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HYDROCYANIC-ACID GAS AGAINST HOUSEHOLD INSECTS.

The use of hydrocyanic-acid gas for nursery stock affected by insects is described in Circular No. 42 (second series), of this Office. Its use on trees in orchards is described in the Yearbook of the U. S. Department of Agriculture for 1900 (pp. 257–260).

Recently it has been fully demonstrated that this gas is an excellent remedy for household insects. Probably its first use for this purpose was in June of 1898 by Mr. Marlatt, of this Office, against Psocids in the residence of Mr. G. K. Holmes, of the Division of Statistics of the Department of Agriculture, using the cyanide first at the ordinary strength employed on fruit trees, then double, and finally quadruple the strength. The Psocids came from recently introduced leather-covered furniture, the covering of which was so tightly fastened as to be almost, if not quite, impervious to the gas; and the treatment was only partially successful. Another early use of this gas for household insects was in 1899 in San Francisco by Mr. Alexander Craw, Chief Quarantine Officer of the Board of Horticulture. In this case it was used against bedbugs, and in very small proportions. Two and one-half fluid ounces of commercial sulphuric acid and 2½ ounces 98 per cent cyanide of potassium were used in a house of several rooms, each containing about 2,250 cubic feet of space; the rooms were closed for two hours, then entirely aired. The operation was apparently successful.

To determine its availability against the insect enemies of stored products or in granaries, some experiments were made during 1898 and the spring of 1899 by Messrs. Marlatt and Chittenden, of this Office, in the presence of D. G. Fairchild and others, against certain grain weevils and the Angoumois grain moth, but with imperfect success, although the proportions used were much greater than in Mr. Craw's experiment. In his recent book on fumigation methods, Prof. W. G. Johnson states that he used the hydrocyanic-acid gas in a granary and storehouse in June, 1899, using it at the rate of 0.1 gram of cyanide per cubic foot of space. The granary was affected by weevils, and, from the report of the owner, it appears that most of them were destroyed, though many escaped. During the same month in an Ohio mill another experiment of this kind was carried on under Professor Johnson's instructions. The owner considered the experiment to be a most grand success. The Mediterranean flour moth and certain granary beetles were destroyed.

Perfectly successful experiments were made, however, during the summer of 1901 by Mr. W. R. Beattie, of the Department of Agriculture, and by Mr. A. H. Kirkland, of Boston, Mass., formerly Secretary of the Association of Economic Entomologists. Mr. Beattie's experiments were against cockroaches, and Mr. Kirkland's in one case against fleas and in the other against clothes moths.

Entomologists have long noticed that insects vary greatly in their susceptibility to cyanide fumes. The ordinary killing bottle used in making collections contains cyanide of potassium covered with plaster of Paris, which the fumes of the cyanide penetrate. Certain weevils, and especially such weevils as Lixus and Sphenophorus and other hard-bodied forms, will frequently be left overnight in a cyanide bottle and recover after being removed. It has been noticed, also, that in greenhouses certain insects recover. The experience gained, however, indicates that the use of hydrocyanic-acid gas in houses is successful against cockroaches, bedbugs, clothes moths, ants, white ants, house flies, and other soft-bodied insects; and as these constitute the majority of the household pests, the use of the gas must now be considered a standard remedy. Moreover, rats and mice are also killed by its use.

Some entomologists recommend as a substitute for hydrocyanic-acid gas a substance which has been more or less effectively used, viz, carbon bisulphide. The great danger in the use of this latter substance, however, from its extreme inflammability and explosiveness of its vapor when confined, renders it, perhaps, less available and more than counteracts the danger to human beings from the use of the hydrocyanic-acid gas.

Recent experience indicates that in order to destroy the household insects mentioned, one fluid ounce of commercial sulphuric acid, diluted with two fluid ounces of water, to increase the bulk of the liquid and insure complete chemical action, and one ounce of high-grade (98 per cent) cyanide of potassium must be used for every 100 cubic feet of space.

Before performing the operation the house must be vacated, and it is well to do this just before nightfall. It is not necessary to remove any of the furniture or household belongings unless of polished nickel or brass, which may tarnish a little. Liquid or moist foods, as milk or other larder supplies that are not dry and might absorb the gas should be removed from the house. All fires should be put out, for while the gas will not burn under ordinary conditions, it is as well to take no risks.

On the floor of each room should be placed a large porcelain wash basin, and into each wash basin should be poured the proportionate amount of water and sulphuric acid. It may be well to place under each wash basin a thick layer of newpapers, in order to avoid

damage to carpet or rugs by the possible spattering of the acid acting upon the cyanide. All windows must be closed, and if they are not tight they should be calked with thin paper or cotton batting. Then the operator, beginning at the top of the house, drops the proportionate amount of cyanide of potassium, previously weighed out into thin paper sacks, into each washbowl, running rapidly from room to room and instantly closing the door behind him, descending ultimately to the ground floor or even to the cellar, running finally into the open air through the open door, which is instantly closed.

Hydrocyanic-acid gas is lighter than air and consequently rises. Therefore, the operation must be begun at the top of the house. The next morning the operator returns to the house, opens the last door, allows a certain amount of airing; then enters hurriedly and opens the windows of the first room or floor; then, after the thorough airing of this one, another in turn, thus gradually airing the whole house. The fumes quickly overcome and are fatal to human beings; hence the necessity for the utmost care and greatest speed in the initial operation and in the subsequent airing, and the undesirability of performing the experiment alone. The house should not be reinhabited until all trace of the odor of the gas has disappeared. This odor resembles that of peach kernels.

The experience of Mr. Marlatt and Mr. Kirkland indicates that the operation can be safely performed in the manner indicated, but there is another way which was originally invented in greenhouse work. An ingenious person, by means of strings and improvised pulleys, can arrange it so that standing outside and loosening the string the cyanide suspended over the receptacle may be dropped simultaneously into the sulphuric acid. It will be, perhaps, not necessary to go into details, since any ingenious person can devise such an arrangement. It is, however, not so certain as dropping the cyanide by hand, since a caught string here or there might lessen the completeness of the fumigation.

While the writer must again emphasize the dangerous and even fatal qualities of this gas when breathed by human beings, it is worthy of remark that in the thousands of operations which have been carried on with this gas in specially constructed houses for the fumigation of nursery stock in the different parts of the country, no cases of fatal accident to a human being have ever been recorded. In one instance mentioned by Prof. W. G. Johnson, a careless negro was overcome by the gas and was removed from the inclosure (dragged out by the feet) before serious results followed.

It follows, from what we have just said, that there may be danger from fumigating one house in a row of houses separated only by party walls, the other houses being inhabited. Unnoticed cracks in a wall would admit the poisonous gas to the neighboring houses. In

such a case a householder must consult his neighbors. In isolated houses, however, with the precautions indicated, the operation will be a safe one. The fact that Mr. Kirkland observed that English sparrows resting on the ridge of one of his houses were killed by the ascending fumes indicates, also, that where the house to be operated upon immediately adjoins a higher structure to which the gas may possibly gain entrance, there may be some danger to the occupants of the higher structure.

A PRACTICAL ILLUSTRATION.

Subsequent to the preparation of the foregoing portion of this circular a large dwelling house in Washington, D. C., was fumigated under the direction of Mr. Marlatt, and the following notes, based on this experience, are appended to more fully illustrate the fumigation process. The house was a fairly good-sized one, and all five floors, counting the garret and the basement, were treated, the space representing nearly 40,000 cubic feet and requiring the use of some 25 pounds of cyanide and a corresponding quantity of acid.

The cubic contents of each room on each floor were carefully computed, and a tabular statement, given below, was prepared designating for each floor and the different rooms the capacity and the amount of water, acid, and cyanide needed.

Table designating rooms, capacity, and amounts of chemicals.

Floor.	Room.	Cubic feet.	Water.	Acid.	Cyanide.
			Fl. oz.	*Fl. oz.*	*Avd. oz.*
Fourth	Garret	*7,000	140	70	70
Third	Front	2,800	56	28	28
	Middle	1,400	28	14	14
	Back	2,200	44	22	22
Second	Front	*5,500	110	55	55
	Middle	2,200	44	22	22
	Back	2,000	40	20	20
First	Parlor	*4,400	88	44	44
	Middle	2,400	48	24	24
	Dining	2,900	58	29	29
Basement	Servant's	1,200	24	12	12
	Hall	2,000	40	20	20
	Kitchen	1,800	36	18	18
Total		39,800	756	378	378

*The charges for these rooms were halved and set off in two vessels.

The rooms were prepared for treatment by seeing that all windows were closed and that the doors and windows of the ground floor were left unlocked or unfastened, so that they could be opened from without. The fireplaces in the different rooms were stuffed with paper and the registers were all closed. The carpets and rugs, where possible, were cleared away from the floor to prevent their being burned should the acid spatter out or boil over, and a large porcelain wash-basin or a porcelain waste jar was put in each room,

two such vessels being placed in the larger rooms. Under each a carpeting of old newspapers was placed. A number of vessels had to be discarded because of cracks, which would be dangerous in view of the heat generated by the process.

The house having been put in a state of readiness for the experiment, and the vessels for the charges having all been placed in their proper locations, the requisite amount of water indicated by the table already prepared (twice the amount of the acid) was poured into each of the different vessels. Following this, the proportionate amount of acid for the different rooms was added to the water in the vessels, the addition of the acid developing a high temperature. The cyanide having been previously weighed out in half-pound lots and put in small thin paper bags, was distributed through all the different rooms in the proper amounts. The division of the bags for the fractional weights was made at the time the bags of cyanide for each charge were placed by the side of the vessels to receive them. The house was now in readiness to be fumigated. Coats and hats and everything needed outside were removed, and two persons went to the garret of the house and quickly placed the bags of cyanide in the already combined water and acid, passing rapidly down to the next floor and repeating the operation, and so on until the basement was finished and the escape was made from the basement door to the street.

The preparation of the different rooms, getting their cubic contents, fixing the vessels, and preparing the charges consumed, in a house of this size, nearly three hours. The gas was left to do its work for three hours longer. The house was then opened cautiously, the doors and windows of the lower floor first, then proceeding by easy stages through the different floors to the garret. The gas coming out of the house when the first doors and windows were opened was in enormous volume, showing that the house had retained it very effectually, and escaping from the house it was distinctly recognizable by its odor at a distance of over half a block. The windows of the adjoining houses were kept closed during the process of airing out. One of the assistants who attended to the aerating of the house was rather too precipitate in going to the upper rooms and breathed more or less of the gas, but suffered no worse results than a rather severe headache which lasted for several hours.

The results of the fumigation were eminently satisfactory; no living insects could be found in the house. The roaches, by thousands, had come out from their hiding places in a vain effort to escape, and had rushed to the cracks under doors and windows, and had there perished. Sometimes they had the appearance of being alive and about to run, and a touch was necessary to demonstrate that they were dead, having been arrested instantly while in motion,

their limbs extended in the normal position for running. Flies, roaches, and bedbugs, and without doubt all the other household pests were killed. The bedbugs, against which the fumigation was especially directed, were found dead in numbers under trunks and about the beds.

The ingredients used were the 98 per cent cyanide of potassium, costing about 40 cents a pound. The sulphuric acid was the thick, almost sirupy commercial brand, costing about 4 cents a pound, the total cost of the materials used being, approximately, $12.

In handling the acid great care should be used in pouring it from the bottle and in putting it into the vessels to avoid spattering on the hands or face, since it will burn rapidly through the skin, and should it spatter into the eyes would cause serious inflammation, or if on the clothing it would burn a hole in the garment. Should a drop fly to the hands or face, bathe the part promptly and freely in water, and the same also for garments or the carpet. It is further desirable to have at hand a bottle of ammonia water to neutralize the acid should it spatter on clothing. The cyanide should be broken up into lumps not exceeding twice the size of a walnut, the powdered and smaller fragments serving equally well. The bags should be of very thin paper. If they are of thick, heavy paper, the action of the acid is delayed, and sometimes prevented completely. If there is any danger of this make two or three slits in the bottom of the bags to facilitate the entrance of the acid. Deep vessels are more satisfactory for the experiment than the wash basins chiefly used, but the latter were available and required no additional expense and served the purpose. Deeper vessels would give greater depth to the water and acid, and accelerate the chemical action. Whenever the room is of such size that more than 2 pounds of cyanide must be employed for it, it is perhaps better to make two charges of half size for such a room. It would have been better, perhaps, in this instance, if the fumigation could have gone on over night, but the owners of the premises were very desirous of occupying it, and the house was aerated between 4 and 5 o'clock in the afternoon. Three persons, contrary to orders, slept in the rooms during the night, and reported no ill effects, although slight traces of the odor were noticeable in the early part of the night.

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Approved:
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