There are many factors that must be considered when designing a spray rig. The following paper on the design and operation of weed sprayers, presented at an Irrigation Operators' Workshop in Denver, Colo., covers those factors that should be considered when contemplating the purchase of a weed sprayer.

Contents for "Design and Operation of Weed Sprayers" Paper

*   *   *   *   *

DESIGN AND OPERATION OF WEED SPRAYERS

Floyd Oliver, Agronomist

P.N. Region, Boise Idaho

Select the Spray Rig to Fit Your Conditions

Efficient weed spraying can be accomplished only with a spray rig which has been designed and constructed for the conditions under which it is to be operated. The vehicle must be capable of speedily carrying its load on the roads or trails leading to the area to be sprayed and then be adapted to move over the spray area at the desired speed. The sprayer tank, engine, pumps, controls, and booms must mix and apply herbicides in a manner which will insure adequate, complete coverage of weeds in all situations. An efficient spray rig should also have those features which insure accurate and safe application of sprays.

Choosing the Vehicle or Truck

The presence and condition of roads or spray trails should be considered in selecting the kind and size of vehicle. It must be capable of traversing rough terrain including steep areas, mud, sand, "high centers," etc.

The following are some of the essential features desired in the vehicle.

- Low center of gravity for stability
- Wide gear and speed range to fit all terrain
- Capacity to haul an economic load of solution and herbicides
- Good maneuverability for turns and "tight" places

Gross vehicle weight and nominal load rating will be determined by the intended load. If an 800 gallon spray load and 200 gallons of herbicides are to be carried, the truck should be in the 19,000-GVW class, commonly referred to as a 2-ton truck. Carrying this large a load on typical channels will require four-wheel drive. In sandy and muddy conditions a two-speed differential and flotation tires will be needed. Power steering is good insurance with a vehicle this large on such right-of-way. For a load of 400 gallons of solution and 100 gallons of herbicides, the truck should be a 16,000-GVW type of 1-1/2-ton truck. Four-wheel drive would still be a good choice here. Depending on your conditions, four speeds forward without the extra range of the two-speed differential may be adequate.

Selecting and Mounting the Spray Equipment

The spraying equipment should be designed to insure proper mixing and accurate, safe placement of herbicidal sprays. The design should provide versatility and adaptation to all materials to be used and conditions encountered. If the sprayer and its controls are kept in an easily dismounted package, the truck may be used for other purposes in the off-season.

Factors to be Considered in Determining the Size of the Sprayer

Average daily output needed. Divide the acreage to be sprayed by the number of days available to get over it once. The spray period available will be determined by:

1. Begin spraying when there has been sufficient growing weather to provide uniform emergence of seedlings to a susceptible stage.

2. Plan to finish the first coverage before weeds become a nuisance by their height or reach stages that are hard to kill without heavy rates. Also, it should be completed before second stands on right-of-way sprayed early become a problem. If the sprayer is used for spot spraying noxious weeds, this treatment will be necessary before they recover from the light boom application and go to seed.

An efficient spray program should cover all the right-of-way to be sprayed within this period. For example, in the Pacific Northwest the available time is about 60 days from April 15 to June 15. Within this period there are only 40 working days in which to do the work. From our experience, a requirement of 40 acres or less per day for a spray round can be satisfied with a swath capability of 30 feet - 10 feet to cover the road and 20 feet on one side. A large rig with 50 or more feet of boom to cover the road, and 20 to 24 feet on each side, will be required where the daily output must be above 40 acres to a minimum of 160 acres.

To consider these factors let us assume a district has about 2,800 acres of right-of-way to spray in the 40 days we have described. The operating roads are such that the sprayer can travel an average of 5 mi/h. Rights-of-way have an average width of 25 feet.

1. Daily production needed:

$$\frac{2,800 \text{ acres}}{40 \text{ days}} = 70 \text{ acres per day}$$

2. Acreage per mile of average right-of-way:

$$\frac{25 \text{ feet}}{8.25 \text{ width of an acre}} = 3 \text{ acres}$$

1 mile in length

3. Travel distance in a day's spraying:

$$\frac{70 \text{ acres}}{3 \text{ acres}} = 23 \text{ miles}$$

4. Time sprayer underway:

$$\frac{23}{5 \text{ mi/h}} = 4 \text{ hours } 35 \text{ minutes}$$

5. Total gallonage applied:

70 acres x 50 gallons = 3,500 gallons

6. Time spent backfilling at 10 minutes per stop:

<u>200-gallon tank</u>

$$\frac{3{,}500}{200} = 17.5 \text{ fills x } 10 \text{ minutes} = 2 \text{ hours } 55 \text{ minutes}$$

<u>400-gallon tank</u>

$$\frac{3{,}500}{400} = 8.75 \text{ fills x } 10 \text{ minutes} = 1 \text{ hour } 28 \text{ minutes}$$

7. Use of time:

Spraying	4 hours	35 minutes
Backfilling	1 hour	30 minutes
Other	1 hour	55 minutes
	8 hours	0 minute

In practice we would do well to cover this acreage in the time allowed even with a large sprayer. The 10 minutes per load allowed for backfilling, adding materials, and making adjustment is minimal and a desirable goal. The time spent in other activities of the crew will include: yard time loading herbicides, travel to and from the site, breakdowns, recordkeeping, and portions of the day lost when the wind velocity is too high to continue spraying.

Width of swath important. The boom swath should be wide enough to cover all the right-of-way on one side of a majority of the channels. Whenever the rig must make more than one pass to do a typical bank, costs in labor and equipment operation may quickly exceed the cost of additional lengths of boom. A large sprayer should have equal lengths of boom on each side so that the wide areas of banks can be sprayed as they are passed without backtracking.

Sprayer Components

The tank should be as large as feasible if we are to obtain an efficient ratio between time spent spraying and backfilling. With consideration for available space, its size should be as large as needed to take up the truck's load capacity after allowance for weight of the spray rig, supplies, and operators. The weight of a tank's contents may be calculated at 62.34 pounds per cubic foot of volume - the weight of water. At least, the tank capacity should equal 15 times the total output per minute of the nozzles. Steel tanks are best, but should be coated with epoxy lining to prevent corrosion and the formation of scale which will clog boom and nozzle openings. Mechanical agitation, using paddles to roll the solution for making emulsions with oil and maintaining suspensions of insoluble materials, is a must for the tank. The agitator shaft should turn at 60 to 90 r/min. Supply tanks to carry 2,4-D and oil, if an herbicide-oil water emulsion is used, should also be provided. A measuring well to meter these materials into the main tank is a great timesaver and should be added to increase efficiency and eliminate spillage. Since the volume of surfactant used is smaller it can be carried in cans.

Centrifugal pumps have most advantages. Centrifugal pumps have many advantages over piston, roller, gear or other types for weed spraying including:

- Less costly for comparable capacities
- Simple design makes for trouble-free performance
- Low cost of maintenance
- Tolerant to abrasive materials
- With open impellor free from clogging by gravel, sand, and other debris

High-pressure pumps not required. High-pressure pumps are not required and are not desired for weed spraying. Sixty pounds of pressure is the maximum which can be used safely even in spot spraying; 40 pounds is adequate in most conditions. Ten lb/in^2 at the nozzles is adequate for boom spraying with some types of nozzles. Centrifugal pumps deliver most per unit of horsepower and insure fast backfilling.

Choose pump with self-priming chamber. A self-priming chamber saves time and eliminates the necessity for a foot valve at the end of the suction hose. The resulting empty hose will save much labor by the spray rig operator.

Selecting the Size of the Pump

The following factors should be considered in determining the size of the pump required.

1. The rate of discharge of all nozzles that may be turned on at once. These may include all the boom nozzles, offcenter nozzles on the ends of the booms to increase the swath width, and a handgun.

2. A high maximum rate of discharge for refilling the spray tank. Ten percent of the tank capacity per minute is a desirable rate and will provide sufficient time for adding material and making adjustments. To obtain high daily production, the portion of the spray cycle when the rig is not spraying should be kept as low as possible.

3. To obtain long pump life, efficient use of the power applied and reserve capacity, a pump should be selected that will deliver the required discharge at about the middle of its operating range.

4. Pressure required. The pump must have the capability to deliver peak combined flow to supply boom and offcenter nozzles and the handgun at the desired pressure. Pump data sheets should be consulted. (Note: Without an elaborate dual-pressure regulation system, the pressure supplied to all these outlets will be the same. Since the boom nozzle pressure is the most important, it will dictate the pressure to be maintained in the manifold by the bypass regulator. After allowance for delivery loss, this will be a total of the desired nozzle pressure plus line loss to the nozzles. When using a low-pressure (10-lb/in^2) nozzle system, this manifold pressure may be on the borderline for proper operation of offcenter nozzles and a handgun. This condition may be improved by taking off a separate large lead for them directly at the pump discharge. See further discussion under section on nozzles.)

Nozzle Discharge can be Determined with this Formula

$$\frac{WSV}{8.25 \times 60} = \text{rate of discharge}$$

W	width of boom
S	speed of travel
V	volume of solution
8.25	width of strip 1 mile long, equal to an acre
60	minutes in an hour

Example: Assume that a sprayer with a 400-gallon tank and a 50-foot boom will travel 5 miles per hour at average speed. Coverage of 50 gallons per acre is desired.

$$\frac{50 \times 5 \times 50}{8.25 \times 60} = \frac{12,500}{495} = 25.3 \text{ gal/min required nozzle discharge}$$

Total discharge of this sprayer may also include an offcenter nozzle at 8 gal/min and a handgun used intermittently at 6 gla/min. Under this condition, discharge will total 39.3 gal/min.

Refill discharge rate, at 10 percent of the tank capacity per minute, should equal 40 gal/min.

In this case, we should select a pump capable of delivering 50 gal/min at a pressure of 40 lb/in^2 in order to have adequate and surplus capacity.

Selecting the Size of the Engine - Adequate Power Desired

Be sure that the spray rig is fully powered with some to spare. This insures adequate delivery under all conditions to each nozzle and handgun, brisk hydraulic system response, and proper agitation without overworking the motor. Factors which go into determining the power required are:

- Maximum pressure required
- Friction loss from the pump to the nozzles
- Efficiency of the pump
- Additional power needed for the agitator and hydraulic pump

Desired maximum nozzle pressure should be combined with pressure needed to overcome friction loss to estimate total pressure required. Line loss from the valve at the manifold to the nozzle orifice may equal 5 pounds. Extra pressure of from 3 to 5 pounds should also be provided for the loss from the pump to the valve. Friction loss expressed in pressure reduction should be obtained for all the lengths of pipe and hose, fittings, and couplings that are linked together to conduct the fluid from the pump to the nozzles. In laying out the system, use pipe diameters equal to the outlet of the pump from that point to the valve manifold, avoid numerous elbows and changes of flow direction and hold transitions through hose and pipe couplings to a minimum.

Engine Horsepower may be Calculated by Using this Formula

$$\frac{\text{Head (lb/in}^2 \times 2.31) \times \text{gal/min}}{3{,}960 \times \text{percent of efficiency}} = \text{horsepower required}$$

Head - Pounds per square inch of pressure required times the height (2.31 feet) of a column of water which will exert 1 pound pressure per square inch.

Gal/min - Total output of all nozzles at design pressure in gallons per minute.

3,960 - Foot gallons per minute or 1 horsepower expressed as the work needed to lift 1 gallon to a height of 1 foot in 1 minute.

Percent of efficiency - The degree to which the pump utilizes the power applied to it.

Example: Nozzle pressure 30 pounds, estimated friction loss 10 pounds, 34 gallons of solution needed to furnish 26 gal/min to 30 nozzles at 0.86 gal/min each, and one offcenter nozzle or handgun at 8 gal/min, pump efficiency 50 percent.

$$\frac{40 + 10 \times 2.31 \times 34}{3{,}960 \times 0.50} = \frac{3{,}927}{1{,}980} = 1.98 \text{ brake horsepower}$$

Gasoline engines are very inefficient. Actual brake horsepower is generally about 35 percent of the nameplate rated power.

$$\text{Rated horsepower} = \frac{\text{brake horsepower}}{\text{engine efficiency}}$$

$$\text{Rated horsepower} = \frac{1.98}{35} = 5.6 \text{ hp}$$

Other estimated power requirements of the sprayer would be:

Hydraulic pumps - 4 to 6 horsepower each including belt loss of power

Two pumps, one for each boom	12
Agitator	2
	19.6 hp

We should select an engine of about the next larger size to provide adequate power. In this example it would be one with a 21.5-horsepower rating.

Refill System

Backfilling should be fast - Spend more time spraying and less time filling. With high capacity in the pump refilling the spray tank can be done quickly thereby holding down the time the sprayer stands still. The suction hose and transition piping should have an inside diameter equal to that of the intake side of the pump. This hose should be wire reinforced to prevent collapse and long enough to reach the water from most ditchbanks on the system. Two sections of 15 feet each, fitted with quick disconnect couplings, will give good reach and convenience. Maximum suction lift of a centrifugal pump is 26.5 feet at sea level; for each 1000 feet of elevation, this is reduced 1.2 feet. Except as expressed in suction lift and line loss, pressure is not a consideration in refilling since there is an open discharge.

The suction strainer should do two things: (1) Keep the hose inlet off the bottom and (2) strain out debris and gravel. You cannot expect to do all the straining at the hose inlet with a very fine screen as silt and algae will clog it and reduce the pumping rate. Take out only that material which will clog the pump.

Cover the open side with galvanized window screen of 20 by 20 mesh with support provided by 1/4-inch galvanized hardware cloth. The screen area should equal about 10 times the area of the suction hose cross section.

A line strainer beyond the pump and just ahead of the valve manifold is much more efficient than having screens in each nozzle, but it should be of the same size or larger than the delivery line. The "tee" type, with cylindrical, replaceable screen element which can be flushed without removal of the element, is a timesaver. The size of the screen openings should be just slightly smaller than the nozzle openings. Spraying out all particles which will pass the nozzle reduces strainer cleaning time. Even for a relatively small nozzle orifice, such as that in flat fan nozzles, a 30-mesh strainer element is fine enough.

Pressure regulator. Accurate pressure regulation is a must for precise nozzle operation and drift control. Since pressure is reduced through bypass of fluid, the regulator and return line to the spray tank should be sized to handle maximum flow. Otherwise, backup can raise pressure during periods of low boom demand.

Gages. Select those which have the desired operating pressure at the middle of the dial if possible. A 15-pound desired manifold pressure may hardly move the needle on a 200-pound gage, and then it is often hard to read.

Manifold and valves. Each boom should have an individual, valved leadoff of a large delivery pipe from the pump. Most difficulties in regulating and making pressures comparable between the booms arise in this area. Slight differences in pressure between inboard and outboard booms will appear anyway as a result of the higher line loss in the latter. This effect can be aggravated by using the clustered, pushbutton or lever selector type of valve assembly, ganged valves or not providing a bypass loop to the downstream end of the manifold. In the latter case, the valves on the end of the manifold may be starved for pressure and output when the others are turned on. Valves should be the quarter-turn ball type which provide straight-through flow with a minimum of restriction.

Booms

Total length should be sufficient to cover the right-of-way of most small- and medium-sized channels on the system. No other factor increases sprayer efficiency more than having good long booms on both sides of the sprayer. If possible, they should be built in three sections to permit close adjustment to the ground surface being sprayed. The best boom height is 30 inches. This gives double coverage and limits the drift potential. Multi-sectioned booms also permit better adjustment to the varying width that occur between the spray road and the water surface, thereby preventing spraying of the water with herbicide. On very small channels, a three-section boom may often be arranged so that the inner and outer sections spray the banks while the middle section is turned off over the water.

On large sprayers with booms on each side, the operator should be positioned well above and as far back from them as possible. This enables the operator to watch both booms easily and permits more accurate judgment of their height above the ground. Provide a horn for signal communication with the driver.

Movement and positioning of the booms, using power from hydraulic cylinders to position the section vertically, enables the operator to continually adjust the contour of the booms to fit the banks. A swing cylinder should also be provided to move the whole boom to any point in the horizontal plane from the carry position on the truck to one at a full right angle to the line of travel. Often a lesser angle will permit closer adjustment to the strip to be sprayed, thereby giving more accuracy of application.

Delivery lines for the booms from the valves to the nozzles should be sized to carry double the nozzle demand, lacking accurate computation of friction loss. This will compensate for loss to the line, fittings, hoses, and couplings.

Extension of the boom swath for reaching extra widths and down long banks of drains can be obtained by mounting offcenter nozzles at the ends of the booms. these are manufactured to operate at pressures from 20 to 60 pounds.

Nozzles

Capacity of the nozzles needed for the sprayer can be determined as follows. First, determine the range of speed that the spray roads will permit. Apply this in the rate of discharge formula as in the following example:

Highest speed - 7.5 mi/h

$$\frac{\text{50 feet swath x 7.5 mi/h x 50 gallons per acre}}{8.25 \times 60} = 37.8 \text{ gal/min}$$

Lowest speed - 5 mi/h

$$\frac{\text{50 feet swath x 5 mi/h x 50 gallons per acre}}{8.25 \times 60} = 25.2 \text{ gal/min}$$

Determine the number of nozzles needed by dividing the total spray swath by 20 inches. This is the standard nozzle spacing.

$$\text{50 feet x 12 inches} = \frac{\text{600 inches}}{\text{20 inches}} = \text{30 nozzles}$$

Obtain the range of nozzle capacity needed by dividing the rate of discharge by the number of nozzles required.

$$\text{High } \frac{37.8 \text{ gal/min}}{30} = 1.26 \text{ gal/min}$$

$$\text{Low } \frac{25.2 \text{ gal/min}}{30} = 0.84 \text{ gal/min}$$

Multiply the difference between these nozzle capacities by 60 percent and add this to the lower figure in order to set the discharge rate slightly above the middle of the range.

$$\begin{array}{r} 1.26 \\ \underline{0.84} \\ 0.42 \end{array} \times 0.60 = 0.25 \qquad 0.25 + 0.84 = \underline{\underline{1.09}}$$

This will provide a gallonage per acre which will not be too high at the minimum speed nor too low at the maximum speed for good coverage. Choose a nozzle which will supply this rate at the desired pressure. In table form the choice would look like this:

Capacity - gal/min	Speed - mi/h 5	6	7.5
0.84	50	42	33
1.10	65	55	44
1.26	75	62	50

After determining the capacity needed, choose a nozzle which will insure low-potential drift and most freedom from clogging.

Drift of herbicide sprays results from movement of small droplets on air currents. It is a product of the size of the spray particle, height of the nozzle, and wind velocity. A small nozzle orifice, which must be operated at a high pressure, produces many more drift-sized particles than does a larger one at low pressure. By spraying with coarse droplets, we increase the margin of safety to crops and the efficiency of the work through being able to spray in slightly stronger wind conditions. Nozzle height with the boom at the horizontal should equal but not exceed 1-1/2 times the design height recommended for the nozzle in the manual. This will double the coverage through overlap and yet hold drift potential to a minimum.

Clogged nozzles use more crew time than any other sprayer malfunction; they also result in poor control by leaving strips of untreated weeds. The size of the nozzle orifice directly governs frequency of clogging - select a large one to reduce clogging. A larger proportion of particles which may plug the orifice will pass through with the solution.

Type of nozzle

Three types of nozzles are commonly used for weed spraying. Each produces spray droplets in a different way by either:

- Forcing liquid through a small opening; example - flat fan nozzles
- Deflecting a stream of liquid off a plate; example - floodjet nozzle
- Swirling the liquid out of an orifice through a circular motion produced in a cylindrical chamber; example - whirl chamber nozzle

A summary of the characteristics of these types is as follows:

1. Flat fan

   a. Comparatively high pressure required - best performance obtained at 30 lb/in^2 or above. Not recommended for less than 20 lb/in^2
   b. Clogs easily
   c. High drift potential
   d. Pattern good at 30 inches height
   e. Orifice subject to rapid wear and mechanical damage
   f. Spacing - 20 inches
   g. Installed in vertical position

2. Floodjet nozzle

   a. Low pressure - 10 to 12 lb/in^2
   b. Fairly free from clogging
   c. Low drift potential from coarse spray
   d. Pattern good with overlap
   e. Durability - excellent. Orifice protected from damage
   f. May be spaced at 40 inches
   g. Installed in horizontal position

3. Whirl chamber nozzle

   a. Low pressure - 8 to 10 pounds
   b. Virtually free of clogging
   c. Low drift potential at proper pressure
   d. Pattern - excellent, covers sides of plant
   e. Durability - very good, outer orifice subject to mechanical damage
   f. Spacing - 20 inches
   g. Installed in horizontal position
   h. Nozzle orifices may be changed to vary capacity

<u>Reels and Handguns</u>

Equip your sprayer with a <u>live reel</u> - one which has solution supplied to the hose all the time. This will save much labor. Reels can be purchased or shop built from rotary couplings obtainable from petroleum equipment supply houses. Make the reel large enough to handle 100 or more feet of the hose you choose. Further refinement can be obtained by powering the reel for rewind with an electric motor.

Effective spot spraying requires a high volume of solution to thoroughly wet heavy growths of perennial weeds, cattails, and willows. Let your crew depend on volume instead of pressure for this job and thereby build in more safety for the operation. Handguns should put out a heavy volume - choose one of the pistol-grip types with short barrel that has an adjustable pattern. Capacity should be at least 6 gal/min. Wands with multiple nozzles are slow and clumsy to use.

The hose to the handgun should be large enough to supply a large volume, compensate for line loss, and yet not be too heavy to pull around easily. Usually, five-eighths of an inch size is large enough. The hose need not be the heavy-duty, rubber type. A good grade of vinyl plastic, nylon reinforced garden hose from the hardware store will carry more solution, cost much less, and be as resistive to herbicide solutions.

If you use low-pressure nozzles, you will probably not have enough pressure to operate a handgun effectively at the same time the sprayer is being used for boom work. Offcenter nozzles will operate at 20 lb/in^2 which is too low for the gun. There are several solutions to this problem:

1. Make provision for the dual pressure system mentioned in the section on pressure.

2. Plan not to spray by handgun unless pressure is increased by:

   a. Adjustment of the bypass regulator.

   b. Partial closure of a valve on the pump discharge below the gun outlet. The valve will act as a restricting orifice and build up pressure for the gun. This method will be less time consuming than readjusting the pressure regulator each time. These choices are feasible as boom and spot spraying simultaneously is rarely practical. With a sprayer of any size the driver and operator will both have plenty to do without using a handgun. Furthermore, gun work is done most effectively and safely on the ground with the sprayer stopped.

Operating the Weed Sprayer

Providing efficient and safe equipment is only half the requirement for a good spray program. The best equipment poorly or recklessly used can result in costly, ineffective weed control and claims for herbicide damage to crops. Properly designed and carefully operated equipment can make spraying practical in areas of high hazard to crops, orchards, and ornamental plantings.

Many Hazards can Result in Herbicide Damage

Drift will occur whenever the spray is broken into fine particles and applied near sensitive crops in windy conditions. Use low pressures and equip the crew with a pocket wind gage. They should make frequent readings of wind velocity and direction and continually observe the spray pattern, thereby developing a "feel" for drift conditions. Unless the right-of-way is isolated from all crops, spraying should stop at 7-mi/h wind velocity. Recording daily wind data is valuable for cases involving complaint of reported drift.

Volatility of ester forms of 2,4-D is high; use only the salts, such as the amine formulation, which are virtually nonvolatile. Make certain your crew understands the amount of active ingredient contained in the formulation.

Proper Sprayer Operation Depends on Well-trained Operators and Carefully Adjusted Equipment

Put your best men on the sprayer; intelligent, alert, interested operators can save the district big money through prevention of losses to weeds and in cost of control. Teach them weed control in the wintertime yourself or send them to weed control courses. Such training is offered by the Extension Service or the State Department of Agriculture in many places. They should know:

- Identification of weeds
- Growth stages and spray timing
- Herbicides, surfactants and rates
- Maintenance of the sprayer
- Calibration and adjustment to varied conditions
- Map reading and land description
- Recordkeeping
- Safety

To find out if they understand these things, give a written test - you may be surprised to find they have operated the sprayer a long time without knowing much about weed control.

Daily weed control records giving the channels sprayed, gallonage and rate, acreage, and mileage will give you a continuous check on the efficiency of the operation.

Periodic observation of the rig in the field is most important in managing the crew as this will reveal their proficiency in:

- Adjusting the speed of the truck to the terrain
- Handling the booms
- Applying proper gallonage and rate through calibration and adjustment
- Avoiding drift and other hazards

The sprayer can be tested in a variety of ways to check its performance.

A tachometer should be used to check the r/min of the engine, spray pump, hydraulic pumps, and agitator.

Use a stopwatch to clock the time needed to refill the tank. This will provide the rate per minute; if it is low, the suction strainer may be plugged or the hose compressed.

A gage inserted at the pump discharge will give actual pump pressure.

Check the manifold gage against a new one - gages wear out fast.

Compare pressures between the manifold and each boom section by inserting a gage on a tee into one of the nozzle openings. If the actual pressure in the boom is low, the nozzles will not discharge their rated capacity and there may be excessive loss due to restrictions in the delivery line. Test each boom section by itself and in combination with other sections to full discharge in order to determine the range of pressure variation. Pressure and nozzle discharge should be reasonably close between sections and between one-boom and full discharge.

Check the flow to each boom section by using a flowmeter. If this indicates the nozzles are discharging more than their rated flow for the pressure applied, their orifices may be worn. This can result in inaccurate applications and poor spray patterns.

Sprayer calibration is dependent on accurate measurement of speed and distance traveled. Since speedometers are usually hard to read at low speeds and may also be inaccurate, speed determination is better done by calculation from distance traveled and time underway. Check the odometer by comparing its performance with that of another vehicle which is known to be accurate or by comparison with highway mileposts. The best odometer would be one having both a tenth and hundredth wheel - some trucks come without even the former. A specially purchased speedometer to give precise speed and distance will pay several times over, particularly if the truck does not have a tachometer. Such speedometers are available on the market. If there is a tachometer on the truck, speeds and r/min can be interrelated for the various gear and range combinations, and the driver can then hold a more constant speed by tachometer than by speedometer. Supply the crew with a stopwatch for easy determination of time underway.

*   *   *   *   *

Multipurpose spray rig. - The commercially available multipurpose spray rig shown in figures 44 and 45 is representative of those used by Bureau forces on the Friant-Kern and Madera Canals, Central Valley project, Calif.

Basically, the spray rig consists of a 600-gallon, stainless steel tank mounted on a 2-1/2-ton truck having a 169-inch wheelbase. A mechanically driven agitator, driven from the pump, insures adequate mixing of the spray solution. Pressure is supplied by a 30- to 50-gal/min, three-cylinder, positive displacement-type pump turned by a four-cylinder, water-cooled engine. The pressure to the spray nozzles is controlled by both a high-pressure and a low-pressure regulator, which allows the boom and handlines to be operated simultaneously at different pressures without affecting one another.

A 15-foot hydraulic boom is usually attached to the truck behind the driver's side of the cab and is capable of being lowered from a vertical position to 35° below horizontal. This feature is necessary so that the boom may be adjusted to the slope of the canal banks. The boom is made in three separate 5-foot sections; each section can be turned on or off independently with a ratchet valve located on a manifold at the rear of the truck. There is an off-center nozzle at the end of the boom to give additional swath width when needed. The outside 5-foot section can be folded back out of the way when not being used. the side boom is held in a horizontal spraying position by friction and swings back along the side of the sprayer for traveling. There is also an additional stationary boom located across the front or rear of the truck to spray the roadway. The booms are controlled by an operator from a platform at the rear of the rig. Two persons should be used on each spray rig instead of having the truck driver attempt to perform the entire operation. Two persons are also desirable in the event of an accident.

Hose reels attached to the sprayer have a capacity for 100 feet of 3/4-inch, lightweight, polyvinyl-chloride, high-pressure spray hose. The spray solution can be applied with hand wands, high-pressure orchard spray guns, or through the boom, depending on the nature and requirements of the operation.

Project personnel have also found that the tank can best be refilled from the canal with a portable type 1-1/2-inch, self-priming pump having a lightweight, 30-foot, 1-1/2-inch, flexible plastic suction hose. The pump is permanently affixed to the truck.

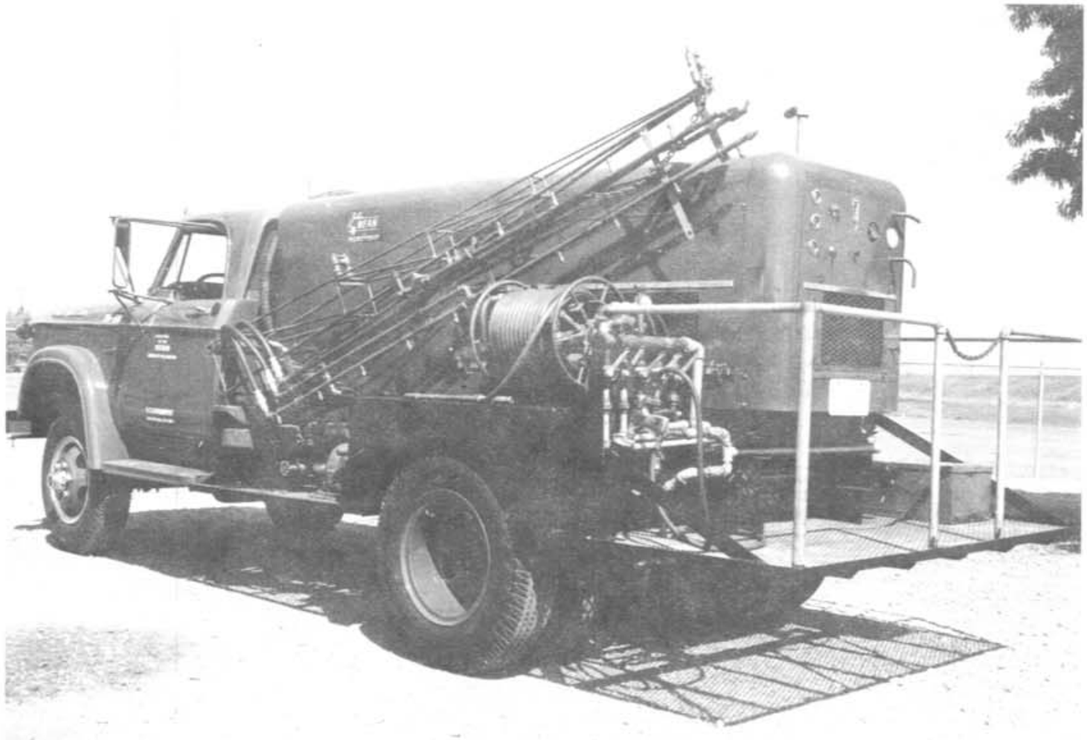

Figure 44

Figure 45

Maintenance forces of the South Platte River project, Colo., found it difficult to control weeds from the single operation and maintenance roadway located on the downhill side of canals in their area. It was particularly difficult to reach weeds on the far side of the canal, although the truck-mounted spray rig used for the work was equipped with adjustable booms that can cover a 260-foot-wide swath.

Following is a description of the *folding spray boom* that was designed and fabricated by O&M personnel, which is used to spray weeds with a handgun nozzle in hard-to-reach places. The hose which carries spray solution to the handgun is on a retractable reel so that the spray operator can always have the right length of hose at the location he is spraying with herbicide.

The folding boom shown in figure 46 is constructed using two pieces of 1-inch angle iron held in place and reinforced by welded bracing. At the point the boom is attached to the truck, the angle irons are spaced 18 inches apart and taper to 6 inches at the end of the boom. The boom is constructed in three 10-foot-long sections with hinges between the second and third sections of the boom.

Figure 46

An adjustable, lightweight, handgun sprayer is used with this boom. The lightweight handgun sprayer is necessary to allow the spray operator more ease of handling on steep, rocky slopes, in high weeds, and in other precarious locations where this spray rig is used. High- or low-spray application rates can be applied with the handgun, depending upon the setting. Experience seems to be the only way to arrive at a proper setting for the type of weeds being treated. A reel-mounted hose expedites any changes needed in hose length. Distances up to 75 feet from the truck can be covered with this device, and the hose is supported to prevent it from dragging on the ground or in the water.

This spray rig was constructed by O&M personnel at:

South Platte River Projects Office
P.O. Box 449
Loveland, Colo. 80537

This office may be contacted for specifications.

Hydraulically operated spray rig. - A combination of fertile soils, water, and a year-round growing season has provided the essential ingredients for the thriving agricultural economy of Southern California's Imperial Valley. These same elements also result in heavy weed growth.

Through the years, Imperial Irrigation District, which operates over 3,000 miles of main canals, laterals, and drains serving in excess of 500,000 acres of irrigated farmland, has run the gamut in methods of weed control. From the early-day use of labor gangs equipped with shovels, brush axes, and machetes through the period of extensive use of weed burners, the District has progressed to the present-day method of chemical weed control, using relatively sophisticated machines for the application of various liquid herbicide mixtures.

The Imperial Irrigation District, also being in the power generation, transmission, and distribution business, uses a fleet of line trucks equipped with booms. Several of these hydraulically operated booms have been adapted to spray booms by personnel of the headquarters shops of the District by adding a pair of movable spray arms mounted at the end of the boom.

It will be noted in figure 47 that the operator sits at a control panel mounted on the swinging pedestal of the boom, affording him a full view of this work. The main boom has a 360° horizontal swing with a vertical movement of 45° below the horizontal. The two spray arms attached at the end of the boom are hydraulically operated from the control panel, and each is capable of a 180° horizontal swing and a 90° up-and-down movement. This allows positioning of the spray pattern to conform to any normal drain section or canal side slope and berm. Each spray arm is equipped with six nozzles operated in groups of three by valves at the control panel.

Figure 47

Other noteworthy features include the jet-agitated, 1,800-gallon tank capable of being filled in 6 minutes, with a 3-inch centrifugal pump using a power takeoff from the truck transmission. One auxiliary gasoline engine powers the spray pump and the hydraulic pump for boom operation. Figure 48 shows a full view of this hydraulically operated spray rig. For information about the spray truck, the address of the Imperial Irrigation District is P.O. Box 937, Imperial, Calif. 92251.

Pumps. - The pump is the heart of any system of application, whether for herbicides or insecticides.

Types of pumps available are: centrifugal, gear, roller, and piston, with a wide pressure range from which to choose. High-pressure pumps which operate at pressures in excess of 800 lb/in^2 are available; however, most spraying situations can be handled with an operating pressure of less than 40 pounds per square inch.

Figure 48

One of the most popular pumps has been the roller pump. A primary reason is its relatively low initial cost. This type may be decreasing in popularity because its life is short compared to many other products and there is too much "downtime."

Next in terms of cost is the centrifugal pump. Use of this pump has grown tremendously in the last few years. It has lower maintenance costs than a roller pump, but does not have the pressure characteristics. While generally adequate, the pump cannot handle pressures in excess of 100 pounds per square inch. Larger models of this pump are used successfully for the transfer of large volumes of liquid where pressure is of little consequence.

Gear and vane pumps are next costwise, although in some cases they cost more than piston pumps. Gear and vane pumps have good pressure characteristics and are longer lasting than roller pumps. In some parts of the country, and for some applications, there is good acceptance of gear pumps.

Piston pumps fall into two types: (1) high pressure, low volume, and relatively high speed, and (2) low pressure, large volume, and low speed. High-pressure pumps must have a power source to give a speed of 500 to 1,000 revolutions per minute. With this power, these pumps will give up to 400-pounds-per-square-inch pressure and in special cases up to 600 pounds per square inch. Volume is generally limited to a range of between 0.10 and 25.0 gallons per minute. The initial cost of these pumps is slightly higher than gear pumps and may be six or seven times the cost of a roller pump. Some operators say that performance and relatively low maintenance costs justify this high initial cost.

Tanks. - Several materials can be used in the construction of a tank: stainless steel; fiberglass; or lined, mild steel. Because of the corrosive nature of many spray solutions, stainless steel may be the preferred material and in the long run is the most practical and most economical.

The tank should incorporate a visual sight gage, and suction should be drawn from a sump or low point in the tank to allow for complete drainage. A manhole-type filler with a hinged cover and strainer should be located on top of the tank to facilitate easy filling and easy access to the inside for internal maintenance. The tank should have adequate capacity so that an unreasonable amount of time is not spent refilling the sprayer.

Spray rig gasket. - A section of 1-1/4-inch outside-diameter, discarded spray hose makes an excellent gasket to prevent spillage around the filler opening of a Bean spray rig. This is a practical method employed on the Central Valley project, Calif., as illustrated in figure 49. The gasket solved the problem of weed control oil slopping out around the cap of the filler opening, making a mess of the rig and the bed of the truck used in the spraying of weeds.

Agitation. - Generally, the three types of agitation that may be used to keep the spray product in suspension are: mechanical, bypass, and jet.

Mechanical agitation is usually the most costly, but is also the most effective.

In many light or farm-type sprayers, an agitation system is merely a bypass in which a portion of the pumped material is returned to the tank under pressure and swirls the unused product about. In some cases this agitation is adequate. Although it is the most economical, it is the least effective.

Figure 49

When using jet agitation, a large amount of liquid is returned to the spray tank on a continuous basis, which produces an adequate and practical means of tank agitation for hard-to-hold materials. This system cannot be called "bypass agitation" because the bulk of the material handled by the pump is being returned to the tank. The design criteria require that enough liquid return to the tank to adequately agitate any materials used. It is possible to maintain good agitation if the one or more jets returning a large volume of liquid to the tank are properly designed and placed. If the tank indicates more circulation should be used than is available through the pump return system, it is not difficult to triple the in-tank circulation by adding a simple jet pump installed at the end of the return nozzle.

The term "jet pump" may sound complicated, but it is an extremely simple, nonmechanical device that introduces a high-speed jet into a larger diameter tube with a gap between the nozzle and the tube. This jet sucks from all sides and pulls the material through the larger tube. The return pressure-setting tubes should be in a horizontal position on the bottom of the tank to avoid picking up air and causing excessive foaming. At least one-quarter of the maintenance of a spray rig has been eliminated with this system of agitation in contrast with the conventional shaft-and-paddle system that involves bearings and seals and mechanical drives with either chain and sprocket, V-belts, or gear boxes.

Strainers. - A heavy mesh basket strainer should be mounted in the filler manhole.

A large basket-type strainer, such as Spraying System's (Bellwood, Ill.) TWB series, placed between the pump and the boom or handgun, upstream of the boom shutoff valve but not on the same line that returns the surplus to the tank, will strain only the material going directly to the nozzles. If the strainer is located so that liquid is introduced down through the inside of the basket then out through the basket to the line leading to the boom or handguns, the strainer is always under pressure whenever the pump is operating. A valve is located on the bottom of the strainer to facilitate cleanout. There is no need to dismantle the entire strainer to clean it; the strainer can be cleaned during operation by opening the valve and allowing a small amount of the spray solution to run out with the debris collected in the basket screen.

Plumbing. - Rubber hose, metal pipe, and/or plastic tubing can be used in this system, but consideration should be given to three factors:

1. Large-size hose and plumbing should be used for the entire system to reduce the pressure drop through the system. For example, 6 gallons per minute pumped through a 1/2-inch pipe will have a pressure drop of one-fourth pound per square inch per foot of pipe. Six gallons per minute through a 1-inch pipe will have a pressure drop of 0.02 pounds per square inch per foot of pipe.

2. All unnecessary pipe fittings, such as elbows and trees, should be eliminated to reduce pressure drop. For example, pressure drop across a 1-inch elbow is the same as the pressure drop across 1 foot of 1-inch pipe. Pressure drop across a 1-inch tee is the same as the pressure drop across 2-1/2 feet of 1-inch pipe.

3. Wherever possible, rubber hose or plastic tubing should be used to reduce corrosion and to reduce the effect of vibration in the system.

Maintenance. - If equipment is used, it must be maintained. Good maintenance and lubrication are of prime importance from an economic point of view. Good maintenance cannot be overemphasized.

Small sprayers and spraying devices. - Few sprayers of any size are single-purpose rigs. The nature of their construction is such that they may be used to spray many kinds of liquids which have a viscosity near that of water or fuel oil. However, smaller sprayers have been constructed for a single purpose, because most parts are readily available for their assembly.

The small sprayers described in this bulletin are types which contain a power supply. Some are powered with small gasoline engines or electric motors; others are a part of a larger piece of equipment, such as a tractor, which supplies needed power.

Many backpack sprayers are available which are manually operated, the pressure being exerted by direct pumping or by air pumps.

Where drift is a highly important consideration, spraying may be at very low pressures - less than 1 pound per square inch.

The nozzle is the one component of a special spraying device that may not be readily available. Where the quantity of fluid applied is small or the distribution of the fluid critical, the proper orifice or nozzle is the controlling factor. An ordinary gun-type nozzle can be used as an effective weed spray gun where high volumes of liquid at low pressures are required. Under these conditions, the coarse droplets produced by the garden nozzle provide good wetting with a minimum of drift. The spray pattern is not uniform, but can be adjusted to cover a distance of from 20 to 25 feet in willows, cattails, or other tall weeds.

Several companies manufacture nozzles for agricultural and industrial use. Information on manufacturing sources may be obtainable from the county extension agent.

Portable sprayer for reservoir waterlines. - Control of noxious weeds on the waterlines of reservoirs storing water for irrigation is often delayed by lack of equipment suitable for spraying. High-volume sprayers of the land rig type are usually too heavy for a boat or are not suitable to travel the rough terrain necessary to spray the waterline from land.

A compact, lightweight unit developed on the Columbia Basin project, Wash., offers no weight problem for a 14-foot aluminum boat, yet can supply ample volume of spray material for tall weeds.

The unit, shown on figure 50, consists of a 3-horsepower, air-cooled gasoline engine coupled by a belt to a single-stage centrifugal pump (input 1-1/4 inches, output 1 inch). Herbicide concentrate, in liquid form, is added to the suction side of the pump in measured proportions controlled by a small orifice or valve.

In practice, the pump and engine are clamped to the front seat of the boat and a 100-foot reel of 3/4-inch reinforced plastic garden-type hose is clamped to the transom. The suction hose with strainer is trailed in the water over the side of the boat.

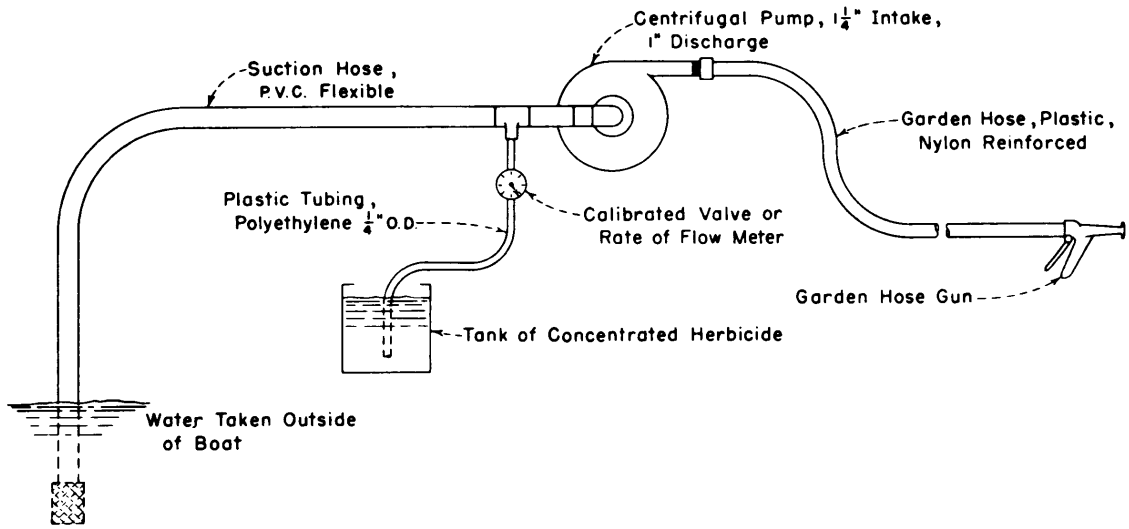

DIAGRAM FOR ASSEMBLY OF BOAT MOUNTED SPRAYER FOR USE ON RESERVOIR WATERLINES

COLUMBIA BASIN PROJECT
EPHRATA, WASHINGTON

Figure 50

A foot-valve strainer combination would be helpful in holding the prime of the centrifugal pump. A piece of 1/4- to 3/8-inch plastic (polyethylene) tubing is attached at one end to the pump suction hose through a valve. The other end is submersed in a 5-gallon container of the concentrated herbicide. An orifice may be inserted in the inlet end of the tube if a fixed proportion is desired. A more flexible, but less accurate, control is obtained by affixing a dial on the valve and marking the different proportions after calibration.

Small patches of weeds may be sprayed from the boat without beaching. Larger or more distant patches may be sprayed by beaching and unrolling up to 200 feet of 3/4-inch hose. An ordinary gun-type garden hose nozzle similar to that shown in figure 51 is adequate where these large volumes of water are available. At 30 pounds pressure, good coverage can be obtained 30 feet from the operator. For longer distances, higher pressures and special guns would be desirable.

Five gallons of 2,4-D at 1 gallon per acre will cover 5 acres, the maximum that one person can spray in a day. The total weight of the apparatus (pump, engine, hose, and reel) and chemical is approximately 150 pounds.

Figure 51

Figures 52 and 53 show the components of a waterline sprayer that was developed by the Washington State Department of Game, Ephrata, Wash., for spraying noxious weeds along shorelines under their adminstration. The old vehicle fuel tank contains the herbicide concentrate, which is metered through the small valve shown between the tank and the pump.

Portable mist sprayer. - A motor-driven mist sprayer can easily be adapted for the application of insecticides for the control of spiders or mosquitoes in areas inaccessible to larger sprayers. Figures 54 and 55 show a "Solo Mist" sprayer in use on the Columbia Basin project. Use of this type equipment may replace handwork in areas inaccessible to wheeled or track-type vehicles and on sites so located that drift of a highly concentrated herbicide onto adjacent crops or other valuable plants is not a factor. Only herbicides registered and labeled for application by mist sprayers should be used.

Hand spray shield. - The lightweight shield for use on a hand boom when spraying various weed control materials shown in figures 56 and 57 was fabricated by project forces on the Central Valley project.

Figure 52

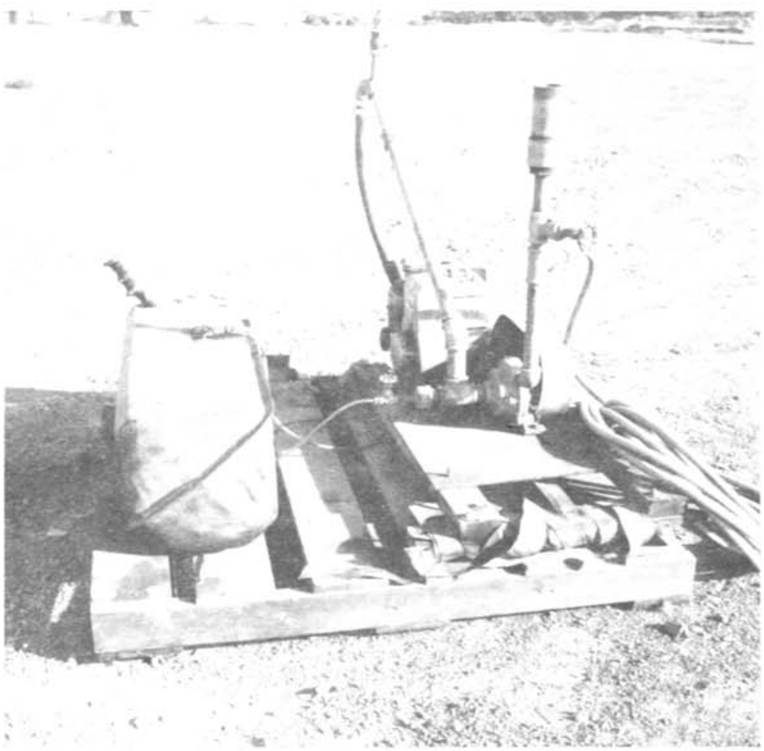

Figure 53

Figure 54

Figure 55

Figure 56

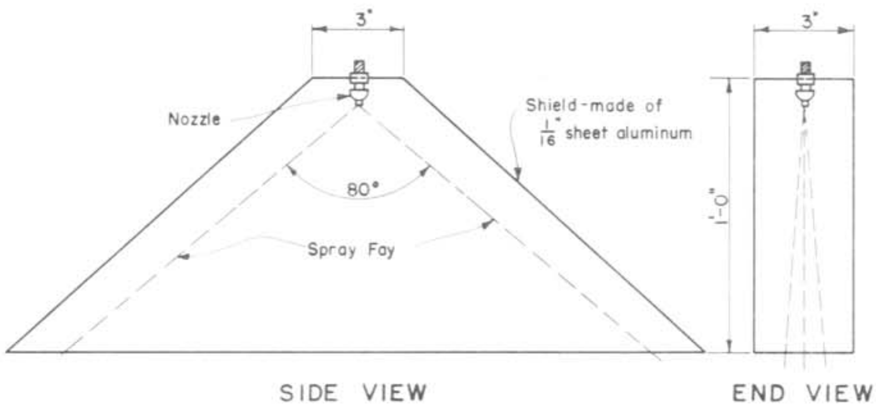

Figure 57

The shield reduces the drift of weed control materials by excluding the wind from part of the spray fan. It is particularly adapted for use in spraying weed oils under overhanging branches of shrubs and trees. The shield effectively prevents the branches from being sprayed by the drifting weed control material.

Portable weed spray unit. - The portable weed spray unit shown in figure 58 was designed and fabricated by personnel of the Fire Mountain Canal and Reservoir Company, the operating agency of the Paonia project, Colo.

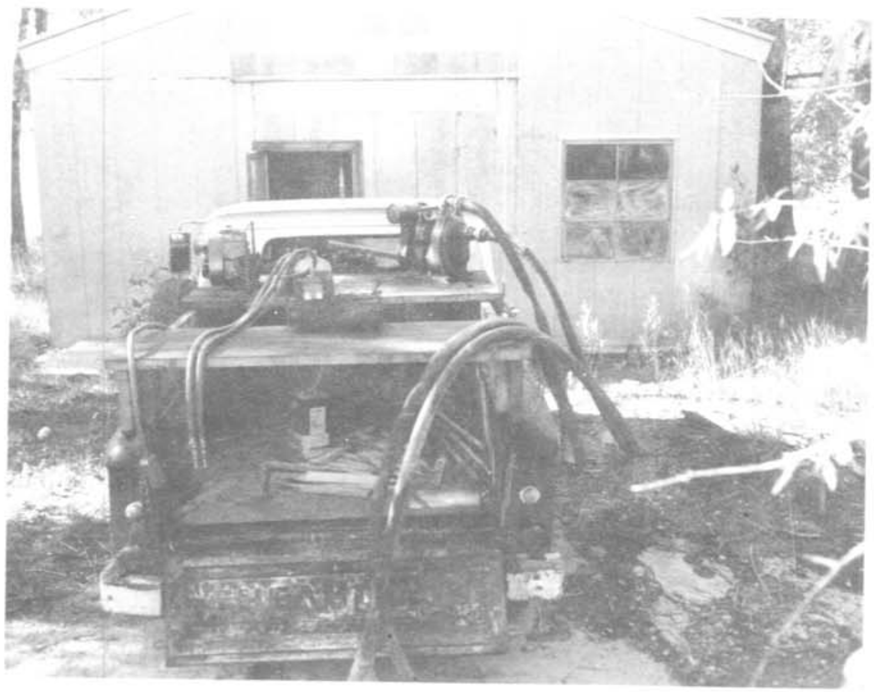

Figure 58

One of the unique uses of this unit by the operators is mounting the unit on the center seat of a small, 12-foot aluminum boat with a 7- to 10-hp outboard motor. By placing the boat and spray rig into the canal, two persons can spray the weeds along the Fire Mountain Canal (165 cubic feet per second) without the need to haul a heavy tank and pump around. When using the boat, if the vegetation is heavy and additional spraying is required, the boat's motor allows several passes to be made at whatever speed required. Using the boat's power, spraying can be concentrated on one side of the canal going down and the other side on the return.

For spot spraying of trees, brush, and weeded areas along the outside bank there is a 300-gallon tank that can be placed into a pickup truck. In the spotting operation, the spray operator sits on the cab of the truck and is then able to start and stop the pump as necessary. He can also control the amount of spray or change the weed killer concentrate to fit the type of vegetation being sprayed.

When spraying from the small boat, the spray can be applied directly to the vegetation and above the waterline. None of the weed spray mixture is lost into the canal water - an environmental consideration. Also, by metering the premixed spray concentrate and sticker, 50 percent of the concentrate is saved and better coverage is possible than by spraying from the O&M road. The boat is small enough that it will float under most of the structures along the canal and light enough that two men can usually carry the unit around those structures that are too low. At siphons, etc., a pickup truck is used.

Following is the list of main components for the portable weed spray unit described above:

The unit shown in figure 59 consists of:

- One 3-hp Briggs and Stratton gasoline engine reduced to 600-r/min output
- One Model C-6310 Hypro ball-bearing pump (13 gal/min at 100 lb/in^2)
- Two 3/4-inch gate valves on intake lines with 1/2-inch inside-diameter rubber suction line for water and 1/4-inch rubber suction line for concentrate (both approximately 8 feet long)
- One Y connection on the outlet for two 8-foot sections of 5/8-inch, heavy-duty garden hose and attached adjustable spray nozzles.

A shop-built metering device to allow a mixture of 1 gallon of herbicide concentrate to 100 gallons of water was constructed from 1/4-inch copper tubing with one end closed and a 1/64-inch hole drilled into it. One-gallon plastic containers are used for the herbicide concentrate so the operator can watch the rate of flow, about 1 pint per minute, of the concentrate.

Airboat weed sprayer. - An airboat equipped with a portable sprayer, as shown on figure 60, is equipped with a 150-gallon fiberglass tank, a portable pump, and a handgun. A regular boat could not be used because of the depth of water and thickness of weeds. The area was restricted for aerial application. Specifications for the airboat are as follows: