Department of Agricultural Engineering

Senior Project

Development of an "over-the-row" spray containment system for grapevines

by

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ABSTRACT

This project involves the development of a sprayer that would reduce the contamination of the air, soil and groundwater by pesticides as compared to the conventional methods of spraying grapevines. Wind drift being a major source of off-target contamination, an "over-the-row" sprayer was chosen as the basic design. This is a main concern in the state of New York since the rural population is large and the wineries are commercial businesses open to the public.

This report will include the different aspects involved in the design and in the construction of the project. It will also include a discussion on the containment system which makes the design economically attractive for the grapevine growers although the main concern is the environment.

ACKNOWLEDGEMENTS

1) I would like to thank Dr. Rehkugler and the members of the committee that gave me the opportunity to participate in the Research Experience for Undergraduate Program for the summer 1990, which was made possible by the financial support of the Centre for Environmental Research (Hewlett Foundation).

2) I wish to express my sincere appreciation to Dr. Derksen for giving me the freedom to direct my work as I intended as well as being there for advise and support when I needed it.

3) I would also like to thank Cameron Hosmer for his interest and participation in the project and Vincent Lalonde for his greatly appreciated help and encouragement.

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INTRODUCTION

New York is the second most important wine-producing state in the United States with more than 80 wineries making 30 million gallons of wine each year. There are four wine-producing districts in the state of New York: Long Island, along the banks of the Hudson River, along the shore of Lake Erie and on the hillsides along the Finger Lakes.

The Finger Lakes Wine District is one of the oldest and largest wine regions of the United States and it is situated at about the same latitude as the Champagne district in France and as the famous wine regions of Germany.

There is a major concern in the state of New York to reduce the contamination of the air, soil and groundwater by pesticides used in vineyards, since the rural population is large and the wineries are commercial businesses open to the public. This project involves the development of a more environmentally sound sprayer as compared to the conventional methods of spraying in vineyards. Conventional air blast sprayers tend to produce a mist which is easily picked up by the wind and transported to nearby farms or rural residential areas (off-target contamination). With the growing concern for environmental issues, there is a need for other methods of spraying.

The project proposal submitted to the New York Wine and Grape Foundation for funding, suggested the design of an "over-the-row" sprayer prototype to reduce contamination of the environment and also to evaluate the potential for recovery of the spray that wasn't deposited on the plants. This is a significant advantage for the grower since it reduces his/her operating costs.

A grapevine grower of the Finger Lakes district, Mr. Cameron Hosmer (owner of "Hosmer Winery") contacted Dr. Derksen of Cornell University to propose the use of his high-pressure high-volume sprayer. His winery is located in Ovid, NY, on the hillside overlooking Cayuga Lake. He owns a total of 40 acres where grow 6 different types of grape: Chardonnais, Riesling, Cayuga, De Chaunac, Catawba and Seyval. The soil type is mostly silt loam with some clay and all the plots are subsurface drained although they are on slopes of 2% to 4%. He sprays for the control of powdery mildew, downy mildew, black rot as well as for leafhopper and berry moth. His actual spraying system consists of a sprayer tank of 500 gallons, a 3-cylinder piston pump with a capacity of 25 gallons per minute (gpm), 2 spraying booms of 9 nozzles (Spray System: D3 orifice and #25 plate) operating at 400 pounds per square-inch (psi). He sprays approximately 50 gallons per acre prior to bloom (around June 25th) and then 100 gallons per acre.

OBJECTIVES

1) To design a grapevine spraying system that reduces air, soil and groundwater contamination by pesticides.
2) To design a rigid, light, over-the-row unit with an easy to move collapsible hood that can be built in a farm shop with welding facilities for less than one thousand dollars.
3) To build a supporting frame, a hood frame, a hood, an alternative spraying system and a recovery system to be adapted to Hosmer's existing sprayer tank.

LITERATURE REVIEW

The only useful reference found regarding the design of hooded spraying systems is a brochure written in April 1948 by E. F. Taschenberg from the New York State Agricultural Experiment Station in Geneva, N.Y. It has been published under the title "Hooded booms for grape spraying". At the time, the main interest was to reduce the wind drift as to permit spraying in critical periods of pest control and to improve spray coverage. Most of the information contained in the brochure comes from observations and conversations the author had with farmers, agricultural agents and entomologists, while preparing his paper. It was intended to describe the different kinds of hoods as well as their respective advantages, disadvantages and details of construction. There is an over-the-row sprayer that was built from the plans of Mr. Taschenberg in Geneva. We had the chance to observe its behaviour in the field and decided on the good and bad points that we wanted to past on to our design. Basically, the general idea is the same but the final product strongly differs to meet the objectives stated above.

The advantage of the hooded system is not only to reduce wind drift but it also permits the recovery of the spray that missed the target. This is a way to improve spraying efficiency by lowering the operating costs (smaller amount of pesticides used as well as less time wasted for filling

operations). This has been a concern in crops as sweet corn (Harrell, Hare and Jones, 1975) where an "Ultra-low-volume" sprayer was modified to recover the spray which was applied in three times the volume as with the unmodified model. The pest control wasn't significantly improved although the environment was less contaminated. Recycling has also been a concern in spraying blueberries where 40% of the output spray of a high-pressure high-volume sprayer with an enclosed spray zone, was recovered (Beasley, Rohrbach, Mainland and Meyer, 1983).

DESIGN

The following will highlight the design criteria for each of the parts of the project. The drawings of the actual design can be found in Appendix 3 and the materials and methods used in the construction of this project can be found in Appendix 1.

A) SUPPORTING FRAME

This frame has to support the inner spraying system which is hooked to supporting rods. It also has to support the recovery system since the inner catching pan is attached along the length of the sprayer and in future work, the inner pump will be attached there, too. But the most important goal is to support the hood frame through the upper and lower tracks which will be discussed in detail later. The main design criteria is for the frame to fit on Hosmer's sprayer and to provide support for all of the above.

(Drawings 2 & 3)

B) HOOD FRAME

This frame is the main part of the "over-the-row" unit. It has to be a rigid and light steel structure that can be easily collapsed to less than 3 feet of width for travelling on the road. The height should be 7 feet above

ground at mid-span since the highest post in the field is 6 feet and the sprayer might run over groundhog holes. The width should be 6 feet from the tank to the outer boom to allow the grower to select the optimum width for spraying throughout the growing season. The length should be about 7 feet long to cover the sprayer length and give a good protection against drift. For this purpose it has to hold a sheet of polyethylene. It also has to support the outer spraying boom of 9 nozzles as well as any type of catching pan for recovery (and eventually a pump).

(*Drawings 2 & 3*)

C) ROLLERS, SHAFTS AND TRACKS

This is the selected mean to provide a quick and easy way to move the hood frame from its travelling position to its operating position and vice-versa on the supporting frame. For this purpose, the rollers have to roll easily on the tracks with minimum wear and they have to be chemically resistant since they will be used in a pesticide environment (very corrosive). The shafts have to support the "over-the-row" unit total weight since they are the link between the rollers and the pipe tracks. The tracks have to support the rollers, restricting their vertical movement but allowing for some displacement along the axis of the shaft. Some movement restriction along the track (horizontal) should be provided to secure the hood in travelling and operating positions.

(*Drawing 4*)

D) HOOD

The hood is a polyethylene sheet that acts as a wind break and as a runoff wall for the spray that missed the target. It has to be easily installed on the hood frame, be rigid enough to withstand passing through branches and cover the whole surface with a minimum of joints.

E) ALTERNATIVE SPRAYING SYSTEM

This is to give the grower the opportunity to use his actual or the over-the-row unit spraying system. It has to hook to the existing spraying system on the output side of the pump and have a valve to select either systems. It must operate at 400 psi requiring the use a high pressure hose. The nozzle booms should be as similar as possible to the existing system in terms of number of nozzles, nozzle spacing and orientation.

(*Drawing 5*)

F) RECOVERY SYSTEM

The main goal is to recover the runoff from the hood walls and pump it back into the spray tank. For this purpose, we need any type of catching pan and any type of filter to keep branches and leaves from getting in the pumping system. We also need a pump with the following specifications:

light weight (<10 pounds), small size, be driven by a 12-Volt motor, take DC amperage from the tractor battery, have a capacity of about 5 gpm (if not, we need two pumps), be able to run dry (diaphragm), best if self-priming up to about 7 feet, parts have to be corrosion resistant.

(*Drawing 6*)

DISCUSSION

A week and a half was spent searching for references on hooded spraying systems and on recovery systems. As mentioned in the literature review, not much has been done recently on the subject as most of the present interest in improving spraying efficiency seems to be the development of electrostatically charged spray droplets. A first draft of the over-the-row unit was made according to Mr. Taschenberg's work. The design criteria were discussed with the grapevine grower and basic dimensions of the actual spraying tank were noted as shown on drawing 1 in Appendix 3.

Another week and a half was spent designing and drawing according to the objectives stated above. Basic weight and stress calculations were performed on the tubing and the pipe used in the final design. Stress calculations have also been done on the shafts according to their diameter and length to make sure bending or shearing does not occur (refer to Appendix 2). It should be noted that the time constraint on the construction of the unit pressured us to choose ONE design (and to work around it), the objective not being to end up with an "ultimate" design.

The construction (over six weeks) was slowed by the lack of experienced labour at times of greatest need (especially for welding) and by shipping delays for parts ordered. Some changes to the design have been highlighted while building the unit in the shop.

The **supporting frame** should have been built half an inch wider since there is a slight bump on one side of the sprayer tank that wasn't noticeable by eye. The frame fits very tightly so some paint was scratched out when it was mounted on the tank. The bottom end of the two middle legs of the frame should have been cut with an angle to give a better clearance on the wheels.

The only major change on the **hood frame** is the pipe bending. It was very hard to make a smooth and consistent arc with the pipe bender we used. This made the welding of the upper and lower pipe tracks very difficult since we wanted them to be perfectly parallel to each other and perfectly perpendicular to the roller shafts that were already welded on the pipe tracks (this is to assure easy movement on the tracks).

The idea behind the **rollers and tracks** is good but the sheet metal tracks had to be made in a commercial shop (because of the high gage used) and although we specified the dimensions and the tolerances, the results were very poor at a very expensive price. The rollers have a diameter of 1 1/2" and we wanted a clearance of 1/16" over but the shop made the tracks roughly 1/16" under which make the rollers very difficult to move on the tracks. At this moment, the hood is not easily collapsible although it could have been if it wasn't for the wrong tolerance on the tracks. This design has a total of 45 rollers even though stress calculations on the shafts showed that a single shaft would not have sheared under the

weight. Since we wanted easy movement, the alignment of the three pipes along the length of the sprayer had to be consistent so a greater number of rollers was selected. The fact that I had to do some of the machining myself made me realized that I went overboard on the number of rollers. I ended up cutting 45 shafts but facing and cutting grooves 90 times... I would suggest 27 rollers as being satisfactory for the job. The grooves to house the external retaining rings were cut too far apart making it necessary to use two washers on each side. The 7/16" washer fitted too tight so I had to drill all 90 of them with a 33/64" drill bit on the lathe. (The next one up being 9/16" which was too loose). The use of the washers was to prevent the rollers from rubbing on the sides of the tracks.

The **hood** itself has to be thought all over. The polyethylene sheet (and the way it is mounted) is temporary. Time constraint limited us to observe water accumulation in the gutters only, as discussed later.

The **alternative spraying system** has an inner and an outer spraying booms of 9 nozzles. At first, we thought of putting 4 nozzles on a branch and 5 on another, both branches being spaced by one foot on each of the inner and outer sides as we saw on the Geneva sprayer. But Hosmer being satisfied with his existing system, we kept all nozzles on one boom for each side. The spacing between the nozzles is greater since we used longer galvanized steel nipples (L=4") but similar spraying pattern can be achieved by turning the elbows and tees to the desired position for each

nozzle. The booms were attached to the supporting and hood frames by muffler clamps which were quite adequate for the job.

For the **recovery system**, the initial idea was to catch the dripping from the plant as well as the runoff from the hood walls so the catching device had to be deep and large. But we finally decided to use gutters because they were readily available and easy to install. This project is a prototype that will be modified in the coming years to better suit the field conditions and the gutters seemed to be the easiest type of catching pan to work with at this stage. The pump we had ordered to recycle the pesticides into the spray tank, came in two days before I left Cornell. So the desired recovery system is at its early stage and much work has to be done still.

While putting everything together at Hosmer's, some minor field modifications have been done. The supporting frame was mounted an inch back from its original position to give more clearance on the wheels and one and a half inches up to clear the lid bolts on top of the sprayer tank. The supporting rods were welded on the supporting and hood frames as for the booms to be attached to them at the proper height for spraying. Some additional fittings were added to the alternative spraying system (a close nipple and a 90 elbow per boom) for the hoses to point in the direction of the sprayer tank. The gutters were fixed on the frames with a gentle slope towards the back.

The grower was satisfied with the unit behaviour on the road since the collapsed width gave good manoeuvrability and the structure didn't bounce a lot.

The alternative spraying system worked fine and we did recover the water (testing liquid) in the gutters. In static testing, a lot of water was lost by drift in the axis of travel. In dynamic testing, a surprisingly large amount of water was recuperated in the gutters through full foliage plants. More work should be done to make the gutters watertight since they leaked where the end caps were soldered on.

As for the behaviour of the over-the-row unit in the field, the grower was concerned about the spacing between the two spraying booms in the different stages of growth of the vines since he wants a small width in the early season for good soaking of the bark for fungi control and a larger width as the foliage becomes more important throughout the season. This was taken care of by pins to restrict movement at any width desired between about two and a half to six feet. Again, he was quite satisfied with the manoeuvrability and the rigidity even at the full extended width. He was also concerned with the visibility from the tractor which is important to control the unit in the field. Although the polyethylene used is blue, the grower didn't have any difficulty to drive the sprayer along the row (no testing was done at the end of the row but the grower had assured us that he had plenty of room for turning).

CONCLUSION

The prototype has met most of the objectives stated above apart of the fact that the hood and the recovery system are at their early stages.

The air contamination is greatly reduced by the use of the polyethylene sheet as a hood even if it is only a temporary device. A clear plastic or even a fibreglass sheet should be considered for permanent use. The grower should use the over-the-row unit for at least a season before he can give his recommendations for future work. We can already, at the light of the field testing, suggest the use of "curtains" (long strips of polyethylene) to partly cover the back of the hood to reduce wind drift along the axis of travel.

The soil and groundwater contamination could be even more reduced by the use of wider catching pans although it would affect the manoeuvrability. Wider pans would permit to recover the runoff from the walls as well as the dripping from the plants and part of the drift. The pans should be covered with some type of filter (like window screen for example) to keep branches, leaves and any kind of debris out of the pumping system. Finally, pumps should be installed to recycle the recovered spray into the spraying tank. Hoses can be drawn into the tank through the existing opening in the lid.

Many seasons of use will provide us with more information for improvements as well as for the economical advantages of the recycling. Future work could include the spraying of two rows at the time with an over-the-row unit on each side of the sprayer.

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(ARS-S-65)

Higdon A., Ohlsen E.H., Stiles W.B., Weese J.A. and Riley W.F.-Mechanics of materials (Fourth Edition).- John Wiley & Sons Inc., U.S.- 1985.

Taschenberg, E.F.-Hooded booms for grape spraying.- NY state Agricultural Experiment Station, Geneva, NY.- April 1948.

APPENDICES

APPENDIX 1: materials and methods

A) SUPPORTING FRAME

Materials:

-1.5" Square tubing (wall thickness = 1/8"),

length = 53" X 6 to support the tracks

length = 90" X 2 along the length of the sprayer

length = 38.5" X 6 to fix on the sprayer

length = 20" X 6 between lower and upper tracks

-Two 1/2" steel rods, length = 33"

-Scrap steel for caps

-2" Angle Steel, length = 5" X 6

-10 bolts 3/8" and nuts

Methods:

-Cut steel tubing, rods and angle steel to proper length

-Weld the square tubing as shown on Drawing 2 & 3

-Weld caps on the open ends of the tubing and rods on the frame

-Drill holes through the angle steel

-Weld angle steel to supporting frame

-Bolt angle steel to sprayer tank frame

B) HOOD FRAME

Materials:

-Three 1" diameter steel pipe (wall thickness = 1/8"),

length = 146" for "over-the-row" use

length = 12" for bottom track

length = 52" for upper track

-Three 1/2" steel rods, length = 73"

-Two 1/2" steel rods, length = 33"

Methods:

-Cut pipe to proper length

-Bend pipe as shown on Drawing 2

-Weld the upper and lower pipe tracks

-Weld the rods to hood frame as shown on Drawing 2

C) ROLLERS, SHAFTS AND TRACKS

Materials:

-45 "Bostone" Plastic Rollers, 1 1/2" O.D., 1/2" bore dia., length = 1"

-45 steel shafts, 1/2" dia., length = 4"

-16-gage sheet metal

-90 7/16" washers and 90 9/16" washers

-90 7/16" external retaining rings

-1 1/2" Angle steel

length = 93" X 3 and length = 53" X 3

-3 1/4" bolts (pins)

Methods:

-Cut 1/2" rods to a length of 4" for shafts (X 45)

-Drill holes through the pipe to house the shafts (X 45)

-Cut 2 grooves on each shaft using the lathe to house the external retaining rings

-Weld shafts to pipe

-Assemble snap rings, washers and rollers on the shafts as shown on Drawing 4

-Cut the 1 1/2" angle steel to proper lengths

-Cut, bend and spot weld the sheet metal (tracks) which was done at Wheaton's sheet metal shop

-Drill holes on upper side of the tracks for pins

-Weld sheet metal tracks and angle steel at proper height depending on the spacing between the shafts on the upper and lower tracks

D) HOOD

Materials:

-Polyethylene sheet

-Screws and washers

-Tie straps

Methods:

-Put polyethylene sheet on with screws and washers

-Use tie straps as a temporary mean of attaching the polyethylene in the retractable part of the hood

E) ALTERNATIVE SPRAYING SYSTEM

Materials:

-Teflon tape

To join to existing system

-1 Stainless steel valve (in/output = 3/4")

-2 3/4" 90 Elbows

-2 3/4" Tees

-2 Bell Reducers 1/2" to 3/4"

-2 1/2" nipples L=2"

-8 3/4" nipples L=2"

For the 2 nozzle booms

-High pressure hose (L=12' and L=22')

-2 1/2" nipples L=3"

-4 1/2" close nipples

-2 1/2" caps

-18 1/2" Tees

-20 1/2" 90 Elbows

-18 1/2" nipples L=2"

-16 1/2" nipples L=4"

-4 1 1/2" muffler clamps

For the 18 nozzles

-18 D3 Discs

-18 #25 Cores

-18 Slotted strainers

-18 Nozzle caps

-18 Nozzle bodies (Type TT)

-18 Bushings 3/8" to 1/4"

-18 Bell Reducers 1/2" to 3/8"

Methods:

-Put fittings together with Teflon tape as shown on Drawing 5

-Hook to Hosmer's existing system

-Hook to supporting and hood frame rods with muffler clamps

F) RECOVERY SYSTEM

Materials:

-Half-round galvanized steel gutters, length = 81"

-4 end caps for gutters

-Some sheet metal supports for the gutters

-Some bolts and nuts

In the future

-Pump

-3/8" hose

-some fittings

Methods:

-Cut gutters to proper length

-Solder end caps on gutters and put silicon for water tightness

-Fix gutters on supporting and hood frames with supports and bolts as shown on Drawing 6

In the future

-Fix pump on supporting frame

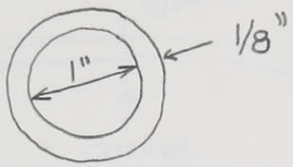
-Put fittings together

-Connect hoses to pump and gutters

APPENDIX 2: sample calculations

A) WEIGHT CALCULATIONS

① PIPE



Length = 12' 2" (hood frame)
1' (sliding piece)
4' 4" (sliding track)
17' 6" = 210" (1 branch)

$$\text{Volume} = \frac{\pi}{4}(O.D^2 - I.D^2)L$$

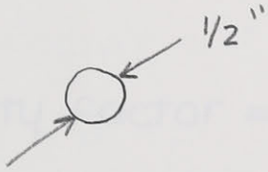
$$= \frac{\pi}{4}(1.25^2 - 1^2)(210)\ in^3$$

$$\text{Volume} = 93\ in^3$$

$$\rho = 0.278\ \frac{lb}{in^3}\ \text{(Wrought iron)}$$

$$W_{pipe} = 93(0.278) = 26\ lbs\ \text{(1 branch)}$$

② RODS



Length = 3(73") + 2(33") = 285"

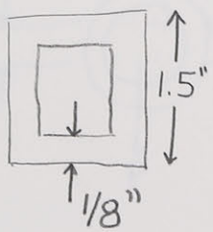
$$\text{Volume} = \frac{\pi}{4}(0.5)^2(285)\ in^3$$

$$\text{Volume} = 56\ in^3$$

$$\rho = 0.284\ \frac{lb}{in^3}\ \text{(structural steel)}$$

$$W_{rods} = 56(0.284) = 16\ lbs\ \text{(rods hooked to hood)}$$

③ TUBING



Length = 53" x 6
90" x 4
38.5" x 6
20" x 6
1029"

$$\text{Volume} = \left[(1.5)^2 - (1.25)^2\right](1029") = 707\ in^3$$

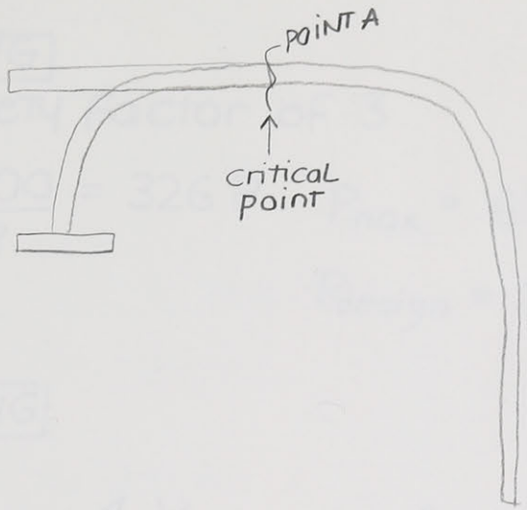
$$\rho = 0.284\ \frac{lb}{in^3}$$

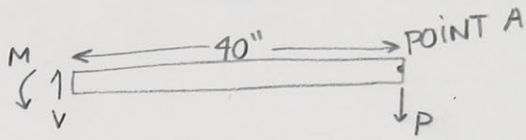
(i)

W_{tubing} = 200 lbs (supporting frame)

B) STRESSES CALCULATIONS (APPROXIMATE)

① PIPE





≈ cantilever beam

$V = P$

$M = PL$

$$\sigma = \frac{My}{I} = \frac{PLy}{I}$$

$L = 40"$

$$y = \frac{d_o}{2} = 0.625"$$

$$I = \frac{\pi}{64}(O.D.^4 - I.D^4)$$

$$I = \frac{\pi}{64}(1.25^4 - 1^4)$$

$I = 0.0708\ in^4$

$\sigma = 353\,P$ psi

$\sigma_{max} = 48\,000$ psi

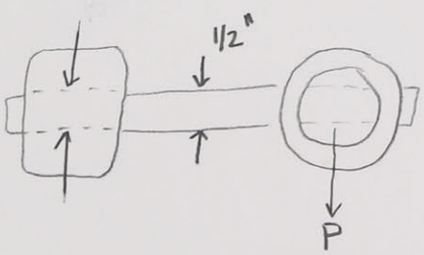
BENDING

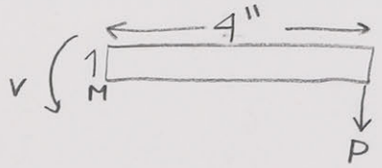
for a safety factor = 3

$$\frac{48\,000}{3} = 353\,P \qquad P_{max} = 45 \text{ lbs}$$

$$P_{design} = \underset{(W_{pipe})}{26 \text{ lbs}} + \underset{(W_{rods})}{\frac{16 \text{ lbs}}{3}} = 31 \text{ lbs} \qquad \underline{OK}$$

② SHAFTS





$V = P$

$M = PL$

$$\sigma = \frac{My}{I} = \frac{PLy}{I}$$

$L = 4"$

$$y = \frac{0.5}{2} = 0.25"$$

$$I = \frac{\pi}{64}(0.5)^4 = 0.0031\ in^4$$

$\sigma = 326\,P$ psi

$\sigma_{max} = 66\,000$ psi

BENDING

for safety factor of 3

$$\frac{66\,000}{3} = 326\,P \qquad P_{max} = 67.5 \text{ lbs}$$

$$P_{design} = 31 \text{ lbs} \qquad \underline{OK}$$

SHEARING

$$\tau_{\substack{max \\ design}} = \frac{4}{3}\frac{V}{A} \qquad V = P$$

$$\tau_{\substack{max \\ design}} = \frac{4}{3}\frac{P}{\frac{\pi}{4}d^2} = \frac{16\,P}{3\pi d^2} = 7\,P$$

$$\tau_{max} = 25\,000 \text{ psi}$$

for safety factor = 3

$$\frac{25\,000}{3} = 7P \qquad P_{max} = 1190 \text{ lbs}$$

$$P_{design} = 31 \text{ lbs} \qquad \underline{OK}$$

APPENDIX 3: drawings

Drawings and
photographs to
come Monday
Dec. 3.
Text can be checked now.
EM

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ACKNOWLEDGEMENTS

1) I would like to thank Dr. Rehkugler and the members of the committee that gave me the opportunity to participate in the Research Experience for Undergraduate Program for the summer 1990, which was made possible by the financial support of the Centre for Environmental Research (Hewlett Foundation).

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INTRODUCTION

New York is the second most important wine-producing state in the United States with more than 80 wineries making 30 million gallons of wine each year. There are four wine-producing districts in the state of New York: Long Island, along the banks of the Hudson River, along the shore of Lake Erie and on the hillsides along the Finger Lakes (refer to Appendix 1).

The Finger Lakes Wine District is one of the oldest and largest wine regions of the United States and it is situated at about the same latitude as the Champagne district in France and as the famous wine regions of Germany.

There is a major concern in the state of New York to reduce the contamination of the air, soil and groundwater by pesticides used in vineyards, since the rural population is large and the wineries are commercial businesses open to the public. This project involves the development of a more environmentally sound sprayer as compared to the conventional methods of spraying in vineyards. Conventional air blast sprayers tend to produce a mist which is easily picked up by the wind and transported to nearby farms or rural residential areas (off-target contamination). With the growing concern for environmental issues, there is a need for other methods of spraying.

The project proposal submitted to the New York Wine and Grape Foundation for funding, suggested the design of an "over-the-row" sprayer prototype to reduce contamination of the environment and also to evaluate the potential for recovery of the spray that wasn't deposited on the plants. This is a significant advantage for the grower since it reduces his/her operating costs.

A grapevine grower of the Finger Lakes district, Mr. Cameron Hosmer (owner of "Hosmer Winery") contacted Dr. Derksen of Cornell University to propose the use of his high-pressure high-volume sprayer. His winery is located in Ovid, NY, on the hillside overlooking Cayuga Lake. He owns a total of 40 acres where grow 6 different types of grape: Chardonnais, Riesling, Cayuga, De Chaunac, Catawba and Seyval. The soil type is mostly silt loam with some clay and all the plots are subsurface drained although they are on slopes of 2% to 4%. He sprays for the control of powdery mildew, downy mildew, black rot as well as for leafhopper and berry moth. His actual spraying system consists of a sprayer tank of 500 gallons, a 3-cylinder piston pump with a capacity of 25 gallons per minute (gpm), 2 spraying booms of 9 nozzles (Spray System: D3 orifice and #25 plate) operating at 400 pounds per square-inch (psi). He sprays approximately 50 gallons per acre prior to bloom (around June 25th) and then 100 gallons per acre.

OBJECTIVES

1) To design a grapevine spraying system that reduces air, soil and groundwater contamination by pesticides.
2) To design a rigid, light, over-the-row unit with an easy to move collapsible hood that can be built in a farm shop with welding facilities for less than one thousand dollars.
3) To build a supporting frame, a hood frame, a hood, an alternative spraying system and a recovery system to be adapted to Hosmer's existing sprayer tank.

LITERATURE REVIEW

The only useful reference found regarding the design of hooded spraying systems is a brochure written in April 1948 by E. F. Taschenberg from the New York State Agricultural Experiment Station in Geneva, N.Y. It has been published under the title "Hooded booms for grape spraying". At the time, the main interest was to reduce the wind drift as to permit spraying in critical periods of pest control and to improve spray coverage. Most of the information contained in the brochure comes from observations and conversations the author had with farmers, agricultural agents and entomologists, while preparing his paper. It was intended to describe the different kinds of hoods as well as their respective advantages, disadvantages and details of construction. There is an over-the-row sprayer that was built from the plans of Mr. Taschenberg in Geneva. We had the chance to observe its behaviour in the field and decided on the good and bad points that we wanted to past on to our design. Basically, the general idea is the same but the final product strongly differs to meet the objectives stated above.

The advantage of the hooded system is not only to reduce wind drift but it also permits the recovery of the spray that missed the target. This is a way to improve spraying efficiency by lowering the operating costs (smaller amount of pesticides used as well as less time wasted for filling operations). This has been a concern in crops as sweet corn (Harrell, Hare

and Jones, 1975) where an "Ultra-low-volume" sprayer was modified to recover the spray which was applied in three times the volume as with the unmodified model. The pest control wasn't significantly improved although the environment was less contaminated. Recycling has also been a concern in spraying blueberries where 40% of the output spray of a high-pressure high-volume sprayer with an enclosed spray zone, was recovered (Beasley, Rohrbach, Mainland and Meyer, 1983).

DESIGN

The following will highlight the design criteria for each of the parts of the project. The drawings of the actual design can be found in Appendix 2, pictures in Appendix 3 and the materials and methods used in the construction of this project can be found in Appendix 4.

A) SUPPORTING FRAME

This frame has to support the inner spraying system which is hooked to supporting rods. It also has to support the recovery system since the inner catching pan is attached along the length of the sprayer and in future work, the inner pump will be attached there, too. But the most important goal is to support the hood frame through the upper and lower tracks which will be discussed in detail later. The main design criteria is for the frame to fit on Hosmer's sprayer and to provide support for all of the above.

(Drawings 2 & 3; Pictures #)

B) HOOD FRAME

This frame is the main part of the "over-the-row" unit. It has to be a rigid and light steel structure that can be easily collapsed to less than 3 feet of width for travelling on the road. The height should be 7 feet above ground at mid-span since the highest post in the field is 6 feet and the

sprayer might run over groundhog holes. The width should be 6 feet from the tank to the outer boom to allow the grower to select the optimum width for spraying throughout the growing season. The length should be about 7 feet long to cover the sprayer length and give a good protection against drift. For this purpose it has to hold a sheet of polyethylene. It also has to support the outer spraying boom of 9 nozzles as well as any type of catching pan for recovery (and eventually a pump).

(*Drawings 2 & 3; Pictures #*)

C) ROLLERS, SHAFTS AND TRACKS

This is the selected mean to provide a quick and easy way to move the hood frame from its travelling position to its operating position and vice-versa on the supporting frame. For this purpose, the rollers have to roll easily on the tracks with minimum wear and they have to be chemically resistant since they will be used in a pesticide environment (very corrosive). The shafts have to support the "over-the-row" unit total weight since they are the link between the rollers and the pipe tracks. The tracks have to support the rollers, restricting their vertical movement but allowing for some displacement along the axis of the shaft. Some movement restriction along the track (horizontal) should be provided to secure the hood in travelling and operating positions.

(*Drawing 4; Pictures #*)

D) HOOD

The hood is a polyethylene sheet that acts as a wind break and as a runoff wall for the spray that missed the target. It has to be easily installed on the hood frame, be rigid enough to withstand passing through branches and cover the whole surface with a minimum of joints.

(*Pictures #*)

E) ALTERNATIVE SPRAYING SYSTEM

This is to give the grower the opportunity to use his actual or the over-the-row unit spraying system. It has to hook to the existing spraying system on the output side of the pump and have a valve to select either systems. It must operate at 400 psi requiring the use a high pressure hose. The nozzle booms should be as similar as possible to the existing system in terms of number of nozzles, nozzle spacing and orientation.

(*Drawing 5; Pictures #*)

F) RECOVERY SYSTEM

The main goal is to recover the runoff from the hood walls and pump it back into the spray tank. For this purpose, we need any type of catching pan and any type of filter to keep branches and leaves from getting in the pumping system. We also need a pump with the following specifications: light weight (<10 pounds), small size, be driven by a 12-Volt motor, take DC amperage from the tractor battery, have a capacity of about 5 gpm (if

not, we need two pumps), be able to run dry (diaphragm), best if self-priming up to about 7 feet, parts have to be corrosion resistant.

(*Drawing 6; Pictures #*)

DISCUSSION

A week and a half was spent searching for references on hooded spraying systems and on recovery systems. As mentioned in the literature review, not much has been done recently on the subject as most of the present interest in improving spraying efficiency seems to be the development of electrostatically charged spray droplets. A first draft of the over-the-row unit was made according to Mr. Taschenberg work. The design criteria were discussed with the grapevine grower and basic dimensions of the actual spraying tank were noted as shown on drawing 1 in Appendix 2.

Another week and a half was spent designing and drawing according to the objectives stated above. Basic weight and stress calculations were performed on the tubing and the pipe used in the final design. Stress calculations have also been done on the shafts according to their diameter and length to make sure bending or shearing does not occur (refer to Appendix 5). It should be noted that the time constraint on the construction of the unit pressured us to choose ONE design (and to work around it), the objective not being to end up with an "ultimate" design.

The construction (over six weeks) was slowed by the lack of experienced labour at times of greatest need (especially for welding) and by shipping delays for parts ordered. Some changes to the design have been highlighted while building the unit in the shop.

The **supporting frame** should have been built half an inch wider since there is a slight bump on one side of the sprayer tank that wasn't noticeable by eye. The frame fits very tightly so some paint was scratched out when it was mounted on the tank. The bottom end of the two middle legs of the frame should have been cut with an angle to give a better clearance on the wheels.

The only major change on the **hood frame** is the pipe bending. It was very hard to make a smooth and consistent arc with the pipe bender we used. This made the welding of the upper and lower pipe tracks very difficult since we wanted them to be perfectly parallel to each other and perfectly perpendicular to the roller shafts that were already welded on the pipe tracks (this is to assure easy movement on the tracks).

The idea behind the **rollers and tracks** is good but the sheet metal tracks had to be made in a commercial shop (because of the high gage used) and although we specified the dimensions and the tolerances, the results were very poor at a very expensive price. The rollers have a diameter of 1 1/2" and we wanted a clearance of 1/16" over but the shop made the tracks roughly 1/16" under which make the rollers very difficult to move on the tracks. At this moment, the hood is not easily collapsible although it could have been if it wasn't for the wrong tolerance on the tracks. This design has a total of 45 rollers even though stress calculations on the shafts showed that a single shaft would not have sheared under the weight. Since we wanted easy movement, the alignment of the three pipes

along the length of the sprayer had to be consistent so a greater number of rollers was selected. The fact that I had to do some of the machining myself made me realized that I went overboard on the number of rollers. I ended up cutting 45 shafts but facing and cutting grooves 90 times... I would suggest 27 rollers as being satisfactory for the job. The grooves to house the external retaining rings were cut too far apart making it necessary to use two washers on each side. The 7/16" washer fitted too tight so I had to drill all 90 of them with a 33/64" drill bit on the lathe. (The next one up being 9/16" which was too loose). The use of the washers was to prevent the rollers from rubbing on the sides of the tracks.

The **hood** itself has to be thought all over. The polyethylene sheet (and the way it is mounted) is temporary. Time constraint limited us to observe water accumulation in the gutters only, as discussed later.

The **alternative spraying system** has an inner and an outer spraying booms of 9 nozzles. At first, we thought of putting 4 nozzles on a branch and 5 on another, both branches being spaced by one foot on each of the inner and outer sides as we saw on the Geneva sprayer. But Hosmer being satisfied with his existing system, we kept all nozzles on one boom for each side. The spacing between the nozzles is greater since we used longer galvanized steel nipples (L=4") but similar spraying pattern can be achieved by turning the elbows and tees to the desired position for each nozzle. The booms were attached to the supporting and hood frames by muffler clamps which were quite adequate for the job.

For the **recovery system**, the initial idea was to catch the dripping from the plant as well as the runoff from the hood walls so the catching device had to be deep and large. But we finally decided to use gutters because they were readily available and easy to install. This project is a prototype that will be modified in the coming years to better suit the field conditions and the gutters seemed to be the easiest type of catching pan to work with at this stage. The pump we had ordered to recycle the pesticides into the spray tank, came in two days before I left Cornell. So the desired recovery system is at its early stage and much work has to be done still.

While putting everything together at Hosmer's, some minor field modifications have been done. The supporting frame was mounted an inch back from its original position to give more clearance on the wheels and one and a half inches up to clear the lid bolts on top of the sprayer tank. The supporting rods were welded on the supporting and hood frames as for the booms to be attached to them at the proper height for spraying. Some additional fittings were added to the alternative spraying system (a close nipple and a 90 elbow per boom) for the hoses to point in the direction of the sprayer tank. The gutters were fixed on the frames with a gentle slope towards the back.

The grower was satisfied with the unit behaviour on the road since the collapsed width gave good manoeuvrability and the structure didn't

bounce a lot.

The alternative spraying system worked fine and we did recover the water (testing liquid) in the gutters. In static testing, a lot of water was lost by drift in the axis of travel. In dynamic testing, a surprisingly large amount of water was recuperated in the gutters through full foliage plants. More work should be done to make the gutters watertight since they leaked where the end caps were soldered on.

As for the behaviour of the over-the-row unit in the field, the grower was concerned about the spacing between the two spraying booms in the different stages of growth of the vines since he wants a small width in the early season for good soaking of the bark for fungi control and a larger width as the foliage becomes more important throughout the season. This was taken care of by pins to restrict movement at any width desired between about two and a half to six feet. Again, he was quite satisfied with the manoeuvrability and the rigidity even at the full extended width. He was also concerned with the visibility from the tractor which is important to control the unit in the field. Although the polyethylene used is blue, the grower didn't have any difficulty to drive the sprayer along the row (no testing was done at the end of the row but the grower had assured us that he had plenty of room for turning).

CONCLUSION

The prototype has met most of the objectives stated above apart of the fact that the hood and the recovery system are at their early stages.

The air contamination is greatly reduced by the use of the polyethylene sheet as a hood even if it is only a temporary device. A clear plastic or even a fibreglass sheet should be considered for permanent use. The grower should use the over-the-row unit for at least a season before he can give his recommendations for future work. We can already, at the light of the field testing, suggest the use of "curtains" (long strips of polyethylene) to partly cover the back of the hood to reduce wind drift along the axis of travel.

The soil and groundwater contamination could be even more reduced by the use of wider catching pans although it would affect the manoeuvrability. Wider pans would permit to recover the runoff from the walls as well as the dripping from the plants and part of the drift. The pans should be covered with some type of filter (like window screen for example) to keep branches, leaves and any kind of debris out of the pumping system. Finally, pumps should be installed to recycle the recovered spray into the spraying tank. Hoses can be drawn into the tank through the existing opening in the lid.

Many seasons of use will provide us with more information for improvements as well as for the economical advantages of the recycling.

Future work could include the spraying of two rows at the time with an over-the-row unit on each side of the sprayer.

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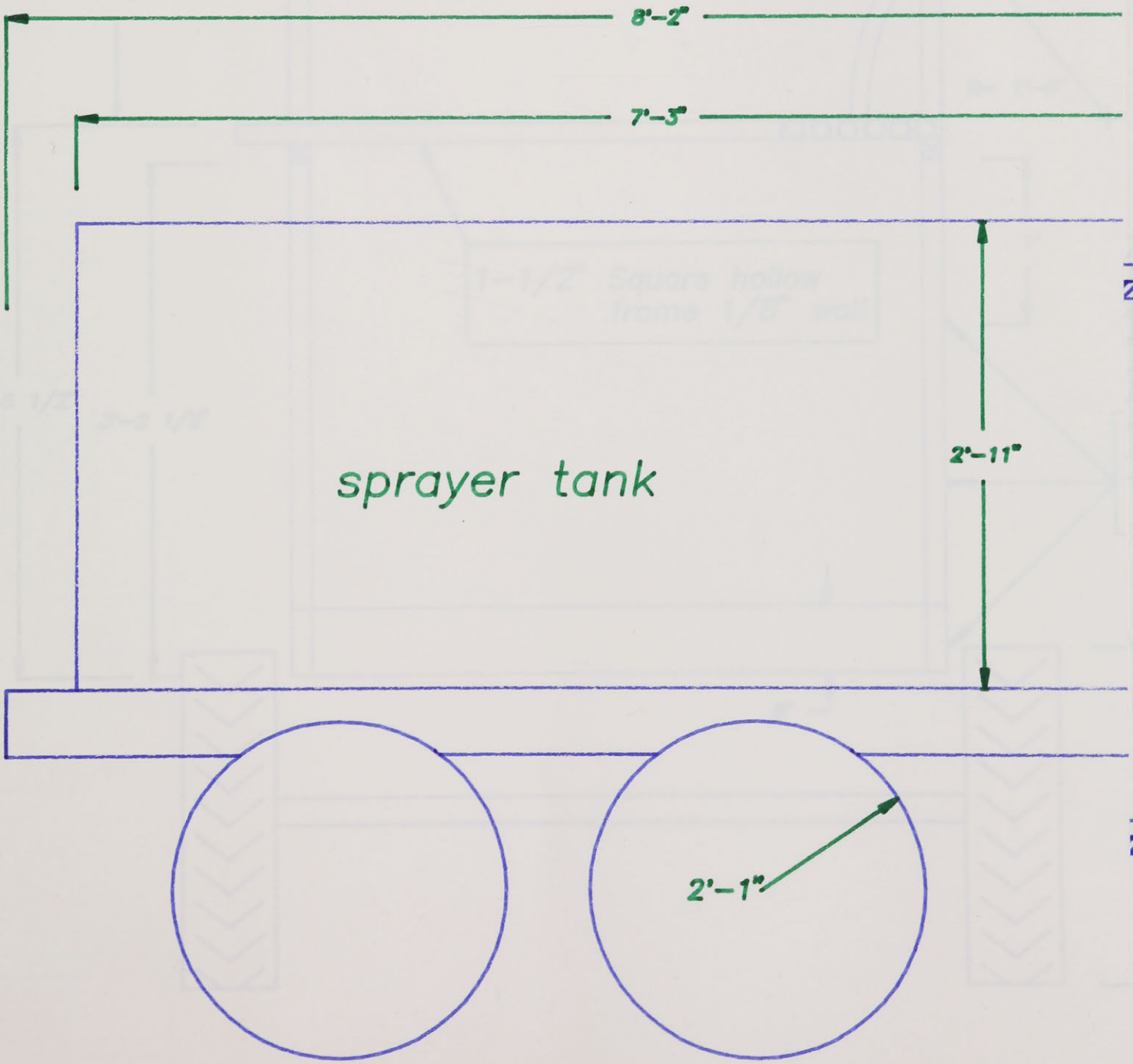
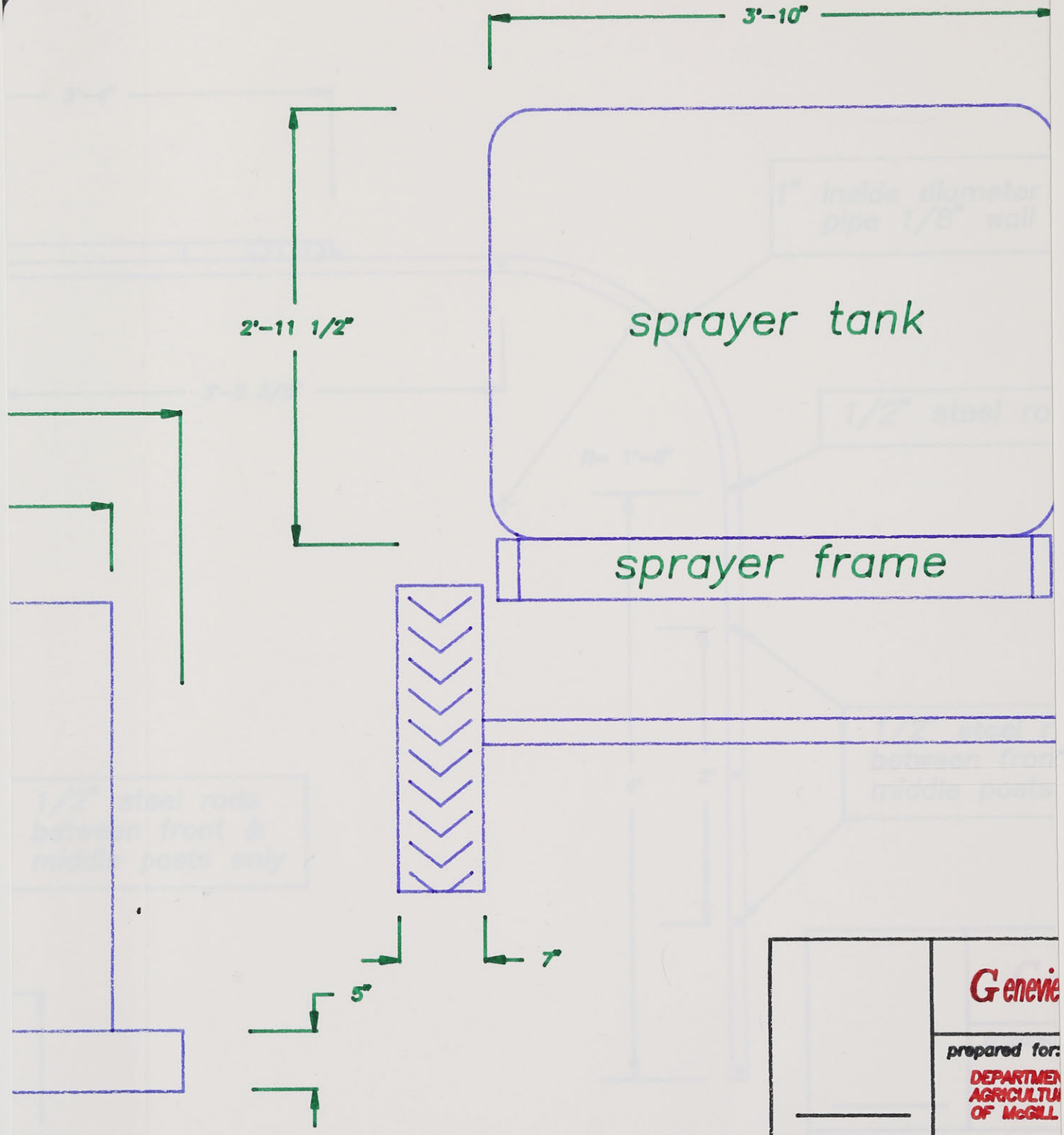
Hosmer's sprayer

end view



side view



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DEVELOPMENT
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GRAPEVINE SP

PLAN: GP01 | revision

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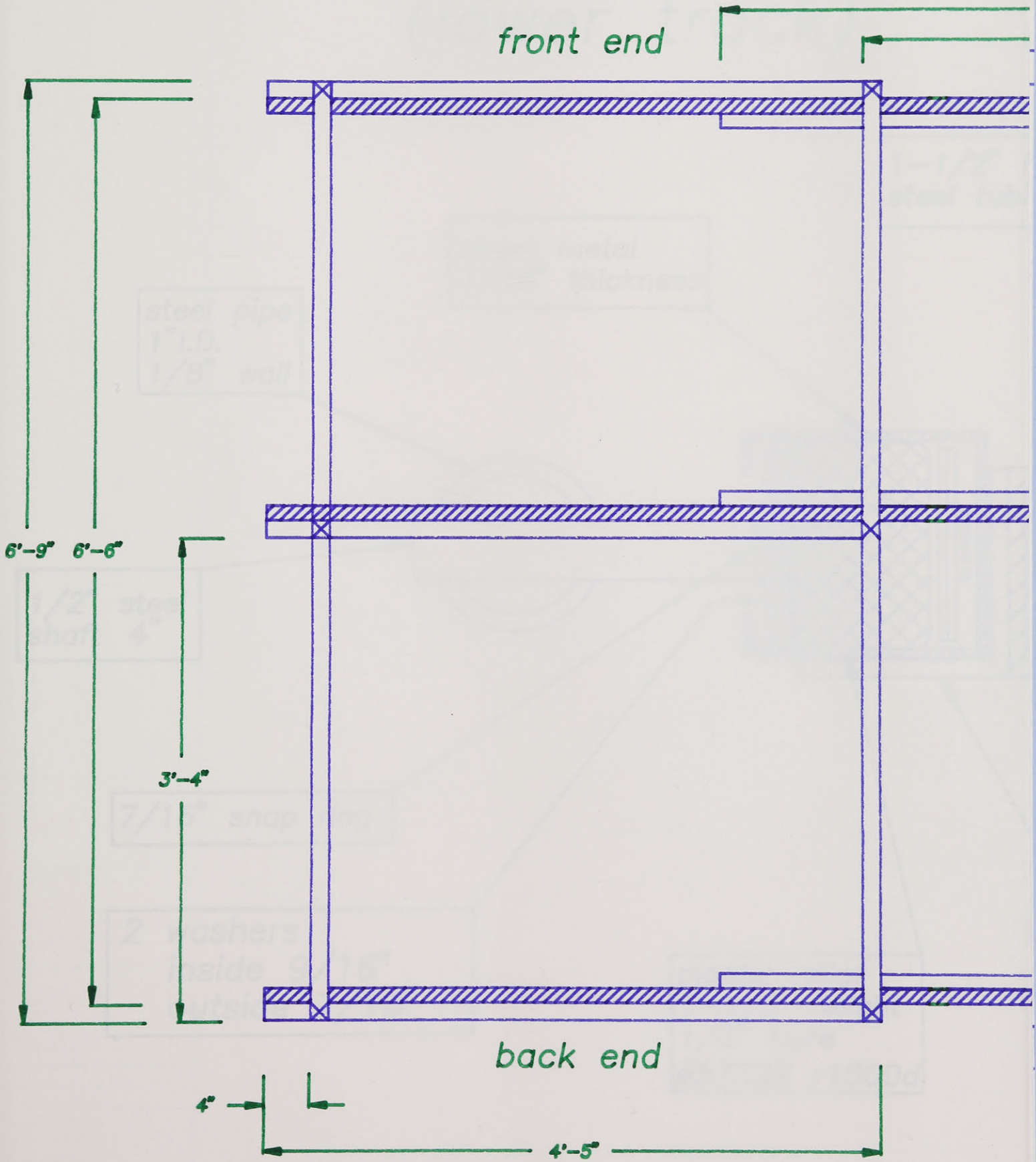
drawed by: Genevieve
approuved by: Genevieve

Top view of fr



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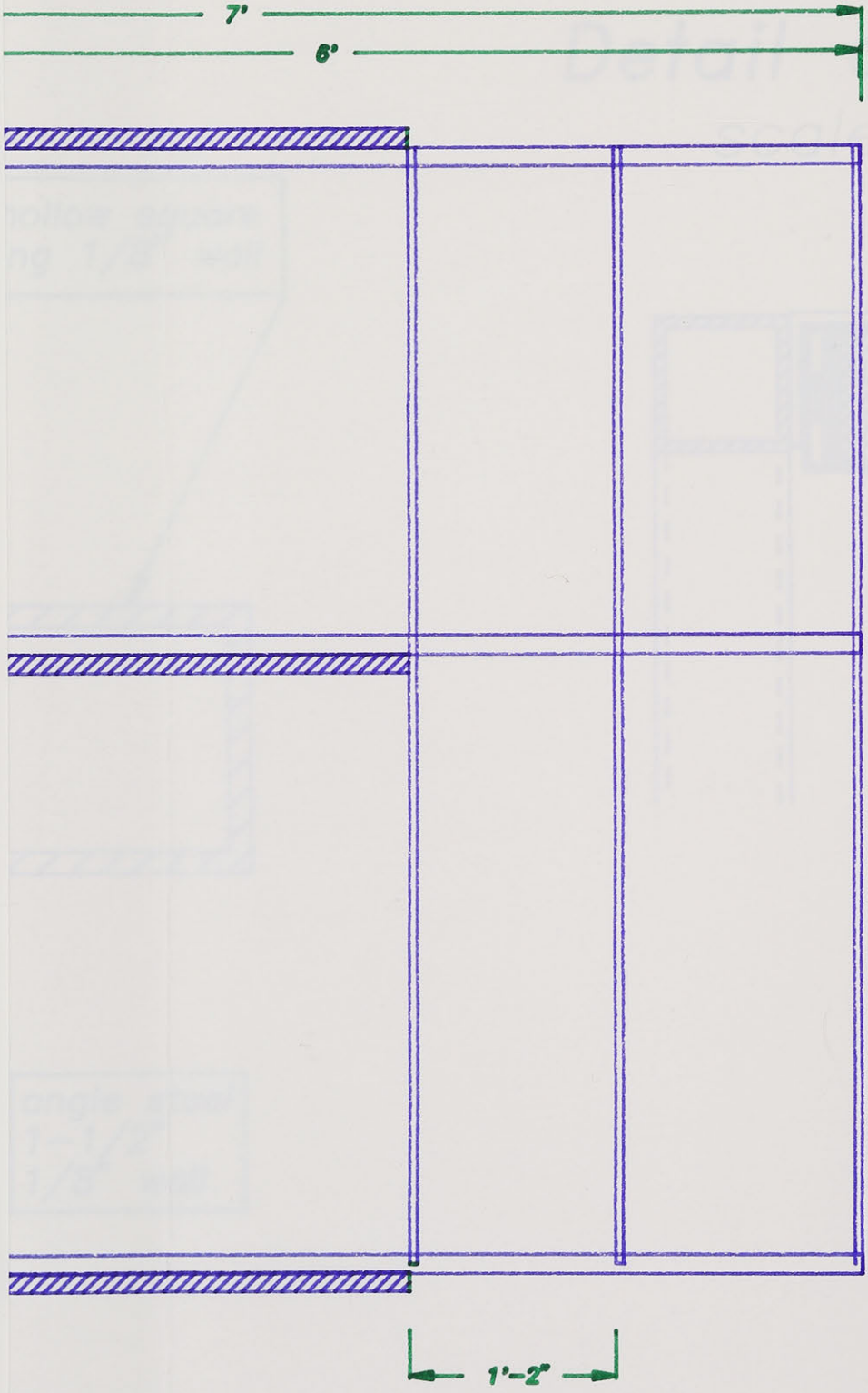

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drawed by: Genevieve
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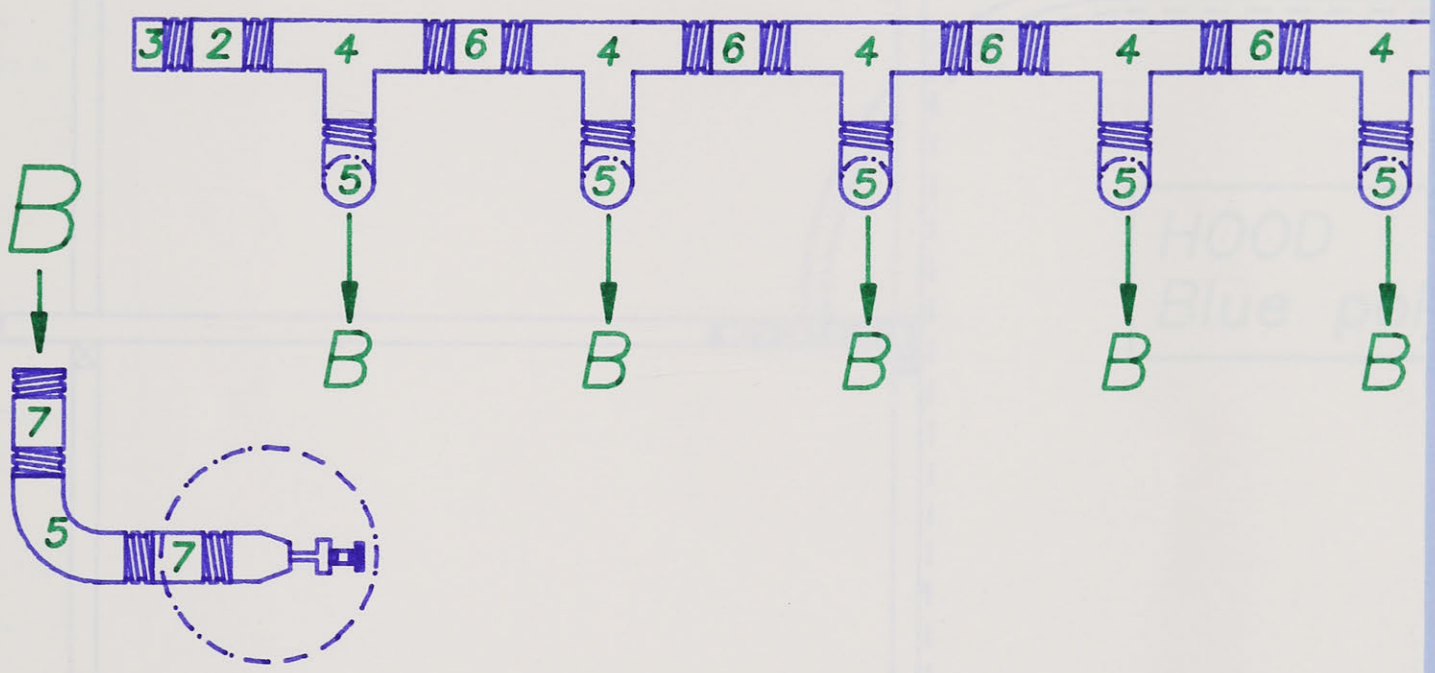
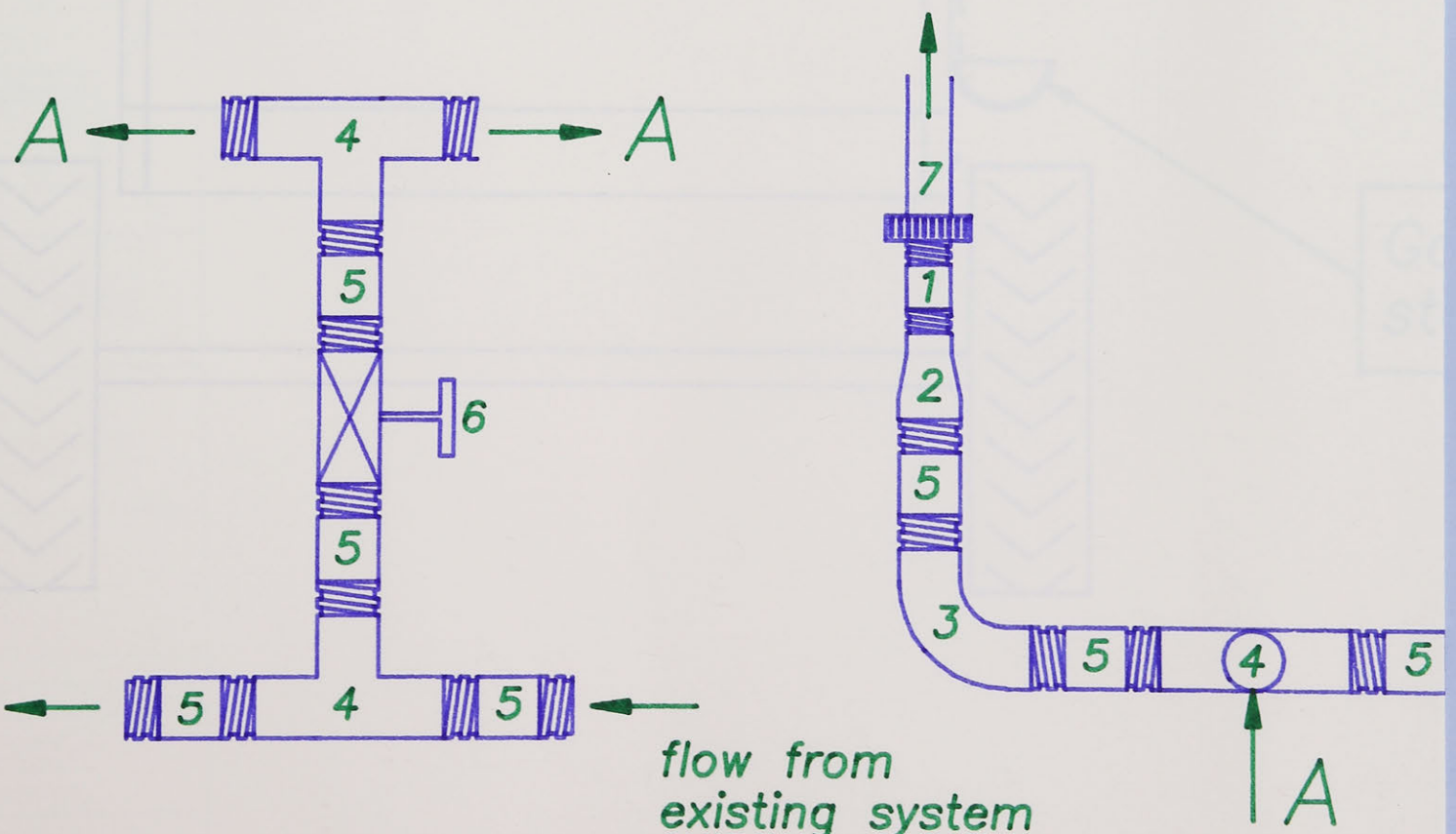
Piping for spr

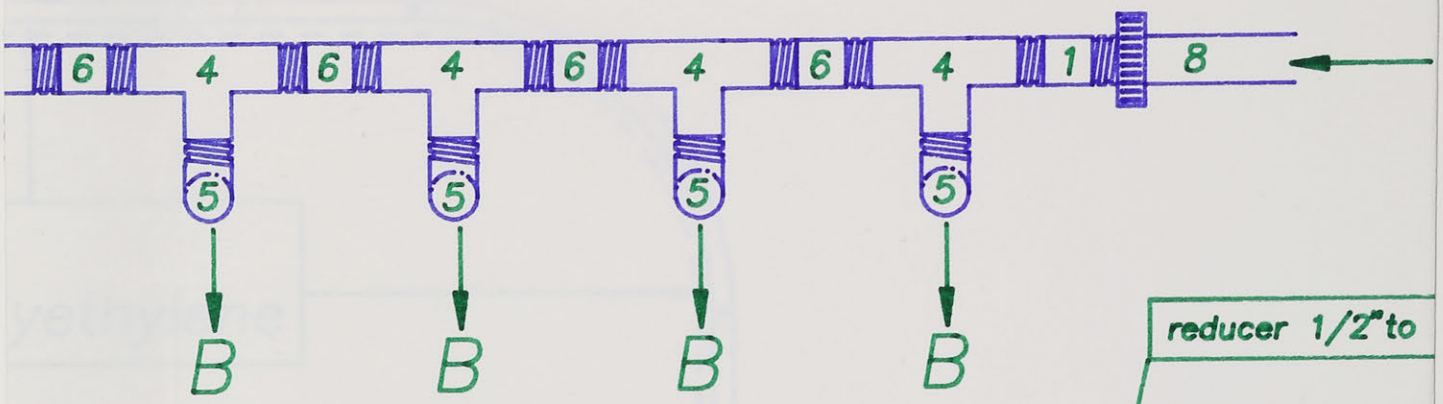
Nozzle boom (1 of 2 booms)



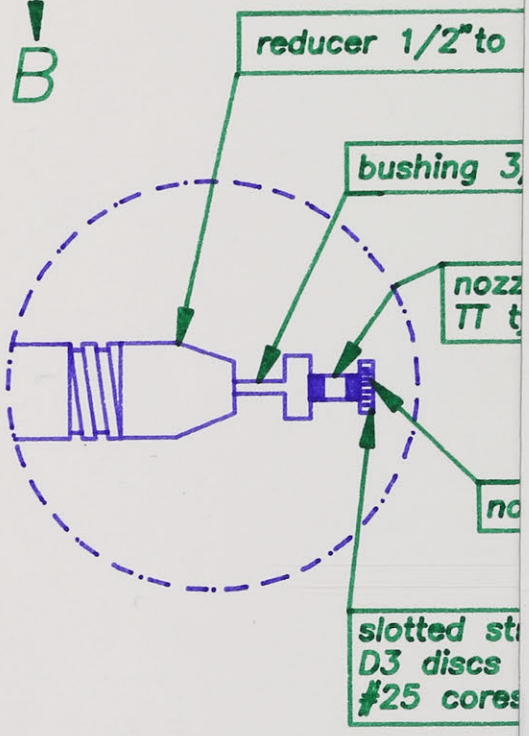
Piping to join existing & new



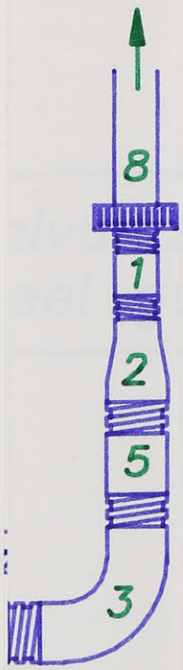
rayer nozzles



1	1/2"	nipple 3"
2	1/2"	nipple 1"
3	1/2"	cap
4	1/2"	tee
5	1/2"	90 elbow
6	1/2"	nipple 4"
7	1/2"	nipple 2"



system



1	1/2"	nipple 2"
2	reducer 3/4"	to 1/2"
3	3/4"	90 elbows
4	3/4"	tee
5	3/4"	nipple 2"
6	3/4"	stainless steel valve
7	HP hose with 1/2" fitting	12' to inner boom
8	HP hose with 1/2" fitting	22' to outer boom

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DEVELOPMENT
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PLAN: GP01 | revision

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