AN ECONOMIC STUDY OF THE SAN JOSE SCALE.

Thesis for the Degree of M. S.

Charles G. Woodbury

1906

THESIS

For the Degree of Master of Science.

Michigan Agricultural College.

An Economic Study of the San Jose Scale; its Allies,

History and Methods for its

Extermination.

C. G. Woodbury

June 1906.

THESIS

An Economic Study of the San Jose Scale; its Allies, History and Methods for its Extermination.

Chapter I.

Conditions and Object of the Work.

During the fall of 1905 certain experiments were undertaken at the college with a view of accumulating facts which would tend to determine the relative efficiency of fall versus spring applications of the lime-sulphur wash in the eradication of San Jose scale. Three applications of the wash were made; in the fall, winter and spring respectively. The formula used in all cases was as follows; 15 pounds clean stone lime, 15 pounds flowers of sulphur, and 50 gallons of water. This mixture was boiled about an hour and a half.

The following patent preparations were also tested to determine their relative merits, compared one with another and of all as compared to the lime-sulphur wash.

Tobacco-potash, Whale-oil Soap, No. 6. James Good,. Philadelphia, Pa.

Caustic-potash Whale-oil Soap, No. 3. James Good, Philadelphia, Pa.

Kil-o-scale. Griffith and Turner Co., Baltimore, Md.

Horicum. Hammond Paint and Slug-shot Works, Fishkill-on-Hudson, N. Y.

10411

Scalecide. B. G. Pratt Co., 11 Broadway, New York, N. Y.

Target Brand Scale Emulsion. American Horticultural Distributing Co., Martinsburg, West Va.

Target Brand Scale Destroyer. American Horticultural Distributing Co., Martinsburg, West Va.

Scale spray. Sherwood-Carmody-Smith Co., Watervliet, Berrien Co., Mich.

Salimene. Monmouth Chemical Works, Shrewsbury, N. Y.

One other scale remedy was tried which, although not a ready made preparation, is just making its way into favor among those having most to do with the eradication of San Jose scale. This is the kerosene-limoid mixture, commonly known as K-L. It is made according to various formulae, depending on the percentage of kerosene desired. That used by the writer was what is called a fifteen per cent solution and is made as follows; to 30 pounds slaked lime, 7½ gallons of kerosene was added, stirring thoroughly into a thin sloppy mass. This was diluted with 41½ gallons of water, violent agitation being kept up while the water was being added.

It is the usual practice at the present time to spray for San Jose scale in the late winter or early spring, when the trees are in a perfectly dormant condition. If this work, usually something of a bug bear to the fruit grower, can be successfully done in the fall, some of the most objectionable features may be eliminated. Except in unusually wet seasons

the orchard is dryer and in better condition to work in at this time of the year than it is in the spring; owing to the greater ease of application and to the fact that the average fruit grower has more time at his disposal in the fall than in the spring, if done in the fall the work is much more likely to be done in a thorough manner. The necessity for thoroughness cannot be too strongly emphasized and its extreme importance will be brought out in a later chapter.

Perhaps the chief advantage claimed for fall spraying however lies in the fact that the scale itself is attacked at a season when it is supposed to be unable to offer such great resistance to the wash as it is in the late winter when thoroughly encased in its almost impervious coat of mail.

Some work along the line of fall spraying for San Jose scale has recently been done in other states, notably in New York and New Jersey. Although perhaps enough has not yet been done so that any final dictum may be announced, yet the apparent success of fall spraying at these places has been sufficiently encouraging to make it seem desirable to determine if spraying with the lime-sulphur wash at this time of year, is equally advantageous under Michigan conditions.

The greater part of the work described in this paper was on pear, although some peach, apple and plum trees were also used, in order to see if the species of the host, within the limits of economic importance, would be an important

factor in determining the efficacy of the application. Note was also taken of the effect of the various sprays upon the host plant, as to the general vigor of the sprayed compared to unsprayed trees; as to the effect of the sprays in checking any other disease that might be present, and as to the effect of the application of the various sprays on the vitality of the fruit-buds.

Since the college had no plum, peach or pear orchard sufficiently infested with San Jose scale to afford a profitable basis for experimentation, it was necessary to go among the neighboring farmers and fruit growers for material. A sufficient number of plum and pear trees were found upon the farm of Mr. H. P. Gladden of Ridge Farm, about one mile north of Lansing. This gentleman consented to the use of a portion of his orchard for experimental purposes and it was at this place that the greater part of the work was done. Mr. Gladden's pear orchard consisted of about six hundred ten-year-old trees. A plot of a portion of the orchard is given in Plate I, showing the arrangement. The trees are eighteen feet apart in rows twenty feet apart, except the dwarfs, which are eighteen feet apart in rows ten feet apart. The orchard was in heavy timothy sod about three years old. The infestation of the orchard was nearly uniform and only moderately severe.

In connection with the work in spraying for San Jose scale, a comparative study was made of various other species of Coccidae

with a view of making clear the distinctions between the San Jose scale and some of its immediate allies. Especial attention was given to those scales most liable to be mistaken by the fruit grower for San Jose.

An examination was made of the college campus and the location of the infestation of San Jose scale placed upon a map. See Plate II.

Chapter II.

Experimental Work.

The experimental work embraced the spraying of about four hundred trees and included the testing of eleven different kinds of sprays for San Jose scale. The trees were mostly pears but in addition to the pears sprayed there were also thirty Japan plums, ten peach and ten apple trees. The pears and plums as has been before mentioned were situated on the farm of H. P. Gladden; the apples were in the variety orchard of the Horticultural Department at the College; the peach trees were on the farm of Mr. Porter about one mile west of Lansing.

A plot of a portion of Mr. Gladden's orchard is given in Plate I. The varieties are arranged as follows, beginning at the right hand side of the plot; six rows of standard Bartlett, one row standard Howell, six rows dwarf Duchess, six rows dwarf Anjou, two rows standard Lawrence. The trees were sprayed as follows;

Gladden's Pear Orchard.

Lime-Sulphur Wash:- October 23, 10 Anjou pears; October 27, 25 Duchess pears; October 27, 25 Bartlett pears; October 27, 15 Anjou pears; November 13, 13 Bartlett pears; December 9, 12 Bartlett pears; December 9, 25 Duchess pears; December 9, 25 Anjou pears; March 29, 25 Duchess pears; March 29, 25 Anjou pears.

Japan Plums.

Lime-Sulphur Wash:- October 23, 10 Japan plums; December 9, 10 Japan plums; March 29, 10 Japan plums.

October 3, 10 Peaches at Porters.

November 4, 5 Apples at college.

December 7, 5 Apples at college.

Patent Sprays in Gladden's Orchard.

Caustic-potash Whale-oil-soap: April 7, 5 Duchess pears; April 7, 5 Anjou pears.

Tobacco-potash Whale-oil-soap: April 7, 5 Bartlett pears; April 7, 5 Anjou pears; April 7, 5 Duchess pears.

Kil-o-scale: April 12, 15 Howell pears.

Scale-spray: April 12, 5 Bartlett; April 12, 5 Duchess; April 12, 5 Anjou.

Salimene: April 12, 5 Bartlett; April 12, 5 Duchess; April 12, 5 Anjou.

Scale Emulsion: April 12, 5 Bartlett; April 12, 5 Duchess; April 12, 5 Anjou.

Horicum: April 12, 5 Bartlett; April 12, 5 Duchess; April 12, 5 Anjou.

Scale Destroyer: April 12, 5 Bartlett; April 12, 5 Duchess; April 12, 5 Anjou.

K-L: April 14, 15 Lawrence.

Weather Conditions and Effect on Sprays.

During all of the spraying with the lime-sulphur wash the weather was fair and cool, except for a few days following the application of the lime-sulphur wash to the apple trees at the College on November 5th. The spraying of these trees was followed by a hard three days rain. There was practically no effect however caused by the rainfall on the appearance of the sprayed trees. On April 8th, the day following the application of the Tobacco-potash Whale-oil-soap and the Caustic-potash Whale-oil-soap there was a rainfall of .66 inches at the college. On April 9th, almost immediately following the application of Scalecide, successive light showers occurred for several hours. As this preparation emulsifies readily in water it was assumed that it would readily wash off and it was at first thought that a repetition of the application would be desirable. The trees were examined on the afternoon of the same day on which they were sprayed however and no effect was observed from the slight wetting they had received in the forenoon. They had not lost the dark and oily appearance caused by the spray and consequently they were not sprayed a second time.

Description of Patent Sprays.

Scalecide:- Fifteen trees were sprayed with Scalecide on April 9th, five each of Duchess, Bartlett and Anjou. Scalecide is one of the so-called soluble petroleum sprays.

The formula for its use as a dormant spray is one gallon of Scalecide to twenty gallons of water. Before dilution it has much the appearance of machine oil. When water is added it at once forms a milky emulsion, which remains stable in any proportion of water very satisfactorily. The material is very easy and convenient to use and has no disagreeable features in handling. It is non-corrosive and does not injure the face, eyes or clothing. It has been highly recommended by two or three experiment stations where it has been used quite extensively.

On April 12th, ninety trees were sprayed with the six different kinds of spray material the descriptions of which follow. Five trees each of Duchess, Bartlett and Anjou being used, except with Kil-o-scale, when fifteen trees of Howell were used because there were not satisfactory specimens of the other varieties left which were at once in good vigor and yet infested with scale sufficiently to afford a good basis for experiment.

Salimene:- This material is pea-green in color and about the consistency of putty except for a little clear solution, perhaps about a pint on the top of a gallon can. When water is added considerable stirring is necessary in order to dissolve the material. Salimene is made of lime, sulphur, salt and petroleum and when diluted for spraying is of a light pea-green color. When sprayed on the trees it gives them

much the appearance of those treated with the lime-sulphur wash.

Salimene is prepared for spraying by mixing one gallon Salimene with from sixteen to twenty gallons of water.

Scale-spray:- The appearance of this preparation is somewhat similar to that of Scalecide, being oily and rather colorless, but seemingly of a thinner and lighter nature than Scalecide. When water is added an emulsion is readily formed. The emulsion, while white, seems to be very thin and has the appearance of water to which a little milk has been added. The dilution of this material which is recommended by the manufacturer for a dormant spray, is one gallon Scale-spray to twenty gallons of water.

Target Brand Scale Emulsion:- This material has the characteristic machine oil appearance of many of the petroleum preparations. The sample used by the writer, however, made a very unsatisfactory emulsion in cold water. Lumps of oily, greasy material collected on the surface of the water and would not dissolve. Some of the preparation seemed to mix with the water making it a dirty whitish color, but it separated constantly and collected on the surface in lumps which were hard to strain out when putting the mixture in the spray barrel, and made a slimy coating over the funnel and inside of the mixing barrel. Moreover, some difficulty was experienced later in spraying, as some of the viscid insoluble portion got into hose and nozzle, and while not causing a complete stoppage

of the flow it was difficult to force out. When the barrel was rinsed preparatory to putting in another kind of spray, lumps of grease came out which had collected during the time the spraying was in progress.

Horicum:- This is a dark green material, one of the lime-sulphur compounds, and has a very offensive odor doubtless due to the decomposition of some of the sulphur compounds. It is of a semi-solid consistency and must be shaken out of the can. It dilutes very readily in cold water, the formula being one gallon of Horicum to sixteen or twenty gallons of water. When water is added and the material is ready for use it forms a dark pea-green spray which shows up well on the trees when dry, giving them a whitewashed appearance.

Target Brand Scale Destroyer:- This is manufactured by the ~~same~~ company that makes the Target Brand Scale Emulsion. Scale Destroyer is a heavy, sluggish, dark liquid, resembling black molasses in color and consistency. It forms a milky emulsion with cold water with a fair degree of ease, about five minutes vigorous stirring being required to secure a uniform emulsion. The formula is one gallon of the Scale Destroyer to twenty gallons of water.

Kil-o-scale:- This is another oily looking compound. Instead of being comparatively clear however, as Scale-cide, it has a muddy brown color when stirred. On standing a clearer portion separates and comes to the top, leaving a heavier

brown layer at the bottom. Care must always be taken on this account to thoroughly shake or stir the containing vessel before emptying the Kil-o-scale out. The necessity of this stirring is recognized and emphasized by the manufacturer. When water is added Kil-o-scale makes a good emulsion and is easy and pleasant to handle.

Tobacco-potash Whale-oil Soap:- When not dissolved in water this material is a dark brown color and is thick enough so that it pours out of the keg or barrel very slowly. As would be expected, it has the characteristic fishy odor of whale oil preparations but no smell of tobacco was perceptible. It was used at the rate of one pound of the soap to one gallon of water. The soap was put in a fifty gallon barrel, the right amount of water poured in, then steam was turned in through a hose. By the time the water had come to the boiling point the soap had about all dissolved. The material was sprayed on the trees while still hot, as when cold it tends to jellify and is then difficult to force through the nozzle.

Caustic-potash Whale-oil Soap:- This has practically the same appearance and possesses the same odor as the other soap. It was somewhat thicker however, and took longer to go into solution, but this was thought to be due to the previous cold weather to which it had been exposed and to which the Tobacco-potash Whale-oil soap had not been. The formula was the same as for the other soap and no difference was

observed in the effect on the tree or in the appearance when sprayed.

K-L:- The Kerosene-limoid preparation, commonly known as K-L, is a mixture of kerosene and lime diluted with water. It has been quite extensively used at the Delaware Agricultural Experiment Station and is highly recommended in some parts of the country. Some of the advantages claimed for K-L are that it is easily made without heating materials; moderate in cost, pleasant to handle, effective and adhesive, requires no straining, is plainly visible on the tree and is absolutely uniform in the percentage of kerosene in any part of the mixture. Not quite all of these claims of its advocates were borne out in the experience of the writer. The method of making it has already been touched upon in Chapter I. The lime used was sifted air slaked lime, although nearly any form of lime is said to be effective. The most important point to be observed in making K-L is to be sure to get a good emulsion. This is supposed to be obtained by violent and continued agitation of the mixture while the water is being added. The difficulty in securing this emulsion, and the danger of the mixture if it is not secured, appear to be the greatest disadvantage of the kerosene-limoid combination. The air slaked lime precipitates rather rapidly in the spray tank and a good agitation is a necessity, otherwise the lime packs against the sieve or the bottom of the pump and shuts

off the flow of liquid. In the respect of durability of suspension, K-L compares unfavorably with the lime-sulphur washes.

Subsequent Observations.

About an hour after the application of Scalecide, on April 9th several light showers fell. It was thought that perhaps the material might have washed off, so an inspection was made on the afternoon of the same day. The trees were plainly distinguishable from those not sprayed, by the dark and oily appearance of the bark. The Bartletts sprayed were not infested badly enough to judge of the number of scales killed. On Duchess and Anjou the scales had not sloughed off at all but appeared shrivelled up.

The application of the Whale-oil soaps was followed by a more or less continuous rainfall during the succeeding eighteen hours, about six or eight hours having elapsed between the spraying and the beginning of the rain. The trees were sprayed on April 7th and were examined April 10th. As this is a caustic preparation and the bark of the tree actively absorbs the potash the effect of the soap would be felt within a very short time after the application, and the insecticidal properties of the preparation might have been expected to get in their work before the rainfall began. This was evidently the case as all the scales appeared to be dead when examined April 10th, having turned from the normal lemon yellow color

of life to a dark orange. They had not sloughed off however. The material, notwithstanding the rainfall subsequent to the application, was still plainly visible on the trees giving them a whitened appearance as though covered with dried soap-suds. The bark likewise had an oily feeling ~~to the touch~~.

April 20th,- ~~T~~ten days later the trees were examined again. Those sprayed with soap still had the whitened appearance.

Trees sprayed with Horicum were most conspicuous in the orchard. The whitewashed appearance had not left them in the least. The material apparently does not wash off. No fruit buds seemed to have been injured as all were beginning to get green. No live scales were found beneath the white coating on the trees.

Trees sprayed with Salimene were likewise noticeably whitened but the coating was not so heavy as those receiving Horicum. The trees sprayed first with Salimene, which received the material from the bottom of the tank, were much whiter, showing that the settling is comparatively rapid. In this respect Salimene seems inferior to Horicum. No fruit buds were injured and only a small percent of live scale was found.

No difference was observable in the appearance of trees covered with Kil-o-scale and those which had not been sprayed at all.

K-L. These trees were quite conspicuously whitened and the material appears to stay on well. No fruit buds were

injured and no live scale were found.

April 28,- On this date the final examination of the whole orchard was made. On trees sprayed in fall with the lime sulphur wash by far the greater part of the scales were dead but enough were found alive to perpetuate the breed the coming season. In estimating percentage of dead scales only those were considered to be dead which were shrivelled and without juice. The matter of a simple test of death is one which should receive more attention than has hitherto been given it. It is sometimes claimed that an orange colored scale is dead and that when alive they are of a light lemon yellow. The distinction holds true in the main, but the writer has found many scales of an orange color which were full of juice and apparently thriving; on the other hand scales are frequently found which have the lemon yellow color of most living scales but which are juiceless, shrunken and apparently dead. In view of this difficulty, one is tempted to question the accuracy of many published statements as to the exact percentages of dead scales in an orchard. On the basis for distinction between dead and living scales given above, it was somewhat encouraging to find that there was hardly a dead scale in the row adjoining the fall sprayed trees, which had received no treatment. On fall sprayed trees the lime sulphur coating was barely distinguishable; on winter sprayed trees the spray was scarcely more noticeable, while on those sprayed

in the latter part of March the lime sulphur coating was very plainly visible.

On the winter sprayed trees in places where the lime sulphur coating was visible, a few live scales were found beneath the coating of spray. The same condition was found in some places on fall sprayed trees.

Patent Sprays.

Kil-o-scale:- In some places no live scales could be found, at others there were plenty to make trouble the coming summer.

Scale-spray:- Material slightly visible, appearing like dried soapsuds, numerous live scales.

Scalecide:- No scales were found alive.

Scale Emulsion:- Live scales apparently quite abundant. The bright yellow color had been preserved however in the dead scales making them very difficult to distinguish from the living insects.

Scale Destroyer:- Material not visible on trees; quite a number of live scales.

Tobacco-potash whale-oil soap:- No change was noted from the condition reported under examination of April 20th.

Caustic-potash whale-oil soap:- No difference observable in the action of this soap and the preceding.

Salimene:- Material apparently very durable on trees.

Very few live scale could be found.

Horicum:- Appearance of trees same as on April 20th. No live scale were found beneath the coating of spray material on the trees.

K-L:- The lime made the trees conspicuously whitened and the coating does not wash off readily. The effect on the scale was very satisfactory. No live scales were found.

Chapter III.

Conclusions.

The Lime-Sulphur Wash.

From the known facts as to the action of the lime-sulphur wash, that is, that its effect is cumulative and not immediate, it seems to the writer that spraying in the spring is preferable to a fall application. There are indisputable advantages in fall spraying in the ease and cheapness of application, but after all efficiency is the essential thing and the work described in this paper seems to indicate that spring spraying is more effective. The most beneficial action of the lime-sulphur wash in the opinion of the writer is found in its work on the young scales. If the application is made in fall and the old scales are not all killed, by the time spring comes there is not enough material left on the tree to be effective, and the progeny of the survivors of the fall spray meet no check to their increase. If these considerations are true, it follows that the ideal methods for the extermination of the scale in a badly infested orchard is to make two applications, one in the fall just about the time the leaves drop, and another in the spring just before growth begins. The fall spray will kill the greater part of the scales, which are perhaps more susceptible to insecticides at this time, and the spring application will prevent the survivors from multiplying. It must be taken into consideration, however,

in dealing with scale, as with many other enemies of the farmer, that prevention is cheaper than cure. The San Jose scale from now on will probably be a continual source of trouble in fruit growing and the better way to deal with it, is to not allow the orchard to be half killed before taking remedial measures. If spraying for San Jose scale be made part of the seasons routine in every orchard and a single application a season be made while the scale is not yet thoroughly established, little trouble need be expected from this source.

Methods for preparing. Many formulae and methods of preparation have been advocated for the lime-sulphur wash. While the formula used has generally been found to give satisfaction, yet in the opinion of the writer, there would be an advantage in a greater proportion of lime. It is claimed by adherents of the 15-15-50 formula that the amount of lime used is sufficient to go into combination with all the sulphur, and that every additional bit of lime is mere whitewash. This may be true, but it is apparent from the investigations of Mr. Haywood* that the lime prevents the too rapid solution or evaporation of the insecticidal properties of the compound. These are chiefly due to the breaking down of calcium thio-sulphate. An excess of lime, while possessing no insecticidal value in itself, holds the material on the tree longer than

*Composition of the Lime-Sulphur-Salt-Wash. J. K. Haywood.

if just enough lime is used to satisfy the chemical reactions with the sulphur. Moreover it has the additional advantage of making the spray more plainly visible on the tree and consequently greater thoroughness is likely to be obtained in application. Twenty or twenty five pounds of lime to fifteen pounds of sulphur the writer believes makes a better wash.

Much depends upon the manner of mixing the lime and sulphur. Frequently the sulphur is dumped on top of the water in which the lime is slaking. When added in a mass in this manner, the sulphur is slow to mix with the water and a longer time in boiling is required to make it do so, than if the sulphur is first mixed with a little water into a thin paste which may then be easily diluted. When enough water has been added to about cover the required quantity of lime, this material may be put in. The water should be nearly to the boiling point when the lime is added in order to insure good slaking. If this method is followed, every piece of lime is immediately surrounded with sulphur, a high degree of heat is generated by the slaking, and less subsequent boiling is required to secure the right combination.

Effect on trees: There was no injurious effect on the trees which were sprayed before the leaves had fallen. No fruit buds were injured by any of the lime-sulphur applications, nor were the trees harmed in any way. No difference was observed in the behavior of different species of hosts, in regard

to their susceptibility to injury by spraying nor in regard to the susceptibility of the scales living upon them, to the spray. The last observation here recorded was too early in the season for a judgment to be formed as to the fungicidal value of lime-sulphur, and as to its value for pear-blight or peach-leaf curl.

Patent Sprays.

The various prepared sprays may be grouped into three classes; the lime-sulphur-salt compounds, the soluble oils and the soaps. In insecticidal value, there seems to be but little difference in the best spray of any of these classes.

The results which the writer secured with the soluble oils do not afford a basis for such a flattering report concerning their value as has been given by some experimenters. With one very thorough application of the oils about 90 to 95 per cent of the scales seemed dead. Scalecide was the most satisfactory of the soluble oils. The disadvantage of Kil-o-scale was the heavy brown precipitate which forms in the containing vessel on standing. Scale Destroyer was fairly good but did not form an emulsion so readily as Scalecide. Scale Emulsion was unsatisfactory as explained in Chapter II, page 10 Scalespray while making a fairly good emulsion fell below all the others in efficiency. As a class the soluble oil sprays have the advantage of easy preparation, perfect solution; they

have the disadvantage of being washed off the tree by the first rain. This proves to be a serious drawback only when the application of the spray is succeeded almost immediately by rainfall. Unlike the lime-sulphur wash the effect of the oils is almost immediate, so that a repetition of their application is unnecessary unless the rainfall occurs within a few hours.

Of the two ready made lime-sulphur sprays used, Horicum was more satisfactory than Salimene, because of the ease with which it is prepared for use. The material goes into solution very readily, stays in suspension well, is adhesive and conspicuous on the trees. Salimene, while apparently similar in composition, is much thicker. About fifteen minutes stirring is required to dissolve it and it settles rather rapidly. One advantage of no inconsiderable importance which both the lime-sulphur-salt sprays possess over the soluble oils, is their durability on the trees, They are apparently as impervious to water as the home-made lime-sulphur wash and are just as conspicuous on the trees after withstanding several rains as they were just after applying.

The soaps have no apparent advantage over the lime-sulphur washes or the soluble oils. On the other hand they have the disadvantages of requiring a considerable amount of time and hot water in their preparation, and of the necessity of making the application while the material is still hot.

In all of the so-called patent preparations considered the item of cost has not been mentioned. This is for the reason that it seems to the writer that these sprays are most suitable for use in a small way, where only a few trees are to be treated. Under such conditions a few cents difference in cost is immaterial. Where a large number of trees are to be treated, the lime-sulphur wash has no superior. When large quantities are to be used so that the best methods of making, such as boiling with steam, elevated tanks, are the cheapest, the cost of the lime-sulphur wash has been found to be less than that of any patent preparation now on the market.

K-L.

The experience with the kerosene-limoid mixture was in the main satisfactory. This material has the advantages of adhering to the trees well, of being plainly visible and of requiring no heating in mixing. The disadvantages found in its use by the writer, was its rapid settling, causing a clogging of the fine screen on the bottom of the pump. The settling also caused the first trees sprayed to receive more than their share of lime, which of course prevented the balance of the trees from getting quite so much as they should. This disadvantage was due in part to the fact that air slaked lime was used. The coarse particles were removed by screening, but even then the air slaked lime, when mixed with water, will not form nearly so flocculent a mixture as will freshly hydrated

or dry slaked lime. K-L has no injurious effect on the buds and was as efficient against the scale as any spray used. It is a good spray and one that can be made easily at home. Great care must be taken however to give violent agitation when the kerosene is added in order to secure a permanent mixture. The difficulty of doing this properly is the worst feature of K-L, for if a permanent mixture is not formed great danger will attend its use, as some of the trees will be treated to practically pure kerosene.

Summary of Conclusions.

Lime-sulphur wash: If but one application of the lime-sulphur wash is made let it be in the spring just before growth begins.

If the orchard is badly infested spray both in fall and spring.

If in a neighborhood where San Jose scale exists, spray for it regularly, as for any other expected pest, bearing in mind that spraying is insurance on the crop.

A greater proportion of lime than is contained in the 15-15-50 formula is desirable.

In making the lime-sulphur wash first mix sulphur with a little hot water, then add enough hot water to cover the lime to be used, then add lime, stir vigorously and keep the mixture boiling, adding more hot water when lime has slaked.

Patent Sprays.

Of the lime-sulphur preparations Horicum is the best, is durable, smooth in spraying, and efficient, but is disagreeable and offensive to handle.

Scalecide is the best of the soluble oils. It is non-corrosive and easy to handle. It is efficient if not washed off by rain soon after being applied. A slight shower does not impair its efficiency.

As a class the prepared sprays are better to use in a small way where it is not desired to go to the trouble and expense of making the lime-sulphur wash.

K-L- This is a good spray if made right. Dry slaked lime should be used, violent agitation when the kerosene is added is essential. The danger of not securing a stable emulsion will prevent K-L from supplanting lime-sulphur wash for use in large commercial orchards.

Chapter IV.

San Jose Scale on the College Campus.

It had been known for some time that there was more or less San Jose scale present about the campus at the college. It was known that it was present in considerable quantity, infesting some of the ornamental shrubs, but whether the infestation had spread to other species to any great extent, how dangerous it was and how widespread, and whether it had yet attacked a very great variety of hosts, were questions that had not yet been solved. That these questions should be answered was necessary in order that the best method of dealing with the pest might be determined and some decisions reached as to whether it would be most economical to spray or to destroy the infested plants. Accordingly, with a view of finding out the present location of the pest and determining the best method of eradicating it, an examination of the campus was made and a map drawn. Upon this map, a photograph of which is given at Plate II, the infestations of San Jose scale were shown.

The outlines, roads, walks, etc. were made by the writer by means of a stereoptican enlargement of an old map in possession of the college. The buildings erected since the survey from which the old map was made, together with the trees and shrubs were located by Messrs. Spencer and Lambert of the class of 1906.

It would be manifestly impossible to examine microscopically all of the plants shown on the map, but a fairly thorough examination was made, especial attention being given to the most common hosts of the San Jose scale. The number and location of the infestations are shown on the map in yellow. It was found that the scale was present on Japan Quince in almost every place where this shrub had been set. Frequently but one or a few bushes in a bed were infested. The original source of infestation on the bushes is generally supposed to have been from affected nursery stock, but there is strong circumstantial evidence that the first infested bushes came from the South Haven Experiment Station. Aside from the Japan Quince the scale was found upon a few scattered fruit trees, pears, plums, peaches and cherries being attacked. It seems to be characteristic of this pest that it is liable to confine its attacks to a single species of host-plant and to multiply on it for a long time with its usual rapidity, until some chance or unfavorable condition or other circumstance causes it to obtain a foothold on a host hitherto foreign to it in that particular locality, then to spread with its usual virulence on its new found prey. Hence, although now present for the most part only on Japan Quince at the college, yet if prompt measures are not taken to eradicate it the time cannot be far distant when it will cease to confine its attacks to this shrub and may spread to the shade trees, other shrubs, or

almost any of the plants which now adorn the campus. In the case of the Japan Quince at the college, then, the best and most economical remedy is doubtless the destruction of the affected plants. Their value either intrinsically or for landscape gardening purposes is not great enough to warrant their preservation when their continued existence as a congenial host and breeding place for the San Jose scale makes them a menace to the species hitherto unattacked by this dreaded pest.

Chapter V.

Popular Descriptions of the San Jose Scale and Some of its Close Allies.

The systematic study of the scale insects of the United States is of comparatively recent origin. Targioni Tozzetti, the great Italian entomologist who did some of the earliest important work on the study of the Coccidae, is still living and writing. Professor Comstock of Cornell University, who has earned a world-wide reputation by his invaluable studies in the classification of the Coccidae of the United States, is still in the prime maturity of active life.

The interesting family of insects known as scale insects belongs to the suborder Homoptera of the genus Hemiptera. This order takes its name from two Greek words meaning "half-winged", the name referring to the structure of the wings in some of the genera. Homoptera likewise means "like-winged". Among the different families of the suborder Homoptera the Coccidae are distinguished by several very peculiar characters. "In this family we find those members of the Hemiptera which depart most widely from the type of the order.

The adult female is always wingless and the body is either scale-like or gall-like in form, or it may be grub-like and clothed with wax. The waxy covering may be in the form of powder, of large tufts or plates, of a continuous layer or of a thin scale, beneath which the insect lives. The males of

Coccidae, unlike all other Hemiptera, undergo a complete metamorphosis. The adult males have only a single pair of wings, the hind wings being represented by a pair of club-like halteres. Each of these is furnished with a bristle, which in all the species we have studied, is hooked and fits in a pocket in the wing on the same side. The males in the adult state have no organs for procuring food, as the mouthparts disappear during the metamorphosis of the insect and a second pair of eyes appear in their place." +

For our purpose at this place, however, the most important thing is first, to distinguish the scale insects from others, and second to distinguish those species of scale insects which are of great economic importance from those concerning which the fruit grower need have no particular anxiety. This will be taken up from the entomologists standpoint in a later chapter. At this place let us briefly consider those characters of the scale insects which can be appreciated by the mind which has not been especially instructed in entomology, and seen by the eye unaided by the compound microscope.

At present then, we need only to consider the characters which differentiate one sub-family of scales from other insects, because it is to this sub-family, called the Diaspinae, that all of the scale insects to which particular attention

+"Manual for the Study of Insects,-- J. H. Comstock.

will be given in this paper belong, except the Lecaniae. This sub-family Diaspinae includes nearly all of the scale insects which are troublesome enemies to the fruit grower. It may be briefly said that the Diaspinae, or armoured scale group includes those species of scale insects which form a scale composed in part of moulted skins and partly of an excretion of the insect. "This apparantly trivial character is correlated with important structural characters, which mark a well defined group"+. For the average man however it is simply this minute, somewhat convex, smooth and usually brown or grayish scale, which he needs to learn to recognize as being the stronghold beneath which the real insect lives.

Of all the species of scale insects which occur in the United States, numbering about eight hundred, there are comparatively few of great economic importance. What there are occur chiefly in the following genera; Lecanium, which belongs to another sub-family than the Diaspinae and differ radically from all other genera, Aspidiotus, Mytilaspis and Chionaspis. Not much attention need be devoted here to the Lecaniae, because although there are a few in Michigan of economic importance, such as the Brown Apricot Scale and the Peach Lecanium, yet they are so different from all other scale insects that most Lecaniums can easily be distinguished at a glance from scales

+Second Report of the Cornell University Experiment Station, 1882-3, J. H. Comstock.

of any other genus, by their comparatively large size when mature and very convex shape. It will be necessary to do no more here than to refer to Fig. 2, Plate III. This is a photograph of a Lecanium which occurs near the Michigan Agricultural College on wild cherry and may serve as a type of the genus. The small holes seen in the scales are caused by parasites and show where the mature insects, the eggs of which had been laid within the scale, have made their escape.

It is in the genus Aspidiotus that the worst scale enemies of Michigan fruit growers may be found. It is in this genus also that the greatest difficulty is encountered in distinguishing between several very closely allied species which are rendered of importance chiefly because of their close relationship to that dreaded pest of orchard and garden, commonly known as the San Jose scale. The genus Aspidiotus takes its name from the Latin name of the shield or aspidium carried on the arm of the Roman soldier. Aspidiotus is simply the diminutive form of the word and means "little shield". The similarity in the shape and appearance of the scale of an insect of this genus and the shield of the old Roman soldier is striking and the analogy is still further supported by the fact that a thriving colony of San Jose scale is nearly as well protected from the attacks of its enemies under its solid array of little shields, as was the closely-formed shield-locked phalanx of the famous Roman legion.

Since the San Jose is the worst scale pest we have it may serve as the basis of a division into two classes of the common scales which the fruit grower finds infesting his trees, depending on their degree of resemblance to this dreaded pest. Following such a division as this, there would fall into the first or dangerous class first of all the San Jose scale, which Professor Comstock named in 1880, with prophetic foresight, "the pernicious scale", (Aspidiotus perniciosus.) Closely resembling it are the Eccentric scale (A. ancylus) the European fruit scale, (A. ostreaeformis) and the English walnut scale, (A. juglans-regiae.) In the second or comparatively innocuous class will come the Oyster-shell bark louse, (Mytilaspis pomorum) and the Scurfy bark louse, (Chionaspis furfurus.)

In the first division, which for convenience will be spoken of as the San Jose group, we have four species of scales which resemble each other very closely in appearance, but differ greatly in the amount of damage they may be expected to inflict. One reason for the greater destructiveness of the San Jose scale is the fact that there are several broods each season, four having been determined in the latitude of Washington, D. C. Professor Kellog of Leland Stanford Jr. University has estimated the possible progeny of a single over wintered female in a single season to be 3,216,080,400 scales. Another peculiarity of this scale is that it is viviparous,

the young being hatched within the body of the mother and born alive. Fortunately none of its close allies approach the San Jose in fecundity. In speaking of this arbitrarily so-called San Jose group it must be borne in mind that there are many other species of Aspidiotus, all of which resemble each other more or less closely. But these three were selected because they all occur in various parts of Michigan, all work on many of the same host plants as the San Jose scale, and while comparatively harmless in themselves, appear to be the scales most frequently confounded with the San Jose. Fortunately the worst of the group, the San Jose, has some characters which make it easier for the amateur to distinguish it from the other three than to distinguish the other three from each other. In common with other species of Aspidiotus, all the members of the San Jose group have the following characters; the scale of the female is circular with the exuviae (a term applied to the moulted skins of the larval scale, which are incorporated into and form a part of mature scale) either central or more or less marginal; "scale of the male but little elongated, with the exuviae more or less central; scale usually resembling that of the female in color and texture." The exuviae are usually yellowish or light orange. On a branch where the scales are thickly crusted together, it is almost impossible to tell which of the three close relatives of San Jose a scale may be, without the aid of a compound microscope, and then only by an expert.

They are all small, circular, though sometimes irregularly so, dark gray or almost black in color, orange colored exuviae more or less central. In none of them is the adult female so nearly circular as in San Jose. The Eccentric scale usually has a brighter colored exuvium than the San Jose, and it is more frequently near the margin of the scale, rather than in the center. The exuvium of the European fruit scale is similar to that of the San Jose but the central part is not so dark and it is seldom central. One characteristic appearance of the bark of an infested plant is suggestive, though not proof of the presence of San Jose scale. This is a reddish spotted discoloration on the young growth. The scale frequently causes this discoloration and the attention is often first directed to a plant by its appearance. A closer examination is apt to reveal the scale itself in the center of each small discolored area. The best character by which to distinguish the San Jose however is the prominent ring-and-nipple on the young scales. What this is will be readily comprehended by a glance at Fig. 1, Plate IV. and at Fig. 3 Plate V. It is formed by a depressed ring with a central protuberance. This is one of the most distinctive characters of the San Jose scale and is not nearly so plainly marked on any other species. In Michigan the condition is most easily recognized in winter when the young are hibernating in a half grown condition. The specimen shown in the photograph at

Fig. 1 Plate IV. was from a peach twig cut in January. In photographing the scales were enlarged several diameters, and on the natural specimen a hand lens is necessary to see this character. Fig. 3 Plate V. is a photograph of a piece of apple badly infested with the scale. The ring-and-nipple shows here also. Fig. 2 is the same except that it was not magnified so much and looks much as the specimen would appear to the unaided eye. Fig. 2 Plate III. is a photograph of Sam Jose scale on an old peach twig and shows how a severe infestation makes an ashy looking deposit on the bark. Fig. 3 Plate IV. is of San Jose scale thoroughly covering a young twig of Japan Quince. This is also enlarged. Fig. 1 Plate V. shows a female scale passing the winter in the adult stage. The scale is just below the bud on the right hand side of the twig. This seems to be a favorite place for the old females to pass the winter.

In the other scales of this group which we will not attempt to further differentiate here, the scales are usually lighter colored, the orange colored exuvium is more conspicuous and more frequently near the margin of the scale and the ring-and-nipple, while occasionally present is not nearly so prominently developed nor so noticeable. The European fruit scale on a branch of spiraea is shown at Fig. 1, Plate VI. and at the right hand side of Fig. 3. Fig. 2 Plate VI. shows another Aspidiotus, (A. aurantii) which affects citrus fruits. The

specimen shown is on orange from California.

Of the two scales mentioned as belonging in the second group, by far the most common is the Oyster shell bark louse. This scale has a world-wide distribution and is almost universally present to some extent on apple trees in all parts of the country. A better idea of its appearance can be gained by reference to Fig. 1 and 3 Plate III than can be expressed in words. The specimen shown in the photographs are on apple twigs and are enlarged in photographing about three diameters. The scale itself is much larger than the San Jose, very convex and usually has something of a spiral or twisted appearance. The color varies from gray to light brown. The scale of the female is long and narrow, broadened posteriorly, with the exuvium yellowish and at one end. There is but one brood a year in the north. The female deposits the eggs in late summer and the body then shrinks away leaving the space beneath the scale almost filled with eggs. The scale remains as a protection over winter. The young scales come out in May or June, crawl out upon the bark, become permanently located and within two or three days begin the formation of a scale. The scale is easily recognized and unless present in very great numbers need not cause very much alarm. It is nearly everywhere present, and while it sometimes finishes a tree which old age and hard usage had weakened and devitalized already, it need not cause uneasiness if

present in small quantity in a thrifty and well cared for orchard.

The other scale to be considered in the so-called innocuous class is the Scurfy bark-louse (Chionaspis furfurus). This scale belongs in another genus than the Oyster shell bark louse though their common names are similar. Their appearance however is very different as will be seen by reference to Fig. 3 Plate VII. where a photograph is shown of the Scurfy bark louse on apple. This scale is very common on apple and cherry. The female is distinguished by a dull gray or white color, and is flat or irregularly oval in outline. Like the Oyster shell, it has but one brood a season in the north, the young hatching in May or June from eggs laid beneath the scale the preceding summer. It is a scale from which little damage may be expected. Fig. 1 and 2 Plate VII show another scale of this same genus, which occurs on euonymus. Fig. 2 is a part of the leaf shown in Fig. 1 enlarged more in photographing. Here is seen the type of the male scales of this genus, which are usually white and ridged or carinated.

Chapter VI.

Technical Descriptions of Some of the Common Coccidae.

For the average fruit grower it is enough to be able to recognize the common types of scales which come under his observation in his orchard. If he can distinguish the worst of them all, the San Jose with a fair degree of accuracy; if he knows the general type of the Aspidiotus group to which the San Jose scale and its close allies belong, so that he can tell the scales for which he needs to spray from those to which he need pay no attention, his interest in the Coccidae is satisfied. But for the entomologist desiring to distinguish with certainty between several of the closely allied species of Aspidiotus, such as Aspidiotus perniciosus, A. ancylus, A. ostreaeformis and A. juglans-regiae, the characters which present themselves to the unaided eye are not sufficient.

The characters most used in the microscopical determination of the Coccidae are those of the last segment of the adult female, called the pygidium. An explanation of a few of the terms used for various appendages on this last segment, may not be out of place. Circumgenital gland orifices or spinnerets are terms given to a number of glandular openings about the vaginal orifice. Their function is supposed to be that of aiding in the secretion of the wax which forms the scale. They are arranged in groups, are compound or composed of several

smaller openings and the number in the different groups is of some taxonomic importance.

The lobes are the most conspicuous appendage, and appear as rounded prolongations of the body-wall.

Plates is the name given to small prolongations or appendages which extend posteriorly from the body-wall from between the lobes. They may be either simple, toothed, bifurcate or serrate.

Spines are long pointed tapering appendages situated usually near the base of the lobes.

The varying numbers, sizes, and locations of these organs and appendages form the chief distinction in the appearance of many species of Coccidae.

We shall endeavor then in this chapter to describe and figure the four above mentioned species so that there shall be no danger of confusion, and to illustrate in a general way the methods used in the identification of any of the Coccidae. One or two scales belonging to other genera will be discussed simply to serve as illustrations of the structural differences presented by different types. The outline followed in description will follow in a general way that used by Professor Comstock as it appeared in the Entomological section of the Agricultural Report for 1880.

Aspidiotus perniciosus, Comstock.

The pernicious or San Jose Scale, Plate VIII.

Scale of female: In outline circular, though on thickly infested areas or on rough bark often irregularly so, slightly convex, exuviae more or less central. Color is grayish varying to dark brown or black depending somewhat on the age; the young, especially the males being very dark. Diameter 2 mm.

Female: Body light lemon yellow when alive, oval or sometimes nearly circular in outline. Segmentation is fairly distinct.

Characters of pygidium: There are but two pairs of lobes on the pygidia of A. perniciosus. The first or mesal pair are much larger than the second, converge slightly at the caudal extremity; are usually slightly notched on the lateral margin, frequently about one-third the distance from tip to base. The second lobes are much smaller, notched on lateral margin, sometimes serrate.

On the ventral surface of the margin of the pygidium are two deep incisions each side of the meson. One incision is lateral of the base of each lobe. These incisions are rendered more prominent on account of the chitinized oval shaped thickenings of the body-wall surrounding them.

Between the mesal lobes are two small simple plates, extending not quite to the tips of the lobes. Between the first and second lobes are two plates extending caudad of the first

incision; lateral of the second lobe and extending caudad of the second incision are two or three plates, serrate on their lateral margins. Lateral of the second incision are three prominent processes extending caudad of the body-wall. These are of great value in differentiating A. perniciosus from its allies. No other scale so far as known, posseses this character. The processes are wide at the base and deeply toothed or serrate. They are situated between the third and fourth spines.

The first pair of spines are placed just lateral of the mesal lobes, the second pair lateral of the second lobes, the third pair lateral of the second incision and the fourth pair lateral of the serrate processes just mentioned.

Eggs are white.

Male: "The mature male appears as a delicate two-winged fly-like insect with long feelers and a single anal style projecting from the end of the body; orange in color with a faintly dusky shade on the prothorax. The head is darker than the rest of the body, the eyes are dark purple, and the antennae, legs, and style are smoky. The wings are irridescent with yellow and green, very faintly clouded". +

Distribution: very thoroughly distributed throughout the United States.

+Bulletin No. 3 New Series U. S. Dept. Agriculture, The San Jose Scale, its occurrences in the United States. L. O. Howard and C. L. Marlatt.

Host list:

Apple, crabapple, pear, peach, plum, Japan quince, quince, apricot, Japan plum, Satsuma plum, Prunus maritima, P. pissardi, P. domestica, P. avium, almond, Crataegus, persimmon, English walnut, black walnut, Japan walnut, Lombardy poplar, Carolina poplar, golden-leaved poplar, chestnut, sumac, Catalpa, speciosa, English willow, golden willow, weeping willow, laurel-leaved willow, osage orange, American linden, European linden, ash, dogwood, elm, orange, lemon, lime, June-berry, Acacia, Euonymus, alder, Eucalyptus cornocalyx, laurel, hawthorne, snow-ball, Ptelea trifoliata, silver-maple, Spiraea, rose, strawberry, raspberry, gooseberry, currant, huckleberry, catoneaster, pecan, Actinidia, Lonicera xylosteum, Lymphoricarpus racemosus, cut-leaved birch, milkweed, spruce, cedar, grape, corn.

Aspidiotus ostreaeformis--Curtis.

European fruit-scale. Plates IX and X.

Scale of female: circular in outline, slightly convex, Outline varies greatly in specimens distorted by crowding. "The central third is usually olivaceous black, the remainder dusky ochreous or drak gray". Exuviae more or less central, usually orange yellow in color though sometimes brown, The exuvium is often covered with a thin secretionary covering of wax. It is a common habit of this scale to occur in

segregated clusters,single scales seldom being found alone. Diameter 1-2 mm.

Female: Yellowish in color, ovate to nearly circular in outline, chitinization prominent in old specimens. There are five groups of circumgenital gland orifices or spinnerets, the median group contains five to eight, cephalo-laterals, seven to twelve, caudo-laterals, five to sixteen. Segmentation fairly distinct.

Pygidium: There are two pairs of lobes on the margin; median lobes fairly well developed, slightly converging rounded, slightly notched or dented on lateral margin; second pair of lobes wider than median but much shorter and broader, slightly notched on margin making the outline often vary. Between the mesal lobes are two small simple plates; lateral of the mesal lobes, extending caudad of the first incision, which is between the mesal and second lobes, are another pair of plates, usually finely serrate. Extending caudad of the second chitinized incision in the body-wall is a third group of plates which may be simple, serrate or bifurcate.

"There are usually five long spines on either side, the first at the base of the anterior margin of the median lobes; the second and third opposite, are attached to the base of the second lobe; the fourth and fifth, considerably beyong, equidistant from the second and somewhat longer. The body-wall

is considerably thickened and chitinized at the base of the plates." +

Male: "Male scale darker in color and smaller, one half the size of females; cast skin raised and more or less flat. Often a slight raised rim around the edge; central nipple present. The color is black or brown and the rim around the cast skin and central nipple are often whitened." °

Distribution: Newstead states that it is widely distributed and "common in many parts of Europe where it appears to be a general feeder". Marlatt states that Aspidiotus ostreaeformis is now in New York, Michigan, Ohio, British Columbia, Ontario and Iowa. It is also found in the west in Idaho and California.

Host list: Apple, pear, plum, peach, cherry, birch, poplar, horse-chestnut, linden, alder, Crataegus, maple, aspen, oak, date, palm, Calluma vulgaris.

Aspidiotus juglans-regiae-- Comstock.

The English Walnut Scale. Plate XI.

Scale of female: This scale is of somewhat greater size than the others of the group considered here, being frequently 3 mm. in diameter. Adult female is circular in outline, often irregularly so where the infestation is severe, very slightly

° Bulletin 180, Michigan Agricultural College Experiment Station, Some Insects of the Year 1899 by R. H. Pettit.

+ A Monograph of the British Coccidae. Robert Newstead.

convex, color gray to brown, "exuviae covered with secretion; position of exuviaeis indicated by a prominence which is pink or reddish brown.

Female:Color like so many similar scales, is light yellow with darker orange spots","oral setae and last segment dark yellow", segmentation fairly distinct.

Pygidium: There are four or five groups of circumgenital gland orifices. The anterior group is sometimes wanting or if present consists of one to four, cephalo-laterals seven to eight, "There are two or three pairs of lobes. The median lobes are well developed and vary in outline; the second lobe of each side is less than one half as large as the median lobes, elongated and with one or two notches on the lateral margin; the third lobe is still smaller and pointed or obselete.+ On the margin are two pairs of incisions, lateral of the first or mesal lobes and the second lobes, respectively. The incisions are not deep but the chitinized thickenings of the surrounding body-wall render them conspicuous. Between the mesal lobes are two inconspicuous simple plates. Simple plates also extend caudad from each of the incisions in the body-wall. "The spines are prominent, especially those lateral of the second and third

+ From original description by Prof. Comstock in the Report of the Entomologist, Year Book United States Department of Agriculture 1880.

lobes; the fourth spines are a little nearer the first lobes than the penultimate segment; and the fifth are nearer the penultimate segment. There is also a spine at or near the union of the last two segments.

Scale of male: Resembles that of the female in color; "it is elongated with the larval skin near the anterior end. This skin is covered by excretion but its posterior is marked by a rose-colored prominence as in the scale of the female; the anterior part of the scale as much more convex than the posterior prolongation, which is flattened. There is a rudimentary ventral scale in the form of two narrow longitudinal plates, one on each side of the lower surface of the scale".+ Length 1.25 mm.

Distribution: This scale has been found over nearly all the United States and in Switzerland.

Host list: Walnut, apricot, apple, pear, peach, cherry, Japan plum, locust, maple, etc.

Aspidiotus ancylus. Putnam.

Eccentric Scale or Putnam's Scale. Plate XII.

Scale of female: nearly circular though more frequently oval than any of its close allies; often distorted by crowding; has a marked tendency to segregation. "Exuviae lateral of

+ Reference as previously.

center and covered with thin layer of secretion. This film is white but is easily removed leaving the brick red exuviae exposed. "Scale is dark gray or almost black with a margin of lighter gray. 1.4 mm. long and 1.3 mm wide.

Female: Light yellow in color. After oviposition begins the body becomes more or less circular; previous to this it is ovate.

Pygidium: Four or five groups of circumgenital gland orifices. The anterior group if present at all may consist of from one to six; though seldom more than three; cephalo-laterals five to eight. Only one pair of lobes is present; these are well developed and notched on the lateral margin. Occasionally there is a small notch near the end of the lobe on the mesal margin." There are two incisions in the margin of the pygidium, either side of the meson, one incision lateral of the mesal lobes and one lateral of the second lobes. These are made conspicuous by the thickened portions of the body-wall surrounding them. There are no plates between the mesal lobes, but extending caudad of each incision are two plates, which may be either simple or toothed. The spines are located one on the base of the mesal lobes, near the lateral margin, and one lateral of each incision. "The fourth pair is at two-thirds the distance to the penultimate segment."

Scale of male: "Scale of male resembles that of female in form but is smaller and more elongated. Length 1.2 mm,

width 0.6 mm.

Distribution: This scale is fairly well distributed over the United States east of the Rocky Mountains, and is found also in Germany.

Host list: Ash, beech, maple, oak, linden, peach, cherry, apple, pear, quince, osage-orange, hackberry, currant, bladder-nut, etc.

Aspidiotus nerii Bouche.

Plate XIII. On Cyperus alternifolii.

Chionaspis pinifolia Fitch.

Pine leaf scale insect. Plate XIV.

No description of these two scales will be given as neither are of economic importance. Chionaspis pinifolii is common on conifers throughout the United States. Aspidiotus nerii, is a greenhouse pest common on oleander and frequently hot house plants.

These are introduced simply to serve as types of the variations in character of the pygidia of different species.

The natural appearance on their hosts is shown at Plate XV.

Fig. 1 shows the typical appearance of a scale insect of the genus Aspidiotus under the magnifying glass.

Fig. 2 is the pine scale on Austrian pine.

Fig. 3 is Aspidiotus nerii on Cyperus.

Chapter VII.

A Sketch of the History of San Jose Scale in the United States With a Brief Bibliography.

Perhaps no insect pest in the annals of economic entomology has caused more wide-spread alarm, been the subject of more legislation, and received more attention at the hands of Experiment workers than that ubiquitous little armoured Coccid known as the San Jose scale. The only insects that can approach it in evil notoriety are the Rocky Mountain locust and the Colorado Potato beetle. The effect of the former was of brief duration and was comparatively localized. The potato beetle, starting from its native home in the Rocky Mountain region about 1859 when potato growing had extended as far west as to invade its natural habitat, began its triumphal march Eastward. It reached the Atlantic sea-board in 1874, "having traversed two-thirds of the continent in the short space of fifteen years". Potato growers have now learned to deal with this pest, however and although widely distributed it is not nearly so important a factor in potato growing as it formerly was. Unlike these pests, the San Jose scale seems not yet to have reached the climax of its destructiveness. Its natural enemies, while doubtless of some help, are not yet sufficient to hold the scale in check and sprays although used by intelligent orchardists are not now applied with enough thoroughness

the country over to anywhere near exterminate the scale.

There are two facts which account in some measure for the destructiveness of this pest. The first of these is general and there have been many similar experiences in the horticultural history of our own country. Briefly stated it is this; that when any organism is placed under new conditions the equilibrium or balance of forces caused by the struggle for existence is upset, and rapid multiplication may be expected in the new environment until a gradual readjustment takes place. This removal of pressure upsetting the natural conditions of its life, has taken place with the San Jose scale. It has been nearly freed from the conditions which tended to hold it in check in its native home; it has found large contiguous areas of congenial food plants; it has been almost entirely relieved from the attacks of its natural enemies, and in so far as the struggle for existence has been thus eliminated, it has spread and multiplied. Other illustrations of this law may be observed in the rapid and destructive spread of some of the American grape diseases when unwittingly introduced into European vineyards. The downy mildew had been comparatively innocuous in America but worked havoc in France till the accidental discovery of Bordeaux mixture brought relief. The history of the Russian thistle in our country may likewise be cited as an illustration of the working of this law.

The other fact which accounts more directly and specifically for the abundance of San Jose scale is this: the natural parasites of the insect do not seem able to adapt themselves to change in climatic conditions so rapidly as their host. The scale will spread and thrive where its parasites, which had held it in check in the locality to which it was indigenous seem unable to follow. These considerations together with the fact that San Jose scale has several broods a year in most localities, seem abundant to account for its rapid spread and its deadly menace to the plants which become infested by it.

This insect was first discovered in the United States in the early seventies. It was found on the grounds of Mr. James Lick, near San Jose, California by Mr. J. H. Comstock, now professor of entomology at Cornell University. By him it was described and named Aspidiotus perniciosus or the "pernicious"scale. The name of the locality in which it was first found however, has continued to be the appellation by which it is commonly designated by horticulturists throughout the country. The plants upon which it was found on Mr. Lick's grounds were supposed to have been imported from South America and it was thought for a time that Chili might have been its native home. Later it was found on Japan plums and the scale was thought to be native to Japan. Lately however it has been found by Mr. Marlatt of the Bureau of Entomology working in the interior of China, where the possibility of outside

infection was too remote to be considered and it is now generally agreed among entomologists that to China must be given the credit of producing this pest. After attention had been called to Aspidiotus perniciosus by Comstock, it was found in many parts of California. It spread rapidly and came to be a serious menace to the fruit growers of the Pacific coast before it was discovered in the East. It was first found in the East in 1893 on the grounds of Mr. C. H. Hedges of Charlottesville, Va. It had previously been supposed that the climate of the Eastern United States was unfavorable for the development of this scale and hence the discovery in Virginia was viewed with alarm and perturbation by all who recognized the danger of its attacks. The source of the infestation in Virginia was later found to have been currant bushes from a New Jersey nursery. Early in 1894 specimens from Florida were determined to be San Jose by Dr. L. O. Howard of the Bureau of Entomology of the Department of Agriculture. "Immediately upon receipt of the Florida specimens Mr. Howard concluded that the scales had been found in three such widely separated localities, and as the information gained from the owners of two of the affected orchards led to the supposition that the original stock had been obtained from a large Eastern nursery, the probabilities were strong that the scale had established itself in many Eastern points during the preceding five or six years. He therefore immediately prepared a circular

of warning and had nearly 12,000 copies mailed early in April to all Eastern agricultural newspapers and to very many Eastern fruit growers." By this means many new points of infestation were discovered in the East. The source of all this infestation was undoubtedly two New Jersey nursery firms which had been sending out infested stock for several years preceding, not knowing the dangerous nature of the scale with which their stock was affected. These nurseries either in 1886 or 1887 had both received Japan plum trees from California, one of them direct from San Jose, the very center of Western infestation. These trees had spread the scale throughout the nurseries and through them it had been widely disseminated in the Eastern States.

Since that time the scale has been spreading rapidly in every direction, and no fruit growing district if not already infested, need hope long to escape invasion by this pest. The San Jose scale is now so thoroughly intrenched in nearly all parts of the country that its complete extermination can never be accomplished. It is here to stay. From now on it can be counted a permanent factor in fruit growing. But there is no cloud without its silver lining and the opinion has already been expressed that the San Jose scale is a blessing in disguise. If it causes the neglected worn out orchards which are scattered so abundantly over the state, to be either cleaned, pruned and sprayed or taken out; if it drives the

slovenly neglected orchard out of existence, and the slovenly, careless, neglectful grower of poor fruit out of business and compels better care of remaining orchards, raises the standard of intelligence and efficiency among the remaining fruit growers, then the San Jose scale evil will indeed be a blessing in disguise and its coming will be looked back upon as marking the advent of a new era in horticulture.

Bibliography.

Probably more has been printed about the San Jose scale than about any other insect of economic importance. An exhaustive bibliography of San Jose scale literature would not only contain many references to almost the same work, but would be of no practical value and if inserted at this place would tend to confuse rather than to aid. Only a short list therefore is here appended of some of the bulletins and works on Coccidae which have been found by the writer to be most helpful.

Report of the Entomologist -- Year Book of United States Department of Agriculture for 1880. J. H. Comstock.

Second Report of the Cornell University Experiment Station 1882-3. J. H. Comstock.

Manual for the Study of Insects. J. H. Comstock. Edition of 1895.

Bulletin 3 New Series, United States Department of Agriculture, Division of Entomology,- The San Jose Scale- Its Occurrence in the United States. L. O. Howard and C. L. Marlatt.

Bulletin 12, New Series,- United States Department of Agriculture, Division of Entomology,:-The San Jose Scale in 1896-1897. L. O. Howard.

Bulletin 6, Technical Series, United States Department of Agriculture, Division of Entomology,- The San Jose Scale and Its Nearest Allies. T. D. A. Cockerell. 1897.

The Coccid Genera Chionaspis and Hemichionaspis, Special Bulletin Hatch Experiment Station of the Massachusetts Agricultural College, 1899. R. A. Cooley.

Bulletin 180, Michigan Agricultural College, Experiment Station,- Some Insects of the Year, 1899. R. H. Pettit.

Second Annual Report of the Michigan Academy of Science,- The Scale Insects or Coccidae. R. H. Pettit. 1900.

Bulletin 200, Michigan Agricultural College Experiment Station,- Some Insects of the year 1901. R. H. Pettit.

Bulletin 141, Virginia Agricultural Experiment Station ,- Orchard Studies XIV., The Lime-Sulphur Wash. By J. L. Phillips. 1902.

Catalogue of the Coccidae of the World. Fernald. 1903.

A Monograph of the British Coccidae. R. Newstead, 1903.

Bulletin 254, New York Agricultural Experiment Station,- Fall Spraying With Sulphur Washes. P. J. Parrott and T. A. Sirrine, 1904.

Bulletin 152. Virginia Agricultural Experiment Station,- Experiments with Caustic Soda and Some Patent Washes Against the San Jose Scale. By J. L. Phillips, 1904.

Bulletin 247, New York Agricultural Experiment Station,- The Lime-Sulphur:Soda Wash for Orchard Treatment. P. J. Parrott, S. A. Beach and H. O. Woodworth. 1904.

Bulletin 262, New York Agricultural Experiment Station,- Sulphur Washes for Orchard Treatment. P. J. Parrott, S. A. Beach and T. A. Sirrine. 1905.

American Insects,- Kellogg . 1905.

The Coccidae of Kansas. Hunter. 1905.

Journal of the American Chemical Society, Vol. XXVII. Composition of the Lime Sulphur and Salt Wash. J. K. Haywood, 1905.

Bulletin 90, Mississippi Agricultural Experiment Station,- The San Jose Scale in Mississippi and the Lime-Salt Sulphur Wash. Glen W. Herrick. 1905.

A study of the Lime-Sulphur-Salt-Soda Wash. J. K. Haywood. (Advance Copy) 1905.

Bulletin 166, California Agricultural Experiment Station,- Spraying for Scale Insects. H. J. Quayle, 1905.

Bulletin 186, New Jersey Agricultural Experiment Station,- Late Fall Spraying for the San Jose or Perniciosus Scale. John B. Smith.

Plate I.

Plan of a portion of H. P. Gladden's pear orchard, showing varieties and trees sprayed. The trees marked in yellow (X) were sprayed with the lime-sulphur wash; otherwise as indicated by the enclosures on map.

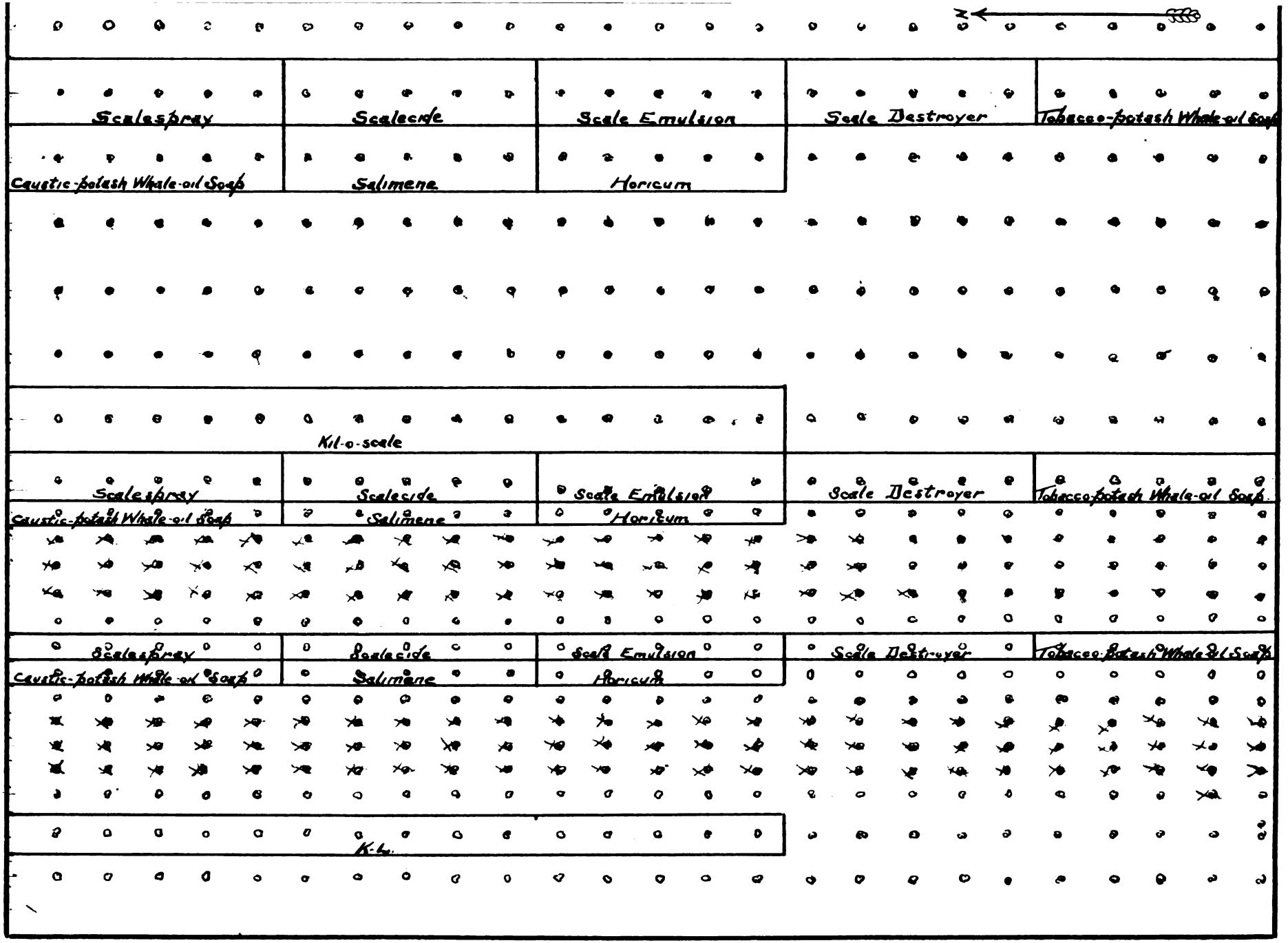

N
Scalespray
Scaleside
Scale Emulsion
Scale Destroyer
Tobacco-potash Whale-oil Soap
Caustic-potash Whale-oil Soap
Salimene
Horicum
Kil-o-scale
Scalespray
Scaleside
Scale Emulsion
Scale Destroyer
Tobacco-potash Whale-oil Soap
Caustic-potash Whale-oil Soap
Salimene
Horicum
Scalespray
Scaleside
Scale Emulsion
Scale Destroyer
Tobacco-potash Whale-oil Soap
Caustic-potash Whale-oil Soap
Salimene
Horicum
K-L

Plate II.

Location of the infestations of San Jose scale on the Michigan Agricultural College Campus.

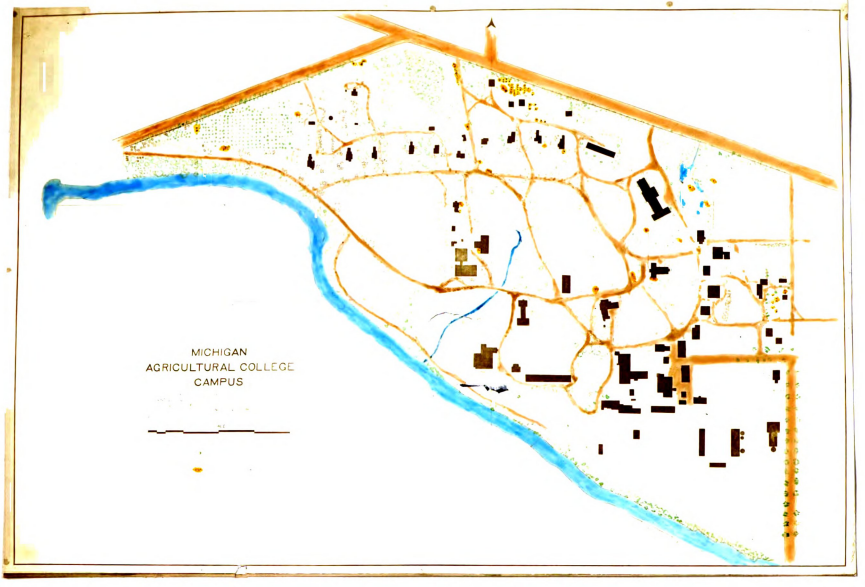

MICHIGAN
AGRICULTURAL COLLEGE
CAMPUS

Plate III.

Fig. 1. Oyster-shell Bark louse, (Mytilaspis pomorum) on twig of apple. Enlarged.

Fig. 2. Parasitized Lecanium on Wild Cherry. Enlarged.

Fig. 3. Oyster-shell Bark louse, (M. pomorum) on twig of apple. (Enlarged).

FIG. 1.

FIG. 2.

FIG. 3.

Photo. L.G.W.

Plate IV.

Fig. 1. San Jose scale (aspidiotus perniciosus) on bark of peach twig. (Enlarged).

Fig. 2. San Jose scale encrusting bark of peach branch. (Enlarged.)

Fig. 3. San Jose scale on Japan quince. (Enlarged.)

FIG 1.

FIG 2

FIG 3.

Photo. C.G.V.

Plate V.

Fig. 1. Adult female of San Jose scale hibernating on peach twig. (Enlarged.)

Fig. 2. San Jose scale on fruit of apple. (Slightly enlarged)

Fig. 3. San Jose scale on fruit of apple. (Enlarged)

Photos by Mr. R. H. Pettit.

FIG 1

FIG 2

FIG 3.

Plate VI.

Fig. 1. European fruit scale (Aspidiotus ostreaeformis) on spiraea sambucifolia. (Enlarged)

Fig. 2. Red scale of California (Aspidiotus aurantii) on fruit of orange. (Enlarged)

Fig. 3. At left Willow scale (Chionaspis salicis) on poplar. At right European fruit scale on spiraea. (Enlarged)

FIG 1

FIG 2

FIG 3.

Photo CGW

Plate VII.

Fig. 1. Chionaspis euonymi(?) n euonymues. The small white carinated scales are males, the larger dusky ones are females. (Enlarged)

Fig. 2. Portion of leaf shown in Fig. 1 still further magnified.

Fig. 3. Scurfy bark-louse (Chionaspis furfurus) on twig of apple. (Enlarged)

Fig 1

Fig 3.

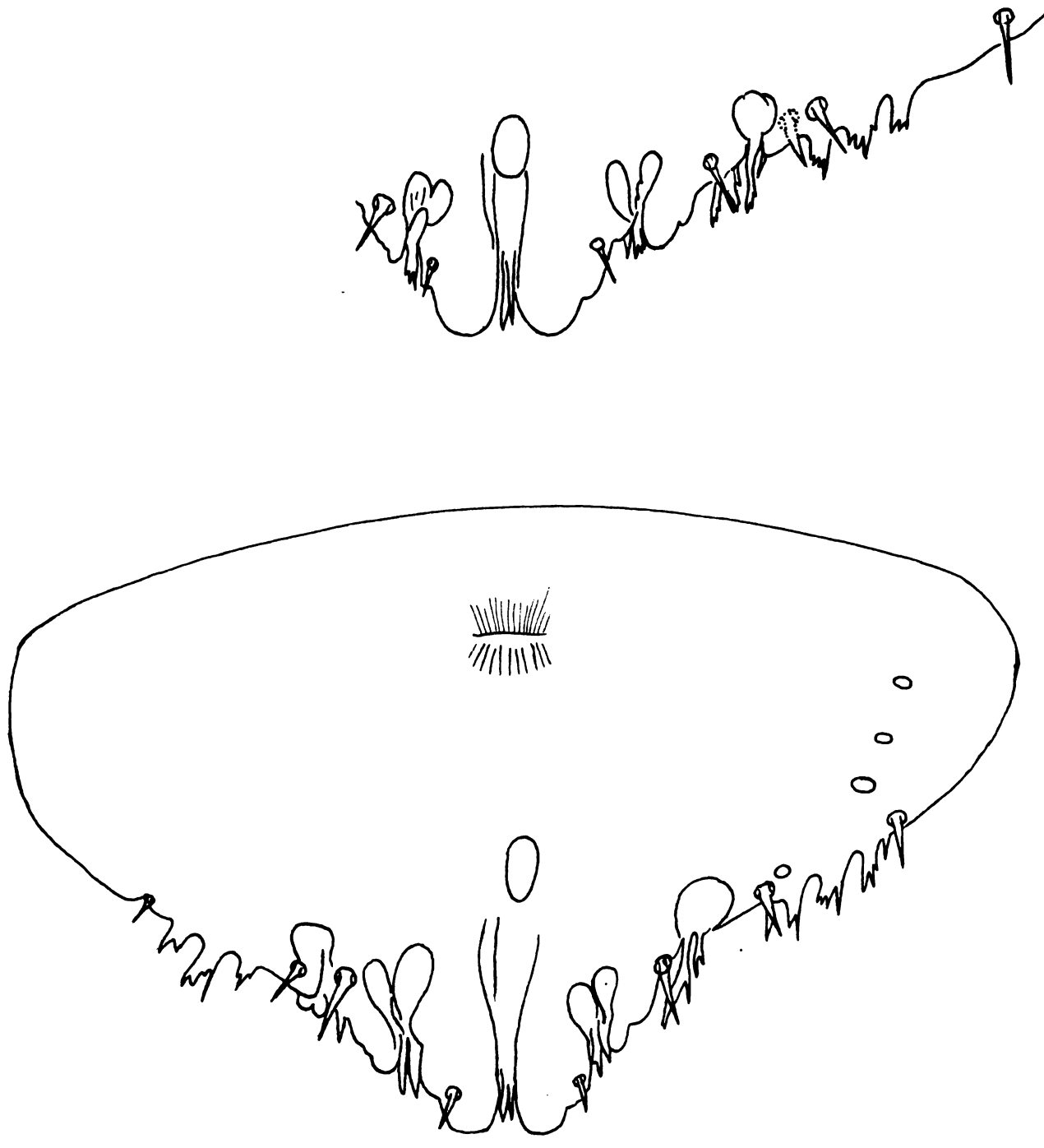
Fig 2

Photo C&W

Plate VIII.

San Jose scale -- Aspidiotus perniciosus

Pygidium of female.



DGW. Ged. ad net.

Plate IX.

European fruit scale (Aspidiotus ostreaeformis)

Pygidia of adult females.

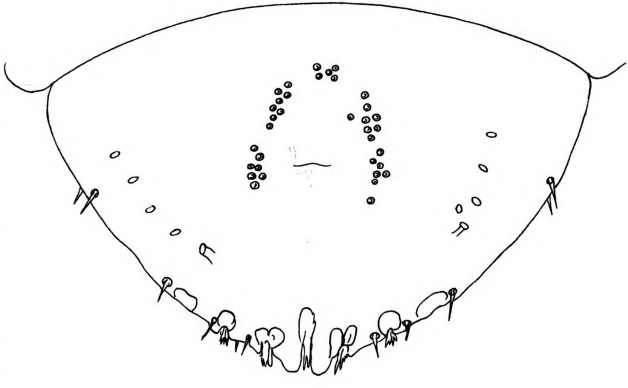


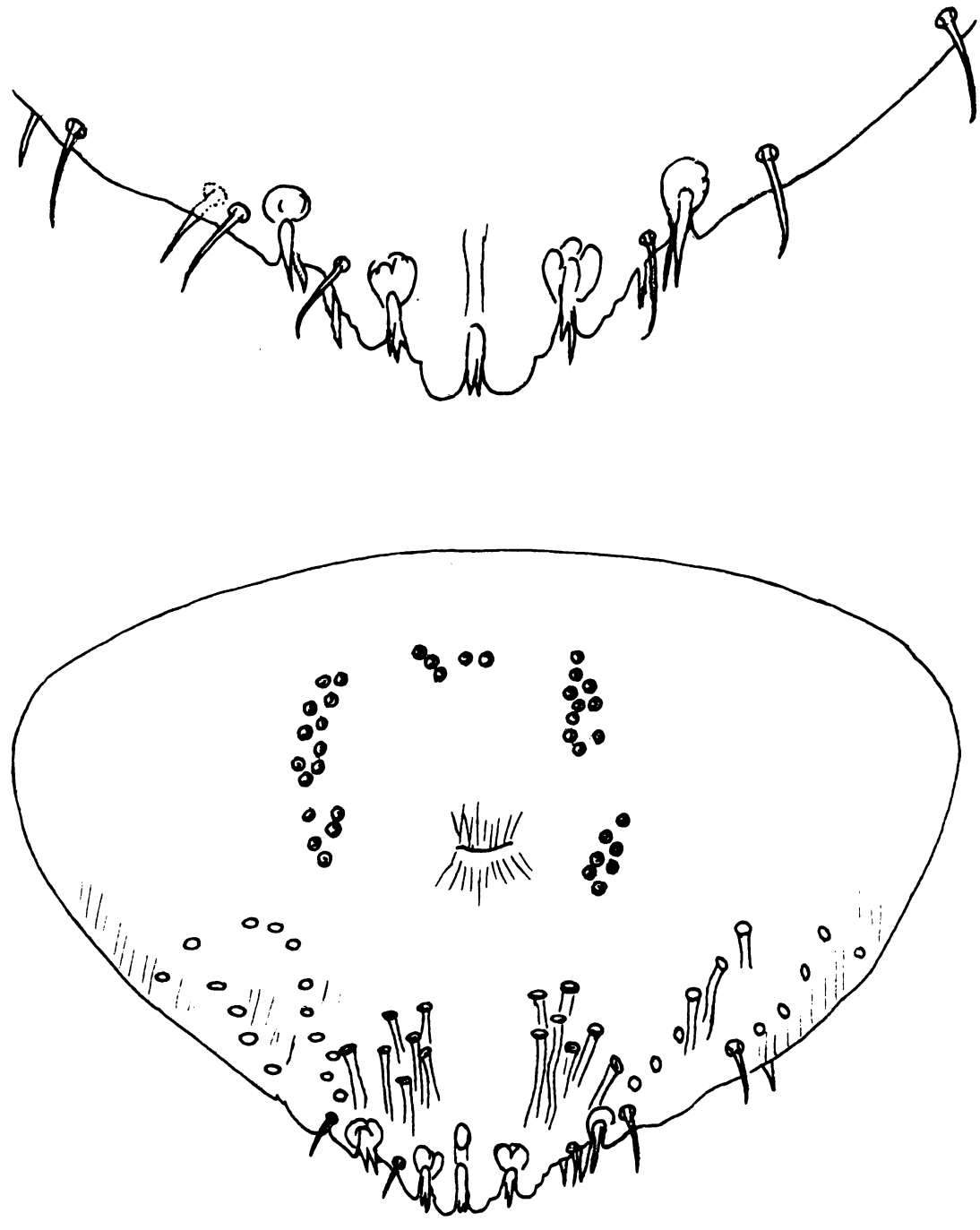
Plate X.

European fruit-scale (Aspidiotus ostreaeformis)
Portions of pygidia of females showing variations in mesal lobes.

Plate XI.

English-walnut scale--Aspidiotus juglans-regiae.

Pygidia of Females.



D(a)V. del. ad nat.

Plate XII.

Eccentric scale (Aspidiotus ancylus)

Pygidium of female.

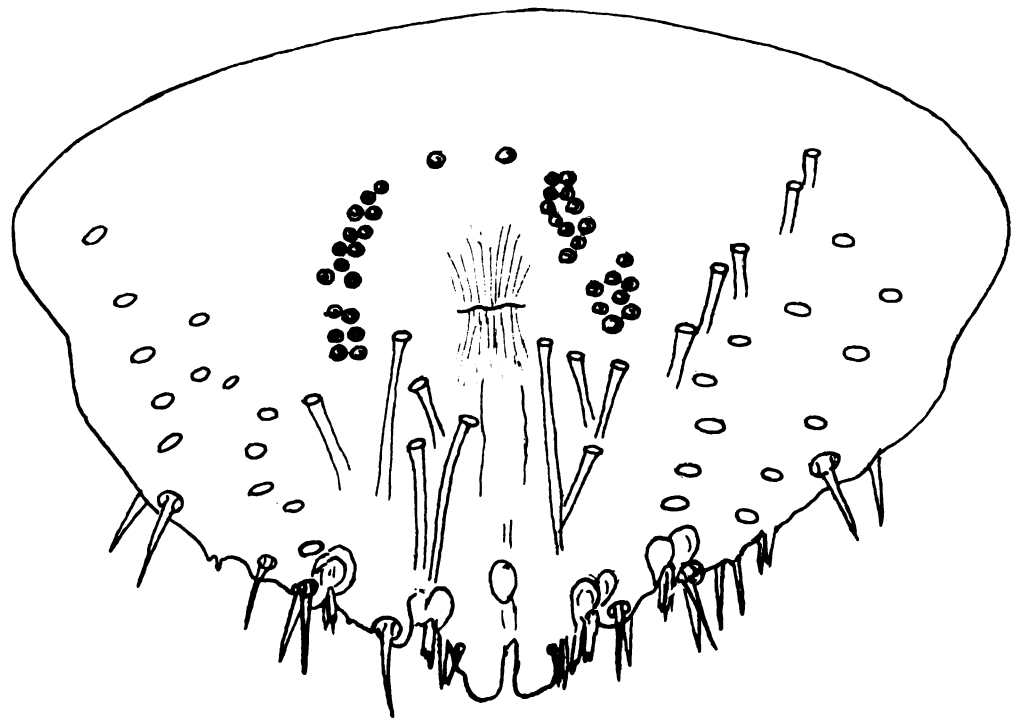
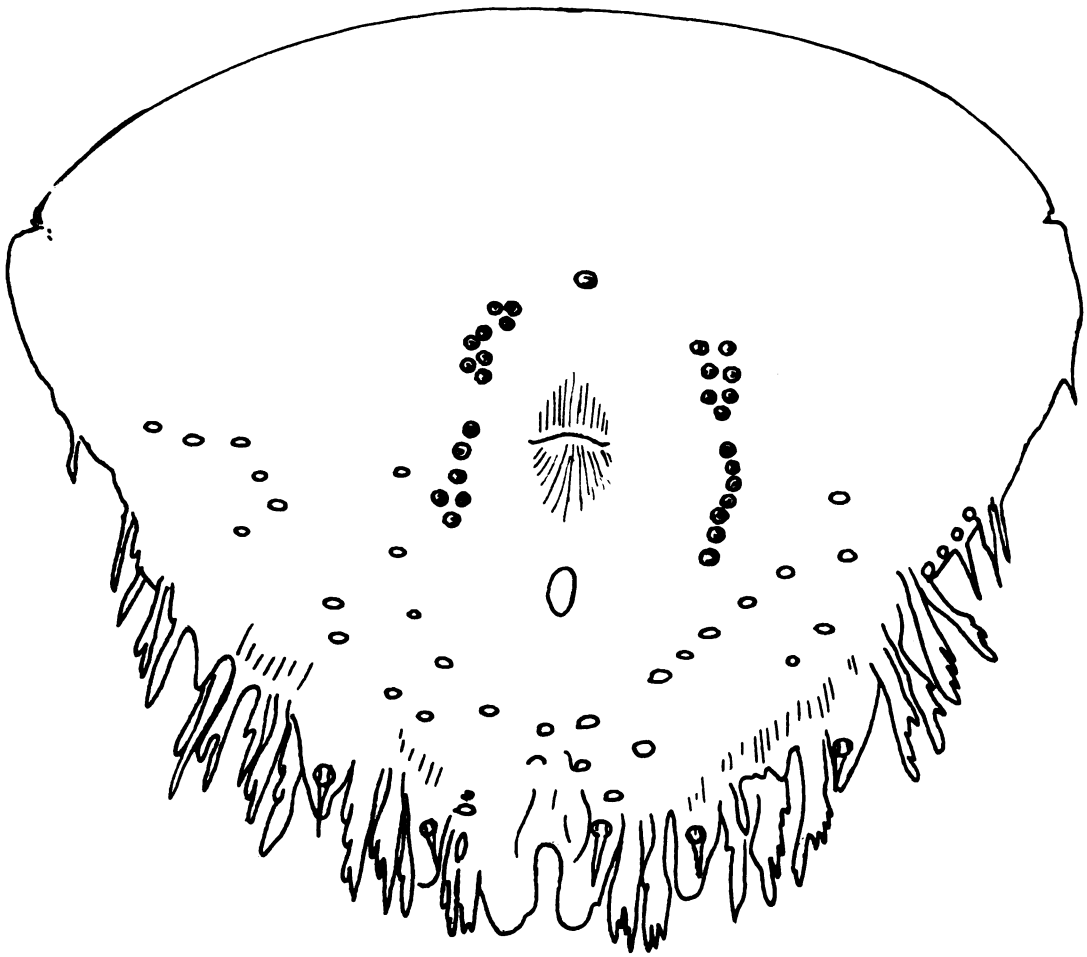


Plate XIII.

Aspidiotus nerii Bouche.

Pygidium of female.



GV del. ad nat.

Plate XIV.

Chionaspis pinifolii Fitch.

Margin of pygidium of female.

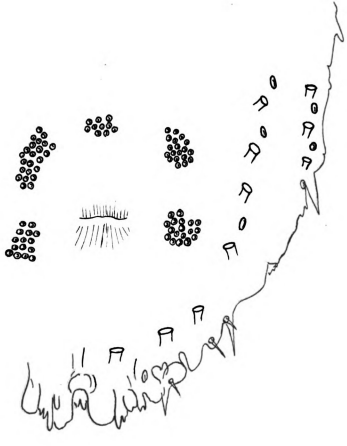


Plate XV.

Fig. 1. Typical appearance of a scale insect of genus Aspidiotus under the compound microscope.

Fig. 2. Pine scale, (C. Pinifolii) on Austrian pine.

Fig. 3. Aspidiotus nerii on Cyperus alternifolia.

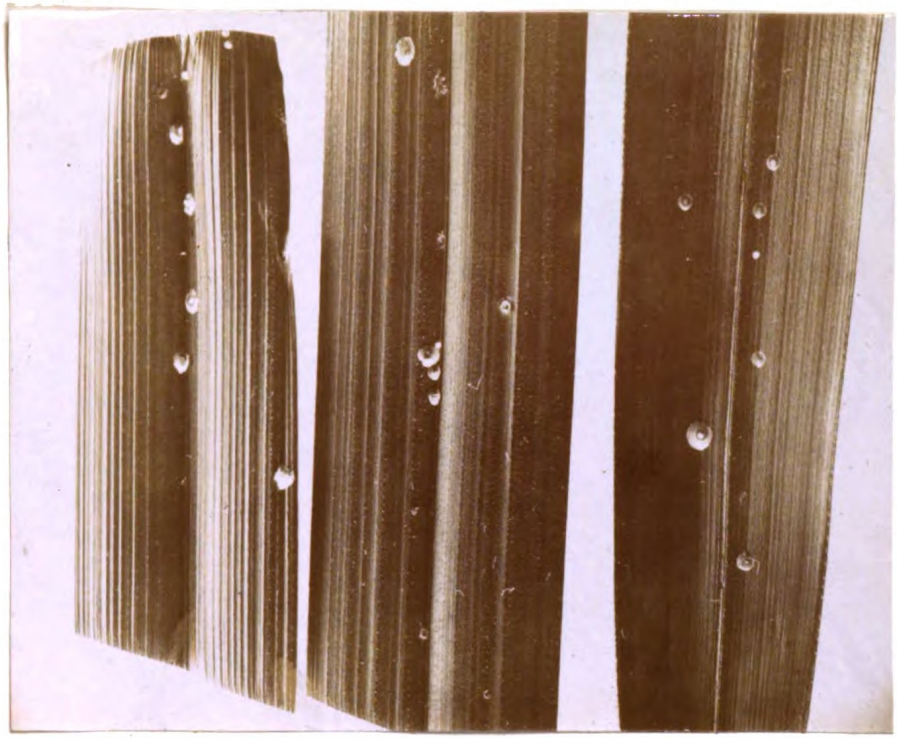


FIG 3.

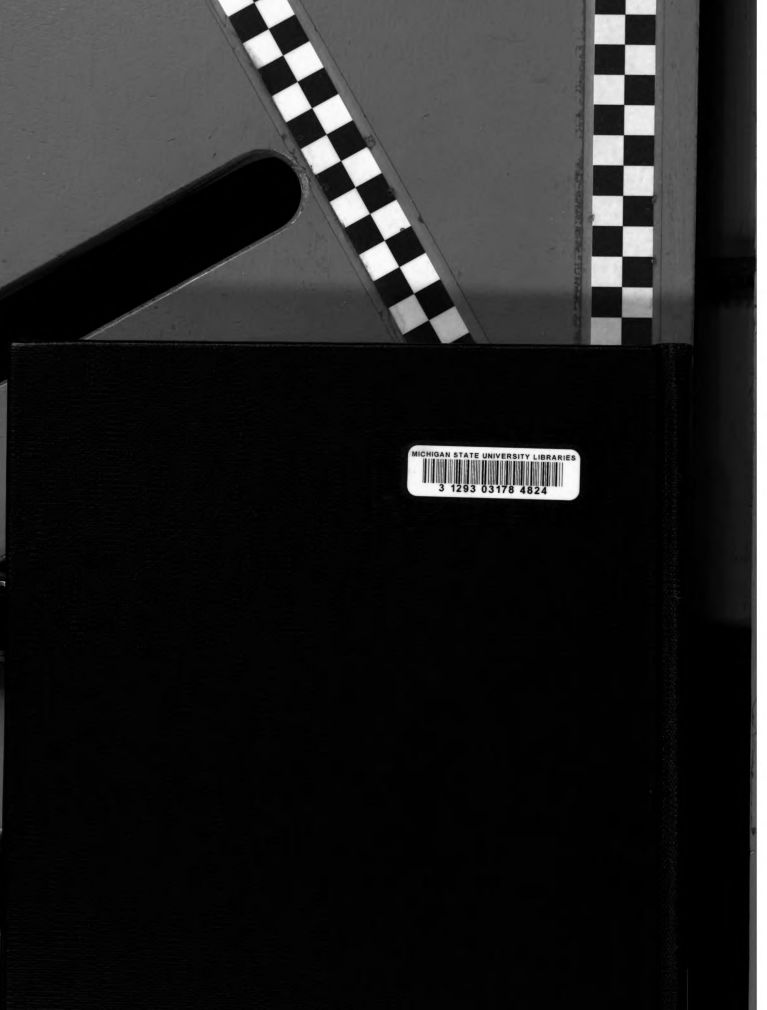
FIG 1.

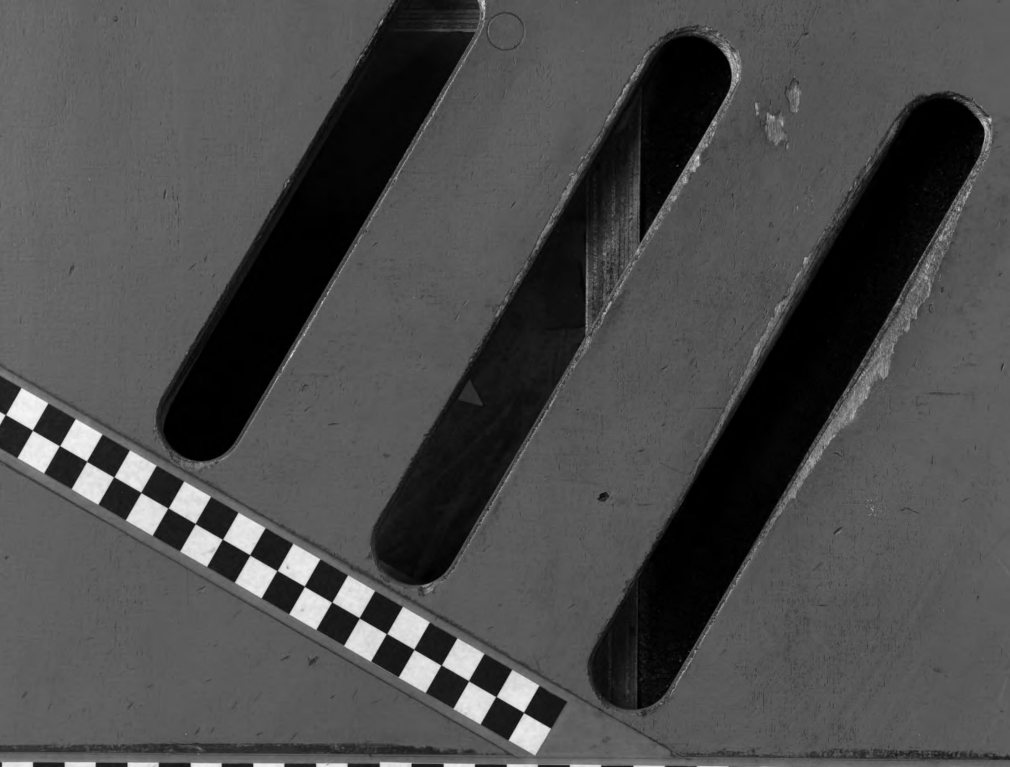
FIG. 2.

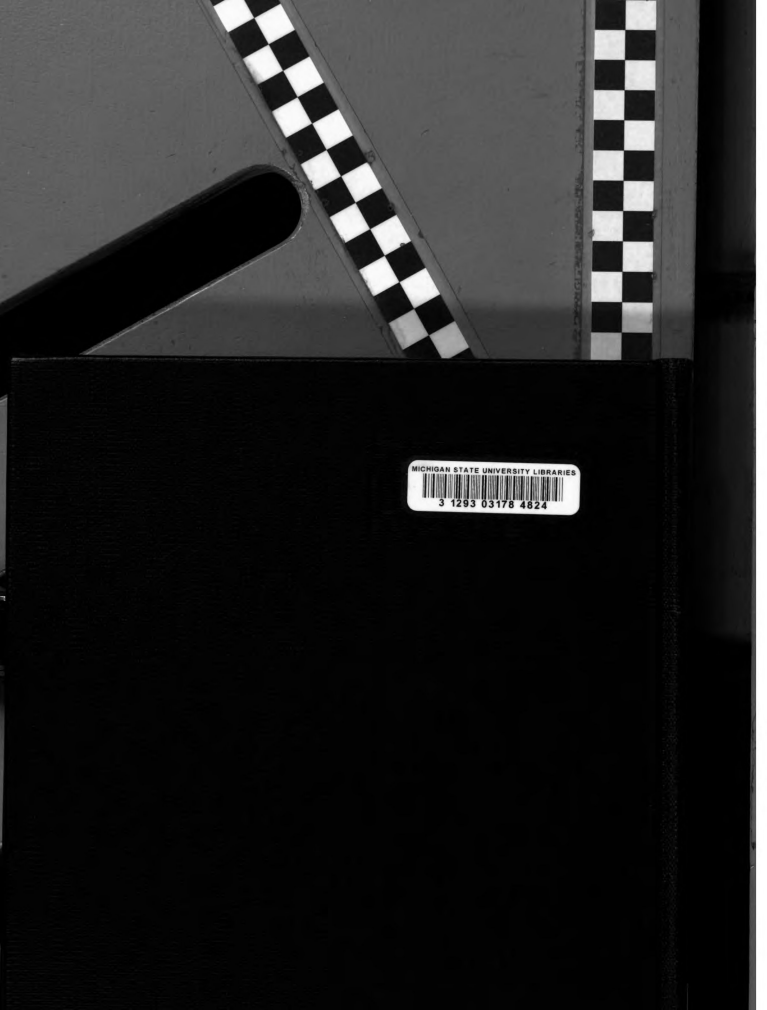
Photo C.G.W.

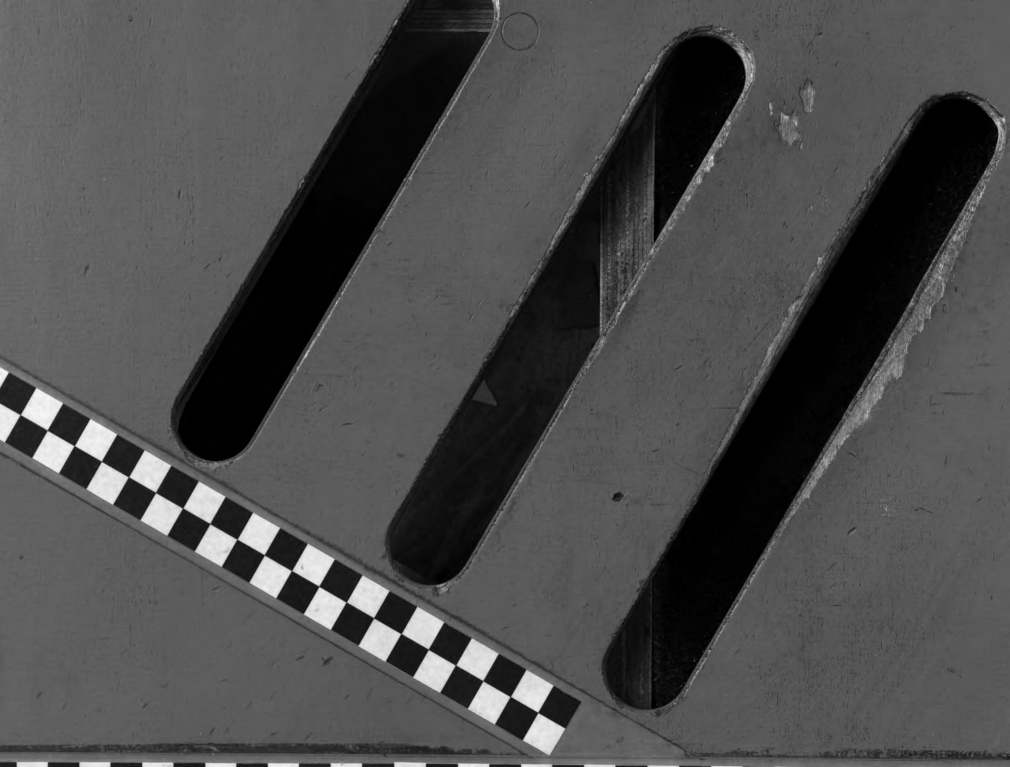
15


MICHIGAN STATE UNIVERSITY LIBRARIES
3 1293 03178 4824


MICHIGAN STATE UNIVERSITY LIBRARIES
3 1293 03178 4824




MICHIGAN STATE UNIVERSITY LIBRARIES
3 1293 03178 4824



MICHIGAN STATE UNIVERSITY LIBRARIES
3 1293 03178 4824