COMPARISON OF LOW VOLUME SPRAY NOZZLES FOR WEED CONTROL

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Elmer Benton Hudspeth, Jr.

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THESIS

COMPARISON OF LOW VOLUME SPRAY NOZZLES FOR WEED CONTROL

By

ELMER BENTON HUDSPETH, JR.

A THESIS

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INTRODUCTION

Purpose of Problem

The effectiveness of 2,4-dichlorophenoxyacetic acid, for weed control, depends on how uniformily it is spread over a given area, rather than the total volume per acre applied. Thus the minimum volume to use is the least that can be spread over the area[6].

The nozzle is a most important part of spray equipment. It is the metering device which actually controls the application of the chemical to the crop. Even slight inaccuracy at the nozzle can result in serious damage to crops or a waste of chemicals.

The purpose of the problem is, therefore, to test and compare the capacity, spray pattern, and the effect of wear on the low volume spray nozzles used to apply 2,4-D for weed control.

Background of the Need for Test

In the United States it has been estimated that weeds cause an annual loss in crop yields of 3 billion dollars[9].

W. W. Robbins (1942), Professor of Botany, University of California states:

> The average cost of tillage on cultivated lands has been estimated at 13 per cent the value of the crop, and approximately one-half of cultivation is made necessary by the presence of weeds.

> In addition to increased production costs resulting from weeds, considerable expense is incurred in eradicating weeds in ditches along roadways, railroad rights of way, and in lawns, golf courses, and waste places. It has been estimated that the average annual cost of labor and material to keep weeds down along railroad rights of way in the United States amounts to $2,500,000 (about $10 per mile).

Farmers were quick to appreciate that if weeds could be controlled with selective chemicals in the growing crops, the productive acreage of their farms could be increased ten to twenty per cent[7].

About five years ago 2,4-dichlorophenoxyacetic acid was introduced as a so-called "growth-regulating" compound. This chemical had several remarkable qualities: it was cheap, selective, adapted to a wide variety of weed problems, and only a small amount of it was required to kill the weeds on an acre of land.

The early sprays of 2,4-D were made at relatively high volumes per acre, with ground-rig applications of from 100 to 200 gallons. Today, however, there is more interest in low-volume sprays to reduce the bulk of material applied per acre. The first spray equipment used for weed control was developed for other purposes. It was strictly specialized and made principally for the application of insecticides and fungicides to row crops. This equipment was also expensive.

Many farmers began to build their own spray machines. Although 2,4-D has the reputation of being the safest of the anti-weed chemicals, the farmers found that it was not always safe. For example, because of its toxicity toward many plants, its misuse did result in injury to some crops and ornamentals. They also found that the sodium salt is not as volatile and is slower in action than the esters.

With the knowledge of the most effective way to apply 2,4-D, the operators began to ask for the answers to the following questions:

1. Is the spray pattern from existing spray machines uniform and evenly distributed?

2. Does the nozzle actually deliver its rated capacity?

3. What effect does nozzle wear have on the spray pattern and capacity?

Thus there was a need for checking the spray patterns and capacities of the many different nozzles that are sold for spraying anti-weed chemicals.

Historical Review

The first spray pattern and capacity tests were made on nozzles used for orchard spraying. In 1909 Howard W. Riley[8] ran tests on high pressure nozzles using an apparatus called a "Sprayograph".

Mr. Riley observed and experimentally determined two main points for each nozzle tested. First he measured the rate of discharge of various liquids at given pressures through different sized openings. Secondly, he observed the characteristics of the spray produced under any given set of conditions.

The rate of discharge was measured by recording the time necessary to discharge into the open air a known amount of liquid.

The character of spray was studied by taking a graphical record of the spray produced on a "Sprayograph". This apparatus worked upon the principle of a focal plane shutter for a camera. A curtain with a slot was made to pass over the record sheet at a constant speed. Liquid colored with red analine dye was sprayed at the desired pressure against the curtain. Power was applied to the curtain and the slot moved down across the front of the record sheet exposing all portions of it to the spray for the same length of time. By having the exposure sufficiently short it was possible to obtain from any nozzle a record on which the spots were so thinly distributed that they were practically all separate and distinct.

At the third Annual Exposition of the National Horticulture Congress in 1910, spraying machine trials and competitions were held under the auspices of the American Society of Agricultural Engineers[5]. Both pumps and nozzles were checked on many different makes of spray machines. The purpose of the test was to furnish purchasers full and complete information in regard to the work, efficiency, design, and construction of spraying machines on the market in 1910.

The spray nozzles were checked for capacity and for fineness, uniformity and adjustibility of spray. The length and breadth of spray was measured for each nozzle, and the evenness of distribution and fineness of spray were measured by a "Sprayograph".

Research carried on by French[2] in 1934, and by French and Crafts[3] in 1936 shows the recognition of the importance of spray pattern. While no method of observing spray pattern is described, its importance is noted and a method of determining the driving force of the spray is indicated.

As better spray chemicals were discovered, and as the spray equipment developed, farmers began to use chemicals for controlling weeds. Mr. O. C. French[4] reported that by 1940 the use of chemicals for controlling weeds had found favor with many farmers. However, the methods of chemical weed control were changing so rapid in 1940 that it was difficult to specify the exact equipment that was required. For this reason industry could not make stock equipment available and the farmers had to adapt and custom build equipment to meet their needs.

During World War II, the discovery of new organic compounds changed the problem of chemical weed control almost over night. These growth regulators not only gave promise of better control of weeds, but could be applied in concentrated mixtures, thus saving much transportation of water. Now, much more definite specifications for spray equipment could be made.

One of the most promising of these growth regulators was 2,4-D. As it became more widely accepted as a selective weed killer, the state agricultural colleges began tests on the characteristics of this chemical. They made available to the farmer information concerning the effect of 2,4-D on different plants and the amount to apply per acre. In addition they specified the kind of equipment needed or best suited for applying 2,4-D. In most instances the nozzle recommended was one that would give a flat spray with no heavy streams or edges. There was need for tests to show which nozzles would give this type of spray pattern.

Professor E. L. Barger and his co-workers at Iowa State College ran distribution tests on individual nozzles in studying the design of chemical weed control equipment for row crops[1]. The test apparatus used consisted of a sheet of corrugated aluminum roofing with 2.7 inch corrugations. The spray material was sprayed on the test rack and caught at the end of the corrugations in graduated cylinders.

Professors G. L. Shanks and J. J. Paterson[10] of the University of Manitoba, Winnipeg, Canada, developed in 1947-48 an apparatus which permits studying the spray pattern from any type of nozzle for any combination of height, pressure, and nozzle spacing. A modification of this apparatus was used in the test here at Michigan State College and is described in another section.

DESCRIPTION OF TESTING APPARATUS

Corrugated Test Tray

The first spray pattern and volume tests were made with the equipment shown in Fig. 1.

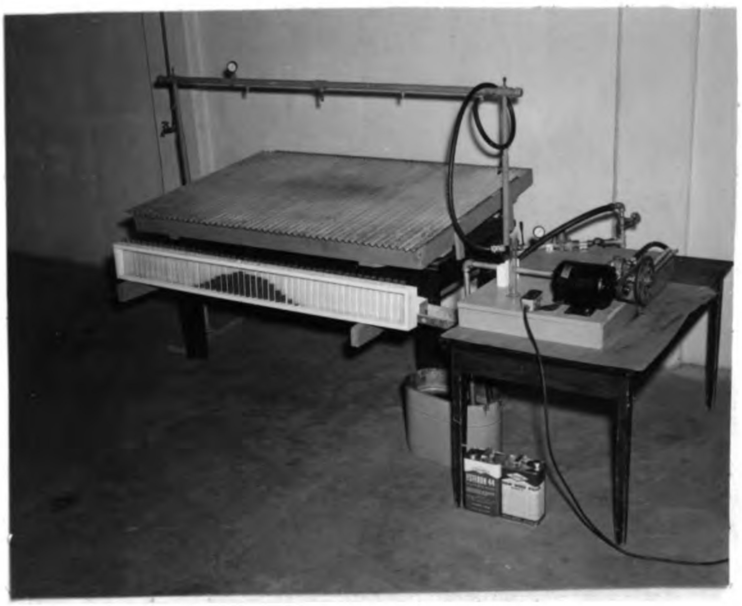


Fig. 1. Corrugated Test Tray and Pump.

The apparatus consisted of a container for spray material, a suction strainer, an electric motor to power the bronze gear pump, a pressure regulator, two pressure gauges, and a 3-nozzle spray boom mounted over special corrugated sheet metal.

The 100 mesh suction screen was attached to the 3/4 inch suction line and placed below the surface of the spray material in a 10 gallon container. The 3/4 inch bronze herringbone gear pump was powered by a ½ H. P. electric motor.

Fig. 2. ½ H. P. Electric Motor and Bronze Gear Pump.

When operated at 600 R. P. M. and at 40 pounds per square inch pressure, the pump had a capacity of 3.1 gallons per minute. The spray material was forced past the diaphragm pressure regulator into the 1 inch spray boom, and sprayed from the nozzles onto the corrugated sheet metal.

The test tray had 1.5 inch corrugations and was a 4 x 6 foot section. The tops of the corrugation ribs were sharp, rather than round as in regular roofing, and the tray was mounted so that the corrugations were inclined 6 degrees in their longitudinal direction (the 4 foot dimension). The degree of incline remained the same throughout the test and the spray materials drained into test tubes placed at the front of the tray.

The spray boom, above the test tray, was mounted on an adjustable standard, Fig. 3. Adjustment for height was obtained by telescoping a 3/4 inch conduit into a 1 inch pipe. Two ¼ inch nuts were welded on the side of the pipe to provide threads for the thumb screws that held the vertical standard in position.

To provide a means of placing the nozzle at any angle between the vertical and horizontal plane; a short section of 1 ¼ inch pipe was welded on top of the 3/4 inch conduit. The 1 inch spray boom was slipped through this section and held in place by a thumb screw. This adjustment made it possible, by turning the boom, to place the nozzle in any desired position. Fig. 3.

Fig. 3. Adjustable Standard
for Spray Boom.

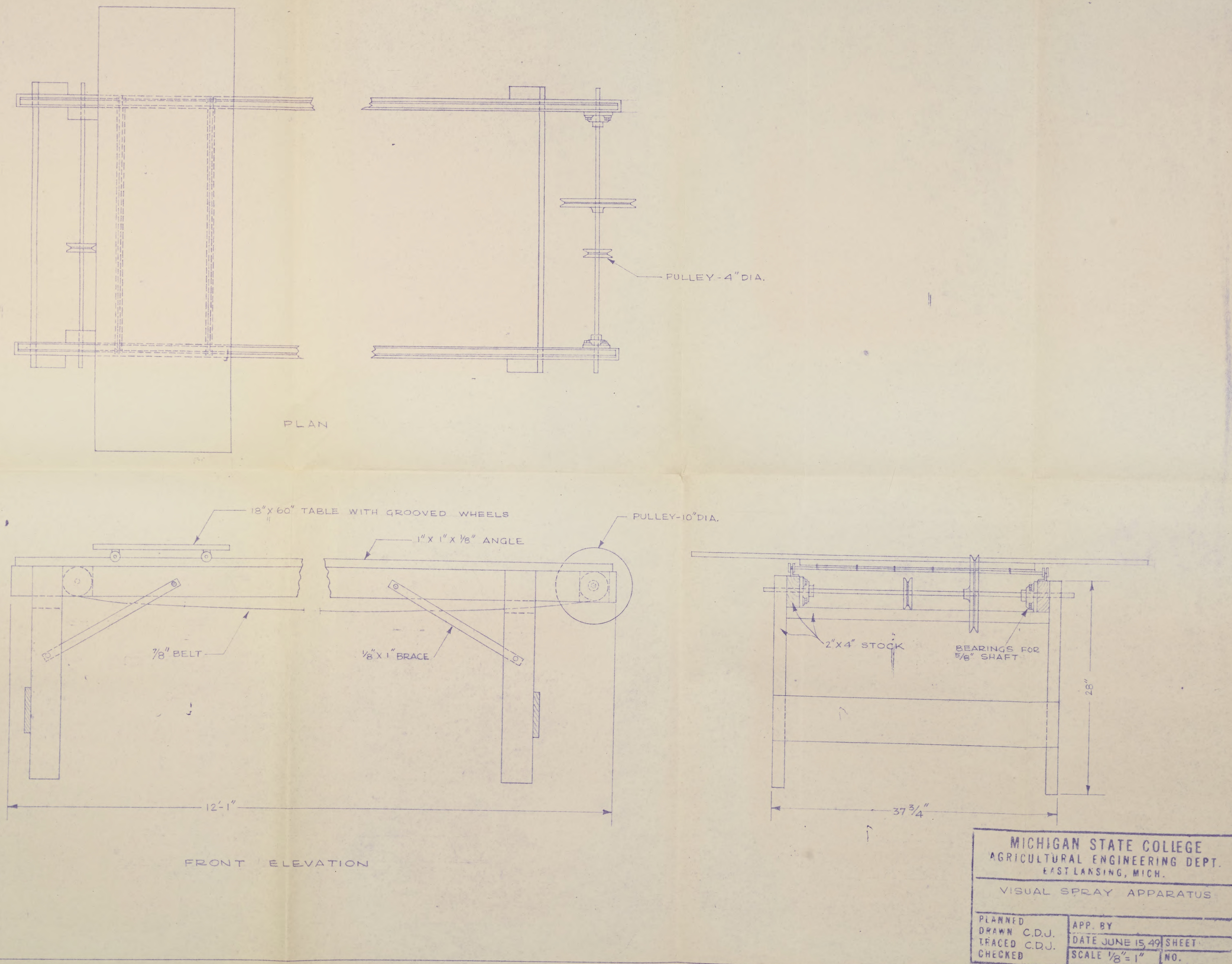
In order to comply with most of the manufacturers' recommendations, as to nozzle spacing, $\frac{1}{4}$ inch couplings were welded on the spray boom 20 inches apart. However, to provide for spacings other than 20 inches, connections that could be clamped at any position on the boom were also made. Fig. 4. These spacing adapters consisted of two $\frac{1}{4}$ inch nipples, a short length of chemical resistant rubber hose, and a $\frac{1}{4}$ inch elbow for the nozzle. The strap iron clamp was welded to the nipple and elbow, and the unit was held in place by a small bolt and wing nut.

Fig. 4. Spacing Adapters
for Spray Boom.

Visual Spray Pattern

The second test apparatus made a visual record of the spray pattern delivered by the nozzle. The machine is shown in detail by the photo, Fig. 5, and the drawing, Fig. 6.

Fig. 5. Visual Spray Apparatus


PULLEY - 4" DIA.
PLAN
18" X 60" TABLE WITH GROOVED WHEELS
PULLEY - 10" DIA.
1" X 1" X 1/8" ANGLE
7/8" BELT
1/8" X 1" BRACE
2" X 4" STOCK
BEARINGS FOR 5/8" SHAFT
28"
12'-1"
37 3/4"
FRONT ELEVATION
MICHIGAN STATE COLLEGE
AGRICULTURAL ENGINEERING DEPT.
EAST LANSING, MICH.
VISUAL SPRAY APPARATUS
PLANNED
DRAWN C.D.J.
TRACED C.D.J.
CHECKED
APP. BY
DATE JUNE 15, 49
SCALE 1/8" = 1"
SHEET
NO.

The main frame of the test equipment consisted of two wooden 2 x 4's 12 feet long on edge and spaced 3 feet apart. These were supported by 2 x 4 legs about 24 inches high and securely braced. A length of 1 inch angle iron, with the sharp corner up, was fastened on top of each of the 2 x 4 rails. This formed a smooth, nearly frictionless track for the 1.5 by 5 foot plywood table which was supported by four fixed wheels. These wheels were 5/8 inch Fafnir flange units. They were simply small ball bearings with a flange on the side and operated on the angle iron much the same as a railroad car wheel on rails.

Fig. 7. Ball Bearings on Movable Table used with Visual Spray Apparatus.

On both ends of the track and fastened to the 2 x 4 main frame were two parallel shafts. Each of these shafts carried a 4 inch V pulley. The driving, 10 inch, V pulley was powered by a 1/3 H. P. electric motor that operated at 1725 R. P. M. With a 2 inch pulley on the motor, the V belt and plywood table travelled 4 miles per hour, which was considered a common speed for tractor mounted sprayers.

A short piece of weak string attached the table to the belt. This was a precaution to prevent damage if the table was not stopped after the spray pattern was completed.

The same 3/4 inch bronze gear pump and adjustable spray boom were used with this equipment as with the first apparatus. Methylene blue dye was sprayed onto paper placed on the plywood table, which was passed under the spraying nozzle at 4 miles per hour. A visual pattern of the nozzle was thus obtained.

TESTING PROCEDURE

Corrugated Test Tray

As a means of determining which nozzles to check, the manufacturers of chemical weed control equipment were asked the name and type spray nozzles used on their machines. It was found that many of the companies did not make their own, but purchased them from other concerns specializing in the manufacture of low volume nozzles.

Test nozzles were obtained from ten different companies. They were capable of applying approximately 5, 10, and 15 gallons per acre when operated at 4 miles per hour and at a pressure of from 20 to 80 pounds per square inch. Each sample nozzle was checked at the height, pressure and spacing recommended by its manufacturer.

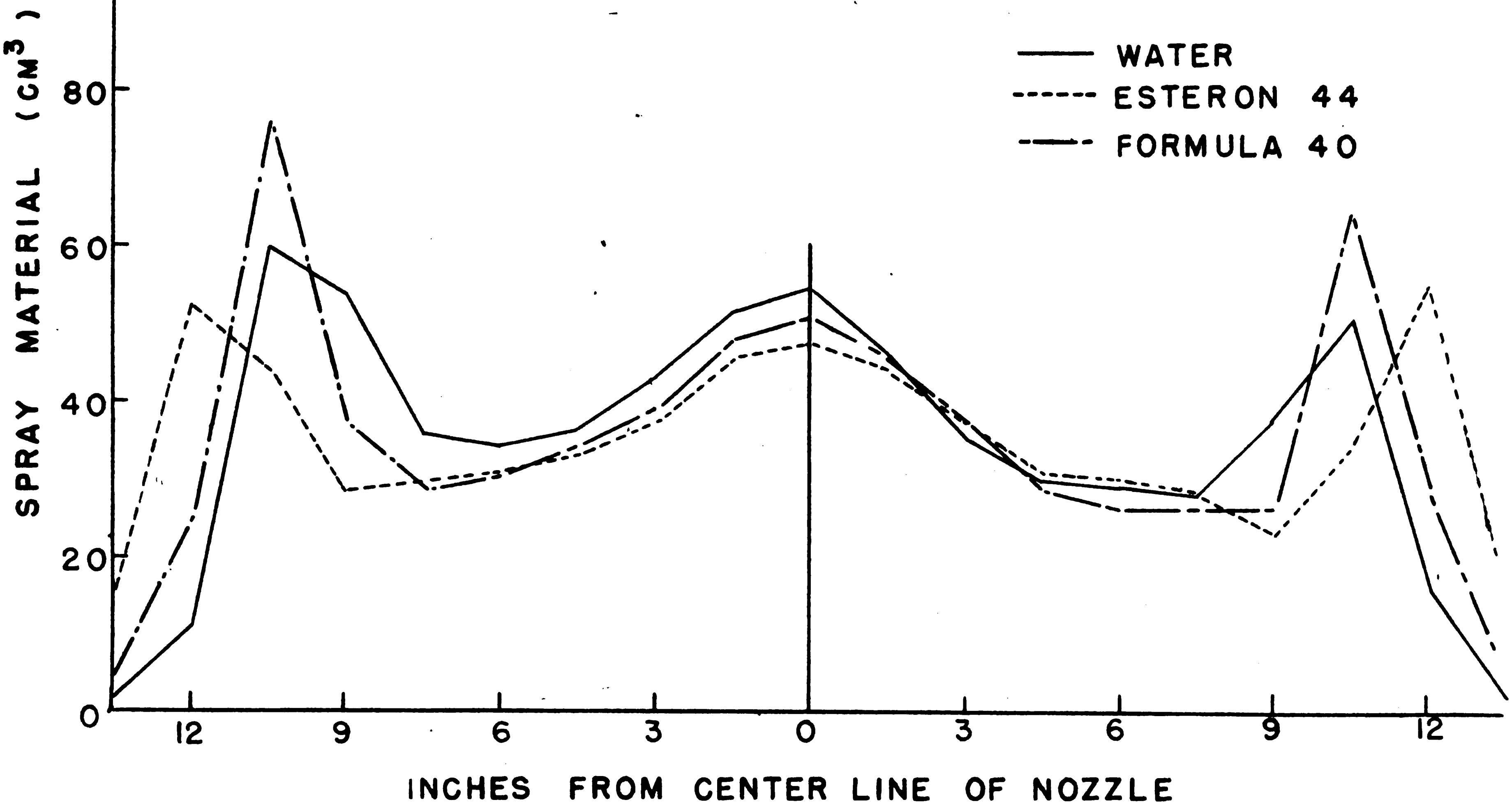
The first test, made with the corrugated test tray, was to check the possibility of using plain tap water, as a spray material, when determining the capacity and spray pattern of the nozzles. The nozzle used in this test had an accurate discharge rate per minute even though the spray pattern did show heavy edges. In addition to plain water, a solution of Dow Esteron 44 and a solution of Dow Formula 40 were used as spray materials. The 2,4-D solutions were used according to the recommended concentrations of 1 quart per 100 gallons of water.

These three mixtures were sprayed through the same nozzle at 35 pounds per square inch pressure, and Fig. 8 shows the resulting pattern and volume discharged. Neither the spray pattern nor the volume, showed any greater variation than could be expected in any two nozzles of the same size and spraying the same material. Therefore, plain tap water at a temperature of 75 to 80 degrees Fahrenheit was used in all the tests.

With the corrugated test tray, the capacity and spray pattern were checked simultaneously. A nozzle was placed in the center of the spray boom and raised 18 inches above the corrugations, the gear pump started, and the pressure set according to the manufacturers' recommendations. After the liquid began flowing off the test tray, the test tube rack was placed under the corrugations and the time for the tubes to fill checked with a stop watch. The tubes were then removed without stopping the pump. Three identical tests were made with each nozzle. In addition, tests were made with two nozzles of each size, in order to insure that a random sample had been used in the check.

A photo of the tubes, Fig. 9 after a test, gives a general picture of the spray pattern, but due to slight variations in the test tube sizes, it was necessary to measure the amount of liquid caught in each tube. The average of three replications was plotted to show the pattern delivered by the individual nozzle. Fig. 10 and 11 are curves that were obtained in this manner.

FIG. 8 SPRAY PATTERN WITH DIFFERENT SPRAY MATERIALS



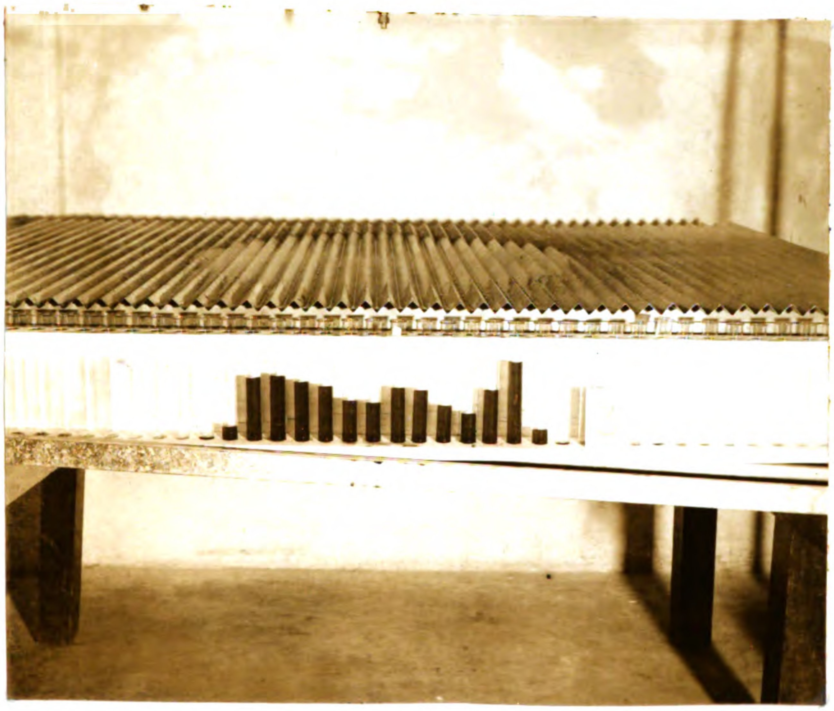


Fig. 9. Test Tubes After Test
Showing Spray Pattern.

FIG. 10 UNIFORM PATTERN SINGLE NOZZLE

(5 GAL. PER ACRE CAPACITY AT 4 M.P.H.)

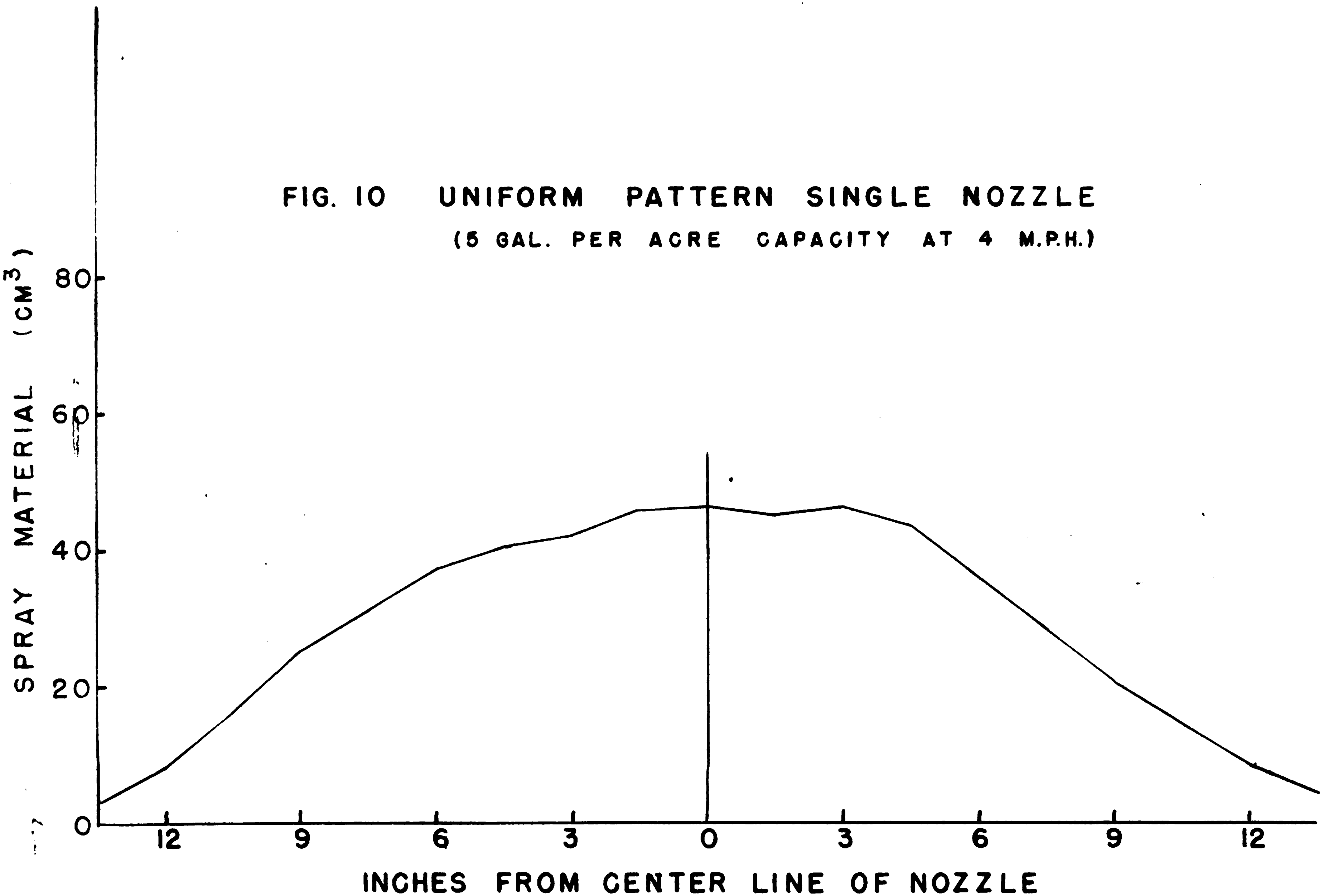
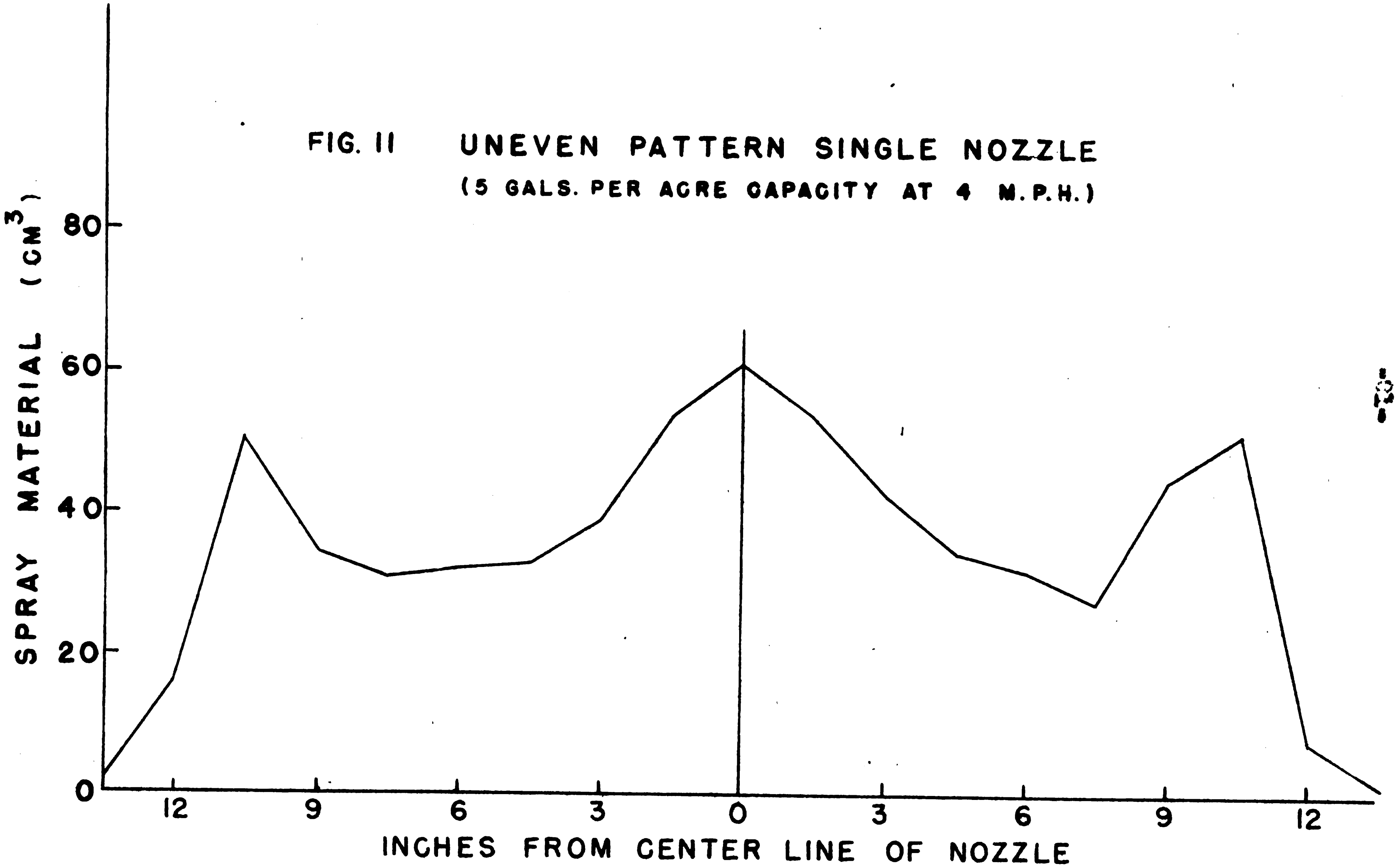


FIG. 11 UNEVEN PATTERN SINGLE NOZZLE

(5 GALS. PER ACRE CAPACITY AT 4 M.P.H.)



The capacity of the nozzle was determined by measuring, with a graduated cylinder, the amount of material discharged in a given time. The results, Table I, show that the capacities of all the nozzles checked were very near the manufacturers' ratings.

After the single nozzles had been studied, three nozzles of each size were placed on the spray boom, and in the same manner as described above, the pattern for the three was checked. Fig. 12 is an example of a curve obtained from three nozzles with a uniform pattern. The heavy lines represent the center of each nozzle. Fig. 13 is a photo of this even distribution, and the curve, Fig. 14, shows the pattern of three nozzles with heavy edges. Those with heavy edges were checked at several different spacings on the boom, and heights above the test tray. A position could not be found, however, that would give as even a distribution as seen in Fig. 12 and 13.

The nozzles that produced the spray patterns shown in Figures 15, 16, 17 and 18, were manufactured by the same company, but had different rates of discharge. Fig. 15 and 16 show the pattern of fan nozzles that deliver 2.5 gallons per acre at 4 miles per hour and 30 pounds per square inch pressure. The patterns in Fig. 17 and 18 were made by nozzles that deliver 10 gallons per acre at the same speed and pressure.

The nozzles with the higher capacity gave the most even

CAPACITIES OF SPRAY NOZZLES

USED FOR WEED CONTROL

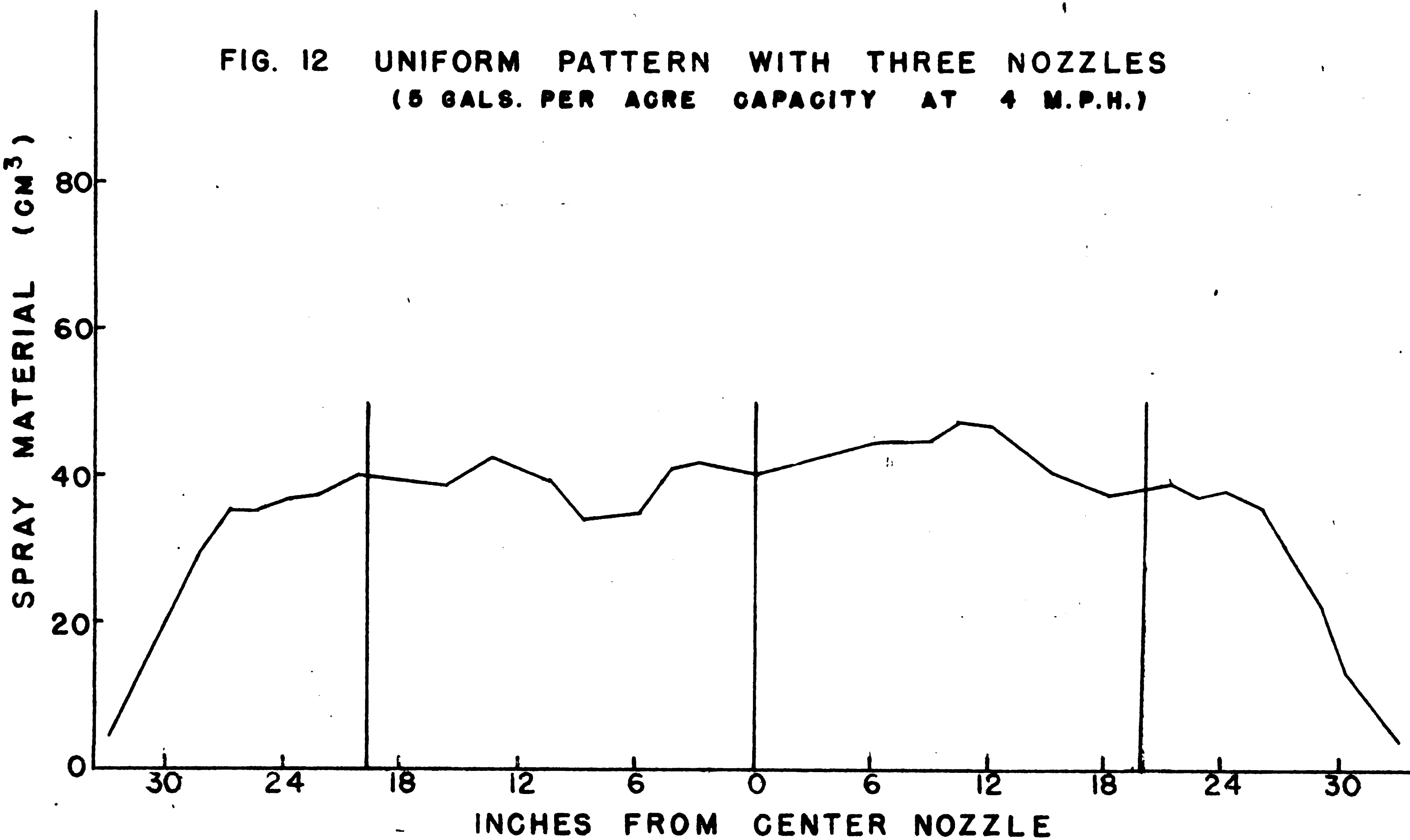
Ground Speed 4 M.P.H.

Manufacturer	Type	Nozzle No.	PSI[1] Pressure	Rated G.P.M.[2]	Test G.P.M.	Rated G.P.A.[3]	Test G.P.A.	Spacing
Monarch	Fan	#20	40#	0.051	0.047	6.4	5.9	12"
		#28	40#	0.100	0.0925	12.5	11.4	12"
		#35M	40#	0.158	0.146	19.7	18.1	12"
Delavan	Fan	AG-2	38#	0.069	0.0695	5.0	5.15	20"
		AG-4	38#	0.140	0.142	10.0	10.5	20"
		AG-4.5	38#	0.162	0.163	12.0	12.1	20"
Spraying Systems	Fan	730039	30#	0.0337	0.0302	2.5	2.25	20"
		730077	30#	0.0674	0.0650	5.00	4.82	20"
		650067	30#	0.0674	0.061	5.00	4.52	20"
		730154	30#	0.135	0.139	10.0	10.3	20"
		730231	30#	0.202	0.210	15.0	15.5	20"
Accessories Manufacturing Co., Inc.	Fan	65.067	40#	0.067	0.065	5.0	4.84	20"
		80.2	40#	0.20	0.187	15.0	13.9	20"
Automatic Equipment Company	Fan	#65	38#		0.388		28.8	20"
		#45	38#		0.143		10.6	20"
		#25	38#		0.0725		5.35	20"
Terado Co.	Fan	Marr V-5	38#		0.074		5.46	20"
		Marr V-10	38#		0.156		11.5	20"
Kromer	Fan	#55	20#	0.243	0.294	18.0	21.8	20"
		#60	30#	0.190	0.235	14.02	17.4	20"
		#70	40#	0.120	0.144	8.9	10.7	20"
Linck Co.	Solid Cone	#5	30#	0.339	0.339	42.0	42.0	12"
		#6	30#	0.438	0.440	54.0	54.3	12"
Century	Hollow Cone	C-5	40#		0.064		4.75	20"
		C-8	40#		0.095		7.05	20"
		C-10	40#		0.108		8.05	20"
Spray Engineering	Fan	31-F-J-2	32#	0.122	0.123	10.0	10.15	18"
		040-F-J-3	23#	0.182	0.190	15.0	15.65	18"
		062-F-K-5	14#	0.405	0.380	20.0	18.80	30"

1 Pounds per square inch
2 Gallons per minute
3 Gallons per acre

Table I

FIG. 12 UNIFORM PATTERN WITH THREE NOZZLES
(5 GALS. PER ACRE CAPACITY AT 4 M.P.H.)



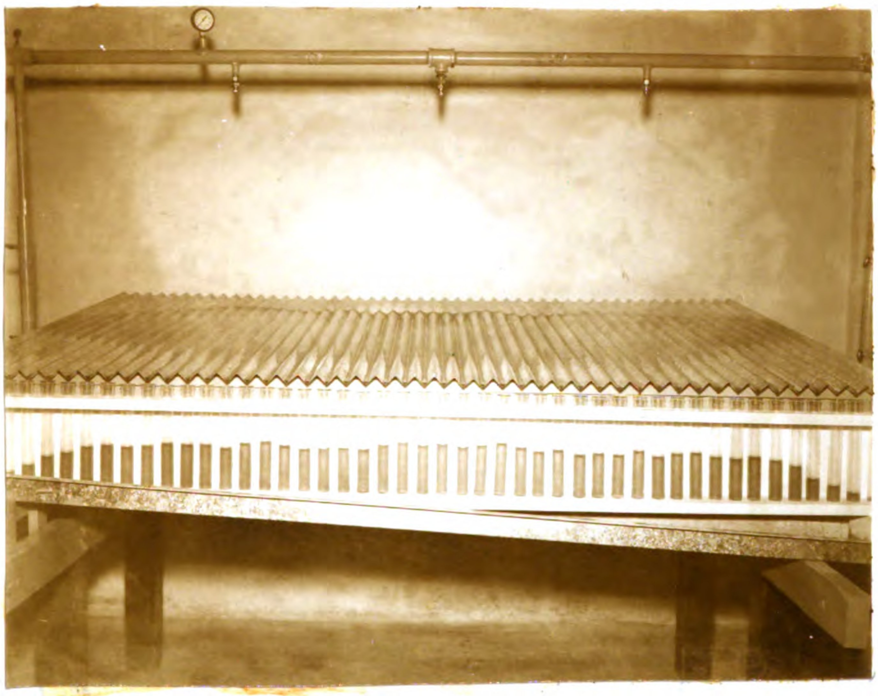
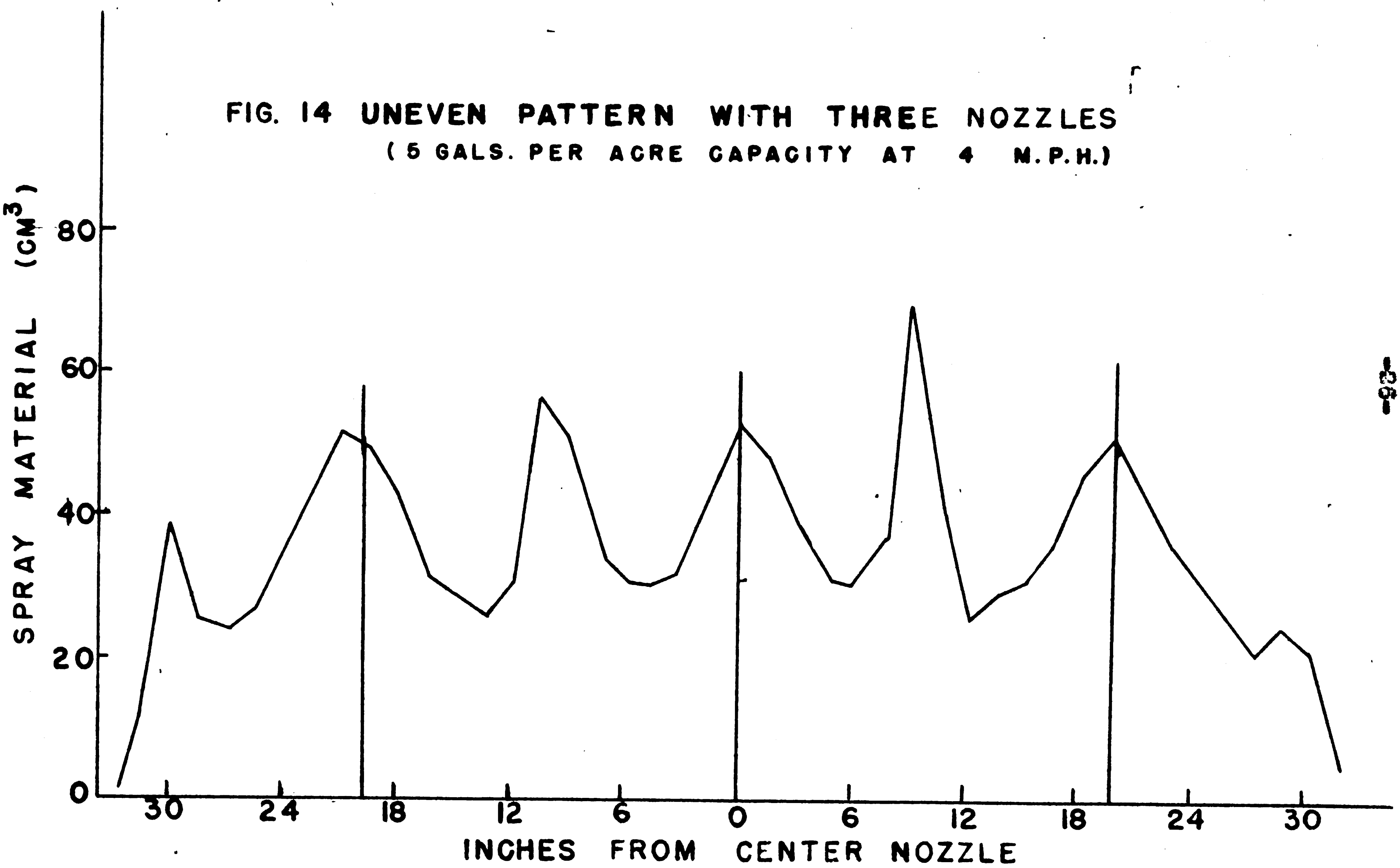


Fig. 13. Uniform Pattern of Three
Nozzles on Boom.

FIG. 14 UNEVEN PATTERN WITH THREE NOZZLES
(5 GALS. PER ACRE CAPACITY AT 4 M.P.H.)



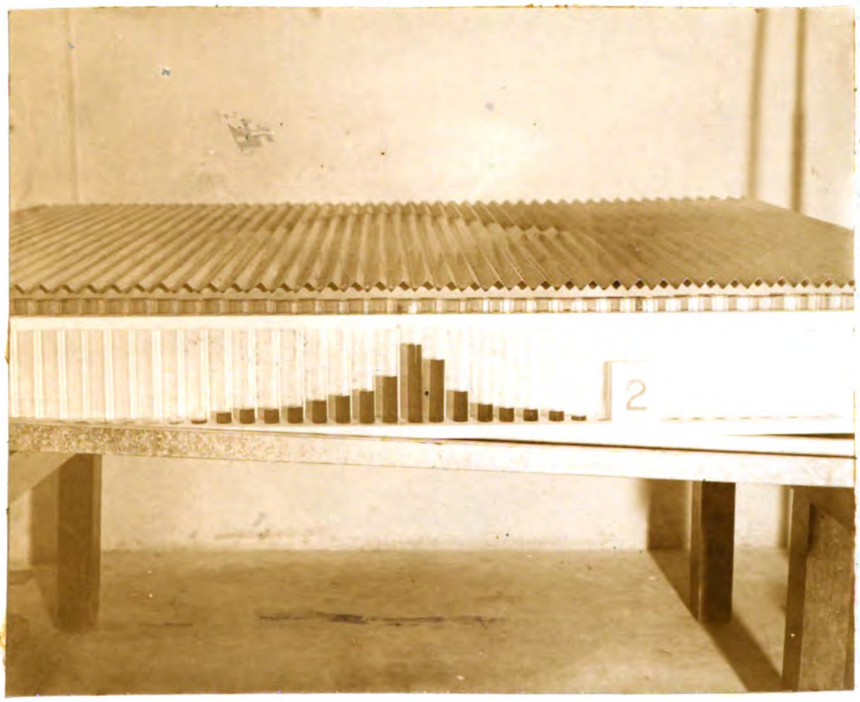


Fig. 15. Pattern for Single Nozzle with 2.5 gals. per Acre Capacity at 4 M. P. H.

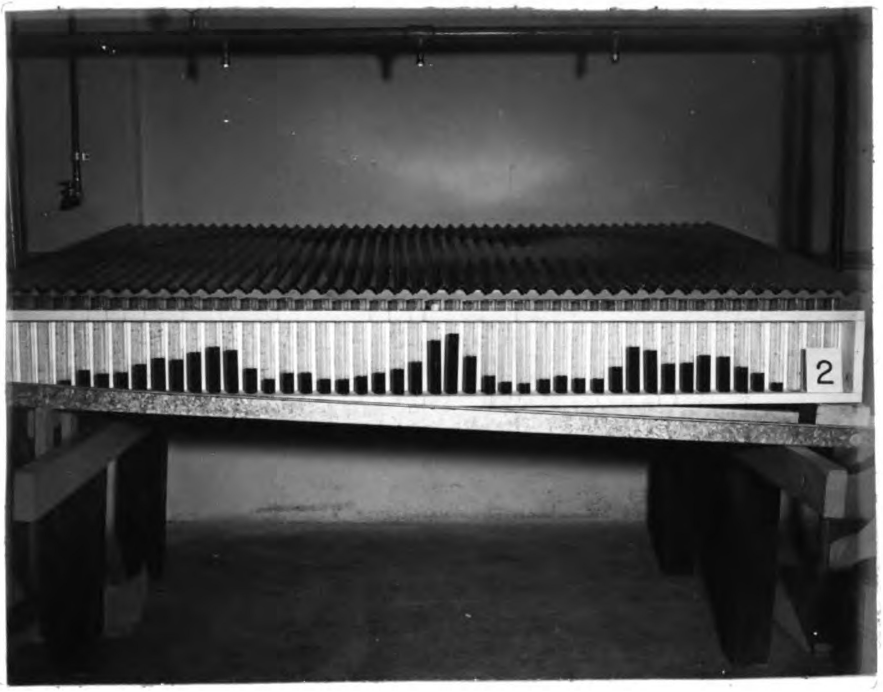


Fig. 16. Pattern for Three Nozzles with 2.5 gals. per Acre Capacity at 4 M. P. H.

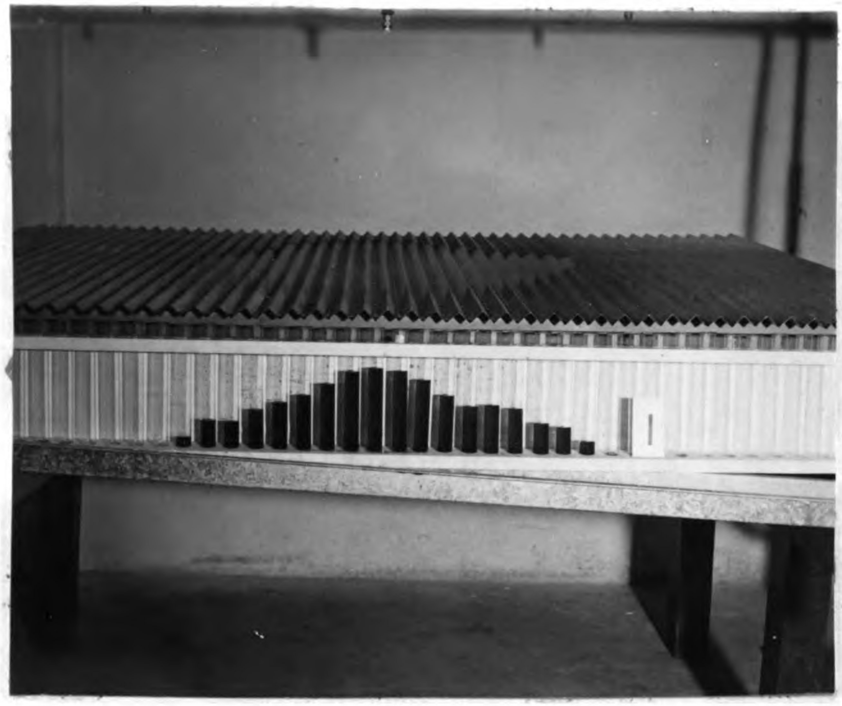


Fig. 17. Pattern for Single Nozzle with 10 gals.
Per Acre Capacity at 4 M. P. H.

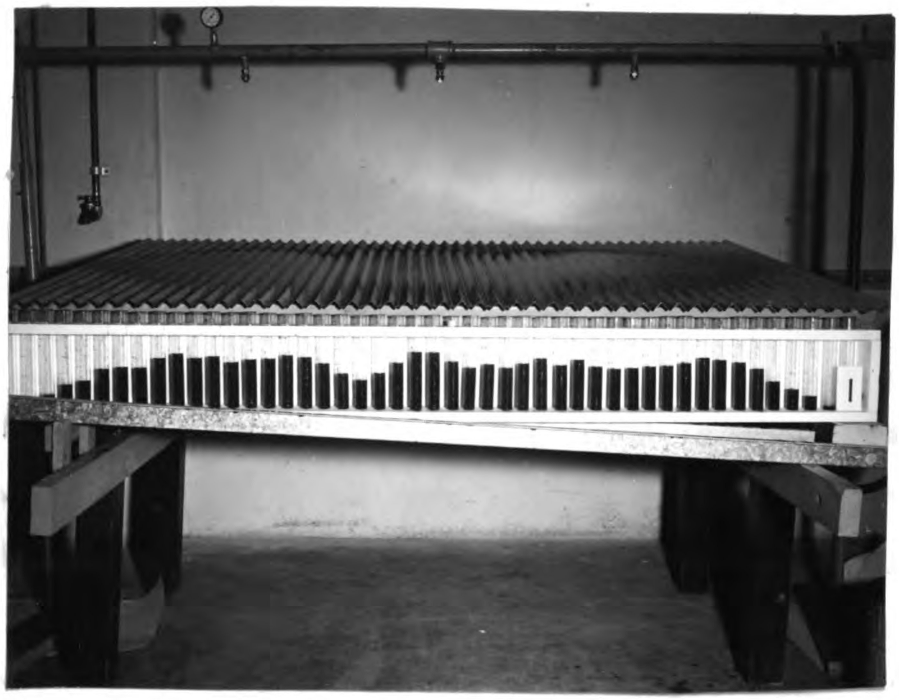


Fig. 18. Pattern for Three Nozzles with 10 gals.
Per Acre Capacity at 4 M. P. H.

distribution of spray material. That is, ones with rates of discharge above 5 gallons per acre, at 4 miles per hour, gave a more even pattern, than those with capacities under 5 gallons per acre at the same speed.

Visual Spray Pattern

The second group of tests was made with the visual spray apparatus. This machine made it possible to record a visual pattern for each nozzle, at any desired spacing and height.

The nozzle, to be checked, was mounted on the adjustable boom, and the boom placed in position over the apparatus. A plain sheet of white wrapping paper was pinned to the plywood table, after it had been moved to the starting end, and attached to the V belt by a string. As soon as the pump started, a container was held beneath the nozzle until the pressure and pattern were normal. Next the motor operating the V belt and table was switched on and the container withdrawn from beneath the spray. The paper passed under the nozzle receiving the spray, and as rapidly as possible the container was returned to catch the liquid until the pump motor could be stopped.

By using methylene blue in the spray material, a clear pattern of the spray was deposited on the paper.

Figures 19 and 20 compare a spray distribution, of a single nozzle with a uniform pattern, made with the corrugated test tray and the visual spray apparatus. When nozzles, with uniform patterns as shown in Figures 19 and 20, are placed on the spray boom, the desired uniformity of application is obtained. The ideal distribution, for applying 2,4-D for weed control, is illustrated by Fig. 21.

A comparison of the distribution pattern of single nozzles, with heavy edges, may be seen in Figures 22 and 23. The oversprayed strips, that occur with heavy edged patterns, are illustrated by Fig. 24.

The spray patterns in Figures 21 and 24 were produced by nozzles with the same rate of discharge, but their spray distributions were different. The effect of this overtreated strip, in using 2,4-D, cannot be answered without further field tests.

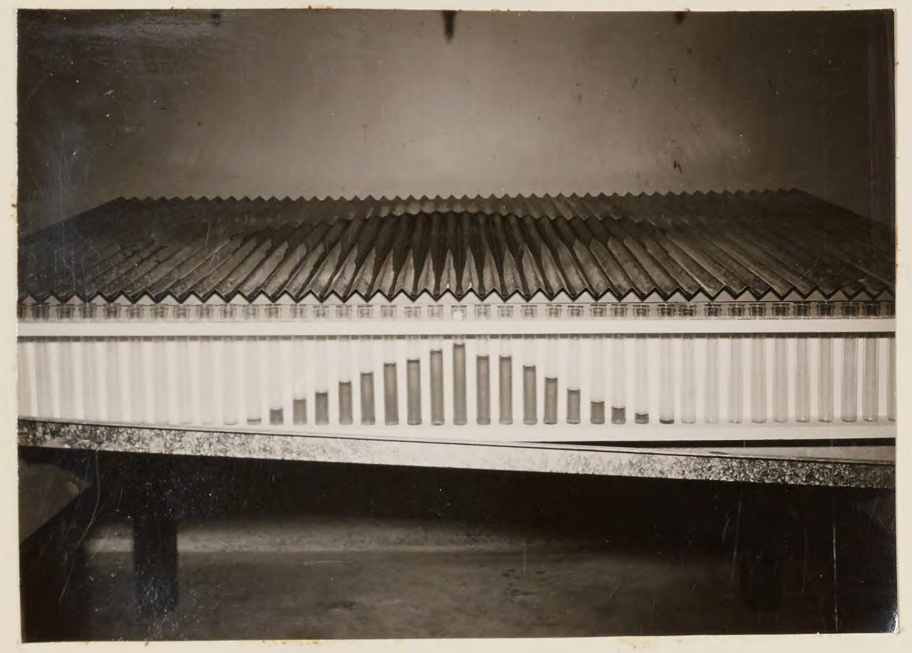


Fig. 19. Photo Single Nozzle Uniform Pattern.

Fig. 20. Visual Pattern Single Nozzle Uniform Distribution.

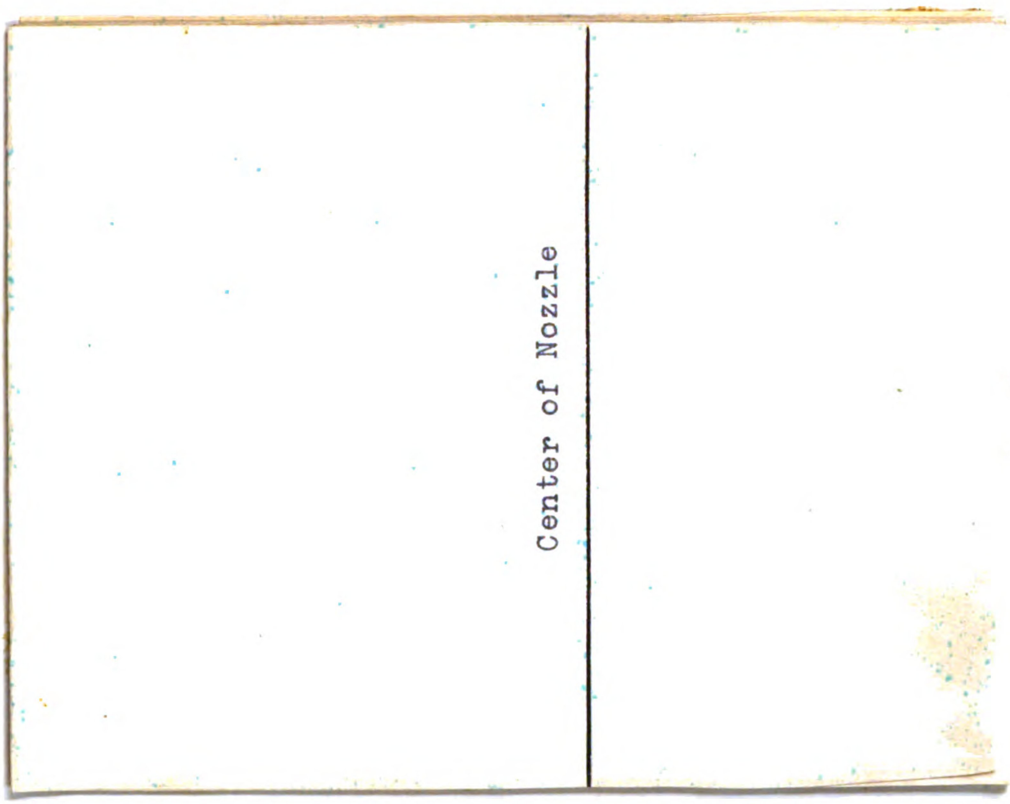


Fig. 21. Spray Pattern Three Nozzles Uniform Distribution.

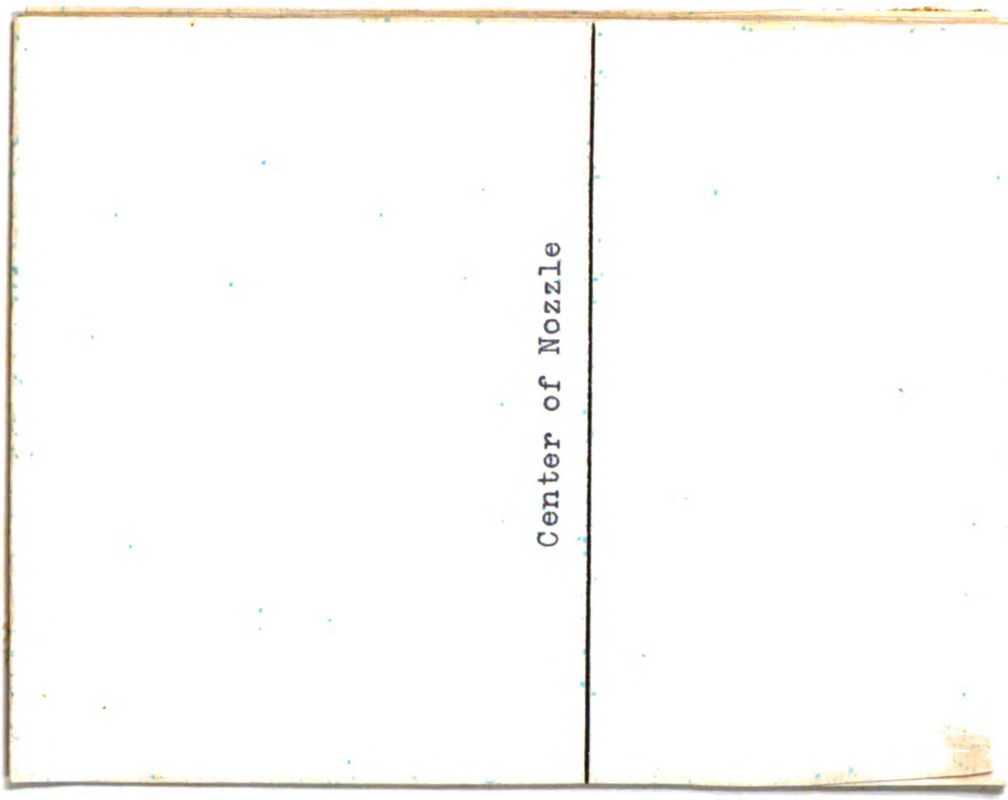


Fig. 21. Spray Pattern Three Nozzles Uniform Distribution.

Fig. 22. Photo of Single Nozzle with Heavy Edged Pattern.

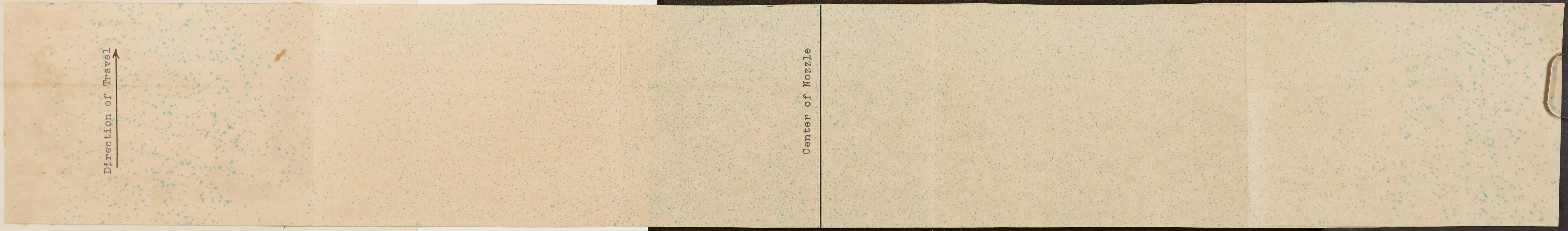


Fig. 23. Visual Pattern of Single Nozzle with Heavy Edged Distribution.

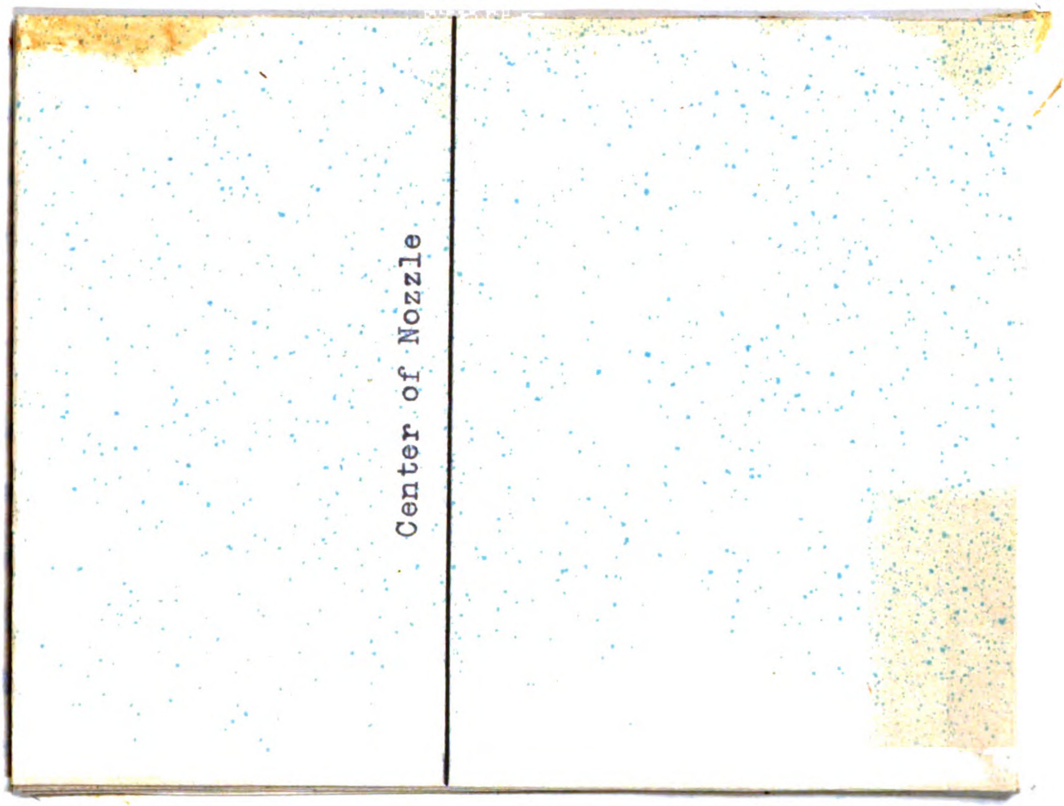


Fig. 24. Spray Pattern Three Nozzles with Heavy Edged Distribution.

Wear Tests

As a third test the nozzles were checked for the effect of wear on spray pattern and capacity. A nozzle with a 5 gallon per acre rate of discharge, and one with a 10 gallon per acre capacity were selected to be used for this test. In the beginning, when checked with the corrugated test tray and the visual spray apparatus, both gave a uniform distribution pattern.

The two nozzles were mounted on the spray boom, placed over the corrugated sheet, and operated at a pressure of 33 pounds per square inch. After 10, 20, and 30 hours of continuous operation, the spray pattern and capacity of both nozzles were checked.

Fig. 25 shows that the variation in rate of discharge and distribution pattern were not any greater than could be expected with two new nozzles of the same size.

A farmer operating a spray rig 4 miles per hour and covering a width of 28 feet, could spray approximately 100 acres in 10 hours. The average operator probably would not need to spray more than 100 acres annually; therefore, the 30 hours of continuous operation represent about 3 years' life for the spray nozzle. Although continued tests should be made on the effect of wear, it is apparent that with the proper care the low volume nozzle should have the same pattern and capacity after 3 years of normal operation.

Comparative ratings of the nozzles tested may be seen in Table II.

FIG. 25 EFFECT OF WEAR ON SPRAY PATTERN

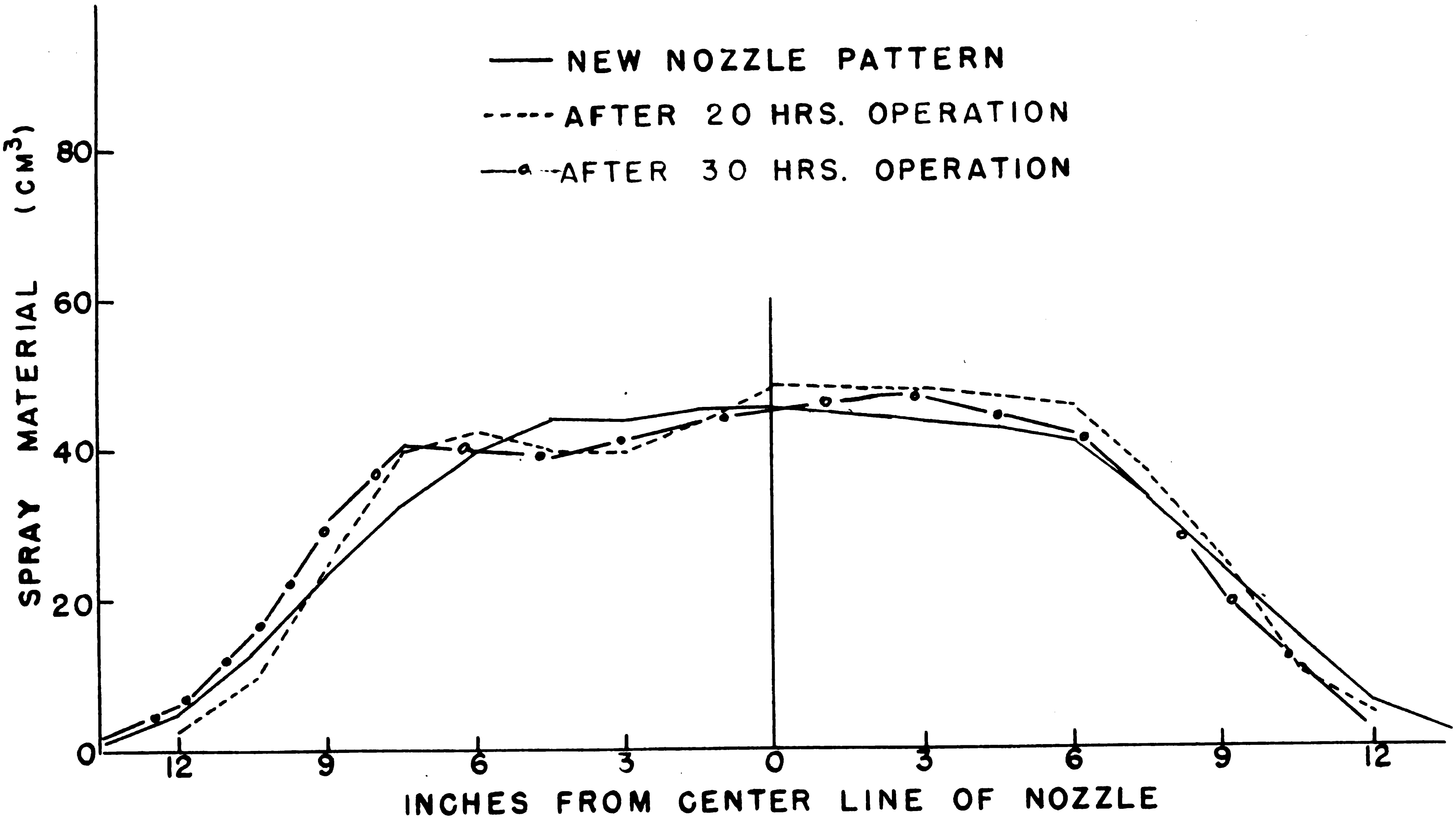


TABLE II

COMPARATIVE RATINGS OF NOZZLES TESTED

Manufacturer	Nozzle Rating	Remarks
Monarch	3	Construction good. Heavy edged pattern.
Spraying Systems	2	Easy to change nozzle tips. Nozzles with capacities of 10 gals. per acre and above gave the most even spray pattern.
Accessories Mfg. Inc.	2	Construction good. Nozzle tip protected should it come in contact with the ground.
Automatic Equipment Co.	4	Difficult to keep from leaking.
Torado Co.	1	Very uniform spray pattern.
Kromer	3	Easy to damage tip should it come in contact with ground.
Linck	3	Higher volume than needed for most work.
Century	2	Hollow cone. Very fine spray.
Spray Engineering	3	Difficult to change disc.
Delavan	3	Nozzles with capacities above 10 gals. per acre give the best spray pattern.

Key to Ratings: 1. Excellent
2. Good
3. Fair
4. Poor

The construction, spray pattern and capacity were considered in the rating of each nozzle.

CONCLUSIONS

1. The two-piece fan nozzle with a uniform pattern, an individual strainer, and a capacity of 10 to 15 gallons per acre meets the requirements for a general weed spray nozzle.

2. The fan nozzle is the best, for weed control, because of its larger droplet spray and uniform coverage. The more atomized spray produced by hollow and solid cone nozzles, has a greater tendency to fog or drift.

3. Uniform distribution of spray material may be obtained from fan nozzles with capacities as low as 5 gallons per acre. However, those with rates of discharge above 8 gallons per acre, at 4 miles per hour, give a more even pattern than those with lower capacities at the same speed.

4. The pattern of each nozzle, on a spray boom, must overlap to give complete coverage.

5. Double coverage does not necessarily give uniform distribution. Fan nozzles, on a boom, that produce heavy edged patterns will give more satisfactory results if their fans completely overlap, but they will not give the distribution produced by nozzles whose patterns are uniform.

6. It is apparent that with the proper care the low volume nozzle should have the same pattern and capacity after 3 years of normal operation.

7. If nozzles are purchased from an experienced manufacturer, their rated capacities will be reliable. However, each spray rig must be calibrated, because manufacturers' ratings, gallons per acre, will only be correct if the speed of travel and pressure are as recommended.

SUMMARY

The effectiveness of 2,4-D, for weed control, depends on how uniformly it is spread over a given area, rather than the total volume per acre applied. The nozzle is, therefore, a most important part of spray equipment as it acts as a metering device which controls the application of the chemical to the crop.

Test nozzles, capable of applying approximately 5, 10, and 15 gallons per acre, were obtained from ten different companies, and the capacity and spray pattern for each was checked on both the corrugated test tray and the visual spray apparatus. In addition, checks for the effect of wear on rate of discharge and pattern were made.

The results show that if nozzles are purchased from an experienced manufacturer, their rated capacities will be reliable. All of the nozzles, however, did not produce a uniform pattern. Those with rates of discharge above 5 gallons per acre gave a more uniform distribution than those with capacities below 5 gallons per acre. Nozzles producing patterns with heavy edges, left overtreated strips in the sprayed area. It is impossible to determine the effect of these oversprayed strips on weed kill without field tests.

The capacity and spray pattern of the low volume nozzles were unchanged after 30 hours of continuous operation. To obtain more complete results the wear tests should be continued, at different pressures, for a longer period of time.

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