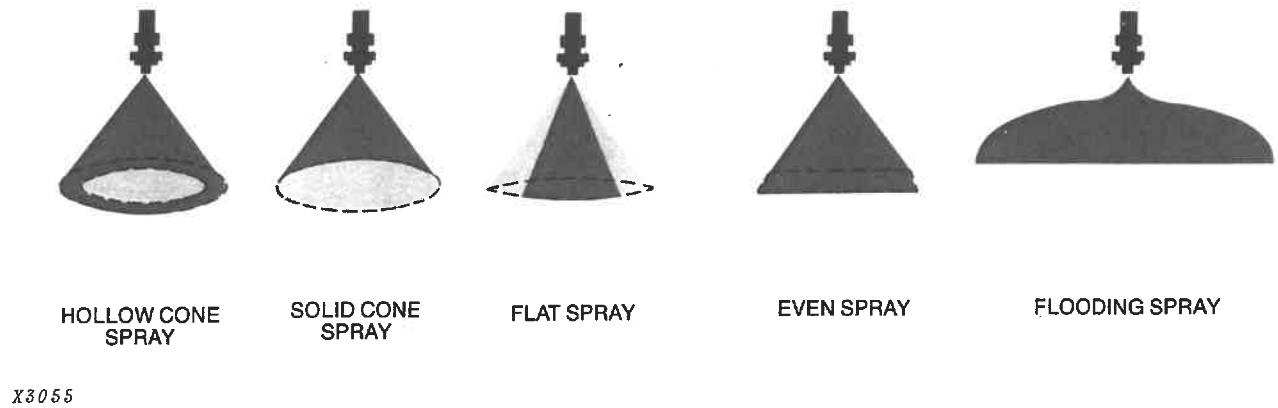



Fig. 24 — Types Of Spray Patterns

flat, even, or flooding spray patterns. With all these nozzles, various flow rates and spray angles are available.

Nozzle tips are most commonly made of: plastic, brass, or stainless steel. Some nozzle tips utilize stainless steel or ceramic orifice inserts to provide increased resistance to damage from abrasive and corrosive chemicals.

Brass nozzle tips are susceptible to chemical corrosion and the material is soft and the tips wear fast. Plastic nozzle tips have good chemical resistance and medium wear life; the orifice is susceptible to damage when cleaned. Nozzle tips made from stainless steel or using stainless steel inserts cost more, but they have very good durability and chemical resistance. Nozzle tips using ceramic inserts have superior wear life, being highly resistant to damage from abrasive and corrosive chemicals.

**As nozzle tips wear, the rate of application increases.** Tests have shown that some wettable powders may wear nozzle tips sufficiently to increase the rate as much as 12 percent after spraying 50 acres (20 ha). For this reason, frequent calibration of equipment is advisable.

### Hollow And Solid Cone Spray

Hollow and solid cone nozzles (Fig. 25) are popular for spraying high-volume fungicides, insecticides, and herbicides on row-crops (Fig. 26).These nozzles are generally used on spray booms or spray guns. They are more resistant to clogging from abrasive, wettable powders than other nozzles.

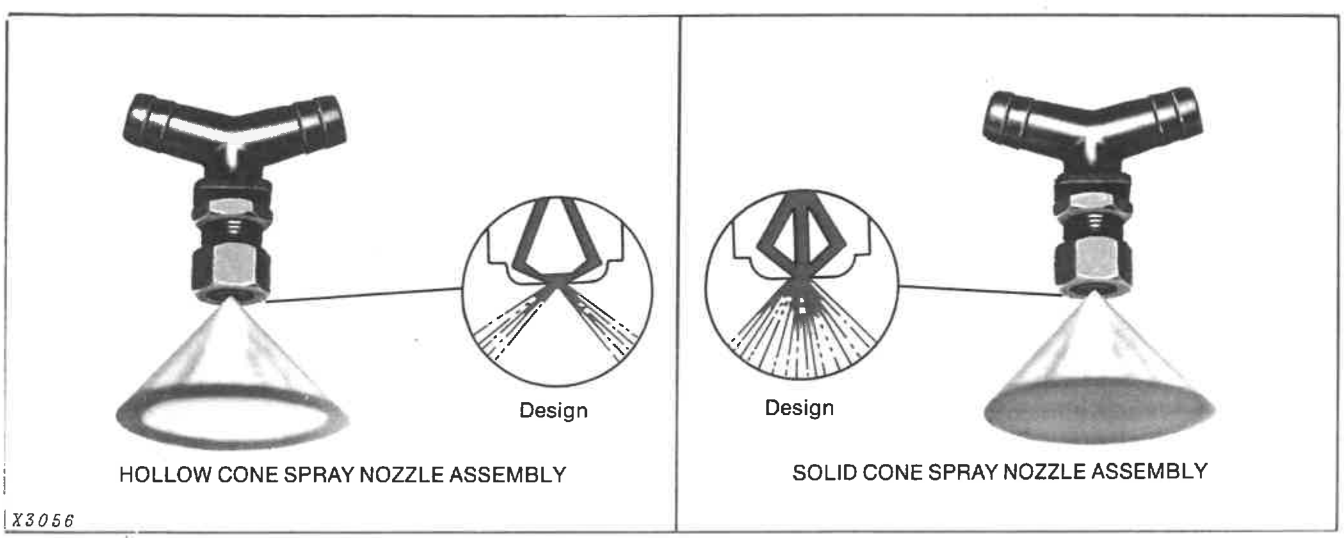



Fig. 25 — Hollow And Solid Cone Spray Pattern Nozzles

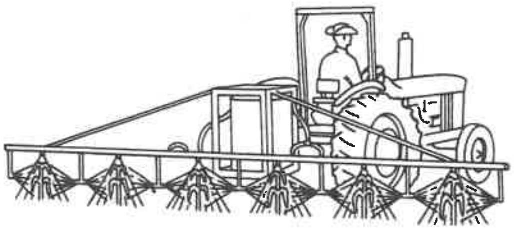


Fig. 26 — Row-Crop Spraying With Cone-Type Nozzles

The hollow and solid cone nozzles spray a cone pattern with relatively large droplets at low pressures. The spray angle may be from 30 to 120 degrees. Hollow cone nozzles (Fig. 25) produce a more uniform, finely atomized spray than solid cone nozzles.

Notice in Fig. 25 how the spray pattern is achieved. Hollow cone nozzles contain a core that swirls the liquid around before it exists the orifice. The solid cone nozzle has a center passage that supplies a jet of liquid which fills in the hollow cone.

Flat And Even Spray

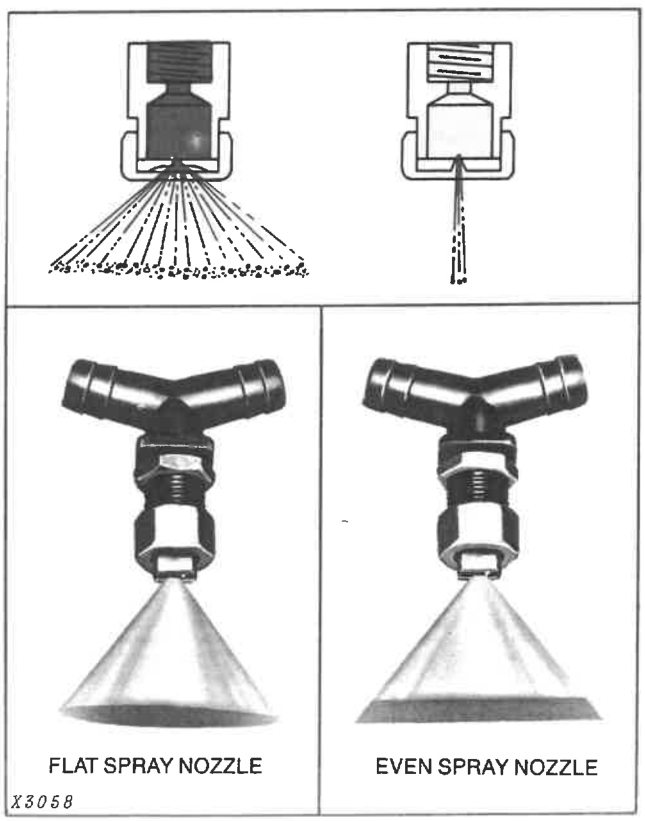



Fig. 27 — Fan Spray Pattern Nozzle

Flat and even spray patterns are produced by a fan-spray nozzle (Fig. 27).

The **flat** spray pattern is used for applying fertilizers, herbicides, and insecticides. It may also be used on boom sprayers, broadcast sprayers, planters, and cultivators.

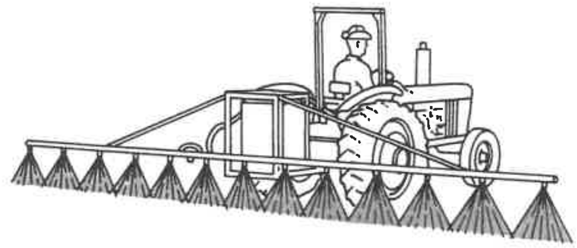


Fig. 28 — Overlapping Boom Spraying

This nozzle sprays a fan-shaped pattern with a gradually tapered edge. The spray angle may be between 65 and 80 degrees. When this pattern is properly overlapped, it provides even distribution of the liquid (Fig. 28).

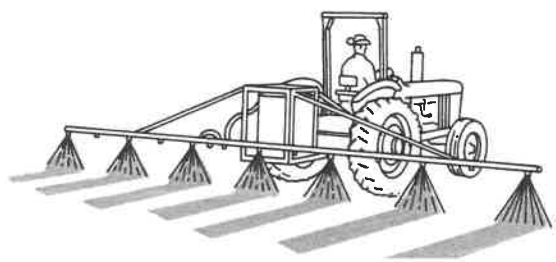


Fig. 29 — Band Spraying

The **even** spray pattern is used for applying liquid in an even band (Fig. 29). Often it is used with planter attachments for row patterns.

The even spray gives a fan-shaped pattern with uniform distribution across its full spray width. The spray angle may be between 80 and 95 degrees.

 Litho in U.S.A.

Flooding Spray

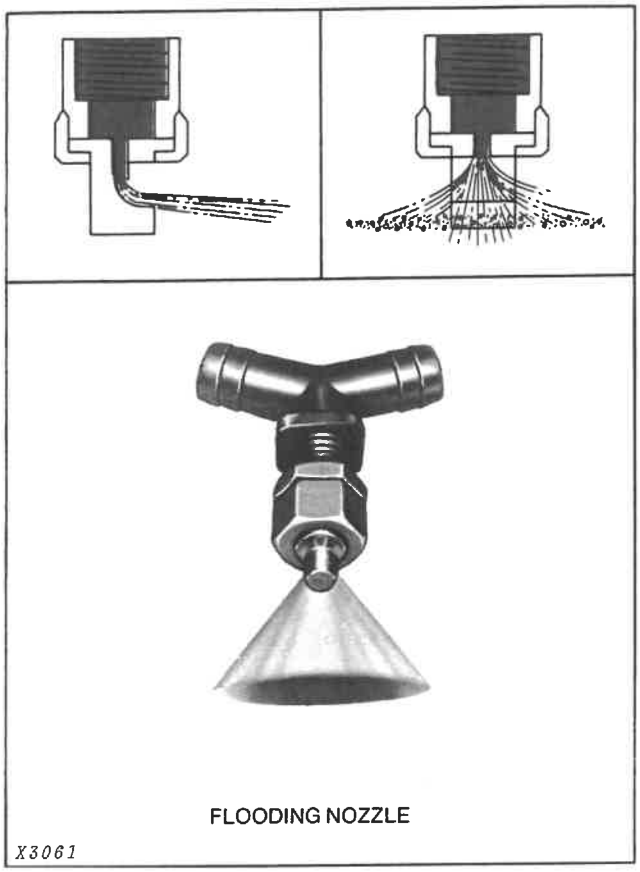



Fig. 30 — Flooding Spray Pattern Nozzle

Flooding nozzles deliver a wide, flat spray with large droplets (Fig. 30). As the liquid discharges from a plain orifice, it strikes a curved deflector which deflects the spray about 75 degrees. The spray angle may be between 70 and 160 degrees. These nozzles can be mounted in various positions to provide different patterns.

Fig. 31 — Boomless Broadcast Spraying

Flooding nozzles are often used for broadcast application of fertilizers and defoliants. Also, they are used in post-emergence application of herbicides. Usually these nozzles are mounted on boom sprayers or lay-by rigs. Sometimes they are used alone as in boomless broadcast spraying (Fig. 31).

OTHER TYPES OF SPRAY EQUIPMENT

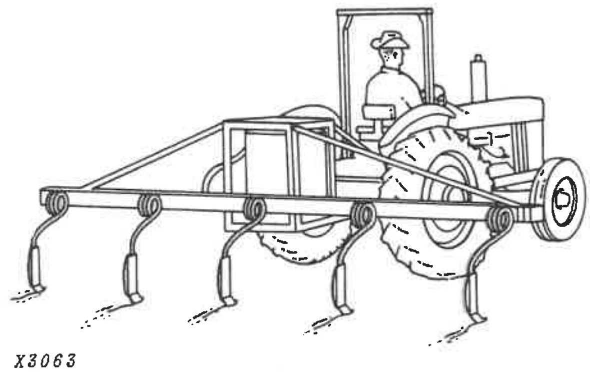



Fig. 32 — Subsoil Application of Liquid Fertilizer

Special equipment is available for other application methods, such as applying liquid fertilizer with subsoil attachments (Fig. 32).

These attachments carry the liquid into the soil under pressure. Nozzle check valves are normally used to prevent spray from dripping when turning at row ends.

Dribble applicators and wide-spray jets are also available.

Fig. 33 — Hand Spraying Gun

**Hand spray guns** are used for selective spraying (Fig. 33).

These guns can be used for fence rows, small weed patches, and for insect control in barns.

The hand gun may be used alone or connected to a mounted spray boom. Most guns contain their own check valves.

**Electronic spray-rate monitors** can be used to improve the sprayer application accuracy. The spray monitor controls the solution flow rate to the nozzles, according to the ground speed of the spray vehicle, to maintain a constant rate of application regardless of variations in the ground speed or terrain.

Several different designs of electronic spray-rate monitor systems are available. A schematic of one type of system is shown in Fig. 34. In this type of system, both the ground speed of the sprayer and the volume of the spray solution flowing through a flow meter is calculated continuously by the monitor unit. The monitor will automatically maintain a constant application rate by changing the nozzle pressure, and thus the flow rate of the chemical solution through the spray nozzles, to compensate for changes in the vehicle ground speed.

When the monitor senses a decrease in the vehicle ground speed, a series of electronic rate correction signals are sent to the electrically actuated pressure regulator. These signals instruct the regulator valve to reduce the pressure to the nozzle, thus reducing the nozzle flow rate, to compensate for the reduced ground speed and maintain delivery at a constant rate. The opposite effect occurs when the vehicle ground speed increases—the pressure to the nozzles is raised to increase the amount of spray solution flowing through the nozzles to match the increase in the ground speed.

Another type of electronic monitor system uses a chemical injection spray system to maintain a constant rate of application. Instead of mixing the chemical with the water in the sprayer tank, the chemical injection system use one or more positive displacement metering pumps to inject a precise amount of chemical into the line carrying water to the booms.

The metering pump is driven by a variable speed electric motor. The chemical injection rate, the water flow rate to the booms, and the vehicle speed are calculated continuously by the monitor. Changes in the vehicle speed are sensed by the monitor unit, and an

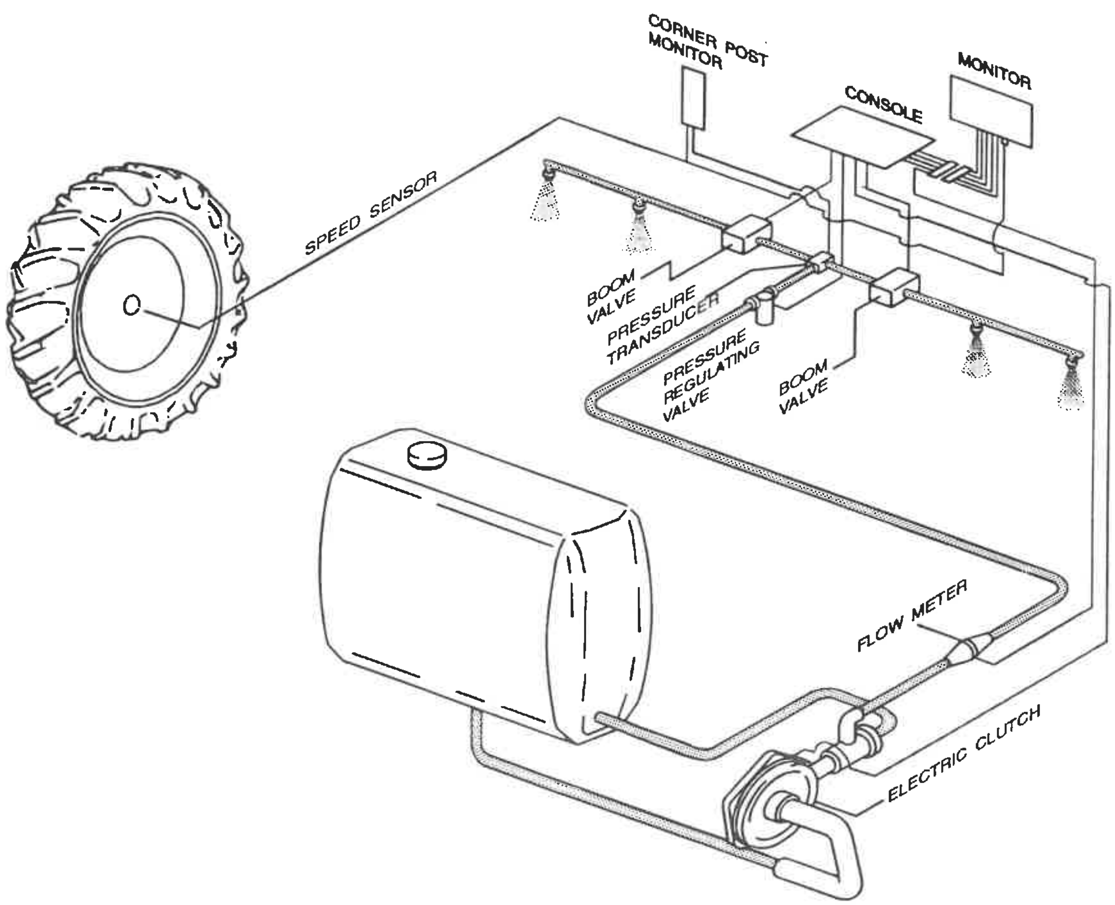



Fig. 34 — Electrical Spray System

electronic signal is then sent to the electric motor control. The motor control automatically varies the motor/pump speed (chemical output) to compensate for the change in the vehicle speed, thus maintaining the chemical injection rate at the preset amount.

A spray monitor can also shut off the spray when the spray rig forward motion stops and when the implement is raised at the ends of the rows. The monitor may also output valuable information such as: remaining tank volume, total area sprayed, field area sprayed, total volume of chemical solution sprayed, and field volume sprayed.

## SELECTION OF NOZZLES

The nozzle tip chiefly controls the spray solution flow rate through a metering passage (orifice) as stated previously. Since there are many requirements of application rates, likewise there are many nozzle tips (Fig. 35) with different orifice sizes. Nozzle tips are usually selected to provide a specific rate of coverage as recommended on the chemical label—most often expressed in terms of gallons-per-acre (liters-per-hectare). In selecting the appropriate nozzle tip, four basic factors must be known:

1. The rate of speed in miles (kilometers) per hour of the spray vehicle.

2. The gallons per acre (L/ha) to be applied.

3. The width of spray per nozzle tip.

4. The combined flow of the spray solution from all the nozzles.

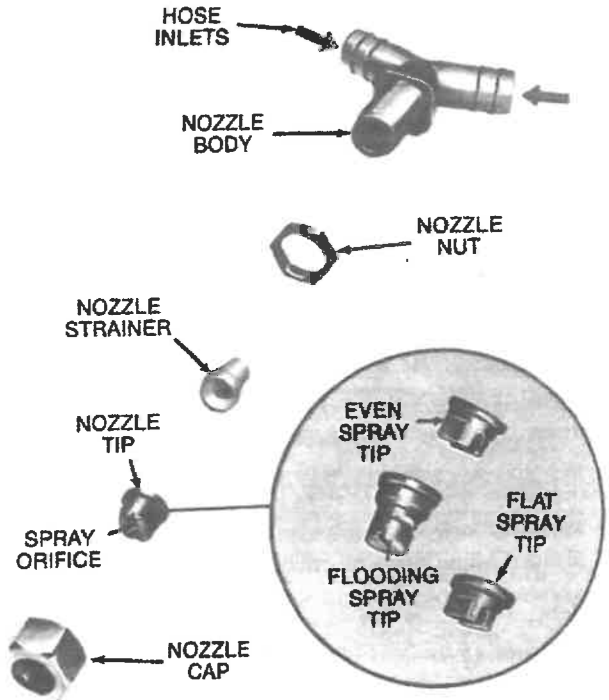



Fig. 35 — Different Types Of Spraying Nozzle Tips

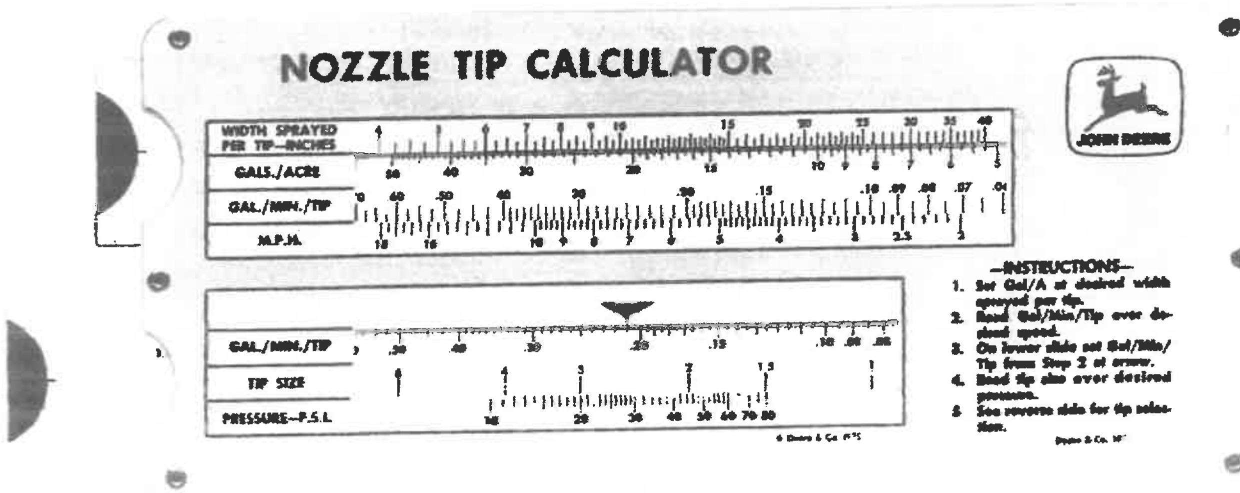



Fig. 36 — Nozzle Tip Calculator—Front



Litho in U.S.A.

Manufacturers of spraying equipment provide charts that help select the appropriate nozzle. Also available is a nozzle tip calculator as shown in Fig. 36. It greatly simplifies all charts into one slide-rule-type calculator. Examples of its use are as follows:

EXAMPLE 1

Problem: To spray at a rate of 15 gallons per acre, (140 L/ha), using 14-inch (0.36 m) bands, at a speed of 6 miles per hour (9.6 km/h), what size nozzle tips and what pressure setting should be used?

Step 1—Set 15 (gals./acre [140 L/ha]) under 14 (width sprayed per tip—inches [0.36 m]).

Step 2—Just above 6 (m.p.h. [9.6 km/h]) read .21 (gal./min./tip [0.79 L/m tip]).

Step 3—Set .21 (gal./min./tip [0.79 L/m tip]) under the arrow.

Step 4—Note that tip size 3 will obtain the desired application rate at a pressure of about 20 psi (138 kPa), or tip size 2 at a pressure of about 44 psi (302 kPa).

*NOTE: Tip sizes 4 or 1.5 might also be used, depending on the pressures attainable with your sprayer.*

Step 5—On the back of the calculator, choose a tip opposite size 2 or 3 which satisfies your particular needs (Fig. 37).

*NOTE: An even spray tip would be desirable in this case.*

EXAMPLE 2

Problem: To spray at a rate of 10 gallons per acre (94 L/ha), using a 20-inch (0.51 m) nozzle spacing, at a speed of 5 miles per hour (8 km/h), what size nozzle tips and what pressure setting should be used?

Step 1—Set 10 (gals./acre [94 L/ha]) under 20 (width sprayed per tip—inches [0.51 m]).

Step 2—Just above 5 mph (8 km/h) read .166 (gal./min./tip [.63 L/m tip]).

Step 3—Set .166 (gal./min./tip [0.63 L/m tip]) under the arrow.

Step 4—Note that tip size 2 will obtain the desired application rate, at a pressure of about 28 psi (193 kPa).

*NOTE: Tip sizes 3 or 1.5 might also be used, depending on the pressures attainable with your sprayer.*

Step 5—On the back of the calculator, choose a tip opposite size 2 which satisfies your particular needs (Fig. 37).

## TIP SELECTOR CHART

| SIZE | TYPE | MATL. | J.D. # | S.S. # | DEL. # |
|---|---|---|---|---|---|
| 1 | Flat* | Brass<br>S.S. | N138114<br>N139273 | 1501<br>1501SS | |
| | Flat | Brass<br>S.S. | N153936 | 8001<br>8001SS | LF-1-80<br>LF-1-80 |
| | Even | Brass<br>H.S.S. | B11652<br>B16010 | 8001E<br>8001EHSS | LE-1-80 |
| | Flood | | | | |
| | Cone | Brass | B14244 | TX6 | HB-6 |
| 1.5 | Flat | Brass<br>S.S. | N65780<br>N65785 | 80015<br>80015SS | LF-1.5-80<br>LF-1.5-80 |
| | Even | Brass<br>H.S.S. | B11653<br>B16011 | 80015E<br>180015EHSS | LE-1.5-8.0 |
| | Flood | Brass<br>S.S. | N150974<br>N150975 | TK.75<br>TKSS.75 | D.75<br>DSS.75 |
| | Cone | H.S.S. &<br>Nylon | B16007 &<br>N85636 | D4 & 23 | D4 & 23 |
| | Off-Ctr. | | | | |
| 2 | Flat | Brass<br>S.S. | N153938<br>N153939 | 8002<br>8002SS | LF-2-80<br>LF-2-80 |
| | Even | Brass<br>H.S.S. | B11654<br>B16012 | 8002E<br>8002EHSS | LE-2-80 |
| | Flood | Brass<br>S.S. | N153946<br>N153947 | TK1<br>TKSS1 | D1<br>DSS1 |
| | Cone | | | | |
| | Off-Ctr. | Brass | N153958 | OC-02 | |
| 3 | Flat | Brass<br>S.S. | N85781<br>N85786 | 8003<br>8003SS | LF-3-80<br>LF-3-80 |
| | Even | Brass<br>H.S.S. | B11655<br>B16013 | 8003E<br>8003EHSS | LE-3-80 |
| | Flood | Brass<br>S.S. | N150976<br>N150977 | TK1.5<br>TKSS1.5 | D1.5<br>DSS1.5 |
| | Cone | H.S.S. &<br>Nylon | B16007<br>N150972 | D4 & 25 | D4 & 25 |
| | Off-Ctr. | Brass | N153959 | OC-03 | |
| 4 | Flat | Brass<br>S.S. | N153940<br>N153941 | 8004<br>8004SS | LF-4-80<br>LF-4-80 |
| | Even | Brass<br>H.S.S. | B11656<br>B16014 | 8004E<br>8004EHSS | LE-4-80 |
| | Flood | Brass<br>S.S. | N153948<br>N153949 | TK2<br>TKSS2 | D2<br>DSS2 |
| | Cone | | | | |
| | Off-Ctr. | Brass | B12350 | OC-04 | |
| 6 | Flat | Brass<br>S.S. | N85782<br>N85787 | 8006<br>8006SS | LF-6-80<br>LF-6-80 |
| | Even | Brass<br>H.S.S. | B13195<br>B16016 | 8006E<br>8006EHSS | LE-6-80 |
| | Flood | Brass<br>S.S. | N150978<br>N150979 | TK3<br>TKSS3 | D3<br>DSS3 |
| | Cone | H.S.S. &<br>Nylon | B17516 &<br>N85776 | D6 & 45 | D6 & 45 |
| | Off-Ctr. | Brass | N153960 | OC-06 | |
| 8 | Flat | Brass<br>S.S. | N153942 | 8008<br>8008SS | LF-8-80<br>LF-8-80 |
| | Off-Ctr. | Brass | B13930 | OC-08 | |
| 10 | Flat | Brass<br>S.S. | N85783<br>N85788 | 8010<br>8010SS | LF-10-80<br>LF-10-80 |
| | Flood | Brass<br>S.S. | B14533<br>B16018 | TK5<br>TKSS5 | D5<br>DSS5 |

Flat and even tips are 80°.
* 15°

AN152375

Fig. 37 — Nozzle Tip Calculator—Rear

 Litho in U.S.A.

## SPECIAL PRECAUTIONS FOR SERVICING SPRAYERS

Some agricultural chemicals are intended to be lethal to certain forms of life. Although some agricultural chemicals may have little or no effect on a normally healthy human being, many are dangerous in the extreme. It is wise to treat all chemicals with great caution. Observe the following guidelines when working on any part of any sprayer which may have been contaminated by contact with chemical solutions or sprays.

Don't take chances. When in doubt, proceed as though contamination is present.

Identify the chemical most recently used. Check container labels or manufacturer's information for specific precautions which may need to be observed.

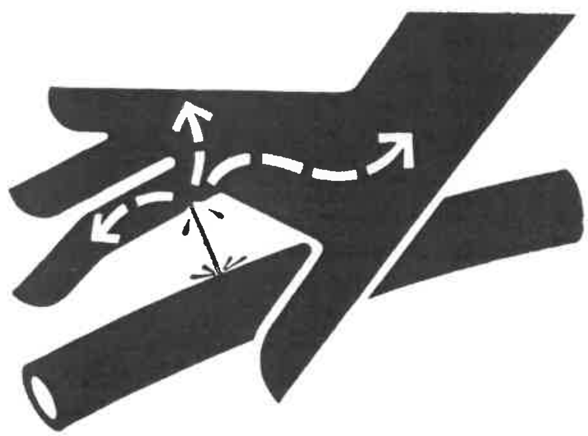


Fig. 38 — Avoid High-Pressure Fluids

Escaping fluid under pressure can penetrate the skin causing serious injury. Do not work on lines, tanks, hoses, or nozzles while the pump is running or the system is pressurized. Shut down the engine and pump, bleed the lines, and relieve all pressures before opening or disconnecting the system or its components. Tighten all connections before applying pressure. Keep your hands and body away from pinholes and nozzles that eject fluids under high pressure. Use a piece of cardboard or paper to search for leaks. Do not use your hand.

If an accident occurs, see a doctor immediately. Any fluid injected into the skin must be surgically removed within a few hours or gangrene may result.

If possible, drain and flush the sprayer tanks, pumps, lines and controls. Refer to the Operator's Manual for specific draining, flushing and disposal procedures.

Avoid all direct contact with sprays, solutions, dusts, powders or residues. Wear protective clothing (rubber aprons, gloves, goggles, respirator masks, etc.) whenever possible.

Loose connections can leak and contaminate the outside of a sprayer. Wear rubber gloves to tighten leaking joints and replace leaking valves or gauges.

Have an emergency soap and water supply available. If a chemical solution is spilled on the skin or in the eyes, it must be flushed away immediately.

Never touch sprayer components with the lips or mouth. If chemical solutions are accidentally swallowed, the instructions on the manufacturer's label must be followed carefully.

If you suspect you have been exposed to a chemical solution that may be injurious, seek medical attention immediately. Delay may have serious consequences.

The information contained in this manual is not intended to replace safety codes, insurance requirements, federal, state, and local laws, rules and regulations. In particular, your service area or jobsite activities may be subject to state safety rules and/or federal regulation under the Occupational Safety and Health Act (OSHA). Familiarize yourself with all regulations applicable to your situation in order to avoid possible safety violations.

After working with chemical solutions or contaminated equipment, take a shower and change to clean clothing. Wash contaminated clothing before reuse.



Litho in U.S.A.

## CALIBRATING THE APPLICATION RATE

To perform accurately in the field, the flow rate of the sprayer nozzles must be known. As we have mentioned, flow rate is affected by nozzle passages, tip design, pressure, viscosity, and density. Let's look at suggestions for calibration.

The purpose of calibration is to ensure that your sprayer is applying the correct amount of material uniformly over a given area. Use clean water to calibrate the sprayer. Most application rate tables are based on the flow characteristics of water.

Worn nozzle tips can create variations in flow rate, spray patterns and droplet size. New nozzles do not lessen the need to calibrate because some nozzles "wear in" during the first few hours of operation, and the flow rate may increase rapidly during this time.

To compensate for wear, sprayers should be calibrated daily and the pressures gradually reduced as needed to obtain the desired flow rate.

*NOTE: When changing speeds, pressures, sprayer configurations, nozzle tips, or the chemical being applied, the sprayer must be recalibrated.*

There are several calibrating methods; however, the method which follows is simple and one of the most direct means of calibrating. The only measuring devices necessary are:

1. *Stop watch*
2. *Container graduated in fluid ounces (milliliters) or quarts (Liters)*
3. *Tape measure*

### Precalibrating

The size, type, and nominal flow rate of the nozzles used must be determined before the sprayer can be accurately calibrated. Check the gallons per acre (L/ha) flow ONLY AFTER setting the proper pressure and installing the proper nozzle tips as indicated by a nozzle tip calculator or your operator's manual.

*NOTE: Select an area where you can safely fill, flush, calibrate, and decontaminate the sprayer without pesticides drifting or running off to contaminate people, animals, vegetation, or a water supply. Select an area where it will be impossible for children to come into contact with pesticides.*

Before calibrating, pump plenty of clean water through the machine to rinse out as much residue as possible. Then use clean water to calibrate it. Don't stand where the spray could splash or drift onto you. There is always some residue on the sprayer parts, so wear rubber gloves to protect your hands.

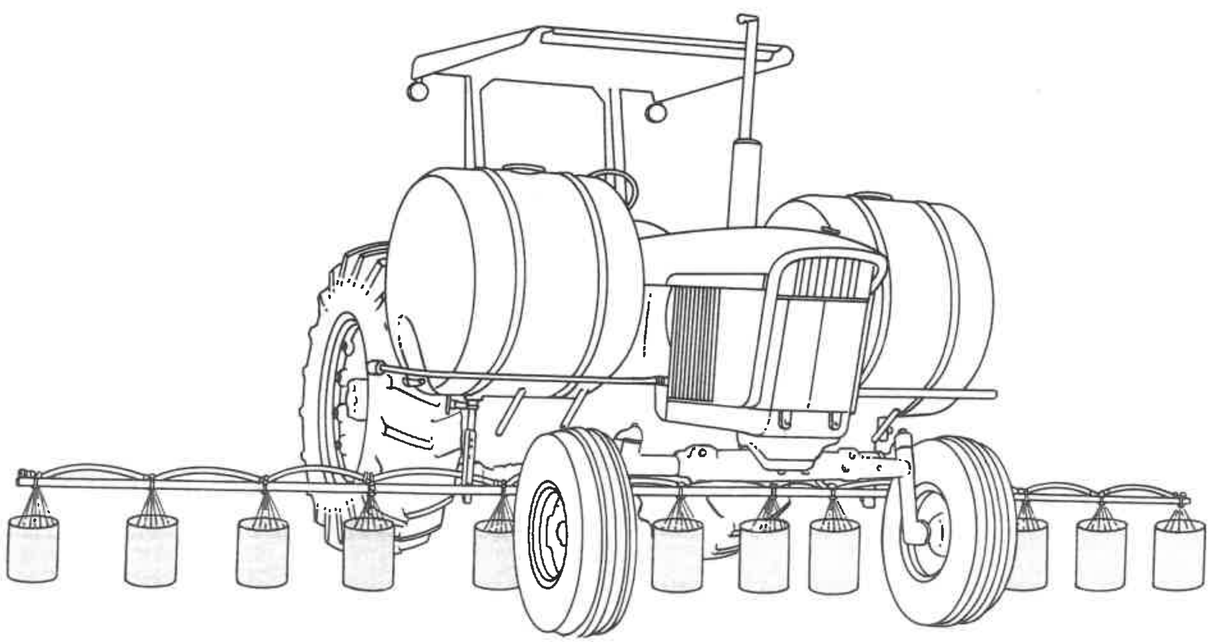


Fig. 39 — Collecting Spray From Each Nozzle

 Litho in U.S.A.

With identically marked nozzle tips in each nozzle, determine the actual rate-of-flow of the nozzles as follows:

1. Partially fill the system with clean water.

2. With the sprayer stationary, operate the sprayer at the pressure setting indicated by the nozzle tip calculator. Check for leaks and spray pattern from each nozzle.

3. Collect the spray from each nozzle tip for the same period of time (60 seconds). Record the sample from each tip and compare with the nominal flow rate indicated by the nozzle tip calculator.

4. Replace nozzle tips having an uneven spray pattern and/or where the rate-of-flow is greater or less than 10% of the nominal.

## HOW TO CALIBRATE

After selecting the proper nozzle you will want to calibrate the spray rig to make sure it sprays the right volume and rate.

1. Fill the sprayer with clean water. Move the sprayer to the field. In this example, let's assume we have a specified application rate of 8 gallons per acre (75 liters per hectare).

2. Accurate calibration means you must know exactly how fast your sprayer is moving over the ground. The tractor speedometer may not be accurate enough, and slippage of the tires will cause the actual speed to be slower than indicated on the speedometer.

**CALIBRATION DISTANCE CHART**

| Rows | | Bands | |
|---|---|---|---|
| **Row Spacing (inches [m])** | **Distance (feet [mm])** | **Band Width (inches [m])** | **Distance (feet [mm])** |
| 40 (1.02 m) | 102 (3,111 mm) | 14 (0.36 m) | 292 ( 8,963 mm) |
| 38 (0.97 m) | 107 (3,263 mm) | 12 (0.31 m) | 340 (10,426 mm) |
| 36 (0.91 m) | 113 (3,446 mm) | 10 (0.25 m) | 408 (12,443 mm) |
| 34 (0.86 m) | 120 (3,659 mm) | | |
| 32 (0.81 m) | 128 (3,903 mm) | | |
| 30 (0.76 m) | 136 (4,146 mm) | | |
| 28 (0.71 m) | 146 (4,450 mm) | | |
| 26 (0.66 m) | 157 (4,785 mm) | | |
| 24 (0.61 m) | 170 (5,181 mm) | | |
| 22 (0.56 m) | 186 (5,668 mm) | | |
| 20 (0.51 m) | 204 (6,216 mm) | | |

To accurately determine the sprayer ground speed, measure the calibration distance. (See the Calibration Distance Chart on this page for the required distance for a given row spacing for broadcast spraying or for a given band width for band spraying.) Mark each end of the calibration distance so it can be seen from the operator's seat.

Drive the sprayer across the marked distance at operating speed and with the initial sprayer pressure. Write down the **travel time, throttle setting, and spray pressure.** Determine the operating speed in miles per hour (mph) or kilometers per hour (km/h). Use either of the following formulas to calculate the speed.

$$\text{mph} = \frac{0.682 \times \text{length of run (ft.)}}{\text{time in seconds}}$$

$$\text{km/h} = \frac{3.6 \times \text{length of run (m)}}{\text{time in seconds}}$$

3. For this example, assume you have calculated a speed of 8 mph (13 km/h) with an initial pressure of 32 psi (220 kPa) in step 2.

Now, with the sprayer parked and the parking brake set, turn on the spraying system. Run it at the same throttle setting and spray pressure you used in step 2.

Collect 2 pints (1 L) of spray from one nozzle and write down the number of seconds required to collect it. In this example; **60 seconds.**

Use the following formula to determine gallons (liters) per minute per nozzle.

$$\text{gpm/nozzle} = \frac{8}{\text{seconds/pint}}$$

$$\text{gpm/nozzle} = \frac{8}{30}$$

$$\text{gpm/nozzle} = 0.27 \text{ gpm}$$

or in metrics:

$$\text{L/min/nozzle} = \frac{60}{\text{seconds/L}}$$

$$\text{L/min/nozzle} = \frac{60}{60}$$

$$\text{L/min/nozzles} = 1 \text{ L}$$

 Litho in U.S.A.

4. Now use the following formula to determine what the gallons per acre (liters per hectare) **application rate** will be at the predetermined speed and sprayer pressure.

*NOTE: The number "5,940" or "600,000" used in the following formulas is a conversion factor. It is a standardized figure that equates the nozzle flow rate, sprayer speed and nozzle spacing.*

$$\text{gpa} = \frac{5{,}940 \times \text{gpm/nozzle}}{\text{speed (mph)} \times \text{nozzle spacing}}$$

$$\text{gpa} = \frac{5{,}940 \times 0.27}{8 \text{ mph} \times 20 \text{ inches}}$$

$$\text{gpa} = \frac{1603.8}{160}$$

$$\text{gpa} = 10$$

or in metrics:

$$\text{L/ha} = \frac{600{,}000 \times \text{L/min/nozzle}}{\text{speed (Km/h)} \times \text{width (nozzle spacing in mm)}}$$

$$\text{L/ha} = \frac{600{,}000 \times 1}{13 \times 500 \text{ mm}}$$

$$\text{L/ha} = \frac{600{,}000}{6{,}500}$$

$$\text{L/ha} = 92.3$$

5. If the calculated gpa (L/ha) does not agree with the desired application rate, adjust the pressure setting and collect spray again. Remember: raising the pressure increases the application rate; lowering the pressure decreases the rate. To double the rate, the pressure must be increased four times. Use nozzles with higher flow rates rather than increase pressure of the sprayer beyond the manufacturer's recommendations.

6. In this example, 8 gpa (75 L/ha) is the desired application rate. So, reduce the pressure down to 22 psi (150 kPa). Then it will take 75 seconds to collect 2 pints (1 liter) of chemical from one nozzle. Again, use the formula:

$$\text{gpm/nozzle} = \frac{8}{75 \text{ seconds/pint}}$$

$$\text{gpm/nozzle} = \frac{8}{37.5}$$

$$\text{gpm/nozzle} = 0.21$$

Or in metric:

$$\text{L/min./nozzle} = \frac{60}{75 \text{ seconds/liter}}$$

$$\text{L/min./nozzle} = 0.8$$

7. Use the formula to determine application rate in gallons per acre (gpa) or liters per hectare (L/ha).

$$\text{gpa} = \frac{5940 \times .21 \text{ gpm/nozzle}}{8 \times 20}$$

$$\text{gpa} = \frac{1247.4}{160}$$

$$\text{gpa} = 7.8$$

or in metric:

$$\text{L/ha} = \frac{600{,}000 \times 0.8}{13 \times 500}$$

$$\text{L/ha} = \frac{480{,}000}{6{,}500}$$

$$\text{L/ha} = 74$$

The sprayer is now spraying at the required rate of 8 gpa (75 L/ha).

8. With the properly mixed chemical solution in the sprayer, operate the sprayer in the field at the ground speed that you measured in Step 2 and at the pressure that you determined in Step 6. You will be spraying at the application rate that you determined in Step 7. After spraying a known number of acres (ha), check the liquid level in the tank to verify that the application rate is correct.

 Litho in U.S.A.

## GENERAL MAINTENANCE

The economical and efficient operation of the sprayer. is dependent on regular and proper care and adjustment.

### LUBRICATION

**CAUTION: Do not lubricate the sprayer while the equipment is in motion or the PTO is engaged. Never allow others to lubricate the sprayer under unsafe conditions.**

Depending on the sprayer design, the following parts may require lubricating:

If the sprayer is equipped with a centrifugal pump and belt drive system, lubricate the grease fitting on the drive belt idler arm. Do not use an excessive amount of grease or allow the grease to get on the drive belt.

If the sprayer is equipped with a piston pump, the crankpin bearing and the cam bearing should be lubricated with grease as specified in the operator's manual.

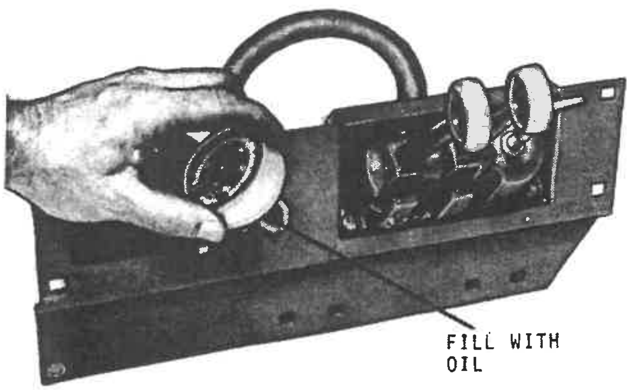



Fig. 40 — Gauge Protector

On sprayer models that have a gauge protector, remove the pressure gauge and fill the gauge protector or fitting with SAE 20 oil (Fig. 40). Install the pressure gauge and make sure it reads zero (0) after installation. If the gauge does not read zero (0), remove some of the oil from the gauge cavity and recheck.

Lubricate the tank shut-off valve when the valve does not work freely, and prior to storage (Fig. 41).

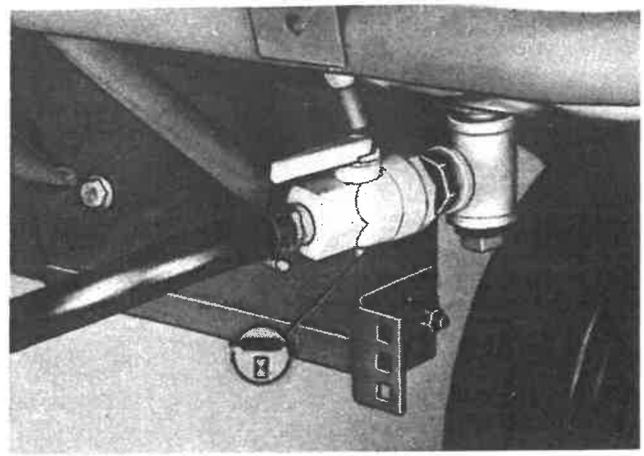


Fig. 41 — Tank Shut-Off Valve

Refer to the operator's manual to determine the exact location of each part that requires lubrication. The operator's manual will also indicate the recommended lubrication interval and the type of lubricant required. Clean the grease fittings before lubricating. Replace lost or broken fittings immediately.

### CLEANING

An important part of sprayer maintenance is keeping the unit clean. Keep foreign materials out of the sprayer. These materials can clog the nozzles and damage the pump and other components.

Sprayers must be flushed and cleaned whenever chemicals are changed, before any repairs are made, or before being placed in storage. Thoroughly cleaning the sprayer after each use will help prevent deposits from forming and damaging the sprayer components.

Before long periods of storage, flush the sprayer system with a 50% solution of clean water and ethylene glycol antifreeze. The antifreeze not only protects against freezing in cold weather, but also coats the interior of the sprayer components with a rust inhibitor and acts as a lubricant to keep parts from sticking.

#### Decontaminate The Sprayer

**CAUTION: All spraying equipment should be decontaminated before performing any repairs or placing the unit in storage. Decontamination should be done in a safe area by washing with a mild detergent and water, or neutralized by means recommended by the chemical manufacturer. Take special care while cleaning to avoid splashing your eyes, hands, or clothing. Wear protective clothing and goggles, or better yet, a full face shield.**

To decontaminate the sprayer, perform the following:

1. Mix household detergent with water, circulate through the system for 30 minutes, then drain.

2. Mix one quart (0.95 L) of household ammonia with 25 gallons (95 L) of water. Pump enough of this mixture to fill the nozzles and let stand overnight.

3. Run this mixture out of the sprayer and flush with clear water.

## Cleaning Line Strainers

Check and clean the strainers as often as operating conditions warrant. Excessive loss of nozzle flow or pressure may indicate a clogged strainer screen.

Before removing the strainer, shut off the solution pump and release pressure in the system by opening all solution control valves and pressure regulators. If possible, drain and flush the system, or isolate the strainer by closing the system shut-off valves.

Release the strainer cap and remove the strainer (Fig. 42). Wash all parts in water or neutralizing agent recommended by the manufacturer of the spray solution chemical. Flush the strainer screen thoroughly. Replace the screen if it is torn, crimped, or collapsed.

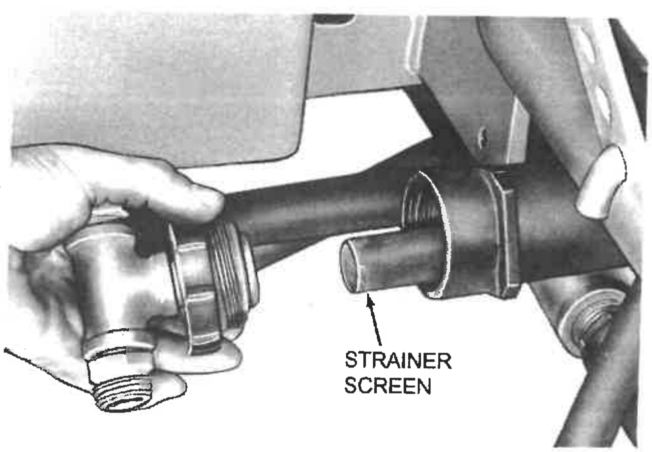



Fig. 42 — Line Strainer

Failure to keep the nozzles clean may result in irregular spray patterns and plugged nozzles. In case of clogging or other nozzle malfunction, shut off the sprayer and release the pressure. Don't attempt to unplug the nozzle in the field. Keep spare tips available for replacement. Later, clean the clogged nozzles as described below. Never touch nozzle tips or other sprayer parts to your lips to blow out trash.

## Cleaning Nozzles

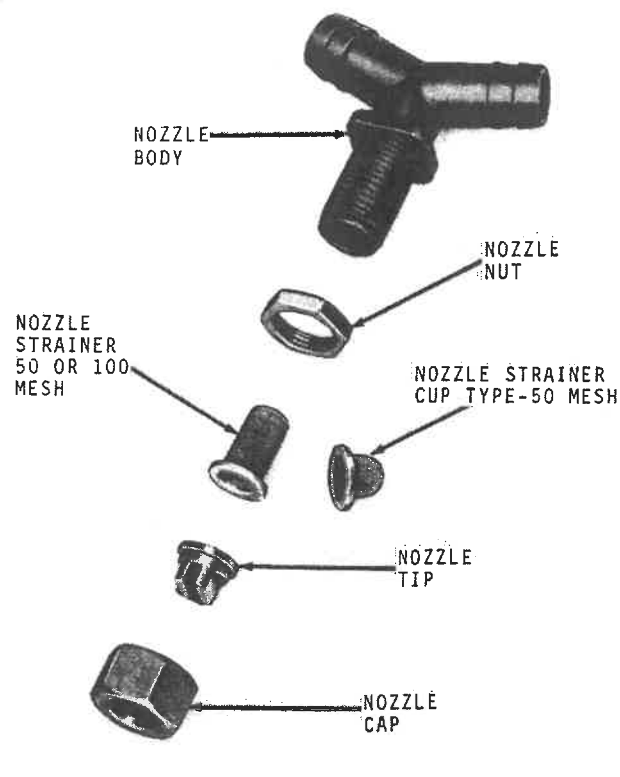



Fig. 43 — Typical Spraying Nozzle Assembly

**CAUTION: Keep spray material from the skin. If spray material comes in contact with the body, wash off immediately with clean water and detergent.**

Remove the nozzle from the spray boom. Refer to Fig. 43. Disassemble the nozzle and wash all components in clean water or in a solvent recommended by the spray solution manufacturer. Clean all parts with a soft bristle brush. It may be necessary to use a wooden pick to clear hardened deposits from nozzle screens or tip openings.

**Do not use metal probes of any kind of clean nozzle tips and screens.** The nozzle orifice is precisely machined to close tolerances, and the use of a metal object for cleaning will damage the orifice.

 Litho in U.S.A.

Fig. 44 — Clean Foreign Material From Nozzle With A Low Pressure Air Hose

A low pressure air hose (under 30 psi [210 kPa]) may be used to clean foreign material from the nozzle (Fig. 44). Direct the spray away from yourself and others. Protect your eyes by wearing chemical splash goggles.

**CAUTION: Never try to clean the nozzles by holding them to your mouth and blowing through them. This is dangerous, since residue on the nozzle can be taken directly into the mouth and swallowed or absorbed through the lips. Don't let chemicals touch your mouth**

At the end of the season, remove and clean the nozzle tips and screens and store them in a jar of diesel fuel.

## NOZZLE ADJUSTMENT AND CARE

Proper nozzle adjustment and care is required to maintain good nozzle performance.

The distance from the nozzle tips to the sprayed surface, the angle of spray, and the spacing of the nozzles all have a bearing on proper spray coverage. Nozzles must be spaced equally along the spray boom and positioned correctly in relation to the row. On wet booms, the nozzle position is fixed and cannot be changed. However, on dry booms the nozzles are clamped to the boom and can be moved.

### PROBLEMS WITH NOZZLES

The illustrations which follow show the most common problems with booms and flat spray nozzles. Similar problems may occur with other types of nozzles.

#### Worn Or Plugged Nozzles

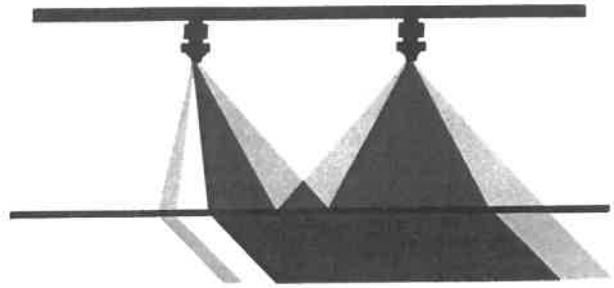


Fig. 45 — Worn Or Plugged Nozzles

Worn or plugged nozzles will result in untreated strips as seen in Fig. 45.

Clean nozzles periodically; particularly when applying wettable powders. A worn nozzle tip may result in over-application and many times cannot be detected by observation. Repeated calibration of the sprayer will detect worn nozzle tips.

If a nozzle clogs or some other part malfunctions, shut down the sprayer and pump, and release pressure from system.

Never touch the nozzle tips or other sprayer parts to your lips to blow out trash. Have spare tips available for replacement.

#### Misaligned Nozzles

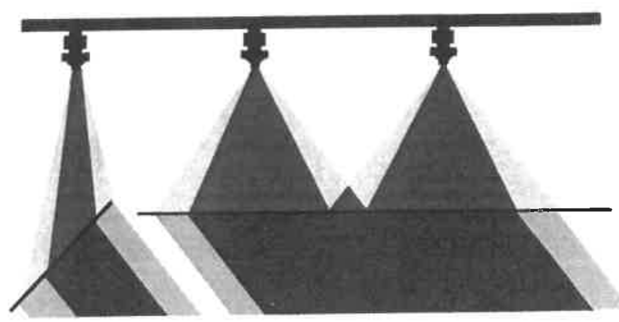
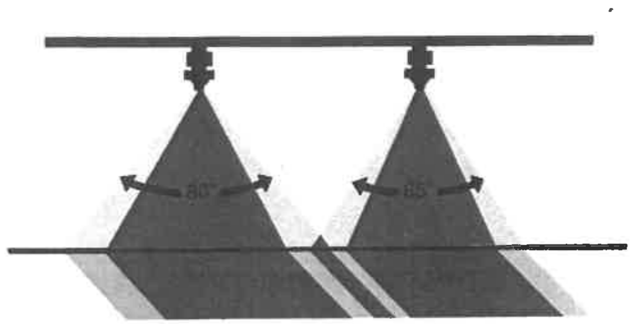


Fig. 46 — Misaligned Nozzles

If flat type nozzle tips are not aligned parallel with the boom, coverage will not be complete (Fig. 46). Wrench flats are provided so that the tips can be properly aligned.

### Improper Nozzle Tips

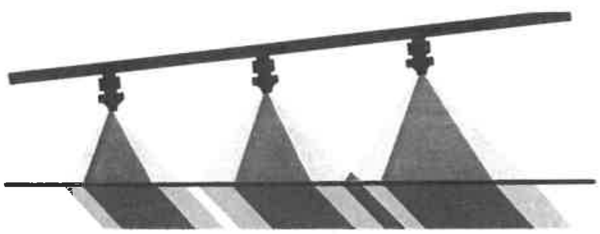



X3068 Do not use 80° and 65° nozzles together

Fig. 47 — Improper Use Of Nozzle Tips

**Nozzle tips of different sizes and angles must NOT be used on the same boom (Fig. 47). Irregular spray coverage will result.**

### Spray Boom Not Level

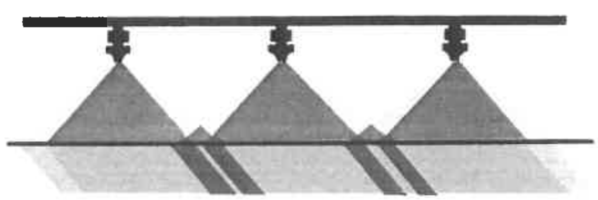


X3069

Fig. 48 — Spray Boom Not Level

**If the boom is not level, coverage will be irregular (Fig. 48).**

### Spray Boom Too Low



X3070

Fig. 49 — Spray Boom Too Low

**If the boom is carried too high or too low, uneven patterns and coverage will occur (Fig. 49). Follow the manufacturer's recommendations for height.**

## TROUBLESHOOTING AND REPAIR

**The decision when and how to replace parts can be a problem unless you have a good knowledge of sprayer component troubleshooting and repair. This section will explain how to diagnose common malfunctions and when to replace worn or damaged parts.**

**CAUTION: All spraying equipment should be decontaminated before being overhauled or placed in storage. Decontamination should be done in a safe area by washing with water, or neutralized by means recommended by the chemical manufacturer. Refer to Decontaminate The Sprayer on pages 62 and 63.**

### CENTRIFUGAL AND TURBINE PUMPS

The centrifugal pump and the turbine pump are similar in construction and operation. These pumps are not self-priming. **If the pump will not prime,** check the following before disassembling:

1. Shut-off valve in the suction line closed.
2. Air leaks in the suction line or connections.
3. Obstructions or bends in the suction line.
4. The control valve on the discharge line may be closed, trapping air in the pump and the line above the pump.
5. Pump speed too slow.
6. Pump drive electric clutch (if used) slipping or not engaging.
7. Pump seal leaking.

To help prime the pump, do the following:

1. Be sure the shut-off valves in the suction and discharge lines are open.
2. Bleed air from the pump by removing the plug below the discharge port.
3. Fill the pump with liquid by removing the suction strainer, raising the suction hose above the pump, and pouring in liquid. When the hose is full, attach the strainer, and kink the hose (anywhere along the line) to hold the liquid in. Reattach the hose to the tank or submerge the end of the hose in liquid, release the kink, and start the pump.

If the pump still will not prime, disassemble the pump and check for the problem.

 Litho in U.S.A.

## Troubleshooting

The troubleshooting chart which follows is designed to give a general guide to diagnosing the common centrifugal pump and turbine pump problems. The troubleshooting chart is designed to help you when such a problem develops, by suggesting a possible cause and the recommended solution.

### LOSS OF PRESSURE

| Possible Cause | Remedy |
|---|---|
| Restricted oil flow to the hydraulic motor (hydraulic driven pumps only). | Check the inlet of the hydraulic motor for foreign material. |
| Inadequate hydraulic pressure or volume on the tractor when using the hydraulic motor-driven centrifugal pump. | Check the tractor hydraulic system to be sure it is up to specifications. |
| Strainers clogged. | Clean the strainers. |
| Kinked suction hose. | Relocate the suction hose to eliminate sharp bends. |
| Collapsed suction hose. | Replace the suction hose. |
| Air leaks in the suction hose. | Replace the suction hose. |
| Worn nozzle tip orifices. This will increase the solution flow, thus reducing the pressure. | Replace the nozzles and recalibrate the sprayer. |
| Restrictor washer installed in the pressure hose coupling. | Remove the restrictor washer. |
| Improper adjustment of the pressure regulator valve. | Adjust the pressure regulator to increase system pressure. |
| Pump is running too slowly. | Check tractor PTO speed. Check for slipping drive belt. Check for faulty hydraulic motor (hydraulic driven pumps only). |
| Leakage at the pump seal. | Replace pump seal. |
| Pump worn and clearances too great. | Overhaul or replace the pump. |
| Pump openings clogged. | Clean the pump inlet and outlet openings. |

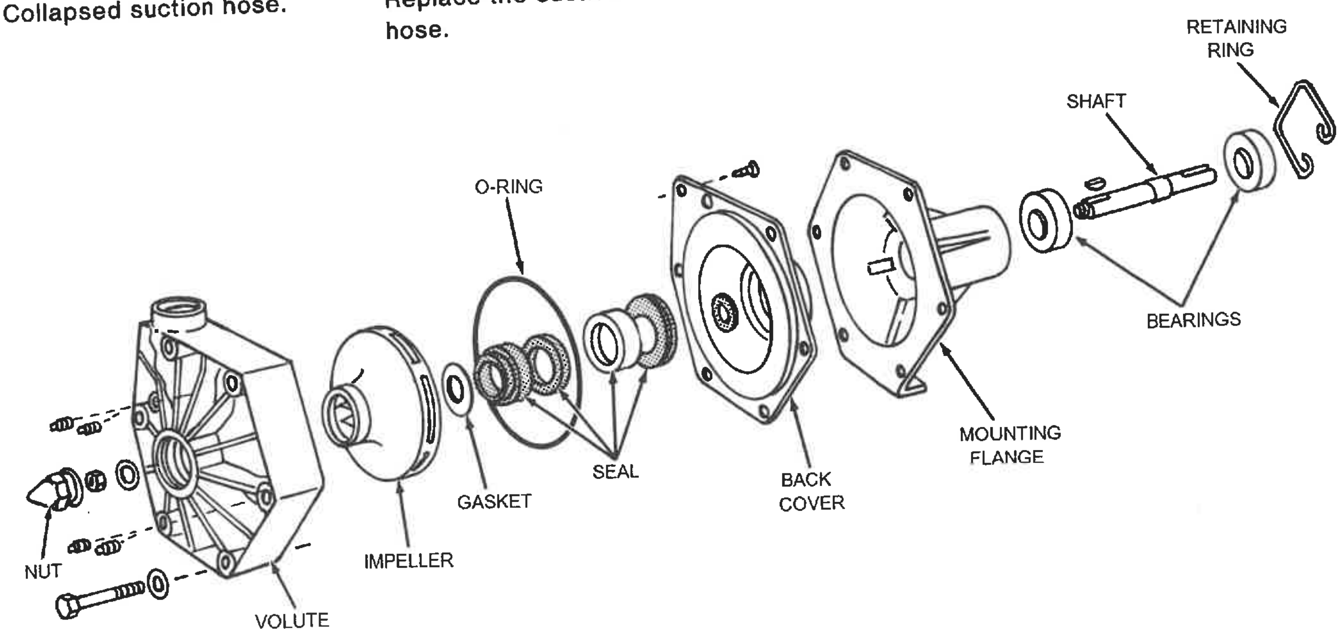



Fig. 50 — Exploded View Of A Centrifugal Pump



Litho in U.S.A.

### Repair

Centrifugal pumps and turbine pumps contain a minimum of moving parts: an impeller and drive shaft with bearings and seals. Repair of these pumps is limited normally to the replacement of these parts. If more extensive repairs are required, such as replacement of the pump housing, you may want to consider replacing the complete pump assembly instead of repairing it. A typical centrifugal pump is shown in Fig. 50.

Look for corrosion on the housing and for wear of the moving parts. Check for leakage at the shaft seal. Seal leakage may be due to the corrosive effect of the liquid being pumped, or it may be due to heat generated from running the pump dry. Replace worn and damaged parts.

*NOTE: The shaft seal is a precision part. Do not let the carbon rotating seal or the ceramic stationary seal drop or allow the lapped faces of these components to be scratched. Lubricate the seal with a light lubricating agent. Do not operate the pump with the sealing faces dry.*

## ROLLER PUMPS

Roller pumps, like centrifugal pumps, are simple in design with a minimum of moving parts (Fig. 51).

### Troubleshooting

These troubleshooting charts are given as a general guide to the common roller pump failures. It lists what the cause might be, and the recommended remedy.

**LOSS OF PRESSURE**

| **Possible Cause** | **Remedy** |
|---|---|
| Clogged suction strainer. | Clean the strainer. |
| Pump running too slow. | Check PTO speed. |
| Kinked or collapsed suction hose. | Change the position of the hose to eliminate bending. Replace the hose if necessary. |
| Obstructions in the suction or discharge line. | Remove the hoses and check for obstructions. The inner lining of a hose may become rotten and pull loose, resulting in clogged passages. (This is not always noticeable on the outside of the hose.) |
| Pump rollers sticking in the rotor slots. | Disassemble the pump and check the rollers and rotor for corrosion or damage. Repair or replace the pump. |
| Pump worn and clearances are too great. | Overhaul or replace the pump. |
| Air leaks in the suction line or line fittings. | Replace the hose or fittings. (These leaks are difficult to locate because the air leaks INWARD.) |
| Nozzle orifices worn, increasing the flow and reducing the pressure. | Replace the nozzles and recalibrate the sprayer. |
| Restrictor washer installed in the pressure hose coupling. | Remove the restrictor washer. |
| Improper adjustment of pressure regulator valve. | Adjust the pressure regulator to increase the system pressure. |

**PUMP WILL NOT PRIME**

| | |
|---|---|
| Air leaks in the suction line or connections. | Replace suction hose and repair or replace faulty connections. |
| Obstructions or bends in the suction line. | Remove the suction hose and check for obstructions. Relocate the hose to eliminate sharp bends. |
| Shut-off valve in suction line closed. | Open the shut-off valve. |



Litho in U.S.A.

S(

## PUMP WILL NOT PRIME—CONTINUED

| | |
|---|---|
| Control valve on the discharge line closed. | Open the control valve. |
| Air trapped in the pump or the line above the pump. | Disconnect discharge hose and pump liquid through the pump. Replace the discharge hose. |
| Pump is worn. | Overhaul or replace the pump. |
| Pump rollers are stuck in the rotor slots. | Overhaul or replace the pump. |
| Pump seals leaking air. | Replace the pump seals. |

### Repair

Repair of a roller pump is limited typically to the replacement of the rollers, bearings and seals (Fig. 51).

Examine the rollers and replace them if out-of-round, swollen, or badly worn. Check the pump body and the rotor for wear. If replacement of the pump body and/or rotor is required, consider the cost of repairing the pump compared with the cost of a new pump before proceeding with the pump repair.

Install the new seals with the folded edge of the seals facing the rotor when the pump is assembled. After the pump is assembled, turn the rotor shaft by hand to be certain that the rotor is not binding. If the rotor does not turn freely, disassemble and correct the problem.

## PISTON PUMPS

Piston pumps are more elaborate than either the centrifugal pumps or the roller pumps discussed so far.

### Troubleshooting

These troubleshooting charts are given as a general guide to the common piston pump malfunctions. It lists what the probable cause might be, and the recommended remedy. These suggested remedies should be applied with caution.

## LOSS OF PRESSURE

| **Possible Cause** | |
|---|---|
| Air leaks in the suction line or fittings. | Replace the suction hose. Check for faulty fittings. (These leaks are difficult to locate because the air leaks INWARD). |
| Clogged suction strainer. | Clean the strainer. |
| Suction hose collapsed. | Replace the suction hose. |
| Obstructions in the suction line. | Remove the suction hose and check for obstructions. (The inner lining in the hose may pull loose and clog the passage.) Replace the suction hose. |

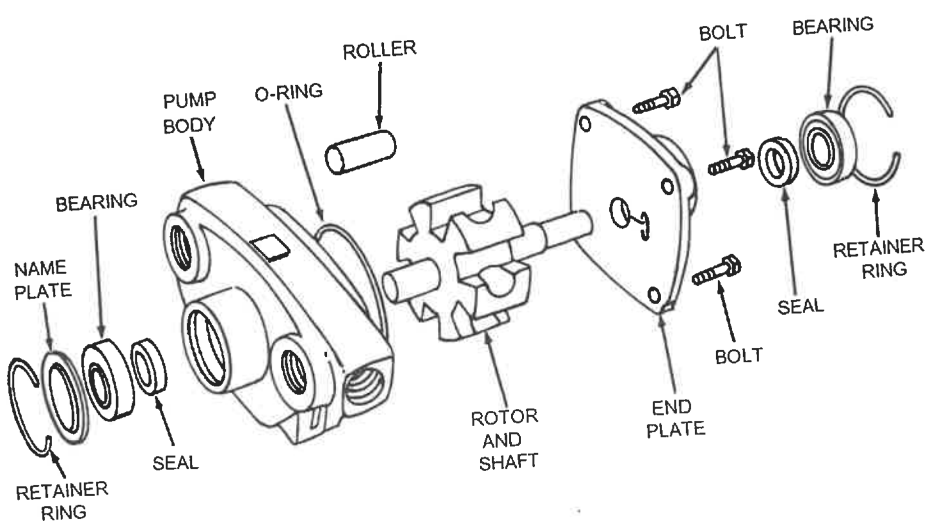



Fig. 51 — Exploded View Of A Roller Pump



Litho in U.S.A.

## LOSS OF PRESSURE (CONTINUED)

| | |
|---|---|
| Unloader valve faulty or set too low. | Adjust the unloader valve pressure setting. Replace faulty valve. |
| Suction lift too high or too long. | Reposition the pump or the supply tank to decrease the lift height or the length of the suction line. |
| Pump is not running at the proper speed. | Check engine speed. |
| Nozzle orifice worn too large, increasing the flow and reducing the pressure. | Replace the nozzles and recalibrate the sprayer. |

## NOISY PUMP

| | |
|---|---|
| Excessive pump speed. | Check engine speed |
| Partially clogged strainer causing the pump to cavitate. | Clean the strainer. |

## DECREASED CAPACITY

| | |
|---|---|
| Suction strainer clogged. | Clean the strainer. |
| Pump moving parts worn. | Overhaul or replace the pump. |
| Drive belt slipping. | Adjust belt tension. Replace the belt. |

## PUMP WILL NOT PRIME

| | |
|---|---|
| Air lock in the pump. | Remove the discharge hose and pump liquid through the pump. Replace the discharge hose. |
| Supply of liquid exhausted. | Fill the tank. |
| Obstructions or bends in the suction line. | Replace the suction hose. Reposition the suction hose to eliminate kinks. |

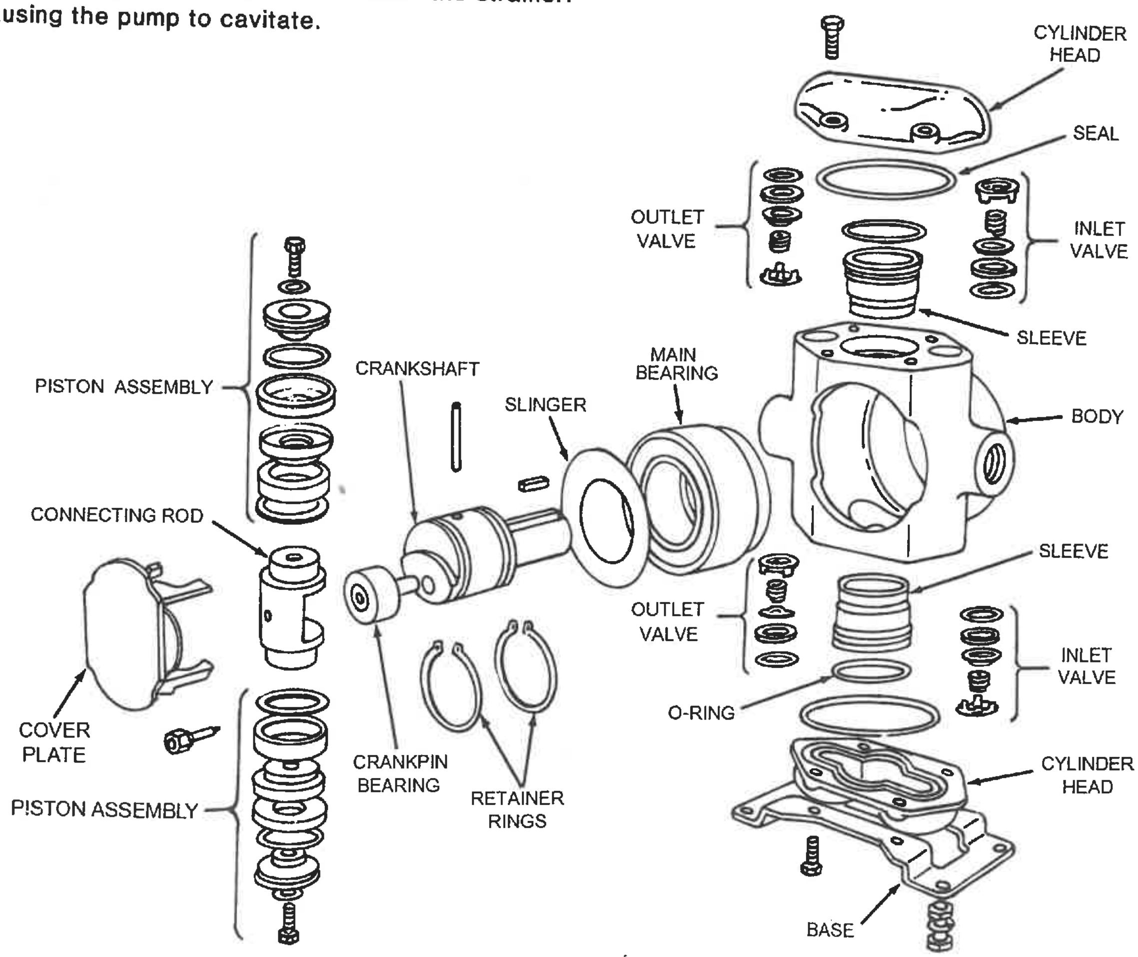



Fig. 52 — Exploded View Of A Piston Pump

 Litho in U.S.A.

**PUMP WILL NOT PRIME—CONTINUED**

| | |
|---|---|
| Valve in suction line closed. | Open the valve. |
| Clogged strainer. | Clean the strainer. |
| Too much vacuum at the suction port. | Reposition the pump if the suction lift is too high or too long. |
| Air bleeder valve is closed. | Open the air bleeder valve. |
| Unloader valve is adjusted to its highest pressure. | Adjust the unloader valve to a lower pressure to eliminate a possible air lock. |
| Pump moving parts are worn. | Overhaul or replace the pump. |

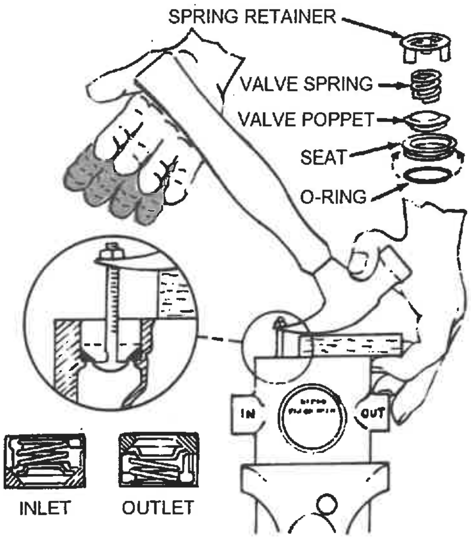



Fig. 53 — Valve Seat Removal

Repair

The repair procedures for piston pumps may vary depending upon the design of the pump. Refer to the manufacturer's repair manual for the exact procedure for your pump.

The following repair procedure applies to the piston pump shown in Fig. 52. To disassemble the pump, perform the following: Remove the cover plate and both cylinder heads. Remove the piston securing cap screws. Carefully tap out both the cylinder sleeves and piston assemblies. Remove the connecting rod. Remove the four valves (Fig. 53). It may be necessary to use penetrating oil to loosen the valve parts. Press the crankshaft and bearing out of the pump body.

After disassembling the pump, clean all parts thoroughly. Inspect the pump body for erosion at all the O-ring seal points and in the valve and sleeve bores. Check for cracks at the inlet and outlet valve ports.

Examine the cylinder heads for wear or cracks. This can result from erosion and/or valve seat hammer.

Check for pitting or grooves in the cylinder sleeves. The cylinder sleeves can be polished to remove light scratch marks. Use No. 120 grit emery cloth initially, then use No. 320 grit emery cloth for final finish. Replace worn or damaged piston parts.

Check crankshaft assembly for wear. Rotate main bearing and crankpin bearing to check for roughness due to damage from lack of lubrication or from moisture. Replace bearings that do not turn smoothly or that appear to be damaged.

To assemble the pump, refer to Fig. 52 and perform the following: Press the crankshaft assembly into the pump body, then insert the connecting rod. Lubricate the O-ring and the inner and outer surface of the cylinder sleeves with water pump grease. Then, press the sleeves into the cylinder bores. The top of the sleeves must be flush with the body surface.

Note carefully the suction (inlet) and discharge (outlet) valve arrangements when installing the valves. The valves are normally identical in construction, but they are installed in opposite directions. The outlet valve seat faces outward and the inlet valve seat faces inward.

Install the piston parts in the order shown in Fig. 52. Install the cylinder heads with new O-rings. Install the cover plate. Test for proper operation of the pump.

SOLUTION CONTROLS

Solution control system malfunctions are likely to be observed as irregular, erratic or difficult-to-control solution application. However, the sprayer solution controls are only one element in an integral system of tanks, pump, lines, valves, hoses, and nozzles. A thorough check of the solution control system will involve inspection of all related components.

Troubleshooting

These troubleshooting charts are given as a general guide to the common solution control malfunctions. They list what the possible cause might be, and the recommended remedy.

**SOLUTION FLOW TOO LIGHT (REGULATOR CLOSED, GAUGE PRESSURE LOW)**

| **Possible Cause** | **Remedy** |
|---|---|
| Tank discharge port blocked or clogged | Remove the tank discharge line and remove the obstruction. Replace the discharge line. |
| Shut-off valve in the tank discharge (suction) line partially blocked, closed, or inoperative. | Open the shut-off valve. Repair or replace faulty shut-off valve. |
| Air leaks in the suction line or suction line fittings. (These leaks are difficult to locate because the air leaks inward.) | Replace the suction hose or fittings. |
| Suction hose partially plugged or collapsed. | Remove the suction hose and remove the obstruction. Replace a faulty suction hose. |
| Line strainer clogged. | Clean the strainer. |
| Pump operating too slowly. | Check the PTO speed. Check the condition of the drive belt or the hydraulic motor. Check for inadequate hydraulic pressure or volume (hydraulic motor-driven pumps). |
| Pump operating parts worn past clearance limits. | Overhaul or replace the pump. |
| Bypass valve (diverter-strainer) plugged. | Remove and clean the strainer. |
| Shut-off valves on pressure line partially blocked, closed, or inoperative. | Open the shut-off valves. Remove obstruction from valves. Replace faulty valves. |
| Pressure regulator faulty or improperly installed. | Replace faulty pressure regulator. |
| Boom control valves faulty or improperly installed. | Replace faulty boom control valves. |
| Restrictor washer installed in the pressure line. | Remove the restrictor washer. |
| Too much agitation flow. | Adjust the shut-off valves on the suction lines and the agitation lines to reduce the agitation flow. |

**SOLUTION FLOW LIGHT (REGULATOR OPEN, GAUGE PRESSURE HIGH)**

| **Possible Cause** | **Remedy** |
|---|---|
| Pressure regulator faulty or improperly installed. | Replace the pressure regulator. |
| Pressure gauge faulty or improperly installed. | Replace the pressure gauge. Check the oil level in the gauge protector. |
| Boom control valves partially blocked, closed, or inoperative. | Open the boom control valves. Remove the obstruction from the valves. Replace a faulty control valve. |
| Boom hoses partially plugged or collapsed. | Replace the boom hoses. |
| Nozzles plugged or restricted. | Replace the nozzles and recalibrate the sprayer. |



Litho in U.S.A.

SO

## SOLUTION FLOW HEAVY (REGULATOR NEARLY OPEN, GAUGE PRESSURE HIGH)

| Possible Cause | Remedy |
|---|---|
| Pressure regulator faulty or improperly installed. | Replace the pressure regulator. |
| Pressure gauge faulty or improperly installed. | Replace the pressure gauge. |
| System pressure too high. | Install restrictor washer in the pressure line from the pump to the control valve. |

## SOLUTION FLOW UNEVEN OR ERRATIC (GAUGE READINGS FLUCTUATE)

| Possible Cause | Remedy |
|---|---|
| Inadequate tank supply. | Fill the tank. Solution level must be above the agitation port for maximum efficiency. |
| Solution contains heavy solids. | Chemical solution poorly mixed. |
| Agitation (return) lines blocked or plugged. | Remove agitation lines and remove obstructions. |
| Pump parts worn past clearance limits. | Overhaul or replace the pump. |
| Pump operating erratically. | Check the PTO drive, condition of the drive belts, hydraulic motor, electric clutch, etc. |
| Gauge protector faulty. | Check the oil level in the gauge protector. Inspect the gauge protector for a faulty diaphragm. |

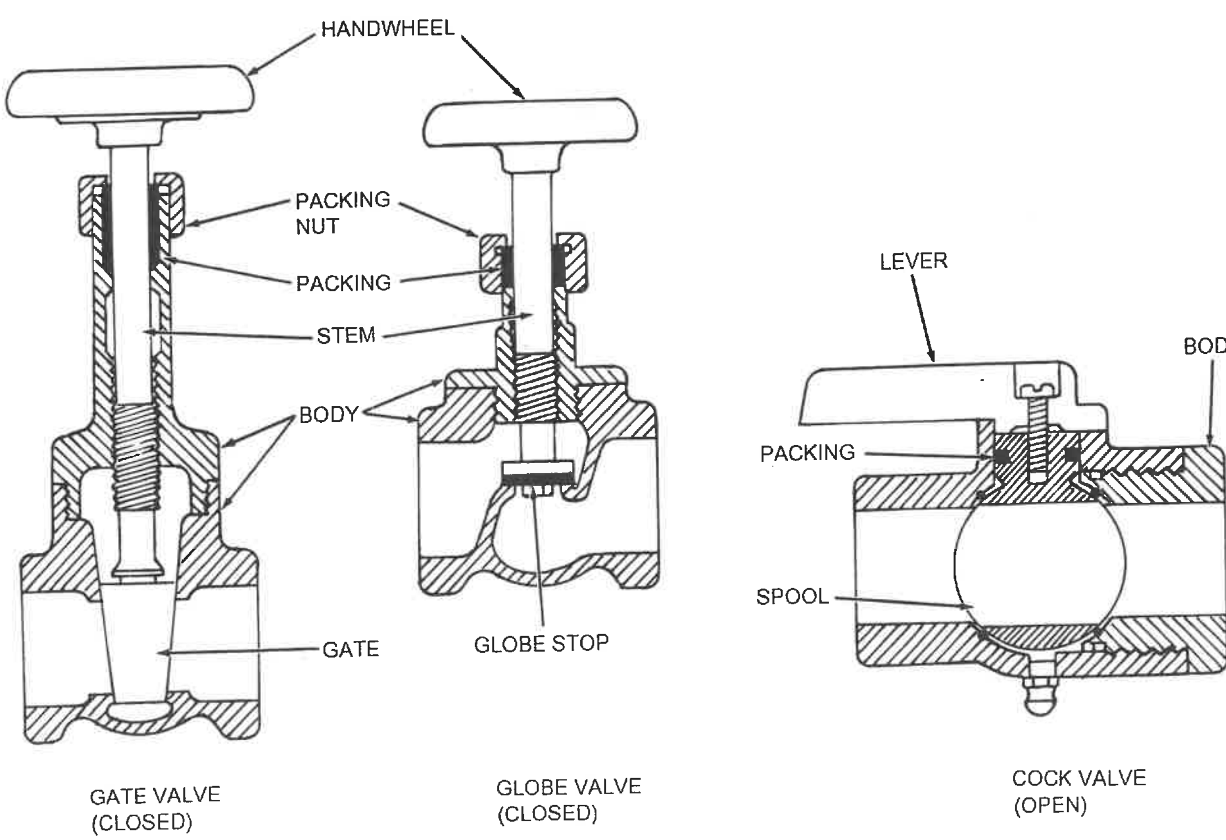



Fig. 54 — Types Of Shut-Off Valves

F(



Litho in U.S.A.

## SHUT-OFF VALVES

Three types of valves are used as shut-off controls in sprayer solution control systems (Fig. 54): gate valves, globe valves, and cock valves.

Shut-off valves are normally located between each tank and the strainer in the suction line leading to the solution pump inlet. Shut-off valves may also be located in the agitation line between the diverter-strainer and each tank.

Although some valves are repairable, many small valves are designed as disposable hardware. It may be less costly to replace a small valve than to repair it. The following repair instructions are for those valves where repair is advisable or necessary.

Before removing the shut-off valve, shut down the solution pump. Release pressure in the system by opening all the system valves and regulators. Drain and flush the system.

Disassembly of the shut-off valve is normally accomplished by separating the two-piece valve body (Fig. 54). Refer to the manufacturer's repair manual for the exact procedure. Examine all parts for cracks, chipping or abrasion. Replace worn or damaged parts.

After assembly of the valve is complete, open and close the valve and visually check for correct seating of the valve and observe freedom of valve action.

## PRESSURE REGULATOR AND SOLUTION CONTROL VALVES

Pressure regulators and solution control valves may vary in appearance, depending on the design, but they are all identical in function.

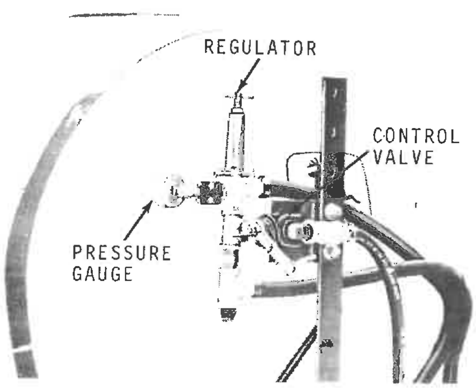



Fig. 55 — Single-Section Valve Pressure Regulator

Single-section valve pressure regulators are installed on fittings separate from the solution control valve mountings (Fig. 55).

### Single-Section Valve Pressure Regulators

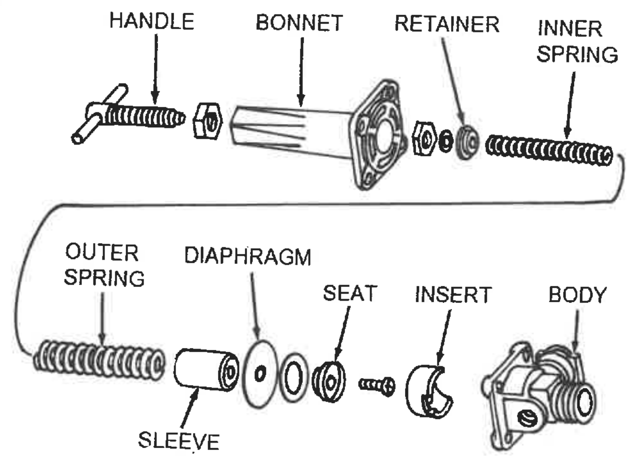



Fig. 56 — Exploded View Of A Pressure Regulator

An exploded view of a typical single-section valve pressure regulator is shown in Fig. 56. Disassemble by removing the screws attaching the bonnet to the valve body.

Clean all parts thoroughly. Replace damaged or worn parts. Reassemble the parts as shown in Fig. 56.

### Single-Section Control Valves

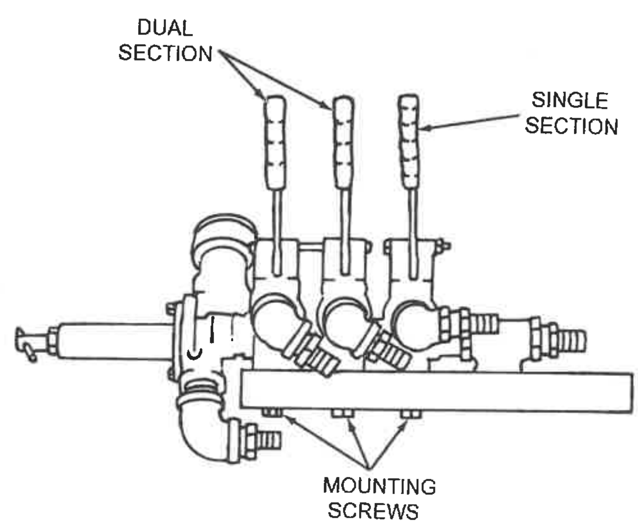



Fig. 57 — Single-Section Control Valves

Single-section control valves may be used alone or in multiples as dual or triple-section controls (Fig. 57).

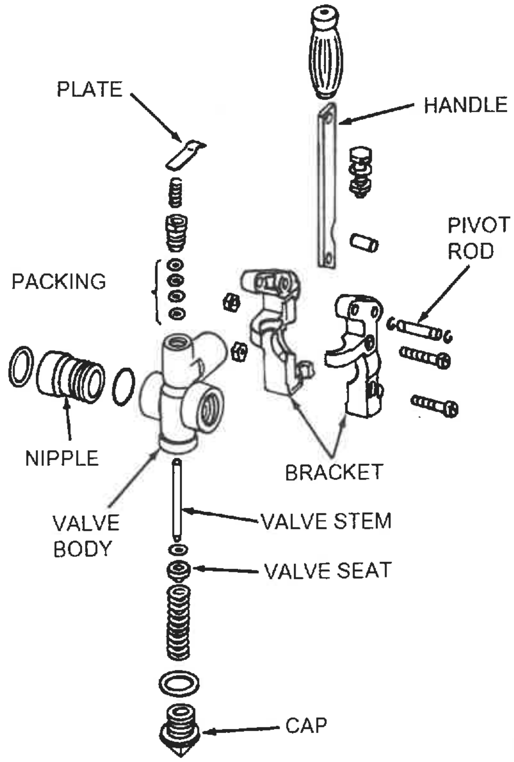



Fig. 58 — Exploded View Of A Single-Section Control Valve

An exploded view of a typical single-section control valve is shown in Fig. 58. Refer to the manufacturer's repair manual for specific disassembly and reassembly instructions.

Clean all parts. Replace worn or damaged parts.

Pressure Regulator And Control Value Unit

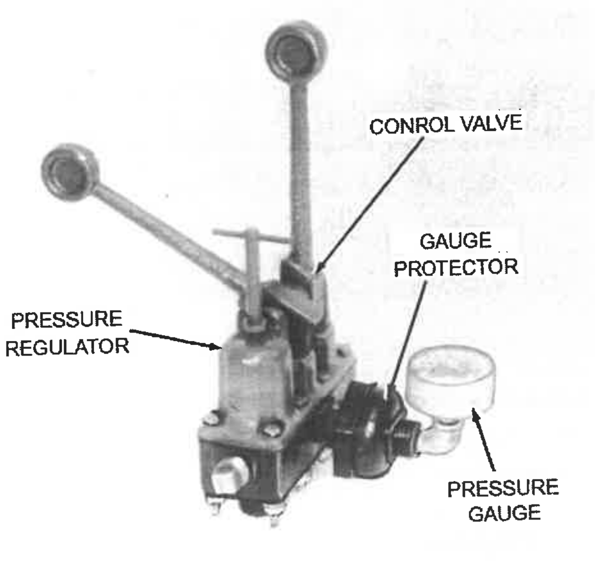



Fig. 59 — Pressure Regulator And Control Valve Assembly

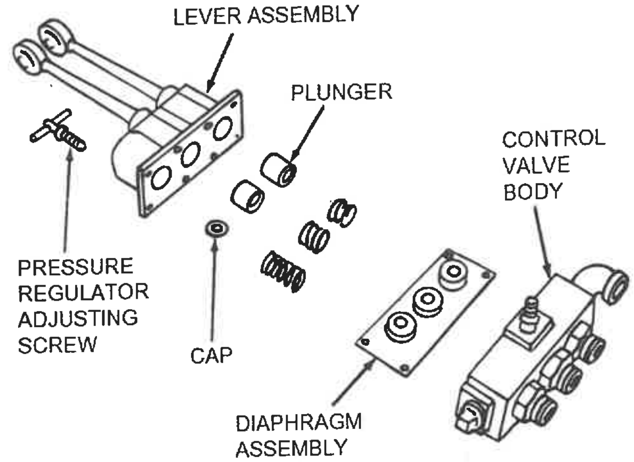



Fig. 60 — Exploded View Of A Control Valve Unit

Some sprayers use a one-piece pressure regulator and control valve assembly (Fig. 59). The pressure regulator and the solution control levers are bolted to the control valve body as a unit.

Between the control valve body and the control levers and pressure regulator is a diaphragm seal and plastic valves (Fig. 60). With diaphragm seals of this type, no working parts of the valve assembly come in contact with the chemical solution.

When servicing these control valve units, examine the diaphragm closely for any rupture, and check the valve seats for roughness. Replace the diaphragm assembly when it shows signs of leaking or when the valve is not working properly.

Check the valve plungers (Fig. 60) for scoring or burrs. Remove the hose adapters and valve seats from the control valve body. Check the valve seat area for roughness. Replace all worn or damage parts.

## PRESSURE GAUGE AND GAUGE PROTECTOR

The pressure gauge (Fig. 59) may be removed for inspection or service without removing or disassembling the control valve assembly. The pressure gauge must be replaced if it does not operate correctly.

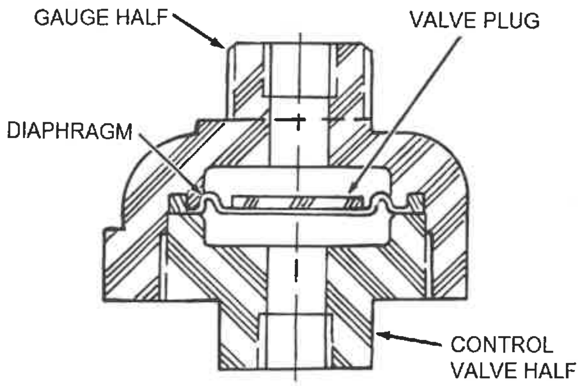



Fig. 61 — Gauge Protector Assembly

A diaphragm is located between the gauge protector halves (Fig. 61). The diaphragm prevents the spray solution from coming in contact with the working parts of the pressure gauge. Ordinarily, the diaphragm may be replaced if it is faulty.

After servicing the pressure gauge or the gauge protector, add SAE 20 oil to the gauge protector cavity until it is full (Fig. 62). Install the pressure gauge and check the gauge reading. Add or remove oil until the gauge reads zero (0).

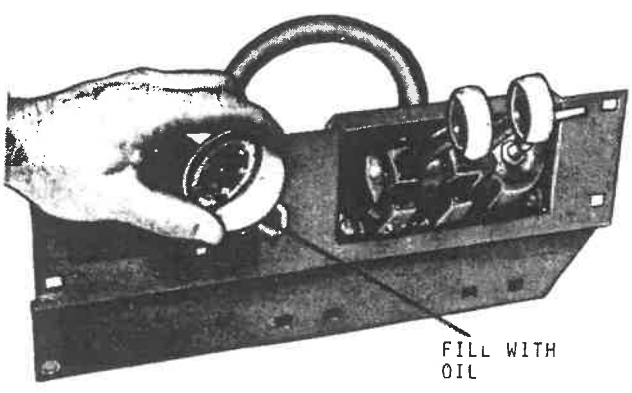



Fig. 62 — Fill Gauge Protector Cavity With Oil

## SUMMARY

For the effective and accurate application of a chemical solution, the sprayer must be properly maintained, adjusted and calibrated, and worn parts must be replaced when necessary.

Proper calibration is probably the most important factor to insure that the sprayer is applying the correct amount of the chemical uniformly over a given area. The sprayer must be calibrated regularly to compensate for wear of the nozzles, and when changing the chemical being applied.

Observe all recommended safety guidelines when working on any sprayer which may have been contaminated by contact with chemical solutions that could be hazardous to your health. Also, familiarize yourself with all the regulations applicable to your situation in order to avoid possible safety violations when working with chemical solutions or contaminated equipment.



Litho in U.S.A.

## MEASUREMENT CONVERSION CHART

### Metric to English

LENGTH
1 millimeter = 0.039 37 inches ............................in
1 meter = 3.281 feet ............................................ft
1 kilometer = 0.621 miles ..................................mi

AREA
1 meter$^2$ = 10.76 feet$^2$ ..........................................ft$^2$
1 hectare = 2.471 acres ...................................acre
(hectare = 10,000 m$^2$)

MASS (WEIGHT)
1 kilogram = 2.205 pounds .................lb
1 tonne (1000 kg) = 1.102 short ton .....sh tn

VOLUME
1 meter$^3$ = 35.31 foot$^3$ ..........................................ft$^3$
1 meter$^3$ = 1.308 yard$^3$ .......................................yd$^3$
1 meter$^3$ = 28.38 bushel ......................................bu
1 liter = 0.028 38 bushel ....................................bu
1 liter = 1.057 quart ..............................................qt

PRESSURE
1 kilopascal = .145/in$^2$
(1 bar = 101.325 kilopascals)

STRESS
1 megapascal or
1 newton/millimeter$^2$ = 145 pound/in$^2$ (psi) ..........psi
(1 N/mm$^2$ = 1 MPa)

POWER
1 kilowatt = 1.341 horsepower (550 ftlb/s) ..hp
(1 watt = 1 Nm/s)

ENERGY (WORK)
1 joule = 0.000 947 8 British Thermal Unit.BTU
(1 J = 1 W s)

FORCE
1 newton = 0.2248 pounds force ...... lb force

TORQUE OR BENDING MOMENT
1 newton meter = 0.7376 pound-foot ...............(lb-ft)

TEMPERATURE
$t_C = (t_F - 32)/1.8$

### English to Metric

LENGTH
1 inch = 25.4 millimeters ..................................mm
1 foot = 0.3048 meters ..........................................m
1 yard = .9144 meters ...........................................m
1 mile = 1.608 kilometers ...................................km

AREA
1 foot$^2$ = 0.0929 meter$^2$ ........................................m$^2$
1 acre = 0.4047 hectare ..................ha
(hectare = 10,000 m$^2$)

MASS WEIGHT
1 pound = 0.4535 kilograms ................kg
1 ton (2000 lb) = 0.9071 tonnes .............t

VOLUME
1 foot$^3$ = 0.028 32 meter$^3$ ...................................m$^3$
1 yard$^3$ = 0.7646 meter$^3$ .........................................m$^3$
1 bushel = 0.035 24 meter$^3$ .................................m$^3$
1 bushel = 35.24 liter ...............................................L
1 quart = 0.9464 liter ...............................................L
1 gallon = 3.785 liters ..............................................L

PRESSURE
1 pound/inch$^2$ = 6.895 kilopascals
= 0.06895 bars

STRESS
1 pound/in$^2$ (psi) = 0.006 895 megapascal ........MPa
or newton/mm$^2$ .................N/mm$^2$
(1 N/mm$^2$ = 1 MPa)

POWER
1 horsepower (550 ftlb/s) = .7457 kilowatt ..kW
(1 watt = 1 Nm/s)

ENERGY (WORK)
1 British Thermal Unit = 1055 joules .........J
(1 J = 1 W s)

FORCE
1 pound = 4.448 newtons ...................N

TORQUE OR BENDING MOMENT
1 pound-foot = 1.356 newton-meters ................Nm

TEMPERATURE
$t_F = 1.8 \times t_C + 32$


Litho in U.S.A.