FUMIGATION AND FUMIGANTS.

(*John L. Froggatt, B.Sc., Entomologist.*)

Insect pests infesting many forms of agricultural products, as well as orchard trees and nursery stocks, can be most effectively treated by the process of fumigation.

This is essentially a combined chemical and entomological matter; the chemical side comprising the study of gases for the dilution or saturation of the atmosphere surrounding the objects to be treated, which will be poisonous to the pests and non-poisonous to the materials on which the pests may be feeding. The entomological side of the work is to study the reaction of insects and plants to the different vapours and gases used, and determine the limits of susceptibility to each poison used of both pests and hosts.

As the chemical used, known as the fumigant, is a poisonous vapour or gas, it is essential that the greatest care be taken to render the enclosure inside which fumigation is to be carried out perfectly gastight. All cracks, holes and other openings must be closely sealed as the first step in the proceedings; pasting strips of brown paper over all such is generally sufficient, unless they are large. Lack of attention to such matters will easily lead to failure in results, and may even lead to the death of animals, or humans, in the vicinity of any leaks.

Provision for efficient ventilation after the process is completed is also essential before starting operations, in the case where buildings are to be treated. Furthermore, the work must be arranged to allow a margin of safety to enable the operator to leave the enclosure before the fumes become sufficient to catch him.

As the quantity of the fumigant, called the "dosage", depends on the cubic capacity of the enclosed space in which the operations are to be carried out, this must first be accurately determined.

Where live plants are not to be treated, the exposure to the gas should be from eight to twelve hours; with plants, the exposure is somewhat shorter.

Fumigation of orchard trees is carried out under specially prepared tents, and, where limited quantities of grain are to be treated, proofed tarpaulins can often be used. In all such cases, the bottom of the canvas must be covered over in such a way as to prevent escape of the fumigant.

Fumigation chambers for general purposes are made of concrete faced with bitumen, and provided with air-inlet valves at the bottom, and an air-exhausting plant at the top. Doors must be made so as to be gas-tight, as also must all air inlet and outlet openings.

When rice, wheat and other cereals and seeds are fumigated, they should be stored after treatment in insect-proof containers, otherwise re-infestation may result. Combining fumigation and storage of maize, &c., large galvanized iron tanks, with a pipe at the bottom which can be closed, are in common use in many countries. The fumigant can be introduced at the top and, after the required period for exposure, the pipe at the bottom is opened, and the fumigant vapours allowed to drain off, after which the openings at top and bottom are closed. Grain can be readily removed as required, and the remainder remains safe from re-infection.

Bulk storage is best maintained in concrete silos, arrangements for fumigation being made outside, and the grain, after treatment, being conveyed direct into the silo.

The choice of chemicals for commercial fumigation is rather limited, the main ones comprising—

Hydrocyanic acid (prussic acid).
Carbon disulphide.
Paradichlorbenzene.
Ethylene oxide.
Sulphur.
Nicotine.
Carbon tetrachloride.
Chloropocrin.

Hydrocyanic Acid Gas.

This is by far the most commonly-used fumigant, and is applicable to practically all fumigation purposes.

The gas is colourless and very slightly lighter than air; it has an odour resembling that of bitter almonds. It diffuses rapidly and, being lighter than air, this is mostly upwards. Under normal conditions, it will not penetrate readily through tightly packed materials, such as sacks of grain and flour. By partially exhausting the air from the chamber, this difficulty is largely eliminated.

The gas is one of the most deadly known poisons, very rapidly killing animals, and also plants when the dosage is too great or the exposure too prolonged.

Hydrocyanic acid gas can be generated in several ways.

1. *From Calcium Cyanide.*—This chemical is obtainable as a powder, in granules and in flakes, and in varying strengths; no acid is required for the generation of the gas, this taking place on exposure to the air, the rate of evolution being dependent on the humidity.

It is eminently suitable for the fumigation of buildings, plants, rodent burrows, and for the treatment of certain types of sap-sucking insects.

In the treatment of orchard trees, the trees are covered with tents and the powder blown in under force, thus eliminating all the trouble with containers, acid, &c., required by the "pot method", referred to later.

For buildings, &c., 1 lb. per 1,000 cubic feet of air space (where the strong grade is used) is sufficient for all ordinary purposes; about double this dosage is required with the weaker grade.

In the United States of America, for the treatment of grain in bulk storage, the chemical is run in with the grain in the chutes.

For the destruction of soil-frequenting pests, and rodents, the chemical is blown into the channels and burrows, and the openings plugged. Ant nests can be cleared out in a similar manner.

2. *From Liquified Hydrocyanic Acid.*—This is supplied in steel cylinders, and is freed by opening a valve at the top of the cylinder, the gas being led into the enclosure by pipes from the valve.

One pound of the liquid is sufficient to fumigate 3,000 cubic feet of air space in buildings, &c.

3. *By the Pot Method.*—In this, the gas is generated by mixing sodium or potassium cyanide in earthenware containers with sulphuric acid and water; specially enamelled iron basins can also be used as containers.

The proportions per 1,000 cubic feet of air space of the chemicals are—

Water	30 fluid ounces
Sulphuric acid (commercial)	15 fluid ounces
Sodium cyanide (pure)	10 ounces

The acid and water are *slowly* mixed togeher, otherwise splashing may occur, and the sodium cyanide dropped in. It is often advisable to place the weighed quantity of the cyanide in a thin paper bag, as the action of the acid on the cyanide is thereby delayed slightly, thus giving a greater margin of safety to the operator.

4. A special chamber or machine is in use in some parts in which the above chemicals are mixed, and the gas led into the fumigation chamber by pipes connected with the generator.

The use of calcium cyanide and liquified hydrocyanic acid are gradually replacing the older methods with the use of acid and potassium or sodium cyanide.

Another form in which this fumigant is available is felted-paper discs impregnated with the fumigant, and which on exposure to the air yield the poison gas. The dosage is varied according to the number of discs used.

Carbon Disulphide, CS_2.

In its commercial form, carbon disulphide is an almost colourless liquid with a strong and disagreeable smell. It rapidly volatilizes into a gas on exposure which, mixed with air, forms an explosively inflammable mixture. Great care has, therefore, to be exercised in using it, the glowing end of a cigarette or the glowing bowl of a pipe, or even a spark from two metal pieces striking together, being sufficient to ignite the vapours.

The gas is two and a half times heavier than air, and, therefore, sinks to the bottom of any container in which it is used; it has great penetrating power through tightly-packed materials. Any container in which it is used, therefore, must be thoroughly gas-tight.

This chemical cannot be used for the fumigation of living plants, owing to its high toxicity towards all forms of plant life and, even in small quantities, it will cause giddiness and nausea in humans.

It is well suited for the treatment of grain, and can also be used for the destruction of ant-nests; for the latter, a small quantity is poured into one or more holes in the nest, which is then covered with wet sacks; after five minutes, one of the bags can be lifted and a flare thrown on to the nest, which is shattered by the ensuing explosion.

The usual dosage for the treatment of grain is 4 to 5 pounds per 1,000 cubic feet of air space in the chamber, allowing 24 hours exposure. The temperature plays an important part in successful fumigation with this chemical, and should not be below 70 degrees Fahrenheit.

Owing to the vapours being so much heavier than air, the liquid should be placed in the top of the container either in a shallow basin, or poured on to sacks; by the latter method, a more rapid diffusion takes place.

Paradichlorbenzene $C_6H_4Cl_2$.

This chemical is available in a white crystalline form, and volatilizes readily on exposure to air; the vapours are about one and a quarter times heavier than air, and are non-inflammable.

It is used against certain root-boring and soil-frequenting insects, and for keeping seeds free from insect pests in storage; it cannot be used with grain that is for consumption by either humans or animals, as it leaves a very strong taint. Cases are on record where grain so treated, and fed to fowls, brought about a taint in the eggs, and, when such grain was fed to dairy cows, a taint came out in the milk.

It is excellent for the destruction of "white ants" (termites) in houses or timber when introduced into the channelling. It will penetrate further when dissolved in kerosene at the rate of 1 lb. to 4 gallons, and the solution poured in. It can also be used for the protection of furs and woollens in tightly closed containers.

The writer has used this chemical with very successful results against the "tobacco beetle", *Lasioderma serricorne* Fabr., infesting bindings of large ledgers, &c., treatment being carried out in a tightly-closed concrete chamber.

Ethylene Oxide $(CH_2)_2O$.

This chemical is a liquid with a boiling point of 14 degrees Centigrade (57 degrees Fahrenheit), and is used extensively at the Port of London for the fumigation of dried fruits, &c., steel barges with gas-proof covers being used for the purpose.

In application, about 10 per cent. of carbon dioxide is added to the fumigant in steel cylinders to provide a greater pressure for expulsion of the ethylene oxide.

Supplementary to this treatment, the warehouses where the cases are stored are sprayed with a solution of pyrethrins in a highly-refined non-volatile oil of the nature of medical paraffin.

Sulphur Dioxide SO_2

This gas is used to a certain extent in insect fumigation, but it is generally not as effective as those referred to previously.

The gas is generated by burning sulphur at the rate of from 2 to 6 lb. per 1,000 cubic feet of air space, the amount depending on the insects to be killed and the material to be treated. In the presence of moisture, sulphur dioxide is a strong bleaching agent.

It is slightly heavier than air, and is not applicable in many cases, as it destroys the viability of the seed of most grain crops, and, also, has a deleterious effect on the baking quality of flour.

The action of burning sulphur in an air-tight container is partly due to suffocation, owing to the removal of the oxygen to form sulphur dioxide, and, also, in part due to the formation of a poisonous gas.

Nicotine.

This alkaloid is used extensively in the fumigation of greenhouses, but has little, if any, application in this Territory.

Carbon Tetrachloride.

This chemical is a heavy liquid, yielding a gas about one and a half times heavier than air, but it is not nearly as toxic to most insects as carbon disulphide, requiring four to five times the dosage for an equivalent result. It has the advantage of being non-inflammable.

Chloropicrin.

The vapour of this chemical is very heavy, but has a low volatility, and is non-inflammable. It corrodes metals, and has an irritating effect on the person using it, causing the eyes to water freely.

The power of penetration of the gas is particularly good, but is markedly affected by temperature.

It is more toxic to insects than carbon disulphide, but the susceptibility of insects to the vapour shows marked variation. It is less toxic to humans than to insects and rodents, but cannot be used for the fumigation of plants.

Owing to the heavy nature of the vapour, this chemical is very suitable for the fumigation of rodent burrows, and it has been used for the destruction of insects (moths, &c.) in upholstered furniture.

Chloropicrin has been used in grain stores and flour mills for killing moths, &c., but some experiments have shown that it has a definite effect on the gluten content, which, however, disappears when the material treated is exposed for several days to the open air.

"White Ant" Fumigation.

A special technique has been developed in Malaya for the fumigation of "white ants" (termites) in living trees. This consists of burning arsenic and sulphur together in a special combustion chamber and blowing the fumes into the channels of the termites through a pipe leading from the combustion chamber.

The highly-poisonous fumes are thus deposited in the interior of the nest inside the trunk of the tree, and results in killing out the pest, without in any way damaging the tree.

RAINFALL MEMORANDA.

Inches of rainfall × 2,323,200 = cubic feet per square mile.
" " " × 14½ = millions of gallons per square mile.
" " " × 3,630 = cube feet per acre.

NEW CEYLON INDUSTRY.*

Ceylon is to try to develop an export trade in brown paper made from coco-nut husks. Good white paper, it has been found, can also be made out of husks, but its manufacture is not economical. The bleaching of the husk fibres for this purpose raises the production cost excessively. But brown paper can be made at an economical cost.

* From Supplement to the *British Trade Journal and Export World*, October, 1938, p. 28, Vol. LXXVI., No. 909.