KENTUCKY

AGRICULTURAL EXPERIMENT STATION

OF THE

STATE COLLEGE OF KENTUCKY.

BULLETIN No. 53.

I. Spraying for Codling-moth.

II. The Use of Arsenites on Tobacco.

III. The Use of Bisulphide of Carbon and Hydrocyanic Acid Gas on Low-growing Plants.

LEXINGTON, KENTUCKY,

DECEMBER, 1894.

KENTUCKY

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KENTUCKY AGRICULTURAL EXPERIMENT STATION,
LEXINGTON, KY.

BULLETIN No. 53.

I. SPRAYING FOR CODLING-MOTH.

BY H. GARMAN, ENTOMOLOGIST AND BOTANIST.

In Bulletin 44 of this Station, published in January, 1893, was given the results of experiments in spraying apple trees to check the destructive rots to which the fruit is subject in this region, and incidentally some facts were elicited concerning the injury from codling-moth that determined me to experiment with reference to the insect injury alone when opportunity offered. The complete failure of the apple crop in 1893 prevented the realization of this intention during that season, and it was not till the summer of 1894 that a chance came to test the use of arsenites for the codling-moth injury. Two janet trees were selected in June for this purpose. They set a fair number of apples, whereas the fruit of but few other trees in the orchard escaped late spring frosts. The trees stand side by side, the sprayed tree being somewhat the larger, but having a branch in a dying condition which tended to make the two more nearly equal, supposing that the size had any influence on their bearing capacity. The tree to be sprayed was numbered 499, the check tree received the number 500.

On July 11, No. 499 was sprayed with London purple mixture (1 lb. to 160 gallons), 7½ gallons being applied to the leaves.

On July 30, August 6, and August 13, this tree was sprayed with Paris green mixture (1 lb. to 160 gallons), 10 gallons being applied on each of these dates.

August 20 and August 27 the tree received 16 gallons of Paris green mixture, 8 gallons on each date.

No. 499 thus received during the summer six applications, aggregating 53½ gallons, and containing, as I calculate, about 2.6 ounces of arsenic.

The fallen apples were gathered under both trees at intervals during the summer, and were examined both with reference to the injury by codling-moth and also as to rotting. The Paris green mixture is not recognized as having special value for checking the fungus diseases of plants, although from the effect of the arsenites on the spores when applied directly, in the laboratory, one would expect it to have a very decided effect when sprayed upon the plants. The results, however, show that it did not have any effect in checking the rot, a statement which it will be seen is more than borne out by the data given below.

No. 499.

Fallen Apples. The apples which fell to the ground were picked up on five different dates, as follows:

Rotting Apples.	July 30,	167,	of which	163	(98 pr. ct.)	were	injured	by	codling-moth
	Aug. 9,	17,	"	13	(76 ")	"	"	"	"	"
	Aug. 22,	231,	"	156	(67 ")	"	"	"	"	"
	Sep. 15,	203,	"	97	(48 ")	"	"	"	"	"
	Sep. 29,	56,	"	23	(41 ")	"	"	"	"	"
	Total	674,	"	452	(67 ")	"	"	"	"	"
Apples not Rotting.	July 30,	104,	of which	98	(94 pr. ct.)	were	injured	by	codling-moth.
	Aug. 9,	11,	"	10	(91 ")	"	"	"	"	"
	Aug. 22,	23,	"	16	(84 ")	"	"	"	"	"
	Sep. 15,	19,	"	3	(16 ")	"	"	"	"	"
	Sep. 29,	3,	"	1	(33 ")	was	"	"	"	"
	Total	160,	"	131	(82 ")	were	"	"	"	"

A total of 834 apples was thus gathered and examined from the sprayed tree, and only 19 per cent. was free from the rot fungus. It is interesting to note that the proportion of not rotting to rotting apples gradually diminishes during the season notwithstanding the spraying. On July 30, 38 per cent. were free from rot; on August 22 the proportion had sunk to 9 per cent., and on the last date of examination, Sept. 29, only 5 per cent. of the apples gathered under the sprayed tree were free from rot.

It is very evident from this result that spraying with Paris green alone cannot be expected to check the rotting of apples.

On the other hand the effect on the codling-moth injury was evidently beneficial. Of the first lot examined, on July 30, 98 per cent. was wormy, and on subsequent dates the percentage declined steadily in both not rotting and rotting apples until September 29 when 41 per cent. of the rotting apples was found affected, and 33 per cent. of the not rotting fruit.

Picked Apples. On September 29 the apples were picked. 213 apples weighing 20 pounds and 1½ ounce were without rot, and 83 (39 per cent.) of these were affected with codling-moth. 104 apples showing a slight trace of rot weighed 9 pounds 3½ ounces, and of this lot 40 (38 per cent.) showed the characteristic codling-moth injury. 557 apples taken from the tree were rotting and useless, and of these 471 (84 per cent.) had been mined by the insect. The entire yield of the tree, including sound and useless fruit, weighed 40½ pounds. The result of the examination of the picked apples may be summarized as follows:

Not rotting	213,	of which	83	(39 per cent.)	were injured by codling moth.		
Rotting	661,	" "	511	(77 per cent.)	" " " "		
Total	874,	" "	594	(68 per cent.)	" " " "		

No. 500 (Check).

Fallen Apples. The apples which fell from this tree were gathered up and examined on the same dates as were those under the sprayed tree, with the following result:

Rotting Apples.	July 30,	87	of which	87	(100 pr. ct.)	were injured by codling-moth.			
	Aug. 9,	31	" "	26	(84 ")	" "	" "	"	"
	Aug. 22	281	" "	257	(91 ")	" "	" "	"	"
	Sep. 15	185	" "	165	(89 ")	" "	" "	"	"
	Sep. 29,	14	" "	13	(93 ")	" "	" "	"	"
	Total, of	598	" "	548	(92 ")	" "	" "	"	"

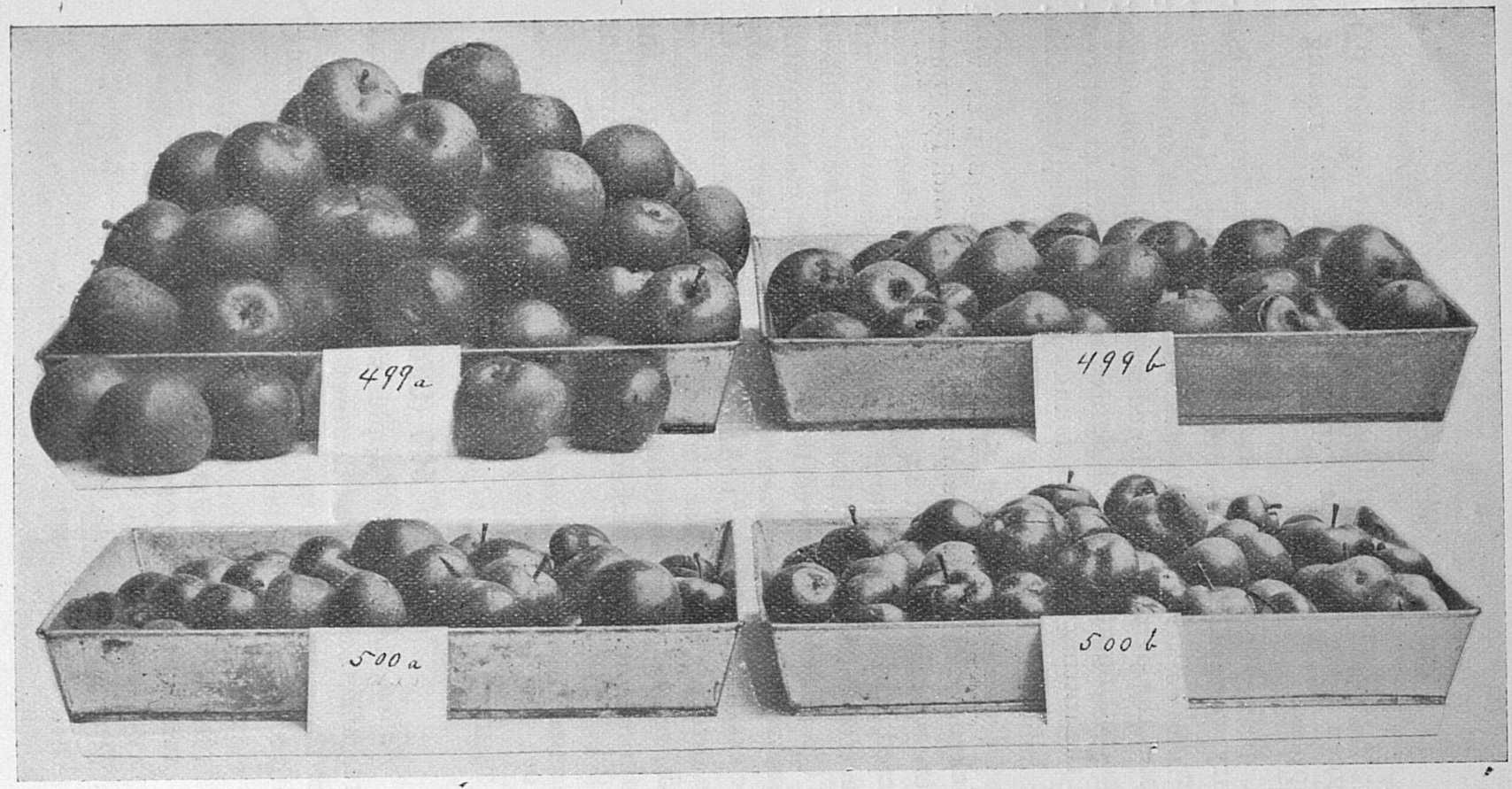

FIG. 1. Picked apples not rotting which were taken from the two trees on September 29. 449 *a*, apples not injured by codling-moth; 449 *b*, apples injured by codling-moth. 500 *a*, apples not injured by codling-moth; 500 *b*, apples injured by codling-moth.

Apples not Rotting.	July 30,	133	of which	131	(98 pr. ct.)	were injured	by	codling-moth.	
	Aug. 9,	26	" "	24	(92 ")	" "	"	"	"
	Aug. 22,	51	" "	49	(97 ")	" "	"	"	"
	Sep. 15,	8	" "	6	(75 ")	" "	"	"	"
	Sep. 29,	2	" "	2	(100 ")	" "	"	"	"
	Total	220	" "	212	(96 ")	" "	"	"	"

It will be observed in comparing these data with those pertaining to No. 499 that the percentage of injury does not here become gradually less and less toward the end of the season. In both rotting and not rotting apples the percentage remains high, averaging for the rotting apples 92 and for the not rotting 96. This fact tends to show that the gradual decrease in the percentage of injured fruit from No. 499 was the result of the spraying.

Picked Apples. The apples were picked from this tree September 29. The whole yield weighed 29 pounds. 176 apples free from rot weighed 12 pounds, 2 ounces, and of these 110 (62 per cent.) were injured by codling-moth. 94 apples weighing 6 pounds, 11½ ounces showed only slight traces of rot; 68 (72 per cent.) showed the work of codling-moth. Of 546 rotting and useless apples taken from the tree, 483 (89 per cent.) were injured by codling-moth. The summary of the examination of picked apples from this tree is as follows:

Not rotting	176,	of which	110	(62 per cent.)	were injured	by	codling-moth.	
Rotting	640,	" "	551	(86 per cent.)	" "	"	"	
Total	816,	" "	661	(81 per cent.)	" "	"	"	

Summary.

1. A comparison of the results of the examination of the two trees shows that the spraying had a beneficial effect in checking the codling-moth injury, though it was not as marked as was expected. The total number of apples from the sprayed tree was 1708, of which 1177 (69 per cent.) were injured by the codling-moth, while in

FIG. 1. Picked apples not rotting which were taken from the two trees on September 29. 449 *a*, apples not injured by codling-moth; 449 *b*, apples injured by codling-moth. 500 *a*, apples not injured by codling-moth; 500 *b*, apples injured by codling-moth.

a total of 1634 obtained from the check tree 1421 (87 per cent.) showed the effect of codling-moth work, leaving a difference of 18 per cent. in favor of spraying. The sprayed tree yielded nearly twice as many sound apples as the check tree.

2. The effect of spraying on the rotting of the fruit was imperceptible. The sprayed tree was in fact slightly more affected by the rot than was the check tree, the former having 78 per cent of all its fruit more or less rotting, while the check tree had 76 per cent. attacked.

3. The relation of codling-moth injury to the rotting of the fruit is not, judging by these experiments alone, very clear. On the sprayed tree 43 per cent. of the rotting fruit was injured by the codling-moth, while of the fruit not injured by rot 57 per cent. was attacked by the insects. On the check tree a reverse result was obtained, 88 per cent. of the rotting apples being attacked by insects, while only 81 per cent. of those not rotting was so attacked. When, however, the rotting apples of both trees are taken together and compared with the not rotting fruit from both it is found that the rotting apples show a smaller percentage of injury from the insects. Taken with the results of examinations of apples made in 1892 the evidence still favors the conclusion reached at that time, viz. that the codling-moth avoids rotting apples.

4. The question so often asked as to the probability of arsenites sprayed upon apples injuring the health of the consumer has as often been answered in the negative, but it can do no harm to repeat the answer to a question of so much importance. The tree numbered 499 in these experiments was sprayed more frequently than is customary among orchardists and so received a larger quantity of arsenic, yet chemical analysis of a half dozen apples from the sprayed tree showed no perceptible quantity on the fruit. The copper obtained by Dr. Peter was doubtless derived from the barrels and the tank of the sprayer,

these having contained at different times during the season mixtures in which copper sulphate entered as an ingredient. The statement of the chemist is given below.

LEXINGTON, KY., Dec. 18th, 1894.

Prof. H. Garman,
Division of Entomology and Botany,

DEAR SIR:

The apples which you brought to the laboratory were tested in the following manner:

The six apples were peeled carefully and the peelings, including the stem-and blossom-ends of the apples, were digested with hydrochloric acid and potassium chlorate in the usual manner. The solution obtained was treated thoroughly with hydrogen sulphide and the resulting precipitate examined for copper and arsenic, after appropriate treatment to destroy organic matter. No reaction for arsenic was obtained, but a very satisfactory test for copper was shown. The quantity of copper, however, was exceedingly small and was not weighable.

The meat and cores of the same apples, treated in the same way, gave no reaction for either arsenic or copper.

Very respectfully,
ALFRED M. PETER.

II. THE USE OF ARSENITES ON TOBACCO.*

BY H. GARMAN.

The practice of spraying orchards with Paris green and London purple appears to have become a permanent acquisition to the intelligent orchardist. It is not many years since this treatment of the trees was assailed by cautious writers and workers as dangerous to health, and by some as of doubtful benefit. Nevertheless it appears to have come to stay. It was shown at the Illinois State Laboratory that a much larger quantity of the poisons could be applied to apple trees than is necessary to check the injury of codling-moths, without leaving a quantity on the ripened fruit sufficient to affect the health of

*The greater part of this article was presented recently before the Entomological Section of the Association of American Agricultural Colleges and Experiment Stations.

those eating it. To the objection that stock might be poisoned by eating grass or clover under the dripping trees, Prof. Cook of Michigan replied that he had demonstrated by giving such food to his horse that it would do no such injury. When it was objected that bees might be poisoned by sipping the poisoned fluids from the blossoms, it was shown that the spraying could be practiced successfully after waiting until the petals of blossoms had fallen. With the cheap and excellent spraying machinery now on the market, there would seem to be no further reason why every one owning an orchard should not increase his profits by spraying.

It is not very generally known, perhaps, that Tobacco is being sprayed with arsenites quite extensively. The same objections to the practice are being urged as were formerly used against spraying apple trees, and I think with greater show of reason in this case. The tobacco leaf when alive is provided with large numbers of glandular hairs which catch the spray and retain the residue from it with tenacity, so that at the end of the season there is likely to be a considerable quantity remaining on the leaves. Is it not possible that this arsenic will injure the user of such tobacco? The danger in using sprayed apples, it may be urged, is lessened by the fact that generally the skin is not eaten, and that even if this is done the possibility of being poisoned can be obviated by first washing or rubbing the fruit thoroughly. Such treatment is not practicable with the tobacco leaf, hence the increased danger. Notwithstanding such objections the practice seems to be growing steadily, as will be appreciated when I say that a single firm at Lexington sold during the past spring and summer 500 sprayers to be used for tobacco.

Now I take it that if spraying tobacco is injurious to health the fact should be demonstrated and published at once. If it is not calculated to affect the user of tobacco,

then let it be known that in the use of arsenites we have a very effective substitute for the laborious process of "worming." It can serve no useful purpose to conceal the truth of the matter. Indeed secrecy practiced in spraying may justly be urged as evidence that the grower using arsenites knows that he is doing wrong. The actual truth appears to be that those who are unwilling to have it known that their tobacco has been sprayed are not afraid of the injurious consequences from using it, but of an unthinking prejudice which knowledge of the fact might excite in the minds of lovers of the weed.

Spraying tobacco can only be made a legitimate part of farm practice by a demonstration that the arsenic left on the plants will not injuriously affect health.

With a view to throwing some light on the subject, a preliminary experiment was tried at the Kentucky Experiment Station this summer, the results of which are herewith presented.

Five plots of 1-10 acre each had been planted by Director Scovell for a fertilizer test, and after the worms began to appear in July we began to spray with Paris green and London purple. The first application was made July 27, when two rows in each of four plots were sprayed with Paris green in water (1 pound to 160 gallons), 34 gallons of this being applied to the eight rows. The plants were thoroughly wetted, the Paris green being perceptible on the leaves afterward. At the same date two rows of the fifth plot were sprayed with London purple in water, the same proportions being employed as in the preceding experiment, and 9½ gallons being used on the two rows.

On August 3 three of the plots which had been sprayed with Paris green mixture were sprayed again, the same proportion of poison to water being used, and 25 gallons being applied. The two rows previously sprayed with

London purple were at this time treated to 10 gallons of the London purple mixture.

It was intended to spray some of the rows a third, and still others a fourth time, but the weather subsequently proved so dry that the tobacco "fired" badly and ceased to grow. Under the circumstances it was thought best not to make further applications.

All the spraying was done with the Nixon Company's cart-sprayer, and one of their climax pumps.

The Effect on the Worms.

It was no part of our original purpose to determine by this experiment the usefulness of the practice. This had already been settled by the experience of practical growers. The sprayed plants were however closely watched and comparisons made between them and the unsprayed rows, the latter being carefully "wormed" throughout the season. Unquestionably more worms appeared on the unsprayed than on the plants sprayed with Paris green. Throughout the summer the plants sprayed with this mixture were at least as free from injury by worms as were the others.

The rows sprayed with London purple mixture did not seem to me as completely defended against the worms as were those sprayed with Paris green, and I thought they were not quite as good as the unsprayed plants of the same plot. My experience with the two arsenites was in this case in accord with results of other experiments on other insects. Whenever the two have been carefully compared by me the Paris green has proved most effective. Since the greater cost of Paris green is not an item of much consequence, considering that the amount required in spraying tobacco is small, we may I believe reject London purple for tobacco spraying in favor of Paris green. The color of the latter making it less apparent on the leaves gives it the preference of growers, and as far as I can learn it alone is used by them.

In our experiments we sprayed two times, it will be remembered, the last one being August 3. The tobacco was not cut until Sept. 7, thus leaving a month between the last application and the time of cutting. During this time the total rainfall, as I learn from Professor V. E. Muncy, the local weather observer, was 3.67 inches, the greater part of which fell on the 12th, 19th and 26th. This is not far from the average* rainfall for this month at Lexington.

There was thus ample time for much of the Paris green and London purple left by the spraying to have been removed by winds and rains.

The Arsenic Left on Tobacco.

The important thing to be decided is of course the quantity of arsenic left on the plants at the time of cutting. Without giving details, I will state that if all the fluid used had alighted on the plants and none had dripped from the leaves there would have been after the single spraying of July 27 on each plant of rows 1 and 2 of plot 1, 2.0659 grains of Paris green, and as about 50 per cent. of this was arsenic each plant would have borne 1.0329 grain of this poison. This is a liberal estimate of the quantity of arsenic which these plants received, for probably not more than four-fifths of the fluid used alighted and remained upon the plants.

On rows 1 and 2 each of plots 2, 3 and 4, individual plants received 4.0913 grains of Paris green in the two sprayings given these plots, about half being applied July 27 and the remainder August 3. Each plant is estimated to have received 2.0456 grains of arsenic.

The two rows of plot 5 treated with London purple received 4.7395 grains of London purple per plant, or 1.8957 grain of arsenic, considering that the London purple contained 40 per cent. of the poison.

An examination of the report of Dr. A. M. Peter on

*Prof. Muncy's records for 9 years give an average of 3.78 inches, the highest being 8.78 in the year 1888, the lowest 0.62 inch in 1875.

the chemical examination of sprayed tobacco will show that whatever the original quantity left on the plants, but a small part of it remained there at the time of cutting.

The largest percentage he recovered by analysis was from Plot 4, rows 1 and 2, from which arsenious oxide at the rate of .329 grain per pound of tobacco was obtained. Considering each plant as producing 16 usable leaves, and four plants as producing a pound of tobacco the poison obtained by him is the equivalent of .0822 grain of arsenious oxide per plant. Since each plant of these rows received in the spraying 2.0456 grains of arsenic it follows that on the usable part of each plant there remained at cutting time only about 4 per cent. of the arsenic originally applied to the plant.

The plants of plot 1, sprayed but once, on July 27, retained on usable leaves only 1.8 per cent. of the arsenic left by spraying.

The arsenic recovered from plants sprayed with London purple amounts to about 3.2 per cent. of that applied.

When it is remembered that but little tobacco is swallowed by the user it seems that the small quantities recovered by Dr. Peter show that spraying once or twice, as practiced by us, would not render tobacco in any way injurious*, but I would add that I do not think mixtures much stronger than those we used should be employed, and that not more than three applications should be made during dry seasons.

Suppose we had used three pounds of Paris green in forty gallons of water. With one application each plant would have received 12.3958 grains of arsenic, and if 1.8 per cent. of this quantity remained on the usable leaves at the time of cutting, analysis would have recovered from one plant .2231 grain, which is at the rate of .8924 grain per pound. If two applications of this strength had been made, calculating from the results of our experiments chemical

*2-3 grains of arsenic constitute, it is said, a fatal dose for an adult.

analysis might have recovered .9819 grain from the usable part of a plant, which is at the rate of 3.9277 grains per pound of tobacco. This is a large quantity, and while these estimates must be considered only as approximations they demonstrate clearly enough the general and essential truth that a quart of Paris green in a barrel of water is more than should be used. If last season had been very wet no doubt less than 4 per cent. of the poison would have remained at the close of the season, but the part of wisdom is to avoid such strong mixtures, since the weather cannot safely be counted on to remove the excess.

Apparatus for Spraying Tobacco.

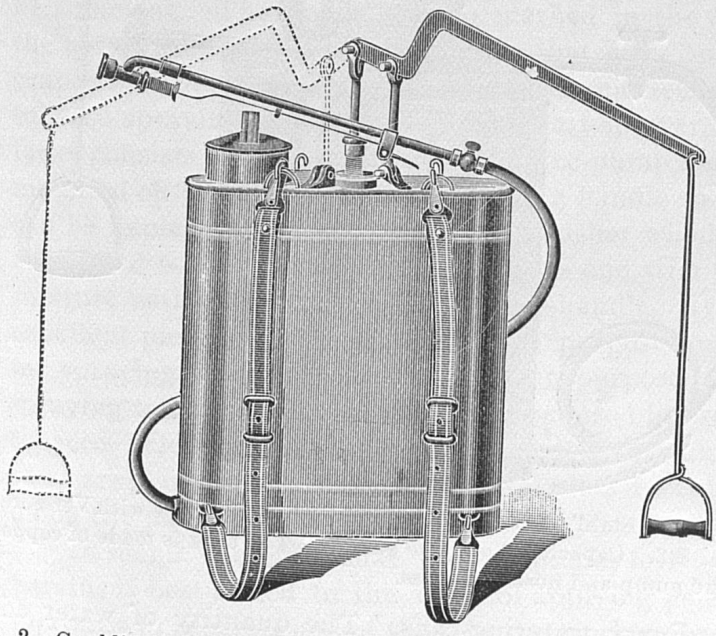

FIG. 2. Gould's Handy Knapsack-Pump. Price with 3½ feet of ⅜ inch hose and vermorel nozzle, $15. A stirrer or agitator is furnished for 50 cents extra. Capacity about five gallons. The tank is made of heavy copper and the working parts largely of brass.

The sprayers most used in Kentucky are what are sometimes called gravitational sprayers. That is to say

they are not sprayers at all, but knapsack-sprinklers. A form now in the market consists of a galvanized iron tank with a capacity of six gallons, so constructed that it can be strapped to the back while in use. At the bottom of the tank on each side is a spout to which a short piece of rubber tubing is attached, bearing at its free end a wooden handle perforated for the passage of the tubing through it and bearing in turn a fine rose of the sort used

Fig. 3. Stahl's Excelsior Knapsack-Sprayer. Price with Vermorel nozzle, $12. Capacity about five gallons. The tank is made of copper and the pump and nozzle of brass.

on ordinary watering-cans. The quantity of water admitted to the nozzle is regulated by a wire clamp which compresses the tubing. The idea prominent in its construction is to sprinkle two rows of tobacco or potatoes as the operator walks between them. This knapsack-sprinkler is a great improvement on the perforated tin can dus-

sprinkler cannot. It permits rapid work, and although usually provided with but a single nozzle I believe can be made to spray as many plants in the same time as the sprinkler. Its main advantage is in the superior quality of the work it permits.

In our use of the knapsack-sprayer, however, one serious defect became apparent, and it is one which characterizes most of the knapsack-sprayers. The weight of Paris green causes it to settle rapidly to the bottom of the can and as the outlet to the nozzle is here the poison is soon discharged leaving the last fluid which emerges with but little Paris green in it. I know the claim is made that the motion of the man using a sprayer keeps the mixture stirred. But in practice I have found this not to be sufficient. The defect was so marked in the case of the sprayer used by us last summer that after spraying grapes and other plants with it, it was rejected for the tobacco spraying in favor of Nixon's cart-sprayer. This latter consists of a wooden tank, with force-pump attached, mounted on wheels and provided with a handle so that it can be hauled about. It has a large dasher which is so connected with the pump that it moves and stirs up the mixture with each stroke of the pump-handle. It is an excellent piece of apparatus for many purposes, notably for spraying orchards, and served our purpose well in spraying tobacco. But it could not be used in ordinary tobacco fields because of the closeness with which the rows are planted. In our experimental plots it was hauled along the paths between the plots.

It seems therefore that the knapsack form of apparatus is best suited to the work of applying poisonous mixtures to tobacco, and of those in the market the force-pump sprayers seem to me much to be preferred. Several different makes are advertized which appear to be about equally good. The following firms are known to me as dealers in these sprayers:

ter sometimes used, and is much superior also to the whisk-broom and bucket. But its only advantage over the improved, copper, knapsack-sprayers containing a force-pump is in its cheapness. It sells for about $4.00, whereas the force-pump sprayers cost from $12.00 to $18 00.

Notwithstanding this I believe the copper knapsack-sprayer must eventually supplant the sprinkler, and that the former is, all things considered, the cheaper. In the first place it economizes material, and enables one to apply mixtures thoroughly and uniformily. It can be used for spraying the copper mixtures so useful for the fungus diseases of plants, which the galvanized iron

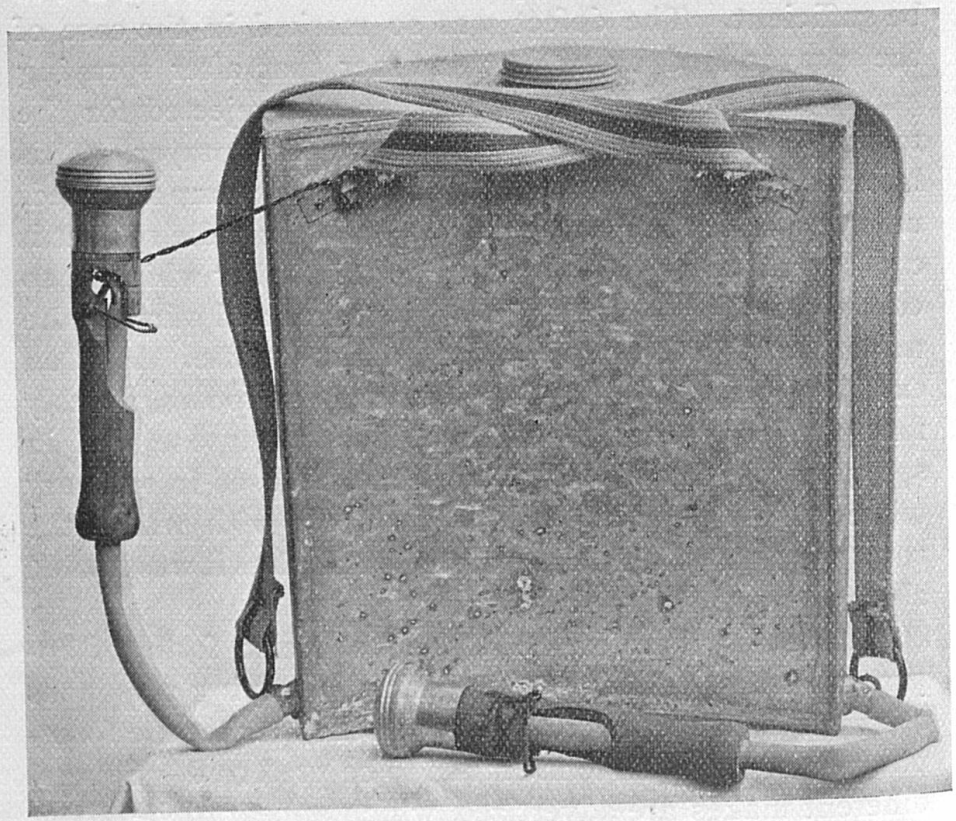

Fig. 4. Drake's Champion Tobacco-Worm Destroyer." The tank is made of galvanized iron. Capacity about six gallons. Sold by E. B. Drake, Lexington, Ky.

The Deming Company, Salem, Ohio.
W. & B. Douglas, Middletown, Conn.
Wm. Boekel & Co., 518 Vine St., Philadelphia, Pa.
The Goulds Manufacturing Company, Seneca Falls, N. Y.
William Stahl, Quincy, Ill.

Nozzles to be Used in Spraying Tobacco.

The nozzle for distributing the fluid is scarcely less important than the pump. There is in some quarters a notion that the rose of a watering-can will do as good work of this sort as the improved nozzles constructed for use with a force-pump. Where the material applied to plants is not poisonous and is very cheap a sprinkler may safely be used, although even here the force-pump and special nozzle would do the work better in less time It should be clearly understood by those contemplating the purchase of sprayers that the rose of a watering-can, no matter how fine the apertures may be, will not make a *spray* such as is produced by a good nozzle. The fluid is expelled through the rose solely by the weight of the water in the tank. It spreads somewhat as it emerges because of the convexity of the punctured disc, and the small streams become more or less broken up by friction against the air, but with such a means of distributing the fluid one must always spray, in the main, downward. With the force-pumps on the contrary one can turn the spray in any direction, and with the form represented in diagram at A, Fig. 5, the underside of the leaves of many low-growing plants can be sprayed almost as readily as can the upper side.

The nozzles usually sold with knapsack-sprayers are called cyclone nozzles and are so constructed that a small stream of fluid is projected against the inside of a round chamber and emerges through a central opening with a whirling motion that causes it to spread in the air in the

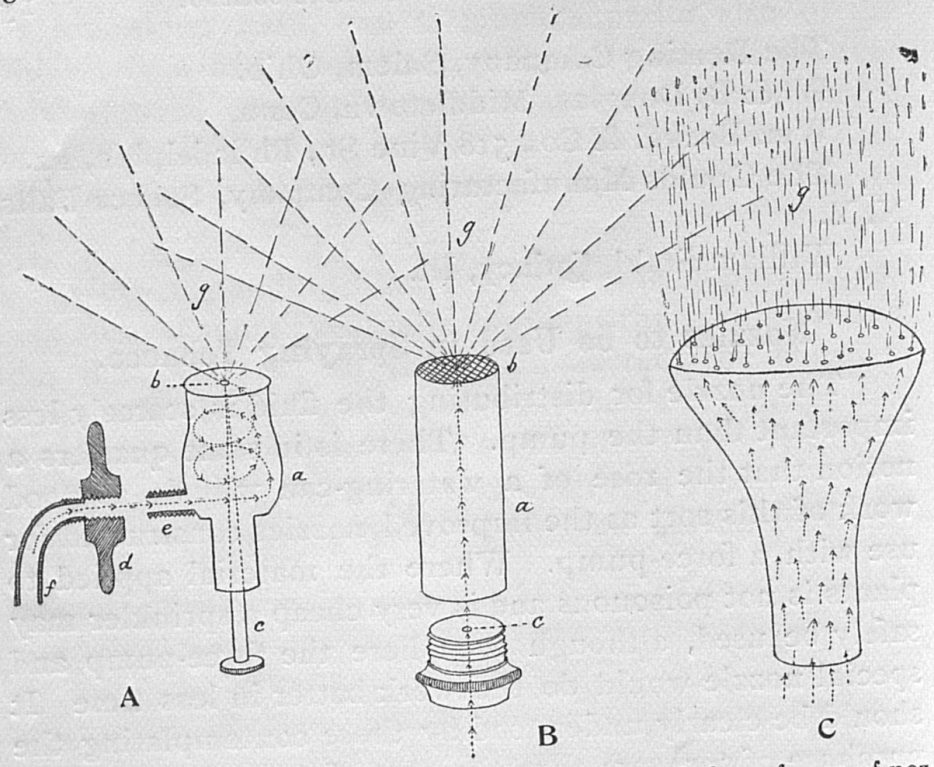

FIG. 5. Diagrams showing the construction of three forms of nozzles.

A. The Vermorel nozzle. *a*, bowl of nozzle; *b*, the single aperture by which the fluid escapes; *c*, a pin which passes through the chamber and serves to dislodge particles that may clog the aperture at *b*; *e*, opening for admission of fluid to bowl; *f*, brass pipe bringing fiuid to nozzle; *d*, a pipe-union with ears, for joining *f* to *e* and also fixing the nozzle at any angle desired. The course of the fluid is shown by the dotted line with arrows; it passes from the pipe *f* through *d* to *e* which latter opens at one side of the bowl, strikes the opposite side of the bowl at *a* and is thus deflected and sent with a rotary motion to the aperture to escape as the spray, *g*.

B. The Nixon nozzle. *a*, the cylindrical chamber or bowl of nozzle; *b*, wire gauze at extremity of chamber; *c*, small opening in a basal piece by which the fluid enters the chamber, following along the dotted line to the gauze *b*, by which it is broken up into the spray *g*.

C. The rose of a watering-can.

form of a fine mist. Such nozzles when well made are excellent for use with tobacco, enabling one as they do to apply a poison very thoroughly and yet economically.

The construction of the Nixon nozzle is shown at B,

Fig. 5. The stream of water is forced by the pump through a small opening at the base of the nozzle and finally strikes a wire gauze at the extremity which breaks it up into spray as it emerges into the air. For ordinary spraying I know of nothing better, but am not aware that this form of nozzle has been constructed for use with the knapsack-sprayers, though doubtless this could be done.

The Time to Spray Tobacco.

As the time of appearance of the first worms varies with the season, it can only be said that the plants should be sprayed as soon as the worms are observed, or just before they appear. Promptness in making this first application is of the greatest importance, and all materials and appliances for the work should be secured some time before they will be needed, so that the pump can be attached to its tank and tested and everything else be in readiness when the proper time comes. The winter months are the best time to arrange these matters.

The worms begin to appear in June. On July 3, 1894, a few nearly grown worms were found on tomato plants, and on the 9th they had gone into the ground for pupation. The adults appear to be somewhat irregular in time of appearance, and probably the process of egg-laying extends over a considerable period of time. Moths are abundant from August 9 to September 2. The worms became most abundant on tobacco in August, but a small brood matured last season in the latter part of July. The second brood were first observed August 9, when the worms were ⅔ inch and less in length. For a season like that of 1894 it would appear, consequently, that spraying should begin about July 4, a second application should be made about the middle of July, and possibly a third about August 1.

The Preparation of the Mixture.

The importance of having a uniform mixture of the Paris green makes it desirable to measure out the poison the night before it is to be used and put it away to soak in a little water. All that is then required when ready to spray is to stir this into water. It is not necessary to use hot water. What is wanted is a mixture, not a solution, and this can be secured with cold water.

The Quantity of Paris Green Required for Tobacco.

Our experiment shows conclusively that the proportion of the arsenites employed (1 pound to 160 gallons of water) will answer the purpose of killing the worms, and

FIG. 6. The Galloway Knapsack Sprayer, made of copper and brass. Capacity, 5 gallons. Price, with Deming Nozzle, or the Bordeaux Combination Nozzle, $15.

will not injure the plants. I judge, however, that growers sometimes use more, and I have learned of some instances in which the poison was used wastefully, not to say recklessly. In this connection the following quotation from a letter received by Dr. A. M. Peter of the Station will explain itself. The writer, a careful and intelligent observer, says:

"The tobacco growers of this county (Shelby) are using Paris green (1 quart Paris green to 1 barrel water) for tobacco-worms. Several have told me that they were using it but claim it will do no harm as they will not use it after the tobacco is topped and the leaf begins to gum. Mr. H. of our county also told me that it was used and secretly at that. What must be done? It may result seriously."

A quart of Paris green to a barrel of water means approximately 3 pounds of the poison to 40 gallons of water, a mixture sufficient, one would think, to kill plants as well as worms, certainly unnecessarily strong. From inquiry among growers I am satisfied that it is not commonly used as strong as this. Very frequently the mixture employed is about that used for orchard spraying, viz. 1 pound of poison to 160–200 gallons of water. In a letter recently received by me from a tobacco grower of extended experience, the writer says: "To those who wish to use poison I would advise the use of (*a*) Paris green, ¼ pound in a 40-gallon barrel of water, with a little whitewash well stirred in. (*b*) That the mixture be kept well stirred in the barrel and sprayer. (*c*) That applications should begin by the 10th of June and be repeated every two weeks to topping, and *that no applications should be made after that time.*"

Another correspondent writing from another part of the State, says: "Paris green has been used by some of the growers of tobacco for a number of years (on the quiet), until within the last two years when it has been used by a majority of growers openly. The use of Paris green upon tobacco for the destruction of worms has been a great saving to the grower in time and labor, and at the same time making a better article of tobacco, the leaves being free from holes. As to the quantity of Paris green used to the acre, this is a very hard question to answer. Where one farmer may use a tablespoonful to

the pail of water, another may not think it enough. There should not be more than two or three applications during the season, the last one some two or three weeks before cutting time."

Another gentleman to whom I applied for information as to the practice among growers of his neighborhood, writes under date Nov. 8, 1894:

"In answer to yours of a few days ago, I would say that the spraying of tobacco with insecticides to destroy the tobacco-worm is in very common use, but not universal; about all tenants that are working on shares use it, but the best raisers of this crop who work their own land abstain as yet from the practice. Still the custom is growing. So far as I can learn the only poison used is Paris green. The quantity of this used at any one application is about the ordinary formula for its use on any other plants. If the worms are not bad for a time they are hand-picked. As soon as they increase the poison is resorted to. It is usually applied by using the knapsack sprinkler, with two nozzles covering two rows at each crossing of the field by each hand at work. Others use hand sprinklers, or common garden sprinklers with very finely punched holes in the nozzle, the pot holding about three gallons of the fluid. The large nozzle enables the hand to cover an entire plant by walking along slowly.

Ordinarily the application of the poison is made only two times, if worms are bad three or more times, the last use of the spray not to be nearer than two weeks to the cutting of the plant. Rain will generally relieve the plants of the visible effects of the spray. Tobacco is not readily affected by this application. It does not readily burn. The cost of production of the crop is somewhat lessened and it has fewer holes in it."

These quotations will serve my purpose of presenting the practice among growers

Dr. Peter's report on the chemical analyses follows:

LEXINGTON, KY, November 8th, 1894.

Prof. H. Garman,

Kentucky Agricultural Experiment Station,

DEAR SIR:

Seven samples of the cured tobacco were taken for analysis from the barn by Prof. Scovell personally. The samples consisted of about 10 leaves, each leaf being taken from a different plant, from about the middle of the stalk. After drying in the laboratory, the samples weighed about 100 grams, or about 3 ozs. each. The whole of each sample was finely ground and 50 grams taken for quantitative determination of arsenic and copper, small amounts of both of which were obtained in every instance. It was found, however, that the chemicals used contained a small amount of arsenic, sufficient to account for that obtained when working on the unsprayed tobacco. As there is not now time to repeat the analysis, it is thought best to make a preliminary report of the results, just as they were obtained, making a correction for the arsenic contained in the reagents, and leave the question of whether there really were traces of arsenic and copper in the unsprayed tobacco for future investigation.

A blank experiment with the reagents used in the analysis gave a quantity of arsenic which, calculated on 50 grams of tobacco taken, would correspond to .0015 per cent. This is a trifle more than was obtained in the case of unsprayed tobacco from plots 1 and 5. No weighable quantity of copper was obtained from the reagents.

As the same quantities of tobacco and of reagents were used in all the tests and all were made in exactly the same way, it is believed that a fair approximation to the amounts of arsenic and copper remaining on the tobacco may be attained by subtracting from the total amounts the largest quantity obtained from any of the unsprayed rows. In the case of the arsenic, this is slightly less than was obtained in the blank experiment but may be considered to represent what could be recovered under the given conditions. The fact that a very much smaller quantity was recovered in the case of the sample from Plot 4, Row 4, is probably to be ascribed to experimental error, which is necessarily large under the conditions obtaining in this work.

It is also to be noted that the London purple used on plot 5 contained no copper.

The following table contains the results obtained, calculated on the tobacco dried at the temperature of the laboratory:

Some other samples have been examined from time to time in this laboratory and the results may be of interest in this connection. The samples are:

No. 2100. Sample of tobacco raised in Shelby County. The crop was said to have been thoroughly treated with Paris green not later than the time of topping. My informant states that the growers of his

TABLE.

Laboratory number	2784	2797	2785	2786	2787	2798	2788	2789
Plot	1	1	2	3	4	4	5	5
Row	1 & 2	4, 5 & 6	1 & 2	1 & 2	1 & 2	4	1 & 2	5, 6 & 7
Per cent. Arsenious oxide obtained	.0022	.0011	.0030	.0048	.0058	.0002	.0036	.0010
Deduct per cent. in Plot 1, rows 4, 5 and 6	.0011	.0011	.0011	.0011	.0011	.0011	.0011	.0011
Leaving per cent. Arsenious oxide from spraying	.0011	None	.0019	.0037	.0047	None.	.0025	None.
Equivalent in grains per pound,	.077	None.	.133	.259	.329	None.	.245	None.
Per cent. cupric oxide obtained	.0016	.0002	.0028	.0040	.0056	.0006	.0013	.0010
Deduct per cent. in plot 5, rows 5, 6 and 7	.0010	.0010	.0010	.0010	.0010	.0010	.0010	.0010
Leaving per cent. cupric oxide from spraying	.0006	None.	.0018	.0030	.0046	None.	.0003	None.
Equivalent in grains per pound	.042	None.	.126	.210	.322	None.	.021	None.
Number of times sprayed	1	None.	2	2	2	None.	2	None.
Arsenite used	Paris Green.	....	Paris Green.	Paris Green.	Paris Green.	....	London Purple.	....

(Shelby) county use 1 quarts of Paris green to a barrel of water and claim that it will do no harm if not used after topping, when the leaf begins to gum.

No. 2117. Tobacco from a crop on which Paris green was used.

No. 2118. Tobacco from a crop on which no Paris green was used.

These two samples were collected by a tobacco buyer who remarks that the tobacco on which Paris green had been used was much better or more free from worm holes than the other. The exact history of these two crops is not known and the statement that no Paris green was used on one of them rests entirely on the testimony of the person who sold the crop and who may not have been correctly informed.

No. 2332. Tobacco grown in Shelby county and thoroughly treated with Paris green as a test. The gentleman who sent in this sample states that it came from two plants that were set apart for experiment and, after the rest of the crop had been sprayed, these two plants received the thick residue from the bottom of the can, thus getting much more Paris green than the rest of the crop.

The following are the results obtained, calculated on the tobacco dried at the temperature of the laboratory:

Laboratory number	2100.	2117.	2118.	2332.
Per cent. of arsenious oxide obtained	.0010	.0158	.0028	.0072
Equivalent in grains per pound..	.07	1.11	.20	.50
Per cent. cupric oxide obtained..	not weighed.	.0058	.0008	.0006
Equivalent in grains per pound..	———	.41	.06	.04

The reagents used in these analyses were found to contain no weighable quantity of either arsenic or copper.

ALFRED M. PETER.

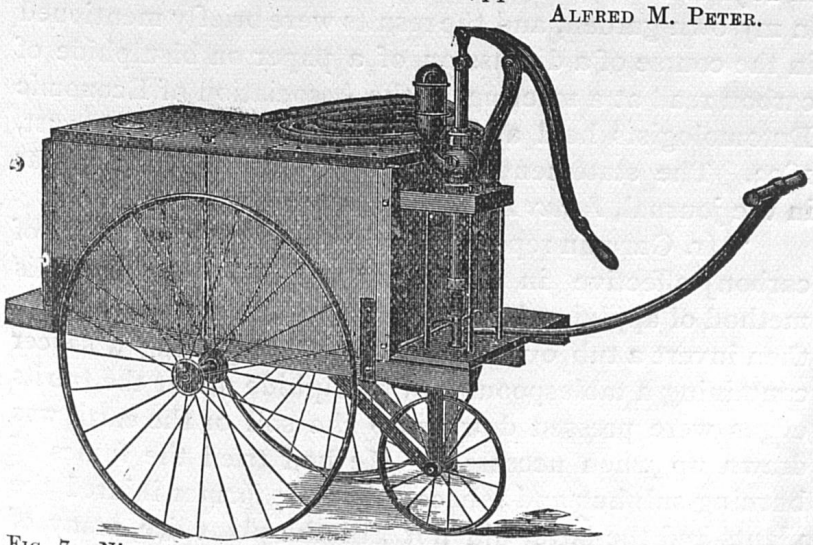

FIG. 7. Nixon's Cart Sprayer (The Little Giant). Price, with sixteen feet of hose and two nozzles, $35. Capacity of tank, 40 gallons.

THE USE OF BISULPHIDE OF CARBON AND HYDROCYANIC ACID GAS FOR THE INSECT ENEMIES OF LOW-GROWING PLANTS.

BY H. GARMAN.

It is often difficult to reach and destroy small insects which prey upon the low-growing plants by the use of sprays or powders, and especially so when the insects feed by puncturing the plants and abstracting the sap, as is the case with aphides and other insects of the same order. These insects cannot be poisoned because they do not eat the leaves, and it often happens that with the best of spraying and dusting apparatus they cannot be cleared from the plants they infest. My attention was especially directed to this difficulty in the course of attempts made in 1892 to exterminate the melon-louse on vines growing in my own garden, and the results were briefly mentioned in the course of a discussion of a paper on bisulphide of carbon read at a meeting of the Association of Economic Entomologists held at Madison, Wisconsin, in August, 1893. The statements made by me at that time appear in the journal, *Insect Life*, and are as follows:

"Mr. Garman reported having found it [bisulphide of carbon] effective in destroying the melon louse. His method of applying it was to roll the vines up in a heap, then invert a tub over them, and after placing a saucer containing a tablespoonful of bisulphide under the tub its edges were pressed down into the soil or the earth was drawn up when necessary. He had tried the fumes of burning sulphur and tobacco, but the former injured the plants and the latter did not kill the plant lice, many of

them gradually recovering after being stupefied by it."

The matter is referred to again in the Annual Report of this Station for 1893 (published in the spring of 1894) in the following words:

"The melon-aphis is a small dark green insect like the rose-aphis of hot houses. It is extremely abundant here, and collects in large colonies on the under side of melon leaves, causing them to curl up in such manner that the insects cannot be reached by employing the usual sprays. The knapsack-sprayer made by Wm. Boekel & Co., of Washington, was used first, the under-sprayer being attached with the idea that the under sides of the leaves could be reached with its help. But it was found to be impracticable, because of the time required in passing along each vine and spraying every leaf. Tobacco smoke was next tried, the melon vines being rolled up and covered with a wooden box, or tub, then puffing the smoke under the edge with a bee-smoker. By this treatment the aphides were stupefied for a time, but if watched afterward for several hours were found to recover. Bisulphide of carbon was next employed, a tub being inverted over the vines and a saucer containing a tablespoonful of the bisulphide being placed under its edge. The fumes of this substance were found to kill the aphides completely, and if not applied too long will do no injury to the vines. Since the aphides usually appear on one or two vines in a field and spread from these as a center, it should be possible by means of the bisulphide to check the injury of the pest."

While engaged in this work several insecticides, not mentioned above, were tried without obtaining results of value excepting in so far as they were demonstrated to be ineffective for the destruction of this insect. Pyrethrum was applied by dusting, by spraying, and by burning, without success, owing to difficulties of a practical sort. Kerosene emulsion was also used. The chief difficulty

with these preparations was to reach and destroy all the lice. This defect will be better understood when I say that the under side of a single leaf often bears enough lice to stock and destroy all the plants of a garden. If a single leaf therefore, of all those infested, is not thoroughly sprayed, though most of the aphides may be destroyed, the mischief will will soon recommence. The fumes of the bisulphide properly employed can be made to destroy everything on the vines except mites. These small creatures are wonderfully tenacious of life, and I have found that to kill them with bisulphide of carbon requires an exposure so prolonged as to destroy the plants on which they live*.

Since my test of bisulphide of carbon was made I have experimented with hydrocyanic acid gas, which proves in some respects even better than the bisulphide for destroying the melon-louse. The experiments were suggested of course by the practice of western fruit growers, and the gas was applied by covering the plants with a small cloth tent and generating the gas under it. The tent made by me is about three feet in diameter across the bottom and when distended will measure about three feet in height at the center. The top is rounded so that it would enclose just about half of a sphere. It is made of stout cotton twill and was given a coat of unboiled linseed oil containing "Japan," to make it gas tight. It can be supported over the plants undergoing treatment by means of stakes driven into the ground, or a moveable frame can be constructed to support it.

*In the course of some recent experiments in this direction the bisulphide was found to be of no value for the red spider on house plants, a conclusion at which I arrived after fumigating a valuable plant until most of its leaves dropped off, but it was discovered that this pest could be very quickly destroyed by inverting an infested plant under a water tap and wetting it thoroughly, then while still inverted dusting the under sides of the leaves, and afterward the upper sides, with pyrethrum.

My procedure for melons is as follows: After placing the tent over the vines, secure its lower edges by placing on them short pieces of heavy wood, leaving however one portion unfastened. Now place a saucer under the tent passing it beneath the still unsecured part of the lower edge, and pour into it 9 cubic centimeters of water and to this add 3 cubic centimeters of commercial sulphuric acid. Finally add quickly 3 grams of cyanide of potassium and close the tent. There will follow a sudden liberation of gas, filling the tent, and destroying every living insect in it (excepting mites). The length of time required to accomplish this varies of course with the size of the tent and the quantities of materials used. For a tent of the size described, and using the above quantities of materials, 4 minutes will suffice. Three minutes will answer if the lower edges of the tent are completely sealed. In my tests a few aphides were found to have recovered at the end of twelve hours, after an exposure of two minutes. With an exposure of one minute the lice appeared dead when the tent was removed, but a good many eventually revived.

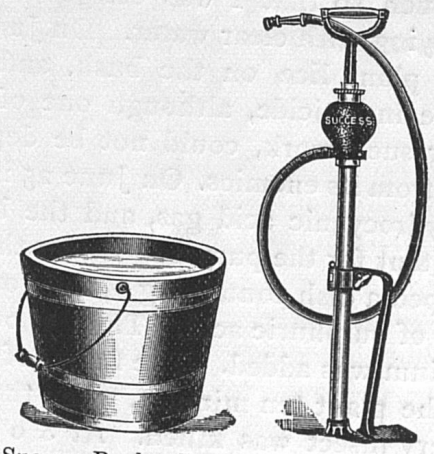

FIG. 8. The Success Bucket Pump, made of brass. Price, $6.00.

As illustrating the usefulness of this gas for destroying aphides on other plants I will give here the results of some experiments on the rose-aphis. This insect appeared in large numbers on the terminal parts of a thrifty young bush in my yard last spring and stopped its growth. The seriousness of the attack was not at first realized, and without intending to make it an object of further experiment the plant was sprinkled with a watering-can and then dusted thoroughly with pyrethrum. This destroyed a good many of the lice, but left others concealed under the leaves and elsewhere, and the injury was soon under way again. On June 20 this bush was sprayed with the preparation known as antinonnin, 1 gram to each quart of water. One gallon was applied in the evening. On June 21 the plant lice were greatly reduced in numbers, but a good many still occurred on the under sides of the leaves, though special pains was taken to reach this surface. The application was made with a very useful little bucket-pump (the "Success") made by the Deming Company, of Salem, Ohio. The antinonnin remained upon the leaves and proved very injurious to the younger terminal growth, so much so that I was obliged to wash it off again by spraying with clear water. On June 22 I noted a good many plant lice on the bush, and it was evident that the insecticide, although one of the best I have used for such work, could not be depended on to free the bush from its enemies. On June 25 it was decided to use the hydrocyanic acid gas, and the bush was enclosed in the tent for the purpose. Under the edge of the tent was slipped a dish containing ¾ fluid ounce of water and ¼ ounce of sulphuric acid. Then ¼ ounce of cyanide of potassium was added. The fumes of the gas were kept about the plant ten minutes, when the tent was removed. Every insect was killed. At 8 o'clock the following morning the tender growth of leaves and twigs

were found to have been badly injured by the gas. No living aphides could be found, but the twigs and leaves were studded with their dead bodies.

In the above experiment the quantity of material used was too large and the exposure too long. Four minutes would have been ample time to kill the aphides. Notwithstanding the injury to the twigs the bush quickly recovered and subsequently made a fine growth, whereas it had previously ceased to grow, and would probably not have increased in size at all if the aphides had been allowed to remain.

I believe from my experience with it that this gas treatment will yet commend itself to gardeners as a means of checking the spread of injurious insects from infested centers. It is certainly the quickest and most effective method known to me of exterminating the insects infesting single plants.

Both bisulphide of carbon and hydrocyanic acid gas are injurious to man, and in using either one must be very careful not to inhale the fumes. The fumes of both escape quickly, hence it is necessary to shut the tent or box promptly after introducing the substances producing the gases. The bisulphide, it must be remembered also, is inflammable.

The bisulphide of carbon is slower in accomplishing the destruction of insects than the other, and must be watched to make sure that treated insects do not escape after being simply stupefied. Under a tub of medium size a tablespoonful should be allowed to act for an hour and a half. Two tablespoonfuls may be made to do the work quicker, but this quantity can be left, as I determined in 1892, about enclosed vines for an hour and a half, without doing the plants any injury.

Bisulphide of carbon is commonly bought in pound bottles and costs about 22 cents for this quantity. Larger quantities may be bought for less. Cyanide of potassium costs about 45 cents per pound. The sulphuric acid should not cost more than 5 cents per pound, and in large quantities may be bought for as little as 2 cents per pound.