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South Africa Horticultural Board

GAS TREATMENT FOR SCALE INSECTS.

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TREATING OF THE OPERATIONS OF THE HORTICULTURAL BOARD'S FUMIGATING OUTFIT, THE APPLICABILITY OF THE FUMIGATION PROCESS IN CAPE COLONY, AND EMBODYING A FULL DESCRIPTION OF THE EQUIPMENT NECESSARY FOR FUMIGATION WITH HYDROCYANIC ACID GAS.

Report to the Horticultural Board by the
Government Entomologist.

JUNE, 1897.

PRINTED FOR THE BOARD OF HORTICULTURE

BY

TOWNSHEND, TAYLOR & SNASHALL, CAPE TOWN.

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WASHINGTON

REPORT OF THE COMMISSIONER OF THE BUREAU OF ENTOMOLOGY
AND PLANT INDUSTRY FOR THE YEAR 1904

Report to the Department of Agriculture
Government Entomologist

JUNE 1905

PRINTED FOR THE BOARD OF ENTOMOLOGY

WILLIAM J. WILSON, CARPENTER

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HON. JOHN X. MERRIMAN,
Chairman of Horticultural Board.

SIR,

In compliance with the request of the Horticultural Board, I herewith submit a report dealing with the operations of the Board's fumigation outfit, and giving detailed information in regard to this most effectual remedy for the Red Scale and other scale insects affecting citrus trees.

Respectfully submitted,

CHAS. P. LOUNSBURY,
Government Entomologist.

Cape Town,
June, 1897.

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GAS TREATMENT FOR SCALE INSECTS.

INTRODUCTORY.

To the researches of American investigators and the experiences of her fruit growers is due the credit for great improvements in insecticidal washes now used in many different parts of the world; and to the same source we owe the introduction of hydrocyanic acid gas for the destruction of scale insects in the orchard. The expediency of a gas as an insecticide for scale insects on citrus and other evergreen trees arises from the practical impossibility of reaching all the insects with a liquid on any but small trees; invariably, some escape destruction on large trees and these become the nuclei of new colonies of the insects, which soon become as great a pest as before.

The destruction of insects by fumigation with poisonous gases or vapours has long been carried on in greenhouses; but that the process could be economically practised in orchards remained to be demonstrated in California little more than a decade ago. In the first report of the Board of State Horticultural Commissioners of California, published in 1882, unsuccessful experiments with steam to destroy scale insects on tent-covered trees without injury to the foliage are recorded by Commissioner S. F. Chapin. A few years later, Alexander Crow, the present entomologist of the California State Board of Horticulture, and Mr. J. W. Wolfskill carried on many experiments with a number of different gases. The work of these gentlemen impressed D. W. Coquillett, then a special agent of the Division of Entomology of the United States Department of Agriculture, and the three united their efforts. Mr. Coquillett soon discovered the value of hydrocyanic acid gas for the purpose. This happened in the latter part of the year 1886. In a short time, fruit growers began to avail themselves of the discovery; at first slowly, and then more rapidly as improved methods of applying the gas were devised until the "fumigation process" superseded to a very great extent the use of washes on citrus trees in California.

WORK OF HORTICULTURAL BOARD.

Need of Remedy for Red Scale.—Our colonial citrus orchards have long been afflicted with the Red Scale. By applications of washes, frequently and thoroughly, some of the most enlightened growers have managed to clean small trees and to keep the scales well in check on large ones ; but the expense and trouble for these results have been too great to induce the mass of growers to spray.

RED SCALE, *Aspidiotus aurantii* Mask. 1, infested leaves ; 1a, male ; 1b, female scale ; 1c, male scale ; 1 is natural size and the others are much enlarged. (From U.S.A. Dept. Agr.)

The Red Scale is by far the most injurious scale insect affecting citrus trees in this colony and in most other countries.

Orchards have fallen into neglect, and consequently, with the increasing demand, oranges and lemons have become scarce and high-priced.

Resolution of the Board.—The Horticultural Board realized the necessities of the case and determined to do its utmost to popularize remedies. A resolution was passed during March of last year to utilize certain funds placed at its disposal by Parliament in providing a demonstration on a large scale which would prove the value

and economy of remedial measures against this insect. Fumigation was finally chosen as the chief means, for while perfectly aware that this treatment could not be universally adopted by private parties owing to the initial expenses, it was also recognised that it had proven best in California, and that if it was popularized in the colony, co-operation among growers or private enterprise could bring it within the means of a large proportion of the growers.

Previous Use of Fumigation in Cape Colony.—The first use of hydrocyanic acid gas to substitute spraying in Cape Colony was, it is believed, by Mr. P. J. Cillie, C'son, of Wellington, who as a Government delegate had been to California during 1893 to acquire general horticultural information for the benefit of colonial fruit growers. Mr. Cillie had a few tents prepared shortly after his return and fully corroborated the Californian experience that fumigation with the gas was far more efficacious than spraying with the very best of washes by cleaning a number of citrus trees in different parts of Wellington. At about the same time that Mr. Cillie was working with the process, another enterprising fruit grower, Mr. Henry Meyers, of Newlands in the Cape Division, undertook to fumigate his orchard. But altogether these attempts to make fumigation a factor in the colonial fruit industry threatened to come to naught through the many obstacles which the introduction of new means and appliances meets in colonies; the principal one of which is, perhaps, the great difficulty of obtaining small quantities of the necessary materials at prices which leave any margin of profit before a steady demand, with consequent lowering of the cost of importation, has been created.

Preparations for the Work.—The real need, then, was to encourage and popularize this remedial measure, thus creating a demand for the treatment which would bring the expense within the limits of economy; or, what really amounts to the same thing, to prove by an object lesson that with proper management the expense is not prohibitive. In July, the Government Entomologist, whose services are available to the Board through the courtesy of the Department of Agriculture, was instructed to have an outfit prepared and to proceed to fumigate the citrus orchards in Wellington. Cyanide for the work was at once ordered from the German manufacturers, who furnish much of that used in California; and the actual work of fumigation was in progress by the 1st of September.

The Wellington members of the Board, Mr. P. J. Cillie and Mr. J. F. Pentz, worked in conjunction with the Entomologist in the initial arrangements, and the latter member rendered still more valuable service by keeping a general oversight of the work while the outfit remained in Wellington. The direct superintendence of the work was entrusted to Mr. P. J. Pentz, also of Wellington. Three coloured labourers completed the staff. The Entomologist planned the

work, purchased the supplies, and, in short, supervised the whole work, visiting the scene of operations on an average of once a fortnight.

Review of Operations.—The outfit was kept in Wellington during the months of September, October and November, during which time about 2,000 trees were fumigated on 23 farms. The great majority of the trees were in wretched condition; they were of all sizes, two of the same height standing side by side being the exception, not the rule. Arrangement in orchard form was generally absent, and on most of the farms vines were grown among the trees. These factors greatly impeded the work, and in connection with the numerous delays caused by unfavourable weather (rain, wind and heavy dews) explain the slowness of the work.

The neglected state of the Wellington trees must not be taken to reflect upon Wellington farming; it is simply the natural sequence of the trees ceasing to be profitable, which in turn is brought about through the ravages of scale insects. Most of the trees had once stood in rows and in a way still stand in them, but great gaps and uneven growth disguise the arrangement.

In early December, the outfit was taken to the Paarl to enable the fruit growers there to become acquainted with the process. About 400 trees were treated on three farms in the Groot Drakenstein ward. For the benefit of the Stellenbosch parties who were interested, the outfit was then taken to Ban Hoek in that division. Here 500 trees were fumigated on one farm. It then became necessary to postpone further work until the arrival of supplies of cyanide. Work was resumed at the time of the Western Province Agricultural Show at Rosebank (February 25th and 26th), when demonstrations were held in a garden close by the Show Grounds for the benefit of those attending the show. The Constantia Fruit Growers were then invited to witness the operations in orchards at Newlands where about 200 trees were treated.

No single estate in the colony, probably, is more visited by farmers than Lourensford at Somerset West. Here were large orchards where the outfit could be worked to good advantage and where numerous visitors would see the results of the work. The outfit was taken to this place during the first week of March, and despite of almost incessant high winds and several rain storms 1,600 trees were fumigated during the following month. At the urgent request of the owners, the outfit was then taken to farms in Ban Hoek, and 1,015 trees on four farms were treated at figures estimated to cover the cost of the work. Worcester was then visited, and the fruit growers of that vicinity invited to witness the treatment of trees at Glen Heatlie. Goudini was next visited, and about 200 trees fumigated on a farm belonging to the Field-cornet. Lastly, 225 trees were treated on one farm at Riebeck West in the Malmesbury Division.

In all above 6,000 trees have been fumigated. These are distributed among five divisions and one or another is within easy access of

most Western Province orange growers. These people therefore have only themselves to blame if they do not learn by actual observation the magnificent results achieved by the fumigation process.

Charges for Treatment.—At Wellington, a nominal charge of 3d. for each tree fumigated was made; and, as elsewhere, the beneficiaries were required to attend to the conveyance of the outfit from one farm to another. It was deemed advisable to

BROWN OR SOFT SCALE, *Lecanium hesperidum* Linn. An infested twig.
(From U.S.A. Dept. Agr.)

The Brown Scale is found in most parts of the colony and in some districts is very injurious to citrus trees.

make only this small charge at first in order to be certain of securing work, and it was presumed that as the charge was merely nominal, the profiting farmers would facilitate the work by being accommodating in the matter of conveyance. But this presumption proved quite erroneous. The treatment which the agents of the Board received at the hands of many (not all) of the Wellington farmers whose trees were fumigated was anything but liberal, and seemed prompted by the contemptible spirit that the Government is a lawful prey to be bled whenever opportunity arises.

The charges for the work since leaving Wellington have been made with a view to cover the actual costs, disregarding wear and tear to the outfit and the time lost in moving about. These charges in general have been 6d. for trees under eight feet in height, and 1s. for those above. The increased charges were necessary to keep up the work, as the funds were nearing exhaustion, but they appear to have proved an advantage in other respects. The work has been more appreciated, and every assistance given to facilitate it, no trouble at all being made about the conveyance of the equipment, however great the distance.

The movements of the outfit have been advertised from time to time in the newspapers, and the public have been invited to be present at stated times in the different towns when full explanations of the process have been given by the foreman.

Object of this Report.—This report is written at the request of the Board to supplement the field work by giving full particulars of the process and of the equipment; and to point the way for others to take up the work where the Board leaves it.

The object-lesson of the efficacy of fumigation is now before the public. An inspection of the trees shows them to have improved wonderfully since the treatment, and farmers are enthusiastic over the results. The Board's field work is finished. There are many disadvantages in carrying on a work of this kind through the Government or body like the Horticultural Board, and now that several thousand trees have been successfully treated, there is no longer any reason for the Board to continue the work. Not every day is suitable for fumigating trees, but as the foreman and his men were working away from home, they had to be paid for days when no work was done equally with those when they were employed. This loss of time greatly augmented the expense, but is a factor which would be largely obviated if the work was done by the farmers themselves, or by a local party with other employment for himself and men when fumigation could not be carried on to advantage.

Acknowledgments.—As stated in the introductory paragraph, we are following Californian precedents. The outfit employed by the Board was modelled after those employed by the Los Angeles County Horticultural Commission as described in Californian publications; other details were furnished by Horticultural Commissioner John Scott, of the same county, in correspondence with the Entomologist. The full-page illustrations were purchased from the Californian State Board of Horticulture; they were engraved from photographs of the Los Angeles County Horticultural Commission's outfit. The illustrations of the red and other scale insects were obtained from the United States Department of Agriculture, through the kindness of Dr. L. O. Howard, the Entomologist of the Department.

THE OUTFIT.

The fumigation outfit of the Horticultural Board consists of tents, poles and other paraphernalia, as hereunder described.

The Tents.—These are 22 in number, and are used for covering trees under 12 feet in height. They are made dome-shaped, the upper portion being curved like the surface of a hemisphere and the lower portion being of uniform character. What is known as "eight-ounce Burlington duck" was most largely used in making the tents; but two other makes of American ducks, "Greenwoods" and "Savannah," were also employed. These cloths come in various widths, but it was found most economical to use the narrowest width, that of 27 inches.

When this width of cloth is used, the proper curve of the tent may be obtained by cutting the cloth on the line of an arc drawn

The space within the outside lines represents the end of breadth before cutting that within the curved lines, the same after cutting. *m* marks the middle of the end, *c*, the point in the side, *l*, the straight connecting line and *h*, the $3\frac{1}{2}$ inch line.

from the middle of the end of the breadth to the point on either side distant one-fourth of the circumference of the completed tent, and passing through a third point $3\frac{1}{2}$ inches out from the straight line connecting the first points. The accompanying sketch will serve to make the meaning clearer. Board models of the required length, $3\frac{1}{2}$ inches at the middle and curving gradually to the ends, were found to be a great convenience in delineating the curves.

The crowns of the tent are reinforced both inside and out with extra pieces of cloth, and rope loops are attached to the crowns both inside and out for convenience in handling the tents.

The tents in use are of four sizes:—I., eight made of six breadths, $2\frac{1}{4}$ yards in length; II., eight of 9 breadths, 3 yards in length; III., three of 11 breadths, 4 yards in length; and IV., three of 13

breadths, $5\frac{1}{2}$ yards in length. The breadths in all cases are 27 inches in width.

A circle of gas-pipe is used to keep the mouth of each tent expanded. The circle is made in halves; the ends are joined by short pieces of larger pipe into which they slip and are held in place by loosely-fitting bolts passing through holes drilled through both the end of the circle and the short connecting piece. Before the ends are connected the halves are attached to the tent by passing them through iron rings sewn to the tent about one foot from the bottom. These rings fit loosely. On all but the smallest tents, one is attached at each seam; the smallest tents have three to each two breadths. It would have been better to have used three to each two breadths on all the tents; the cloth should be reinforced where they are attached.

A stout pole ending in a U-shaped iron rest is used to support the crowns of the larger tents in placing them over and in removing them from the trees; the rest is hooked in the rope loops.

The Sheets.—The sheets are made in the form of a regular octagon. They are six in number, and vary from 32 to 48 feet across. Widths of cloth from 27 inches to 10 feet were used in the construction of different sheets, but it was found most economical to use the narrowest width, the additional expense for sewing being less than the relatively greater value of the cloth. Ten-ounce duck was used for the middle breadths of equal length, and eight-ounce duck for the breadths outside of these. It is not believed that the heavier cloth added sufficient to the strength to make its use desirable, and if other sheets were now to be made, eight-ounce duck throughout would be employed.

In cutting the cloth to secure the octagonal shape, little trouble will be experienced if it is remembered that one side of a regular octagon is equal to about five-twelfths of the total length, and that each breadth will be its own width shorter outside than the breadth next to it toward the middle. For instance, in an octagonal sheet 54 feet across made from cloth 27 inches wide, the ten middle breadths are the full length of 54 feet, the next breadth on each side is 54 feet on the inside and twice its own width or $4\frac{1}{2}$ feet less than 54 feet on the outside. By cutting the breadth for the two sides alternately there will be only one mitre of cloth wasted.

Both sheets and tents were sewed by machine with heavy linen thread (principally Barber's No. 35). The seams in the tents were run down once only, while those in the sheets were turned over and sewed a second time, as the strain on the cloth is much greater in the sheets than in the tents.

Oiling of the Cloth.—To make the tents and sheets impervious to the gas, the cloth after being made up was brushed with a mixture of four parts of boiled linseed oil to one part of turpentine.

The cloth was first well wetted with water, and then the mixture was spread lightly over the surface with a flat brush. A thin coating was found to be sufficient. The turpentine causes the oil to dry more rapidly than it would otherwise do. One gallon of the mixture was used to cover about 25 running yards of the cloth. After being oiled, the tents were hung from trees and the sheets spread out on the ground and left until they were dry. Failure to thoroughly dry the cloth before rolling it up may prove its destruction, as it is liable to take fire by spontaneous combustion.

In California, an extract of the juice of a species of prickly pear (*Opuntia engelmani*), to which is added a little sizing and yellow

OLEANDER SCALE, *Aspidiotus nerii* Bouché. 1, infested Acacia twig; 1a, male; 1b, male scale; 1c, female scale; 1 is natural size and the others are much enlarged. (From U.S.A. Dept. Agr.)

The Oleander Scale is common in the colony but not common on citrus trees; it is, however, very injurious to citrus trees in an orchard at Hex River and is very common on European fruit.

ochre, is used to substitute oil for coating the cloth. This preparation has the advantage of leaving the cloth much lighter and more pliable than oil, besides being much less expensive. Thus treated, sheets up to 60 feet across are manageable, while oiled sheets of this size would be too great a strain on the poles commonly used. Many attempts were made to utilize the extract of our prickly pear (*Opuntia tuna*) for the purpose, but all ended in total failure; the cloth was as pervious after the treatment as before. Another Californian practice is to sew a "skirt" of lighter material than

duck, usually "drill," around the sheets, thus securing greater dimensions with little extra weight.

Uprights for Raising the Sheets.—These take the place of derricks and other cumbersome appliances used by the first fumigators. Two are used, one at each side of the tree. Those employed in the Board's outfit are made of straight-grained, knotless pitch pine deal. This wood was the most suitable of any obtainable in Cape Town. The principal piece of each is a pole, 2 x 4 inches in section and 25 feet in length. Cross pieces, 1 x 3 in section and 6 feet long are bolted to each side at the bottom; and braces of 2 x 4 inches, 5 feet long, also bolted in place, extend from between the ends of the cross pieces to the upright piece. A guy rope, $\frac{3}{4}$ inch in diameter and 35 feet long, is attached to the top of each upright. A rope of $\frac{1}{2}$ inch diameter and 75 feet long answers for tackle; this is passed through a fixed pulley at the top of the pole and then through a movable pulley, and thence back to the top of the pole. The movable pulleys are in view in the illustration. The sheet is gathered four or five feet from the margin and a hitch made about the gather with a short piece of rope, which, when all is ready for raising the sheet, is attached to the movable pulley. This arrangement is superior to hitching the pulley-hook to a ring or loop sewed to the sheet, as the resulting strain when the sheet is raised is far less on the cloth.

To use the uprights, one is laid at either side and the sheet dropped behind the tree; the hitch is then made and the tackle attached. The four men then raise the poles, and when these are vertical, two of the operators steady them by means of the guy ropes, while the other two raise the sheet by pulling on the tackle. When raised sufficiently (see the illustration), the poles are allowed to drop slowly forward, thus bringing the sheet over the tree and in position.

Other Necessaries.—The generating vessels are of lead, this metal being chosen because of its durability and resistance to the chemicals employed in the generation of the gas. The vessels are bowl-shaped and vary from 4 inches in diameter by 2 inches in depth to 8 inches in diameter by 6 inches in depth. Small, heavy, porcelain dishes are used when the quantities of the chemicals are very slight. Porcelain or enamel-ware dishes will answer as substitutes for lead for all sizes of trees but are less economical when much work is to be done because of their less durability.

Carefully balanced scales are used for the weighing of the cyanide; the brass pans of these are protected by enamel-ware plates. Measure glasses graded for fluid ounces are used for measuring the water and acid required to liberate the gas.

A tent for sheltering the supplies of chemicals, a chest in which sundries are locked, half a dozen lanterns, lantern rests, spades, buckets, heavy bottles for temporarily holding small quantities of the acid, and air-tight tins for similar use with the cyanide, complete the equipment.

Tents for Covering Citrus Trees Preparatory to Fumigating.

Sheet for Covering Citrus Trees Preparatory to Fumigating.

DETAILS OF TREATMENT.

Generation of the Gas.—Hydrocyanic acid gas is generated by the action of sulphuric acid on potassium cyanide in the presence of water. The required quantities of the cyanide and water are first placed in the generating vessel, the cyanide being then covered with the tent or sheet and the vessel slipped under almost to the base of the tree; reaching in, the operator then adds the acid, pouring it slowly into the vessel so as to avoid its splashing and thus burning his hand or the cloth. He immediately withdraws and the men shovel a little soil on the edges of the cloth all around to more thoroughly prevent the escape of the gas.

The rapidity of the evolution of the gas depends largely upon the size of the pieces of cyanide. If these are like powder, the reaction is violent and immediate; but if in lumps, the reaction takes place more slowly and continues for a minute or longer. The slow reaction is desired, partly because less injury results to the foliage immediately above the vessel. But the lumps must not be too large, for then the reaction is liable to be imperfect owing to a black coating (carbon?) forming over the lumps and preventing further decomposition by the acid. The water should not be added too soon or part of the cyanide becomes dissolved and gives a violent reaction. The residue which remains in the dishes is buried; and the dishes are washed in clean water before being again used.

The weighing of a large number of doses at one time and keeping them in envelopes or boxes until used was attempted but found to be disadvantageous owing to the affinity of the cyanide for water.

Time Necessary for Treatment.—The cover is left over the tree for thirty minutes in the case of small trees and forty-five in the case of those over twelve feet in height. At the expiration of this period the generating vessel is removed and the residue buried in the soil; the dish is then washed out preparatory to treating another tree.

A number of trees are fumigated together, the endeavour being to treat as many at a time as can be covered and uncovered during the period of exposure. In this way the men are kept continuously busy, the time for the removal of the first tent arriving by the time that the last tree is covered. The largest number of trees fumigated during one night has been 190. The average number has been only a small fraction of this number owing to the delays caused by high winds and rains, and in the conveyance of the outfit from farm to farm and town to town. On several occasions, inclement weather prohibited the work four nights in the week, and at one time there were but two really favourable nights for a period of three weeks.

Absence of Sunlight Necessary.—The originators of the fumigation process observed that the gas was most efficacious and that

less injury resulted to the foliage when the operations were performed at night than when they were carried on in sun-light. It is said that chemical changes are produced in the gas by the action of sun-light and that the resulting gases are more injurious to the plant life and less to animal than hydrocyanic acid gas. Whether or not these theories are correct is of small practical importance, for the foliage of a tree will suffer serious injury if the tree is left covered with an airtight oiled tent for half an hour in sun-light, without the gas being present. Having ascertained this fact, by experience, the foreman in charge of the Board's outfit refrained from covering trees until the sun had sunk from sight on any but cool, dull days. The great majority of the trees treated have been fumigated after sunset. The ideal night for fumigating is quiet, cool, and moon-light, and without dew.

Season for Fumigating.—The operations may be successfully conducted against the Red and Brown Scales at any season of the year. The chances for thoroughly effectual work are best, perhaps, during the latter part of February and March, when young insects are most abundant. The operations of the Board began late in August and have continued through to June without intermission save for the first six weeks of the year, when work was suspended owing to the non-arrival of supplies of cyanide, and during this period the treatment has been uniformly successful.

Injuries to the Tree.—Injury to the tips of new growth generally results. This injury is in no wise serious and is quickly outgrown. The operators consider it a favourable indication, as when such injury results it is quite certain that the gas has been present in sufficient strength to destroy all of the insects. When no "burning" results, there is always the suspicion that not enough cyanide was used.

The blossoms appear to be less affected than the foliage and very little damage is caused to them. The fruit, likewise, is not sensitive but a little generally drops after a few days; this dropping may be due, in part at least, to mechanical injury in raising and lowering the cloth.

If a heavy overdose is administered, all of the foliage and fruit may fall and the young wood die back. Very small trees are most likely to receive an overdose; and unless trees under four feet in height by three in diameter are badly infested with scale insects, it is best not to risk injuring them. Any excess given to a tree of even this size will cause as much damage as seven times the same excess given to a tree of double the dimensions. These remarks apply only when the trees are treated singly, not when a number are treated under the one tent, as can be safely done in nursery rows. If many small trees are to be treated, a frame to keep the tent expanded to encompass a space for which a dose can be safely administered, had best be used.

Lemon and citron trees are more sensitive than orange and greater care must be taken not to overdose them. Decreasing the amount of cyanide by ten per cent. when lemon trees are treated is recommended in California.

Efficacy of the Gas—Applied sufficiently strong and under a tight tent, every living scale insect appears to be destroyed. These perfect results are not always obtained in practice despite of care in keeping the outfit in good order; but living scales have been found on few of the trees fumigated a few weeks after the treatment. A

BLACK SCALE, *Lecanium oleæ* Bern. 1, an infested twig; 1a, an enlarged scale. (From U.S.A. Dept. Agr.)

The Black Scale has seldom been seen on citrus trees in this country but is very injurious to these trees in California.

number of trees suffering from Purple Scale have been fumigated, and the eggs as well as the insects themselves have succumbed. This success was unlooked for and may not always follow; it may also be that some of the eggs escaped although those under several hundred scales examined were all destroyed.

Experiments conducted in the fumigation chamber owned by the Department of Agriculture and situated near the gates to the Cape Town Docks have demonstrated that when the gas is used somewhat stronger than is the practice in orchards, every scale insect and scale insect egg is destroyed. The Australian Bug was among the insects

enclosed in the chamber, and not a single egg hatched among tens of thousands exposed.

Notwithstanding the efficacy of the gas, however, it is quite an impossible task to exterminate the Red Scale where it has long been established, for not only does the scale infest citrus trees but other orchard trees and many garden plants and even some ornamental trees like the Seringa (*Melia azedarach*), Keurboom, Willow, and Cypress. It usually occurs in the greatest abundance on the citrus trees and it is generally from them that the other plants become infested; but when the citrus trees are cleaned, it is but reasonable to suppose that the insect will in time find its way to them from these other trees. Rose bushes are very frequently infested, and as these plants are to be found on almost every farm, the infection is very likely to spread from them to the citrus trees. It may be one year or two years or even longer before the citrus trees become noticeably affected, but sooner or later, the insect is quite sure to get to them and to again require attention.

The tents and sheets should be examined each day, when all rents and holes should be covered by patches. A small piece of cloth about holes caused by the acid should be cut away or the acid will continue to destroy the fibre. The fumigation of trees covered by cloth containing holes is very apt to be a complete failure.

Quantities of Chemicals.—The following table gives the quantities of the chemicals used for various sizes of trees by the fumigators for the Horticultural Board.

Height.	Diameter.	Water.	Acid.	Cyanide.	Space enclosed.
Feet.	Feet.	Fluid oz.	Fluid oz.	Oz.	Cubic Feet.
4	3	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{8}$	(25).
6	4	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{4}$	(65).
8	5	1	$\frac{1}{2}$	$\frac{1}{2}$	(140).
8	6	$1\frac{1}{2}$	$\frac{3}{4}$	$\frac{3}{4}$	(200).
10	6	2	1	1	(255).
10	8	3	$1\frac{1}{2}$	$1\frac{1}{2}$	(435).
12	8	$3\frac{1}{2}$	$1\frac{3}{4}$	$1\frac{3}{4}$	(535).
12	10	$5\frac{1}{2}$	$2\frac{3}{4}$	$2\frac{3}{4}$	(815).
14	8	$4\frac{1}{2}$	$2\frac{1}{4}$	$2\frac{1}{4}$	(635).
14	10	$6\frac{1}{2}$	$3\frac{1}{4}$	$3\frac{1}{4}$	(970).
14	12	9	$4\frac{1}{2}$	$4\frac{1}{2}$	(1,355).
16	10	$7\frac{1}{2}$	$3\frac{3}{4}$	$3\frac{3}{4}$	(1,130).
16	12	$10\frac{1}{2}$	$5\frac{1}{4}$	$5\frac{1}{4}$	(1,585).
16	14	14	7	7	(2,105).
18	12	12	6	6	(1,810).
18	14	16	8	8	(2,415).

Height.	Diameter	Water.	Acid.	Cyanide.	Space enclosed.
Feet.	Feet.	Fluid oz.	Fluid oz.	Oz.	Cubic Feet.
18	16	20	10	10	(3,085).
20	14	18	9	9	(2,720).
20	16	23	11½	11½	(3,485).
20	18	29	14½	14½	(4,325).
22	18	32	16	16	(4,835).
22	20	39	19½	19½	(5,865).
24	20	43	21½	21½	(6,500).

The cyanide used is between 98 and 100 per cent. pure, and the sulphuric acid is 94 per cent. pure. This grade of acid is the ordinary, commercial article; the specific gravity is 1.84. Only these grades of chemicals should be used with this table. The cyanide is weighed in avoirdupois ounces, and the water and acid measured in fluid ounces.

The table is based on the assumption that proportionate amounts are required for trees of different sizes, and that the space encompassed by the cloth is rounded above. One ounce of cyanide is taken as sufficient for 300 cubic feet. The approximate number of cubic feet enclosed is given in the table to show the relation of one tree to another. The quantity of cyanide allowed for the smallest size of tree given in the table is slightly out of proportion to that allowed for larger trees; the reason for this is the difficulty of working with a quantity so small as the proportionate amount without losing as much in handling as might vitiate the results. The table has not yet been used for trees over twenty feet in height.

For several months a table based on the one published by the California State Board of Horticulture (1893-94 Report, p. 106) and by the Los Angeles Horticultural Commission was followed. The quantities recommended for use in this table are not proportionate to the spaces enclosed. This fact was recognised, but deeming that the table had been widely and successfully made use of in California, it was thought perfectly safe to use one based upon it. The results were satisfactory when trees from 8 to 14 feet were treated but the dose for smaller trees proved far too large, and for larger trees, evidently too small.

An explanation of the table was asked of Mr. Alex. Craw, the Entomologist of the California State Board of Horticulture, in a letter addressed to him in September, 1896, but no reply was condescended. Long puzzling over the table, however, has led to the conviction that the quantities are intended to be proportionate. It would appear that the proper amount for a tree of medium size, presumably one 12 feet in height, had been ascertained in practice, and that the

amounts for smaller trees were taken as proportionate to the products obtained by multiplying the heights of the trees by their diameters. The amounts for larger trees were calculated in a different manner, seemingly by increasing the amount by one ounce (60 per cent. cyanide) for each two feet additional in height and diameter, or by one-half ounce when the addition was two feet in one direction only. The difference of one ounce with each two feet was probably observed in the computation of the amounts for the smaller trees and taken to be a constant difference with this difference of size. There is no doubt about the absurdity of the table, whether this be the correct explanation of its computation or not. The table published by Mr. D. W. Coquillett at an earlier date is based upon the use of proportionate amounts for trees of different sizes, as is the table given here.

PURPLE SCALE, *Mytilaspis citricola*, Pack. 1, infested leaf; 2, female scale from above; 3, same from beneath; 4, male scale; 1 is natural size and the others are much enlarged. (From U.S.A. Dept. Agr.)

Known in two orchards in the colony. This is a very injurious scale in the South of Europe and in Florida.

COST OF EQUIPMENT AND CHEMICALS.

Equipment.—The cloth was furnished by Messrs. J. W. Jagger & Co., Cape Town. The bulk of that used, as already stated, was “Burlington” eight-ounce duck, three-quarters of a yard in width. This was purchased by the piece of about 60 yards at 6½d. per running yard. “Savannah” eight-ounce duck cost 6½d.; “Burlington” ten-ounce, 8½d.; and “Savannah” ten-ounce, 8d. “Greenwoods,” 2 yards wide, a duck of about the same quality as the “Savannah” eight ounce, costs 2s. per yard; and a very heavy ten-ounce duck, 3½ yards wide, cost 4s. 6d. in 25 yard pieces. Some of all these qualities and widths were used in preparing the outfit; “Burlington” eight-ounce would be given the preference in purchasing again. These American duck cloths resemble the cloth used for waggon and cart hoods.

The cutting and making of each of the smallest tents cost 3s.; of each of Size II., 4s. 6d.; Size III., 7s. 6d.; and Size IV., 15s. Those of the last size were sewn by a different party. The sheets were sewed with two seams at each join. The sewing charges amounted to the equivalent of 8d. per dozen yards of stitching, and this charge included the cutting. The sewers were Jos. O. Shirley of Woodstock, and James Lonsdale of Wellington.

The circles of gas-pipe were supplied by Messrs. James Robertson & Co., Cape Town. The circles for the smallest tents cost 8s. 3d. a piece; those for Size II. and Size III, 12s. 9d.; and those for Size IV., 14s. 6d. The rings cost from 4½d. to 7d. per dozen. The lead generating dishes were supplied by the same firm at 3s. 6d. each.

The uprights for raising the sheets cost about 20s. each, and the ropes and pulley blocks together about 23s. extra. The linseed oil and the turpentine used in oiling the cloth cost 5s. and 5s. 6d. respectively per Imperial gallon. The oiling was performed by the labourers employed for fumigating.

At the prices paid for the different articles, tents of eight-ounce “Burlington” duck, made and oiled and including the circle of gas-pipe, cost as follows:—

		£	s.	d.
Size I.	(6 breadths 2¼ yards long)	...	1	2 0
Size II.	(9 breadths 3 yards long)	...	1	18 0
Size III.	(11 breadths 4 yards long)	...	2	14 0
Size IV.	(13 breadths 5 yards long)	...	4	0 0

Size I. will cover trees under 5 feet in height and 4 feet in diameter; Size II., trees under 7 feet in height and 6 feet in diameter; Size III., trees under 9 feet in height and 7½ feet in diameter; Size IV., trees under 12 feet in height and 9 feet in diameter. Somewhat larger trees may often be covered as the tops bend with the weight of the cloth, and the side branches may be pressed inward.

Sheets made of the same cloth, oiled, and with the sewing charged at 8d. per dozen yards of stitching, will cost as follows :—

		£	s.	d.
32 feet across (14 breadths)	...	...	5	0 0
38 feet across (17 breadths)	...	...	8	0 0
48 feet across (21 breadths)	...	...	15	0 0

Sheets of these dimensions will cover trees under 13, 16 and 19 feet in height respectively. If a sheet of larger dimensions is required the addition of a skirt as previously spoken of is recommended. This might be of cheap drill or of unbleached calico, as it will not have to withstand a strain like the body of the sheet. A skirt three feet in width would render the largest sheet mentioned serviceable for trees up to 21 or 22 feet in height. When it is desired to treat trees taller than this, the cutting away of the tops should be considered; larger sheets would prove difficult to manipulate unless made of lighter cloth.

Chemicals.—The cyanide used has all been of 98 per cent. purity. That employed during the first six weeks was purchased of Cape Town chemists, the price paid being 5s. a pound plus jars. That on order from Germany then arrived. This cost 1s. 2d. per pound at Frankfort in a 2 cwt. zinc-lined case. The carriage to Cape Town amounted to 10s. A second 2 cwt has since been imported at the same expense; but now three 2 cwt. cases (672 lbs.) have been purchased in London from Messrs. May & Baker, Battersea, at 10d. per pound. The total charges on this lot to Cape Town amounted to less than £29. If imported by private parties there would have been a duty of 12 per cent. and dock dues to add.

The acid used has all been ordinary, commercial sulphuric acid or oil of vitrol of 94 per cent. purity; the specific gravity is 1.84. It has been purchased of Cape Town chemists, 50s. being paid for cases containing four stone jars each holding 42 pounds of acid; lately, one firm (Wentzel & Schleswig) has supplied it in cases containing 2 stone jars holding 62 pounds for 26s. a case. Single jars of both sizes have been purchased for 14s.

Expense Compared to Spraying.—Disregarding the initial equipment and labour required in both cases, fumigation is cheaper than one thorough application of resin wash. At the lowest figures known to us for which the ingredients may be purchased in Cape Town, resin wash (exclusive of the making) costs 7s. for 100 imperial gallons. At least four gallons are required to thoroughly wet an orange tree 10 feet in height and 8 feet in diameter; the four gallons would cost at least 3½d. Estimating the cyanide to cost 1s. 4d. per pound and the acid 3d. per pound, the fumigation of a tree of the same size would cost less than 2½d. As far as the efficacy of the two is concerned, the fumigation is incomparably the superior.

The labour required for fumigating citrus trees is less under favourable circumstances than the labour necessary to spray the same trees.

NATURE OF HYDROCYANIC ACID.

Hydrocyanic or Prussic acid (H CN or H Cy) is one of the most energetic of poisons; all animal life succumbs to it. It smells like the oil of bitter almonds, and may be obtained by distillation from the kernels of bitter almonds and of many other stone-fruits. Enough is said to be contained in one and a half ounces of peach kernels to kill a man. It is extremely volatile, and hence is more generally known in the gaseous than in the liquid state. The gas is lighter than air, and hence rapidly diffuses when generated under a tent. Water dissolves it, and for this reason fumigation is apt to be a failure when the trees are wet.

Animals fatally poisoned with hydrocyanic acid gas survive for a longer or shorter period according to the dose; death may take place as early as the second minute and as late as the forty-fifth. The chances are favourable for recovery when the poison is not fatal within an hour. The nervous system is most affected; death in man is said to be due to paralysis of the heart in the most rapid cases, and to paralysis of the respiratory organs in those which are less quickly fatal. Difficulty in breathing, pains in the head, giddiness, nausea, slowing of the pulse, loss of muscular power, convulsions with expulsion of excretions, dilation of the pupils and protrusion of the eyes, and, finally, cessation of the pulse and breathing are given as the progressive symptoms. Chlorine and ammonia are valuable as antidotes, but should be administered only by medical men. Cold water dashed on the face, neck and over the spine is valuable as a remedy, and respiration should be kept up artificially. One or two employes of the Horticultural Board, after working several consecutive hours with the gas, have felt a slight swimming sensation on nights when little air was stirring, and the writer has felt considerable nausea and giddiness as the result of recklessly venturing into the Dock fumigation chamber before this had been properly ventilated after the fumigation of fruit. No cases of fatal or serious poisoning are known to have anywhere occurred to operators of fumigation outfits, but the deadly nature of the gas has often been impressed upon operators by the untimely end of small animals and fowls which have been unintentionally enclosed with the tree.

The poisonous action of potassium cyanide is nearly identical with that of hydrocyanic acid; $2\frac{1}{2}$ grains or about $1/175$ of an ounce is regarded as a probable fatal dose for man. As this weight would hardly suffice for a *taste* to an inquisitive person ignorant of the nature of the substance, the necessity of keeping the containing vessels plainly labelled "Deadly Poison" and under lock and key when not being used is apparent to everyone. There is nothing in the appearance of potassium cyanide to indicate its nature. The form used for fumigation purposes bears a superficial resemblance to white

sugar sweets (candy), and might easily be taken into the mouth as such by a child. There is, however, always the characteristic odour of hydrocyanic acid about potassium cyanide.

Moisture decomposes potassium cyanide, and it is therefore necessary to keep it in air-tight receptacles. When moistened the substance possesses a secondary injurious action in that it is caustic; the moisture of the hand is often sufficient to cause it to affect the skin if handled, and likewise fragments which come in contact with cloth or paper burn holes.

Careful fumigators refrain from handling the substance with the uncovered hand, lest some cling to the skin or become lodged under the nails and subsequently get introduced into the system with food. Care is, of course, always taken to avoid breathing the gas as it rises from the generating vessel; when mixed with much air, as it immediately becomes when the cloth is removed from the tree, it is not dangerous.

Sulphuric acid or oil of vitrol (H_2SO_4), the acid used to liberate the gas, is one of the strongest of acids; it is an odourless, dense, oily-looking liquid, almost as heavy again as water. When pure it is colourless, but the commercial article is often brownish, owing to the impurities which have fallen into it and become charred. It is intensely corrosive and will burn almost anything with which it comes in contact. Many of the metals are attacked and decomposed. When mixed with water heat is evolved. Painful burns are caused by drops falling on the skin, but as an appreciable period elapses before it burns, the immediate rinsing of the hands in water will prevent injury. Cloth is burnt even by dilute solutions, the acid gradually becoming stronger by the evaporation of the water. Care must therefore be exercised not to splash the cloth in adding the acid to the cyanide. Most colours are changed to red by the acid; the immediate application of ammonia to cloth on which it has been spilled will lessen the injury.

The Cape Government Railway will convey sulphuric acid on certain trains only, and only on the condition that the jars containing the acid are satisfactorily packed in whiting.

GENERAL APPLICABILITY OF FUMIGATION IN THE COLONY.

Eighteen months ago, the writer stated in his annual report that the gas treatment was too expensive for general adoption in the Colony, although in some districts he believed it would pay well. This statement was based upon an estimate of the cost of the outfit and chemicals at the prices for which the different materials could be purchased at retail in Cape Town. No draper would supply the cloth at less than 1s. a yard, and no chemist would sell the required grade of cyanide at less than 4s. 6d. a pound. At these prices for the materials, the statement that fumigation is too costly for general adoption is entirely unwarranted, but it is not in the light of the figures given in the preceding paragraphs.

Relative to the cyanide, the price has fallen over 25 per cent. during the last fifteen months; and the writer is now assured by a Cape Town chemist that he will retail it at about 1s. 9d. a pound. At present little of it is sold, and this fact in part accounts for the high price which was not lessened with the fall in the wholesale price. Enormous quantities are imported into the Transvaal and used in the extraction of gold.

It is now safe to make the statement that, in general, fumigation with hydrocyanic acid is the cheapest remedy for scale insects on citrus trees in Cape Colony. It is not meant by this that the remedy is entirely applicable where a few trees are concerned, as is generally the case in town and suburban gardens. In the majority of such instances the cheapest, best and true remedy is to uproot and burn the trees. As long as they remain, they are a menace to the health of numerous ornamental plants in their proximity.

On isolated farms and in sections where the growing of citrus fruits is not common, it will generally be cheapest and best for each grower to fumigate his own trees. An outfit for use on a single farm need not be expensive. If the trees are of about uniform height, a single cover could be made to suffice for all. For the sake of economy, the cloth should be purchased by the piece. A single piece would answer for four Size I. tents, two Size II., or one Size III. and one Size IV. A sheet about twelve yards across could be made from three pieces of cloth, and enough would remain for a tent of Size II. Considerable saving could be effected by having the sewing done at home. Iron hoops from old casks might be made to serve the purpose of the gas-pipe circle for a small tent; and other means of reducing the cost by home makeshifts will suggest themselves to the thrifty farmer.

The trees might be covered and the gas generated before going in to the evening meal, and thus one or more trees, according to the number of covers, treated on every favourable night without necessi-

tating the employment of extra labour. If for any reason it is inconvenient to remove the covers at the expiration of the customary period, there would be no harm in leaving them on overnight; but in such cases one side should be propped up at the expiration of the time to allow the gas to escape and care taken that they are altogether removed early in the morning.

To show that there is a demand and thus aid in lowering the colonial price, quotations on the cyanide should be requested from importers of chemical supplies. If over 2s. 6d. a pound in small lots is asked, it will probably be far more profitable to import a 2cwt. case from London through a commission merchant. Several farmers might combine to take a case; it will not deteriorate if kept in airtight tins or jars. A case measures somewhat less than two feet each way.

LONG SCALE, *Mytilaspis gloverii*, Pack. 2, infested leaf; 2a, female scale from above; 2c, same from below; 2b, male scale; 2 is natural size and the others are much enlarged. (From U.S.A. Dept. Agr.)

The Long Scale is known in four orchards in the colony. It has proved a very serious pest in Florida.

Because of the exceedingly poisonous nature of the chemicals used, fumigation by the farmer himself is not recommended when the farmers of a neighbourhood or town, either through their fruit growers' association or otherwise, can by co-operation prepare a large outfit and have their trees treated by a trustworthy party, preferably one acquainted with the details of the work; or when a party is at

hand who will undertake fumigation as a private enterprise, providing, of course, in either case, that the treatment can thus be economically secured. There is nothing difficult about the work, nor is previous experience or knowledge of chemicals necessary; but as in almost any work however simple, experience and knowledge are valuable, and especially so as serious consequences may follow negligence or carelessness.

POINTS TO REMEMBER.

Fumigation with hydrocyanic acid gas is by far the most successful remedy known for scale insects of citrus trees, and it is believed that such fumigation may be economically employed on nearly all farms in Cape Colony where citrus trees are grown.

The covers for the trees must be free of holes and be of cloth which has been made air-tight.

The hydrocyanic acid gas is generated by the action of sulphuric acid on potassium cyanide in the presence of water.

The trees are not materially injured if the proper amounts of the chemicals are used, and if the operations are carried on in the absence of sun-light.

The gas is deadly poisonous to man, and extreme care should be taken to avoid breathing it as it rises from the generating vessel; mixed with air, it is not so poisonous. Potassium cyanide is as poisonous as the gas. Sulphuric acid "burns" almost everything with which it is brought in contact.

The chemicals should always be kept under lock and key, and the containing vessels plainly labelled with the name and the warning "**DEADLY POISON.**"

When feasible it is urged that the farmers of a neighbourhood combine and engage a trustworthy man to attend to the work; but when co-operation is impracticable, it is recommended that the farmer fumigate his own trees.

The operations are very simple and can be safely carried on by any careful man.

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