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Control of Insects in Stored and Manufactured Tobacco[1]

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[1] This circular supersedes U. S. Dept. Agr. Cir. 635, Control of Insects Attacking Stored Tobacco and Tobacco Products, by W. D. Reed and J. P. Vinzant.

[2] W. D. Reed, J. P. Vinzant, Ross W. Brubaker, E. M. Livingston, and A. W. Morrill, Jr., conducted much of the early research reported in this paper.

INTRODUCTION

The curing, storing, processing, and manufacturing of tobacco comprise one of the oldest and largest industries in the United States. Most tobaccos are held in storage for 2 years or more for natural aging. During this time the cigarette beetle (*Lasioderma serricorne* (F.)) and the tobacco moth (*Ephestia elutella* (Hbn.)) cause heavy losses. The cigarette beetle is also a pest of tobacco products.

In this country most of the tobacco held for aging is stored near the manufacturing centers. Storage of cigarette-type tobacco is concentrated largely in North Carolina and Virginia; much of this tobacco for export is stored near Norfolk, Va. Large quantities of cigar tobacco are stored in New York, Pennsylvania, Connecticut, and Florida.

Manufacturers prefer to maintain large stocks of tobacco at all times. Total stocks of leaf tobacco on hand in the United States and Puerto Rico in August 1950 were over 3 billion pounds. Tobacco producers take many precautions to eliminate insects from their warehouses and factories, and make a constant effort to keep their stocks free of insects.

Insect damage to stored tobacco and to tobacco products was estimated in 1941 to be in excess of 11 million dollars. In the late 1940's it was probably between 5 and 10 million dollars. During this postwar period tobacco doubled in value, but economic conditions have temporarily reduced the period of aging cigarette tobaccos, which in turn has reduced the proportion damaged by insects.

Losses to cured tobacco caused by insects are of five kinds: (1) Loss in quantity and quality of leaf tobacco; (2) loss in value of manufactured tobacco, such as cigarettes and cigars that become infested in wholesale or retail establishments; (3) loss on exported tobaccos due to refusal of customers to accept infested tobacco, at least unless discounts are granted; (4) discrimination in other countries against infested American tobaccos; and (5) loss of good will, as when a customer turns away from a particular brand after buying an infested product.

Because of lack of purchasing power and of dollar exchange during the past few years, foreign customers have not been able to buy so much American tobacco as they would like. They therefore have been more critical of insect infestation. The attitude of foreign buyers has in turn made the American exporters more alert to insect damage. Moreover, in order to ship tobacco to some countries the exporter now has to certify that his tobacco is free from infestation by the tobacco moth, or show certification of fumigation. Such fumigation is expensive.

The loss of good will to a manufacturer when a purchaser buys insect-infested merchandise is an intangible thing difficult to evaluate. It can seriously hurt a dealer's business before he is aware of it, and it is the kind of loss the very thought of which seriously disturbs any tobacco dealer or manufacturer.

This circular provides information on insect pests of stored and manufactured tobacco and the most effective and economical methods for their control.

THE CIGARETTE BEETLE

The cigarette beetle is cosmopolitan in distribution, having been carried over the world by commerce in tobacco and other materials. Specimens have been described from Tutankamen's tomb in Egypt, which would seem to indicate an African or Asiatic origin for the species. At least it was present in Egypt more than 3,500 years ago. It was recorded as a pest of cured tobacco in North Carolina as early as 1886.

Description and Life History

The adult cigarette beetle is brown and less than 1/8 inch long. The head is drawn under the body when the beetle is at rest and usually when it is dead. The egg is pearly white, elongate, and about 1/50 inch in length. It is fragile, but has a waxy shell which is very resistant to drying. The larvae, or grubs, are tiny when first hatched, but grow to a length of about 3/16 inch. They are grayish white and covered thinly with fine hairs, which appear to be light brown on mature larvae. When full grown they transform into inactive pupae, and later emerge as adult beetles.

In the summer as few as 7 days may be spent in the pupal stage, but in cooler weather 14 to 18 days may be required. The adult beetles may live for 3 or 4 weeks, and one female may lay from 75 to 100 eggs. Most of the eggs are laid during the first 10 days, the heaviest deposition occurring within the first 2 or 3 days after emergence. The eggs hatch in 6 to 10 days, and the larvae mature in 30 to 50 days. In the summer the incubation period is approximately 7 days; the larval stage 35 days; the pupal stage 8 days; the period prior to emergence, mating, and egg laying 6 days—total life cycle 56 days. The four stages of this insect are shown in figure 1.

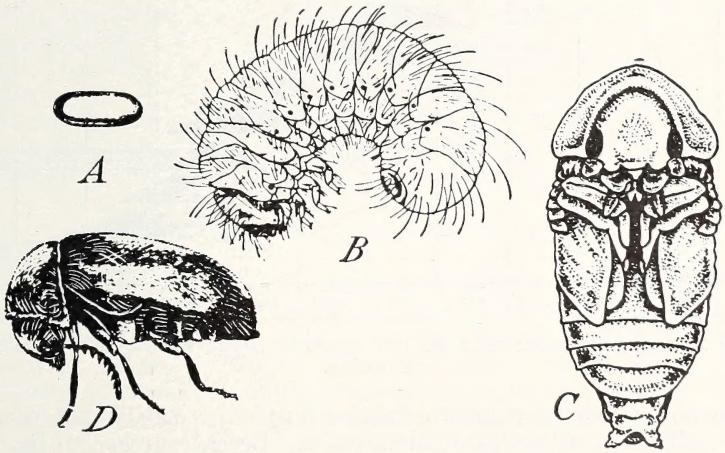

Figure 1.—Stages of the cigarette beetle: *A*, Eggs; *B*, full-grown larva; *C*, pupa; *D*, adult. Greatly enlarged.

Seasonal Occurrence

The seasonal occurrence of the cigarette beetle varies with the conditions under which tobacco is stored and manufactured. In heated buildings, or in the subtropical climate of Florida, there may be no well-defined hibernation period but a slowing of development during the winter. Under such conditions all stages of the insect may be found at almost any time of year. In North Carolina and Tennessee and farther north the beetle passes the winter in the larval stage in tobacco or other hosts. There is usually heavy mortality of immature larvae, and in severe winters the population of mature larvae may be materially reduced. If the tobacco temperature remains below 36° F. for 16 consecutive days, all larvae are killed, and such low temperatures occur outdoors frequently in Virginia. In brick warehouses and factories, however, infestations always survive.

In the Richmond, Va. area the larvae begin to pupate late in the spring, and the first adults of the spring brood usually emerge late in May. Near Charleston, S. C., or Wilmington, N. C., emergence may start as early as the last week of March. The generations overlap, but peaks of emergence of the different broods are rather sharply defined. At Richmond the spring peak is reached usually about the middle of June. Since the major portion of a generation completes development in 50 to 60 days, there are ordinarily two generations and a partial third generation in North Carolina and Virginia. This seasonal occurrence is shown in figure 2. At Richmond there is usually a peak emergence in June, another in August, and a third in October. The third generation is usually smaller than the others, but in mild weather it may be large. A large number of second-generation larvae and all the third-generation larvae pass the winter in this stage.

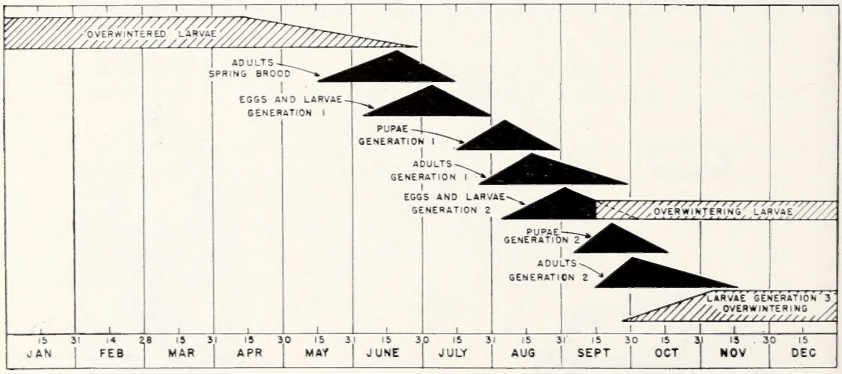

Figure 2.—Seasonal occurrence of the cigarette beetle in Virginia and North Carolina.

The population of cigarette beetles fluctuates widely, but there is some indication of cycles of abundance. Beetles appear to be more abundant every other year and perhaps there is a longer cycle, but the picture is somewhat obscured. In any storage warehouse the most important factors influencing population are temperature, relative humidity, and types, grades, age, and quantity of tobacco present. At times parasitism may also be of some importance.

Habits

Practically all injury to tobacco by the cigarette beetle is caused by the feeding of the larvae. The adults do not feed and the only damage they cause is to cut exit holes to escape from the tobacco or package in which pupation occurred. Most of the adults attempt to leave the tobacco. However, this insect can mate and lay eggs in close confinement, and a certain proportion of the adults do.

This insect attacks all the principal types of cigarette, cigar, chewing, and snuff tobaccos, as well as most forms of manufactured tobacco. Burley and Maryland tobaccos are rarely attacked, however, and have never been known to be damaged.

The larva burrows through the tobacco, cutting rather neat, clean holes, and leaving behind a fine powder of excrement. Cigars and cigarettes are made unfit for smoking by the holes in the wrapper or paper, which prevent a satisfactory draught. Infested smoking or chewing tobacco or infested snuff is generally objectionable to the consumer from the aesthetic as well as the taste standpoint. However, the greatest losses occasioned by the cigarette beetle occur in leaf tobacco in storage. Injury to leaf tobacco is shown in figure 3.

The cigarette beetle also commonly infests cottonseed meal, dry yeast, chili powder, curry powder, ginger, and cayenne pepper. It has been recorded from different parts of the world as feeding on opium, red pepper, paprika, turmeric, saffron, mixed spices, licorice, pyrethrum powder, bran, belladonna, raisins, dried figs, corn meal, rice, leather, and woolen fabrics.

THE TOBACCO MOTH

The tobacco moth is widely distributed in the Temperate and Tropical Zones of the world. It was first reported as a pest of American tobacco in 1930, and now is probably the most important pest of flue-cured and oriental types of tobacco in the United States. It has never been recorded as attacking air-cured, fire-cured, or cigar types of tobacco. In 1937–40 an outbreak of this insect occurred in farmers' packhouses in North Carolina and Virginia. Farmers suffered heavy losses between the time their flue-cured tobacco was harvested and the time it was sold. Slight damage was reported from some farms in 1948 and 1949.

Description and Life History

The adult tobacco moth is a small gray or brownish-gray moth. It measures about 3/8 inch from head to tips of folded wings and has a wingspread of about 5/8 inch. The eggs are laid singly or in loose groups on or near tobacco. They are sandy white when laid, and gradually turn darker. They are slightly elongate, and about 1/45 inch in length. The shell is very tough, and the eggs are only loosely attached. The larvae are tiny when first hatched but grow to 3/8 to 1/2 inch. They are pinkish white and have a few fine hairs. The head is reddish brown, and the body has small brown spots along the back. When full grown, the larvae spin loose weblike cocoons in which they transform to pupae, and then emerge as adult moths.

Figure 3.—Leaves of flue-cured tobacco showing damage by larvae of the cigarette beetle. Approximately 1/3 natural size.

Mating and egg laying usually begin within 24 hours after emergence. The average female probably lays more than 100 eggs, and as many as 279 have been recorded. The eggs hatch in 3 to 17 days, and the larvae reach maturity in 25 to 128 days. The pupal stage requires from 5 to 25 days. Under summer conditions the life cycle from egg to egg averages approximately 50 days—5 days for incubation, 35 days for larval development, and 10 days for pupation. The adult moths may live as long as 7 or 8 days—longer in cool weather. The four stages of this insect are shown in figure 4.

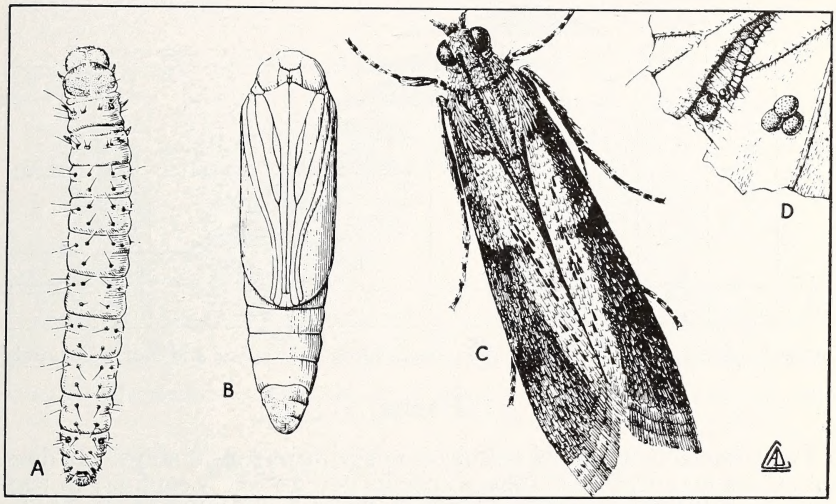

Figure 4.—Stages of the tobacco moth: *A,* Large larva; *B,* pupa; *C,* adult; *D,* eggs and young larva on section of leaf tobacco. Approximately × 7.

Seasonal Occurrence

The tobacco moth passes the winter as a larva. In the fall most of the mature larvae leave the tobacco and migrate to cracks and crevices about the building, where they spin the loose cocoons of silk in which they hibernate. Some larvae may spin cocoons on or near the surface of the tobacco. Immature larvae may remain in the tobacco in an inactive state, and probably many of them fail to survive the winter. However, relatively few immature larvae enter the winter. Once hibernation has begun, the larvae seem able to withstand low temperatures for long periods. Larvae have been reported to survive the winter in unheated buildings in Canada at a temperature of −30° F. In North Carolina and Virginia larvae have been known to survive exposure to near-zero temperatures for periods of 2 to 3 weeks.

At Richmond, Va., pupation usually begins in April, and emergence of the first brood of moths generally starts in May. At Charleston, S. C., and Wilmington, N. C., moths may emerge as early as the last week of March.

The peaks of emergence of the broods of the tobacco moth are a little more sharply defined than those of the cigarette beetle. In the

Richmond area emergence of the spring brood is usually at a peak in the last 2 weeks of May. The population of moths in a warehouse then declines, reaching a very low ebb early in July. A second peak of emergence occurs in August, and a third and usually much smaller peak is often noted late in September or in October (fig. 5). In 1948 and 1949 a full third brood occurred, and at Norfolk, Va., active moths were noted as late as the middle of December.

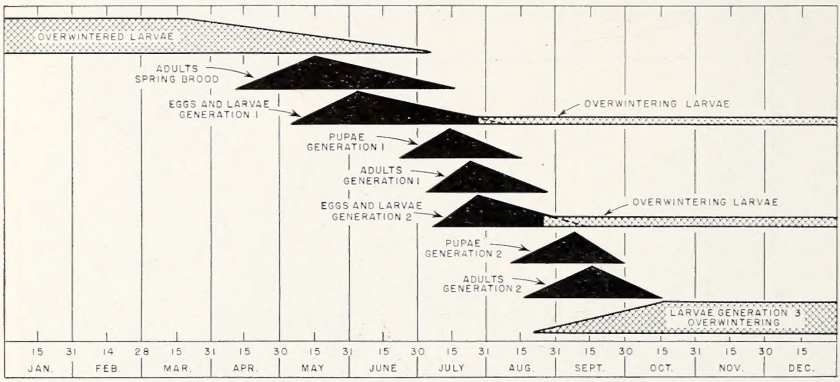

Figure 5.—Seasonal occurrence of the tobacco moth in Virginia and North Carolina.

Habits

The tobacco moth feeds on tobacco only in its larval stage. It does not attack manufactured tobacco products. Attack is confined to leaf tobacco of the flue-cured and Turkish types, preferably of the better grades—those high in sugar and low in nicotine. Tobacco with a sugar content (dextrose before inversion) of more than 10 percent (much flue-cured tobacco contains 20 percent or more of sugar) and a nicotine content of less than 2 percent seems particularly favored.

This insect is a heavier feeder than the cigarette beetle; in a severe infestation it devours many leaves completely except for the midrib and larger veins (fig. 6). In feeding, the larva leaves behind a silken thread that forms a webbing and catches pellets of excrement. Such accumulations of webbing and excrement are unsightly and objectionable to buyers and manufacturers.

Mature larvae move out of the tobacco, or at least to the surface—a necessary migration, because the soft, fragile adult moth could not cut its way out of confinement. It is often trapped when attempting to crawl through very tiny openings. The moth apparently does not mate in close confinement, and so emergence is necessary before fertile eggs can be laid.

The tobacco moth feeds on many stored products besides tobacco. In the United States it has been found in almost all grains, as well as in peas, beans, corn meal, wheat flour, rolled oats, peanut meal, poultry laying mash, stock feed, and various cereal products. It has also been reported as infesting cacao beans, chocolate, shelled nuts, linseed meal, coffee, chicory, ship's biscuits, cottonseed cake, cayenne pepper, rice, pearl barley, and other seeds.

Figure 6.—Damage to leaves of flue-cured tobacco by larvae of the tobacco moth. Approximately ⅕ natural size.

OTHER PESTS OF TOBACCO

Several insects other than the cigarette beetle and the tobacco moth also feed on tobacco and may occasionally cause some injury.

The larger tobacco beetle (*Catorama tabaci* Guer.) is primarily a tropical species, but has been reported from Florida and Puerto Rico. It attacks cured tobacco in much the same way as does the cigarette beetle. It resembles the cigarette beetle, but is larger and black instead of brown.

The phycitid moth *Tlascala finitella* (Wlkr.) was taken from flue-cured tobacco at Richmond, Va., in 1932, and occasional individuals have been observed since that time.

The larva of an *Aglossa* moth, presumably *cupreolis* (Hbn.), feeds on moldy or partly decayed tobacco, and is sometimes observed in warehouses and farmers' packhouses.

The following species are listed in approximately the order of their prevalence:

Tribolium confusum Duv.
Tribolium castaneum (Hbst.)
Henoticus serratus (Gyll.)
Ahasversus advena (Waltl.)
Typhaea stercorea (L.)
Anthrenus verbasci (L.)
Lepisma saccharina (L.)
Ptinus brunneus (Duft.)
Attagenus piceus (Oliv.)
Trogoderma tarsalis Melsh.
Oryzaephilus surinamensis (L.)
Mezium americanum Lap.
Dinoderus brevis (Horn)
Stenobium paniceum (L.)
Sitophilus oryza (L.)
Dermestes maculatus Deg.
Tenebrio obscurus F.
Tenebrio molitor L.
Anthicus cervinus Laf.
Anthicus floralis (L.)

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Many of these insects act as scavengers, eating dead bodies of the cigarette beetle and the tobacco moth; others probably use the tobacco as a temporary shelter.

NATURAL ENEMIES OF STORED-TOBACCO INSECTS

The cigarette beetle and the tobacco moth have a number of natural enemies. The most important are *Aplastomorpha calandrae* (How.), a parasite on the larvae and pupae of the cigarette beetle, and *Microbracon hebetor* (Say), a parasite on the larvae of the tobacco moth. With the exception of certain mites, predators are of only incidental importance. None of the natural enemies have been observed to reduce appreciably the populations of their hosts.

The little pteromalid wasp *Aplastomorpha calandrae* (How.) is often found in abundance in connection with large populations of the cigarette beetle, although unfortunately it is not of appreciable importance in controlling its host. In tightly packed tobacco the female wasps find difficulty in entering the feeding tunnels of the beetle larvae. This parasite is also very susceptible to low temperatures, and the adults seem particularly vulnerable to fumigants and space sprays.

Other small wasps have been reared on larvae of the cigarette beetle but have never been found in tobacco warehouses. Among them are *Cephalonomia gallicola* (Ashm.), *Lariophagus distinguendus* (Föerst), and *Choetospila elegans* Westw.

The predaceous mite *Pyemotes ventricosus* (Newp.) has been noted attacking cigarette beetle larvae, but it is of little value in controlling this pest. Mites of *Seiulus* sp. and of *Moneziella* sp. are also known to feed on beetle eggs to a limited extent.

The adults and larvae of the clerid beetle *Thaneroclerus gérodi* Chev. prey on larvae and pupae of the cigarette beetle in Florida. The cadelle (*Tenebroides mauritanicus* (L.)) and also *Tribolium* beetles are sometimes predators on the inactive stages of both the cigarette beetle and the tobacco moth.

The braconid *Microbracon hebetor* (Say) parasitizes large larvae (fig. 7) of the tobacco moth, but has never been observed in sufficient numbers to give any appreciable control. Few adults of this parasite are seen in tobacco warehouses until late in summer.

Two ichneumonids, *Mesostenus gracilis* Cress. and *Idecthis canescens* (Gray.), are at times fairly abundant in tobacco storages, where they parasitize large larvae of the tobacco moth.

Mites of a species of *Seiulus* attack eggs and adults of the tobacco moth, as do mites of the genus *Laelaps*. *Cheyletus* mites attack the larvae.

The egg-sucking bug *Orius insidiosus* (Say) sometimes enters warehouses and feeds on the eggs and young larvae of the tobacco moth.

A number of spiders prey on the tobacco moth adults. *Theridion tepidariorum* (Koch) weaves extensive webs, which capture many moths. The jumping spider *Salticus scenicus* (L.) often destroys many moths. Other spiders of the genera *Pardosa*, *Pellenes*, *Phidippus*, and *Marpissa* feed on the tobacco moth. However, none of these spiders have ever been observed in sufficient numbers to indicate any appreciable degree of control.

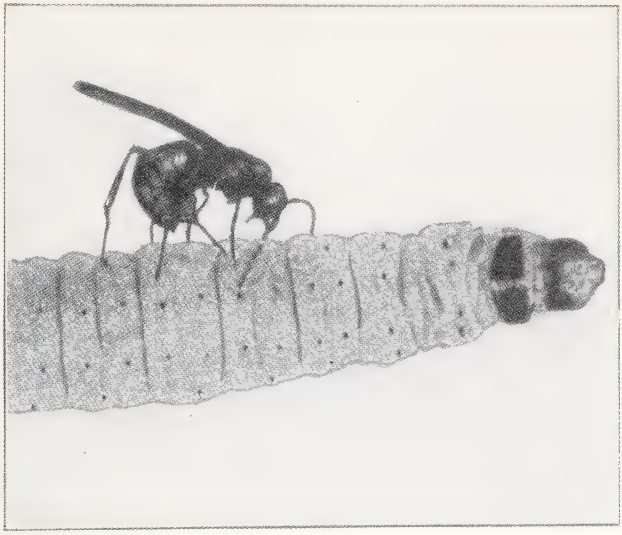

Figure 7.—The braconid parasite *Microbracon bebetor* (Say). Greatly enlarged. (After Doten.)

SOURCE OF INSECT INFESTATIONS IN TOBACCO

Cigarette Tobaccos

IN FARMERS' PACKHOUSES

The tobacco moth is sometimes a serious pest of flue-cured tobacco on the farm. Infestation may begin even in the curing barn and continue until the tobacco is marketed. Most damage occurs in the packhouse, where the tobacco is bulked before grading. Infestation may develop from moths flying from commercial storages or farms nearby, or it may be already established on the farm and carried over from year to year in grain, peas or beans, stock feeds, or other host foods.

IN STORAGE WAREHOUSES

The redrying of flue-cured leaf tobacco before it is packed in hogsheads for storage destroys all stages of the cigarette beetle and the tobacco moth. Hence, leaf tobacco is free of insect infestation when it is prized into hogsheads. However, the crop of bright tobacco is redried from July through December, most of it late in the summer. At this time insects are active, and almost all warehouses and redrying plants, and often the trucks and freight cars in which tobacco is shipped, are infested.

If newly packed tobacco is held for even a few hours in an infested building or vehicle, it may become infested. Moths or beetles fly about and lay eggs on the tobacco or in the cracks of the hogshead or case. The larvae that hatch from these eggs immediately begin feeding on the tobacco. Tobacco packed in July or August can develop

one generation of insects, and under certain conditions two generations, before cold weather begins. Tobacco for export, packed from July through September and held for even a few days in an infested storage, is almost certain to develop an infestation unless it is fumigated before shipment. In its early stages an insect infestation is not easily detected, and new-crop tobacco exported late in the summer may be infested on arrival abroad. Railway freight cars may be infested with cigarette beetles and tobacco moths.

Turkish tobaccos are usually infested before they are imported. The tobacco moth and the cigarette beetle are common pests in Turkey, Greece, and the Balkans, and little effort at insect control is attempted in those countries. Much imported tobacco is fumigated at the port of entry.

Warehouses that have been in use for several years may harbor an infestation even though all old tobacco is moved out before a new crop is received. Tobacco dust and scrap accumulate in cracks and crevices and under dunnage and false flooring. The tobacco moth's habit of leaving tobacco in order to pupate may also help to spread infestations.

Cigar Tobaccos

Cigar tobaccos are attacked by the cigarette beetle only, and this insect is prevalent in almost every area where these tobaccos are stored. The beetle is present in many warehouses and attacks the tobacco soon after it enters storage. During the aging or sweating process some infestation is usually present. Much imported cigar tobacco is already infested when received. Much tobacco is imported from Cuba and Puerto Rico, where the cigarette beetle is prevalent.

Manufactured Tobacco Products

Practically all manufactured tobacco products are attacked by the cigarette beetle. In cigarette factories leaf tobacco is passed through a thermal vacuum, which destroys all stages of the cigarette beetle. However, much of the tobacco brought into a factory is infested, and this tobacco may remain in the plant for several hours, or even days, before being processed. Beetles emerge from this tobacco and readily fly about in the plant. In the factory the shredded tobacco is treated with flavoring and allowed to stand for several days for the flavoring to permeate the tobacco. Eggs laid on the tobacco at this time usually will not hatch until the tobacco has been made into cigarettes and packaged. This is why cigarettes packed in hermetically sealed vacuum tins are sometimes infested.

At a moderate temperature and high relative humidity the cigarette beetle, which thrives best at approximately 80° F. and 70 percent relative humidity, is active and breeds the year round. Great care should be taken to eliminate any accumulations of scrap tobacco and not to retain more than a few days' supply of tobacco in this part of the factory.

The cigarette beetle is a strong flier and has been known to fly 2 miles or more. In any manufacturing center beetles can and probably will fly through any open door or window. They frequently lay eggs on packaged cigars, cigarettes, or other tobacco products in wholesale or

retail establishments, as well as in manufacturing plants. A package covered with paper, cardboard, foil, or cellophane and effectively sealed is protected from cigarette beetle attack. Unfortunately, however, few packages in commercial use today are adequately sealed. Eggs laid on a package hatch into tiny larvae, which often crawl around and through the folds of the wrapping, or penetrate almost microscopic holes or cracks in the package to reach and infest the contents.

Cigars are often held in open trays or boxes for 4 or 5 weeks for aging—an excellent opportunity for infestation.

CONTROL ON THE FARM

Sanitation

Once an infestation has developed in a farm packhouse, the farmer's simplest course is to grade and market the tobacco as quickly as possible. However, he can do a lot to prevent an infestation. As soon as the crop is graded and sold, the packhouse and grading room should be thoroughly cleaned, even the walls brushed down. All scrap tobacco should be hauled away and scattered thinly over the fields or destroyed. No seed, feed, or fertilizer should be stored in the packhouse. In the spring when the moths emerge, they will fly away in search of material in which to lay their eggs. The young larvae from such eggs as may be laid in a clean packhouse will die for lack of food. If grain or feed is stored in the packhouse, the moth will breed in this material until tobacco is harvested.

Use of Residual Sprays

A thorough application of 5-percent DDT spray to the walls and ceiling of the packhouse early in the spring (during April in central North Carolina and Virginia) can be beneficial. DDT spray residues will kill the moths that rest on the sprayed surface for a sufficient time.

Use of Space Sprays

If an infestation develops and it is necessary to hold the tobacco for more than 2 or 3 weeks, it may be desirable to spray the air space inside the packhouse with pyrethrum in oil once or twice a week. The spray should contain 0.2 percent of pyrethrins in a light volatile oil. Manufacturers' specifications for a suitable oil are as follows: Maximum specific gravity at 60° F., 0.797; flash point, 175°; colorless; and no kerosene odor. Such spray may be bought ready mixed, or the farmer can readily mix it himself, using pyrethrum concentrate and the oil.

This spray creates only a slight fire hazard when prepared as directed, and is relatively harmless to man. **No open flames, such as oil lanterns or lamps, and no smoking should be permitted in the packhouse while it is being sprayed.** The spray should be applied as a very fine mist and directed so as to fill the air space. Thorough spraying is important.

Covering of Bulks

Covering the bulks of tobacco with a good grade of plant-bed cloth free from holes gives a certain amount of protection, if the bulks are completely covered and the cloth is tucked in around the bottom. However, every 4 or 5 days during warm weather the cloth should be removed carefully and placed in boiling water to destroy any eggs laid on it.

CONTROL IN STORAGE WAREHOUSES

Insect Traps

To provide an index of infestation and a guide for timing control measures, suction light traps should be installed in all storage warehouses and operated continuously from early spring until late fall.

Such a trap (fig. 8) consists of a barrel, a flange of sheet metal, and a cone of 20–mesh bronze, brass, or stainless-steel screen wire. To the small end of the cone is soldered the rim of a fruit-jar lid, and into this lid is screwed a glass jar of suitable size. A 40-watt light (stronger bulbs are less effective) is suspended from the front of the flange. A fan operated by a small electric motor in the barrel of the trap provides suction. The motor is usually of $\frac{1}{20}$ horsepower or less, so that the fan and light combined consume less than 1 kilowatt of electricity in 24 hours.

Figure 8.—Examining the catch from a suction light trap.

The cigarette beetle is attracted to light, and a suction light trap aids appreciably in reducing populations of this insect. The tobacco moth is not attracted to light, but any insect flying close to the mouth of the trap is caught by the suction. Consequently, although a trap may not significantly reduce the population of tobacco moths, it does catch a sufficient number to reflect the degree of infestation and to indicate the beginning, peaks, and end of seasonal activities of the insect.

A trap, preferably mounted on a cord and pulley so that it can be readily lowered for examination, should be suspended from the ceiling of the warehouse above the top of the hogsheads or bales of tobacco.

If traps are to be used as an aid to control the cigarette beetle, one trap for each 100,000 to 150,000 cubic feet of space is necessary. In small storage units one trap per unit should be used. For use merely as a measuring device to record the relative insect population, one trap per one-story warehouse is satisfactory in storages up to 300,000 cubic feet.

All traps should be operated 24 hours a day. Operation for only a part of a day will not give an adequate sample.

An indicator that is simpler, but less satisfactory, than suction light traps, consists of a fabricated board about 16 inches long by 10 inches wide on which a sheet of sticky flypaper is fastened. The board is suspended at an agle of 45°, and 6 inches below a 40- or 50-watt electric light. One of these indicators should be used for each 50,000 to 75,000 cubic feet of space. Lights over the flypaper should not be turned off at night. The sticky flypaper should be replaced weekly.

A little more elaborate and more effective form of flypaper trap is sometimes used in the cigar industry. It consists of a boxlike frame with flypaper fastened on four sides and a 40- to 50-watt light bulb suspended in the center.

Screening

During the summer adults of both the cigarette beetle and the tobacco moth are constantly flying about. Therefore, all warehouses should be screened, particularly open warehouses where sprays are used (fig. 9). In an unscreened warehouse insects may readily fly out of the building ahead of the spray, only to return within a few minutes after the spraying is done. Furthermore, even should all beetles and moths in a storage be killed, the building will probably become reinfested in a few hours. Observations have been made in screened warehouses where one building was very lightly infested and an adjoining building remained very heavily infested all summer. Such differences would rarely if ever appear in unscreened storages.

Over a period of years it has been shown that space sprays give significantly better control of the tobacco moth in screened than in unscreened warehouses. Galvanized-wire screen may be used, but will usually rust out in 3 to 5 years. A more durable wire, such as copper, bronze, or plastic, will probably prove more economical in the long run. The size of mesh used is important. To exclude the cigarette beetle the openings in the wire should not exceed 0.0396 inch. A 20-mesh wire (20 strands to the inch) is preferable, but an 18-mesh wire is satisfactory if the wire strands are at least 0.02 inch in diameter.

Figure 9.—Interior of a storage warehouse containing hogsheads of flue-cured tobacco. Note the screen doors and the suction light trap.

Open-Type Warehouses

An open-type warehouse is merely a shed with open or partly open sides. It consists of a wooden framework partly covered by sheet metal, usually with louvres, and with a composition roof. The floor may be of cinders, crushed rock, concrete, or wood. Each building may be separate, or a number of units may be constructed in a row, separated by brick fire walls (fig. 10). The open portions of the side

Figure 10.—Open-type tobacco warehouses. Note the louvered sides.

walls of such warehouses are usually covered with hardware cloth or wire screen. Hardware cloth of 4 to 8 meshes to the inch, often called rat wire, was almost invariably used prior to 1939. Such wire, of course, did not exclude insects. Storages of this type vary in size, but most of them exceed 100 by 150 feet by about 16 to 18 feet. The capacity of a single section may range from 800 to more than 3,000 hogsheads. Few of the more modern warehouses have a capacity of less than 1,500 hogsheads.

Since World War II some manufacturers have eliminated the louvres from their open-type warehouses. Such warehouses, usually constructed of corrugated iron, have some of the advantages and some of the disadvantages of both open and closed buildings. They cannot be fumigated, but they can be more efficiently sprayed.

Almost half the cigarette tobacco stored in the United States—most of the flue-cured tobacco held for domestic manufacture—is stored in open- or semiopen-type warehouses. This tobacco is attacked by both the tobacco moth and the cigarette beetle, but generally the tobacco moth is the more important pest. In these buildings insect control is a serious problem. Fumigation is impractical, and dusting with pyrethrum powder, the only control measure widely practiced in the past, is not so effective as desired. This powder is also unpleasant to apply, and leaves an objectionable residue.

Tobacco absorbs odors readily. Furthermore, it rapidly absorbs moisture, and the least excess of moisture may cause mold and rots to develop. An insecticide for use in tobacco warehouses must meet several requirements. Besides being an effective insecticide, the material should be volatile but leave no objectionable odor; it should not leave harmful or objectionable residues; it should not impose any serious fire or explosion hazard; and it should be easy and safe to apply.

Pyrethrum-oil spray fits these specifications. Pyrethrum is a good contact insecticide, and one of the least poisonous. The spray is highly volatile, losing its effectiveness in a few hours. It leaves no permanent odor or objectionable residue. The oil used in this spray is of a light volatile type. The manufacturers' specifications for such an oil are given on page 13. Pyrethrum-oil spray can kill insects only by directly hitting them. It does not penetrate the hogsheads or bales of tobacco and cannot reach the young stages of insects in the tobacco.

Spraying should be started when the weekly trap catch reaches 10 tobacco moths or 10 cigarette beetles. It should be continued until insect activity is checked by fall temperatures. The object of spraying is to kill the adult insects before they have laid many eggs. Sprays should be applied weekly, preferably on the same day each week, and care should be taken to see that all parts of the warehouse are reached. The dosage should be approximately 3 fluid ounces of the pyrethrum-oil mixture per 1,000 cubic feet of air space. (The air space of a warehouse is the volume of the building less the volume of space occupied by tobacco.)

To control the tobacco moth, the spray should contain 0.2 percent of pyrethrins. The cigarette beetle is more resistant to insecticides, and for use against this insect the spray should contain 1 percent of pyrethrins.

A power sprayer has been especially designed for use in tobacco warehouses. This machine has a blower that will deliver approximately 2,400 cubic feet of air per minute at an initial velocity of about 5,700 feet per minute. Such a spray machine will blow finely atomized spray 100 feet or more, and reasonably good coverage can be obtained in open warehouses, even with a breeze of 6 to 7 miles an hour (fig. 11). The spray should be a moderately fine mist. A spray that will hang in the air for not less than 5 minutes or more than 15 minutes is most satisfactory.

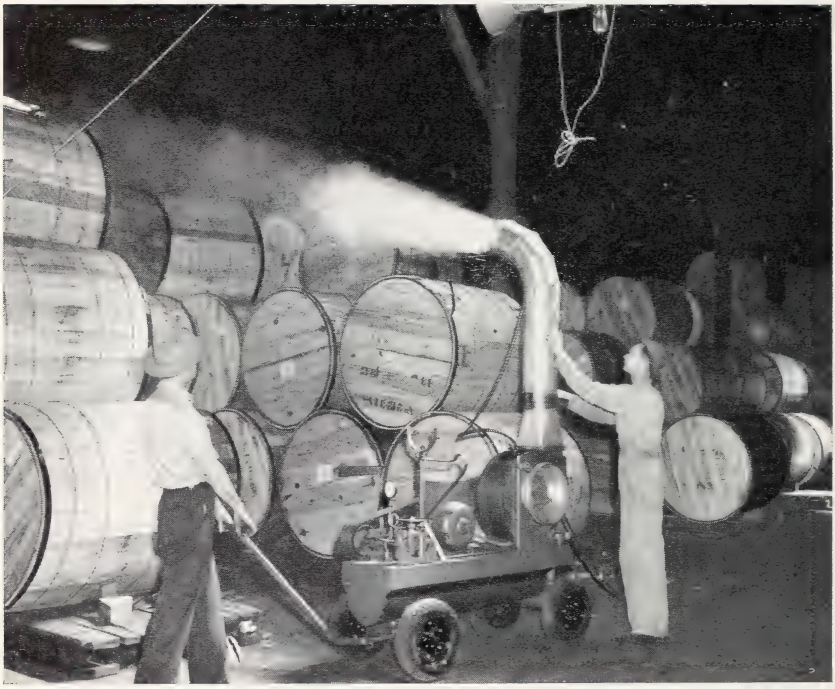

Figure 11.—Applying pyrethrum-oil space spray in a warehouse containing flue-cured tobacco.

Fire-insurance underwriters have approved the use of pyrethrum-oil spray in tobacco warehouses when prepared and used as directed. Although the flash point of the oil used in these sprays is approximately 175° F., such oil is moderately flammable and might be explosive under certain conditions. Only electric spray machines should be used. Sparkproof motors and switches and heavy-duty rubber-jacketed extension cord containing a grounding wire should be used on all sprayers.

All precautions recommended by the interested fire insurance companies should be carefully followed.

Closed-Type Warehouses

The closed-type warehouse differs from the open-type in that it can be sealed for fumigation. Closed warehouses usually afford better

protection from low temperatures, but in them the cigarette beetle is often a more important pest than the tobacco moth. Warehouses of this type may be one story or several stories, but all have doors, windows, and/or ventilators (figs. 12 and 13). The buildings vary greatly in size—from 25,000 to over 1,000,000 cubic feet. Many closed warehouses consist of long rows of sections separated by brick fire walls. They sometimes contain over 100,000,000 pounds of tobacco. The cost of labor in moving such large quantities of tobacco to fumigation chambers makes chamber fumigation impractical. The only feasible method of insect control, therefore, is to treat each warehouse. Warehouse fumigation was required in the past.

Figure 12.—A closed-type tobacco warehouse. Note two-story brick construction and numerous windows.

Figure 13.—A large group of closed-type tobacco warehouses.

One type of closed warehouse, the idea for which was developed by the Stored Tobacco Insect Laboratory of this Bureau, has been adopted by several firms. The walls are of sheet metal over a wooden frame. The joints of the metal are locked and sealed with a calking compound. Ventilators and doors close against gaskets, so that the storage can be quickly and easily sealed for fumigation. Such a building is shown in figure 14. A similar, but more substantial, warehouse can be constructed of cinder block, cement block, or brick.

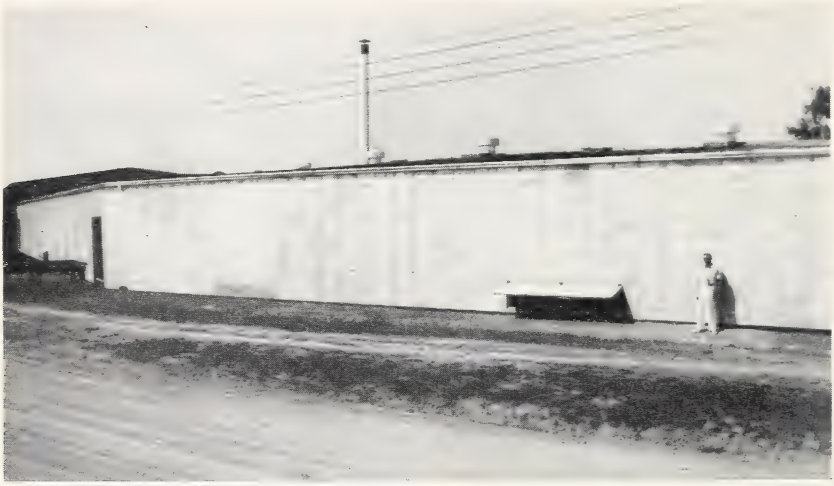

Figure 14.—A metal-clad, closed-type tobacco warehouse, especially designed to facilitate fumigation. Note the ventilators on the side and roof.

SPACE SPRAYS

Pyrethrum-oil sprays are more effective against the tobacco moth in closed-type warehouses than in open storages. The systematic use of space sprays against the adult moths as a preventive measure has proved more efficient and cheaper than fumigation in protecting the tobacco from damage by this insect. Sprays also aid in holding down a cigarette beetle infestation and may decrease the number of fumigations required. In some infested warehouses spraying has given satisfactory control of the cigarette beetle. However, spray does not penetrate the tobacco and kill the young stages of the insects, whereas fumigant does. Against well-established infestations spraying is no substitute for atmospheric fumigation. The adult moths and most of the adult beetles emerge from the tobacco to mate in the open, where they can be killed with spray. Unfortunately a small proportion of beetles do not emerge, and in heavy infestations this number is sufficient to keep the infestation going.

The recommendations for the use of pyrethrum-oil spray in open-type warehouses apply also to closed-type storages.

WAREHOUSE FUMIGATION

For effective control of insects by warehouse fumigation, the building must be adequately sealed. All openings in the walls, floors, and

ceiling, such as windows, doors, ventilators, eaves, skylights, and elevator shafts, must be closed and the building made gastight.

One method of sealing warehouses, which has been followed for some time, utilizes gastight paper (such as sisal kraft paper), paste, asphalt, elastic roofing cement, calking compound, and masking tape. Large openings are closed with heavy paper sealed with paperhanger's paste or, in the case of eaves and flashings, with tarred paper and asphalt. Cracks are filled with a mixture of 4 parts of asbestos fiber to 1 part of calcium chloride and enough water to form a stiff dough. Recently a new method of sealing has been adopted which consists in spraying a vinylite plastic over cracks around windows, ventilators, and other openings. The plastic is applied with a paint-spray gun operated by compressed air. In the old method of sealing the cost of materials is low but the charge for labor is high. The cost of sealing by means of plastic spray under 1948 conditions was approximately two-thirds the cost of the older method because of the smaller requirement for labor. However, the use of plastic calls for spray guns, and air compressor, air hose, and other equipment. Companies having many warehouses can afford such equipment, but the cost is prohibitive for firms with only one or two storages. Sealing with plastic has one big advantage—it can be done very rapidly. Sometimes the need for fumigation develops quickly and speed in preparing the building is important. Sections of tobacco warehouses sealed for fumigation are shown in figures 15, 16, and 17.

For best results in fumigation, the warehouse should be piped with ⅜-inch copper tubing. Small brass spray nozzles should be so distributed as to provide the proper dispersion of gas—one for each 15,000 to 25,000 cubic feet. The piping system should be so arranged that the gas pressure is about the same on all nozzles. Large warehouses with several floors require branch lines with separate risers. From 10 to 18 nozzles may be used to a riser. Detailed plans for piping warehouses can usually be obtained from any fumigating company after a survey of the building.

Unpiped warehouses can be fumigated with hydrogen cyanide by means of temporarily installed rubber hose and nozzles.

For many years hydrogen cyanide has been the fumigant most generally used in tobacco warehouses. Liquid hydrogen cyanide in steel pressure cylinders is used. A small air compressor pumps air into the cylinder through an intake valve until a pressure of about 100 pounds per square inch is reached. The pressure forces the air through the piping system and out of the spray nozzles. When only part of a cylinder of gas is required, the amount may be weighed from the cylinder on portable platform scales.

The operator should read the safeguards at the end of this circular and be certain that all persons and animals are out of the building before beginning introduction of gas. When the required dosage has been forced into the building, the valve on the cylinder should be closed and the piping system blown clear of gas by air pressure. The inlet pipe into the warehouse should then be capped.

The amount of hydrogen cyanide needed varies somewhat with the tightness of the warehouse. A dosage of 16 ounces per 1,000 cubic feet, with an exposure of 72 hours, is considered more or less standard. However, in warehouses with floors of cinders or crushed rock, or

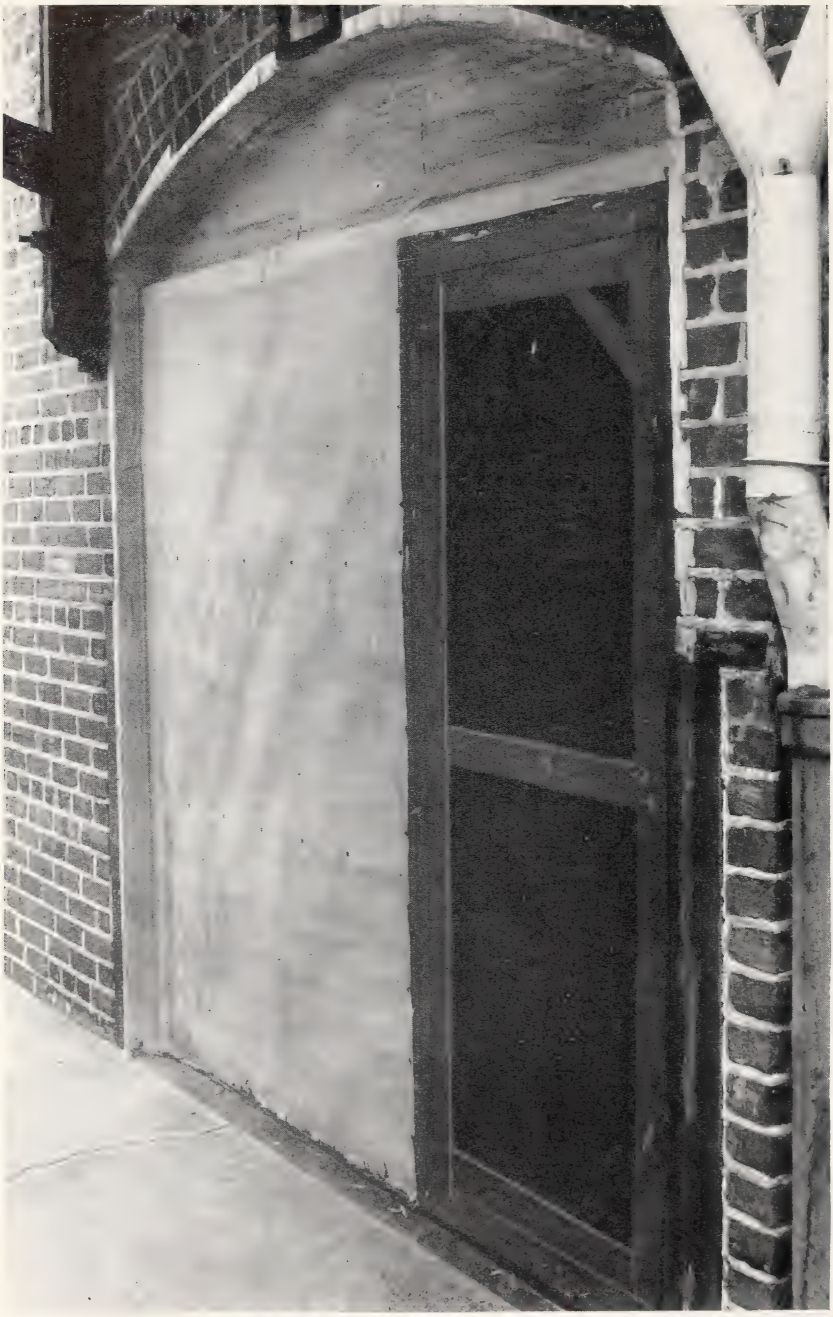

Figure 15.—Door of a tobacco warehouse partly sealed for fumigation. Sisal kraft paper has been tacked and pasted over part of the screen door.

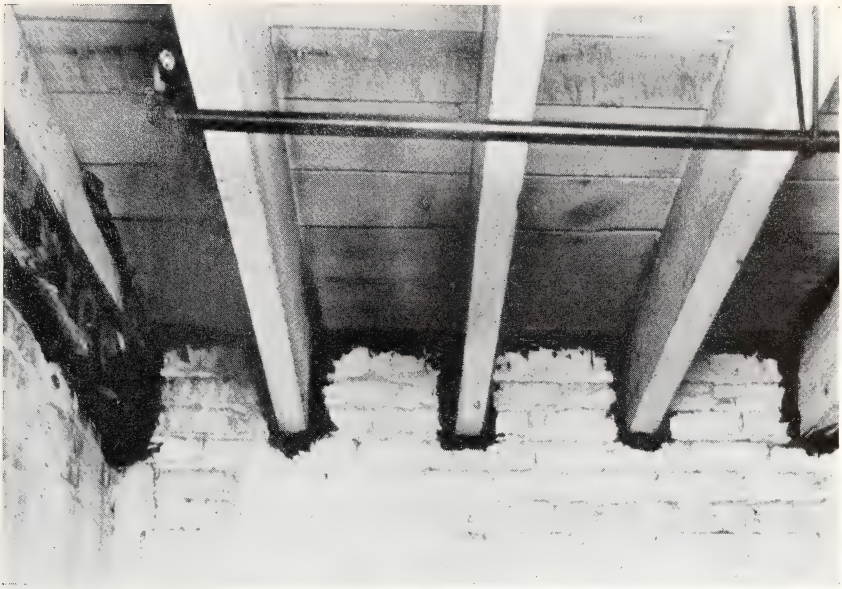

Figure 16.—Eaves of a tobacco warehouse sealed from the inside with plastic cement. The cement was applied with a calking gun operated by hand.

where more than usual leakage is anticipated, the dosage should be increased to 20 ounces. Larger dosages are seldom economical. A series of three or four fumigations at intervals of 20 to 45 days is often advantageous. The dosage may then be reduced to 8 to 12 ounces per 1,000 cubic feet, with an exposure of 24 to 48 hours. The 72-hour exposure, however, gives better penetration.

In all warehouse fumigation the temperature of the tobacco should be 70° F. or higher. As a rule, therefore, fumigation is satisfactory only in summer or early fall.

Under favorable conditions warehouse fumigation destroys all stages of the moth and beetle to a depth in the tobacco of 1 to 3 inches, and kills a few of the insects to a depth of 5 to 7 inches. However, some insects deep in the tobacco almost always survive.

Strong winds during a fumigation may destroy its value; they suck the gas out of a building very quickly.

Infested tobacco moving into a fumigated warehouse may quickly reinfest the warehouse and nullify benefits of a fumigation.

CONTROL BY CHAMBER FUMIGATION

Atmospheric Chamber

Small chambers equipped for the fumigation of tobacco at atmospheric pressure are satisfactory in many tobacco plants. Such chambers are usually 2,000 to 5,000 cubic feet in size but are sometimes larger. A chamber may be constructed of wood and tar paper, metal, concrete, or brick. It should be made tight by installing refrigerator-type doors closing against a gasket and by covering the walls with asphalt, cement, or heavy paint (fig. 18).

Figure 17.—Door of a tobacco warehouse sealed by spraying with a vinylite plastic.

The chamber may be piped in the same way as warehouses. If hydrogen cyanide is to be used, the inlet of the piping system should be in a small room attached to the chamber. The room need be only about 3 feet square—just large enough to hold a platform scales on which rests the cylinder of fumigant. From the top of this room should extend a vent pipe connected to an electric fan. The fan should be operated when gas is introduced into the chamber, so that any leakage is drawn up and away from the operator. The fumiga-

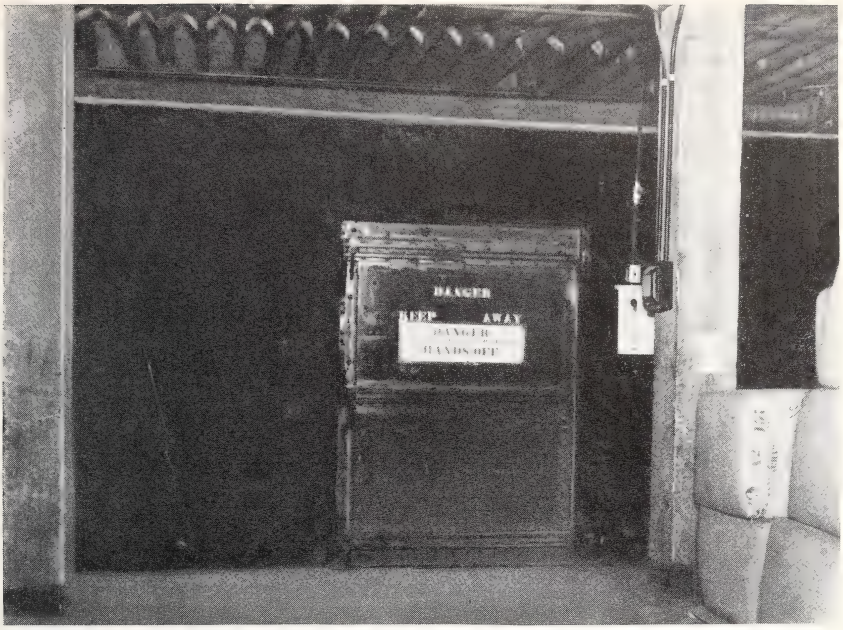

Figure 18.—An atmospheric chamber for fumigating tobacco. Note the refrigerator-type door closing against the gasket.

tion chamber should have a vent pipe, operated by readily accessible valves, extending well above the roof of the building. A powerful fan should be connected to this vent, so that gases from the chamber may be quickly exhausted, and kept running when the fumigation chamber is entered shortly after fumigation.

Both hydrogen cyanide and a mixture of acrylonitrile and carbon tetrachloride have given satisfactory results in atmospheric chambers. Acrylonitrile-carbon tetrachloride may be poured into shallow pans in the chamber. **The operator should wear a suitable gas mask while pouring.** A superior method is to place a large, shallow stainless-steel pan on a steam or hot-water coil near the ceiling of the chamber and run a small pipe through the wall or ceiling of the chamber so that it will discharge into the pan. The outer end of the pipe is connected with a funnel, held in a vertical position. The required dosage of fumigant is placed in a stainless-steel container, which is then inverted into the funnel, and the liquid fumigant flows into the pan by gravity. **However, the liquid acrylonitrile-carbon tetrachloride mixture is flammable and care should be taken to avoid exposure to spark or flame.** At the dosages recommended the gas is not explosive, but, like many other fumigants, it is both flammable and explosive at high concentrations. Unnecessary electric or telephone lines should therefore be disconnected before fumigation is begun. A sparkproof and explosionproof electric fan should be operated in the chamber to prevent stratification of the gas.

Discoids impregnated with hydrogen cyanide may be used in atmospheric chambers, but are more dangerous to handle than the liquid

hydrogen cyanide. **The operator should wear a gas mask with a suitable canister, and leave the chamber as quickly as possible after scattering the discoids. This is a dangerous operation and should not be undertaken by an inexperienced person.**

If hydrogen cyanide is used, the dosage should be at least 16 ounces per 1,000 cubic feet, and as much as 24 ounces may sometimes be used to advantage. The exposure should be 72 hours. If acrylonitrile-carbon tetrachloride is used, the amount should be 32 to 40 ounces per 1,000 cubic feet with an exposure of 72 hours for flue-cured tobacco in hogsheads. For bales of Turkish tobacco and for bales or cases of cigar filler or binder tobacco, 32 ounces with an exposure of 48 hours has proved satisfactory. All dosages given are to be used at a temperature not lower than 70° F.

In the fumigation of tobacco in atmospheric chambers, bales and cases should be stacked with slats between them and with air spaces on all sides to permit the gas to penetrate the tobacco. Better penetration is usually obtained in atmospheric-chamber fumigation than in warehouse fumigation. However, fumigation is not so effective in atmospheric chambers as in vacuum chambers.

Vacuum Chamber

The fumigation of tobacco in partial vacuum is the most effective method known for destroying insect infestations. When properly performed it should kill all stages of the cigarette beetle and the tobacco moth, at all depths in the tobacco (fig. 19). Vacuum chambers are expensive, but they are extensively used because of their efficiency and the rapidity with which they can be operated.

Figure 19.—Perforated capsules containing cigarette beetle larvae or eggs that were placed in the cigars at the time of manufacture to test the effectiveness of fumigation.

EQUIPMENT AND PROCEDURE

Vacuum fumigation equipment consists of a pair of steel chambers strong enough to withstand considerable pressure, a pump of suitable size to evacuate the chambers, a volatilizer for the fumigant (for use in cool weather), and recording gages. Loading platforms and conveyors facilitate the handling of the tobacco. The chambers vary widely in size, most of those in commercial use ranging from 400 to 3,000 cubic feet. In some of the larger units each chamber has a capacity of more than 30 hogsheads.

The tobacco to be fumigated is placed in the vacuum chamber, the door is closed, and the air is pumped out until a vacuum of 28 to 29 inches is registered on a standard mercury gage (fig. 20). The degree of vacuum obtainable varies from day to day with the barometric pressure, but any vacuum of more than 28 inches is usually satisfactory. The proper dosage of fumigant is determined by weighing. The cylinder or drum of fumigant is placed on a platform scales and connected to the intake line of the chamber. When a valve is opened the gas is sucked into the chamber and drawn all through the tobacco by the vacuum. At the end of the exposure period the gas is pumped out of the chamber and vented above the roof of the building. Air is then admitted to restore normal pressure in the chamber. This air is exhausted by pumping and air is again admitted. This procedure—called air washing—is usually performed twice with each lot of tobacco.

The manufacturers of vacuum-fumigation equipment can supply estimates and specifications to meet the needs of individual factories or warehouse operators.

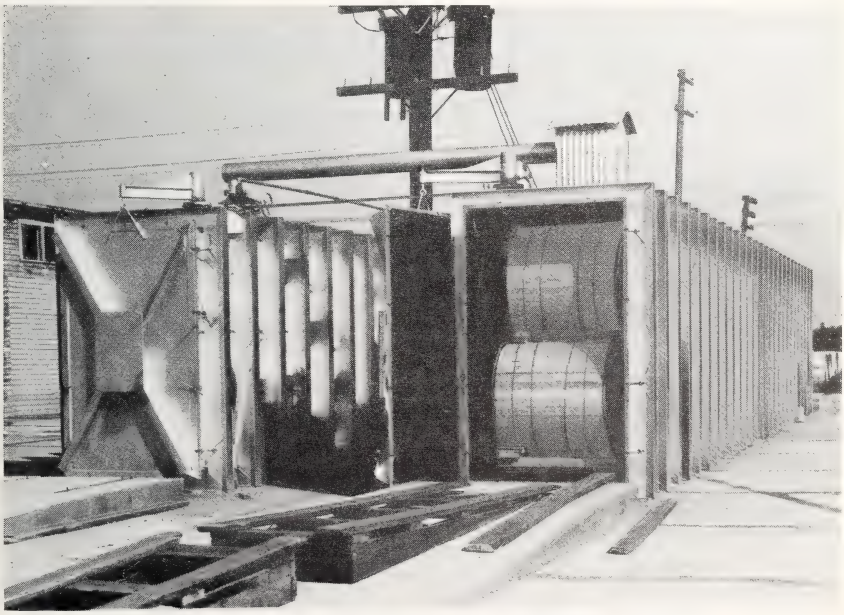

Figure 20.—**Vacuum chambers for fumigating tobacco.**

FUMIGANTS AND DOSAGE

Several fumigants may be used in vacuum fumigation of tobacco.

Hydrogen cyanide is popular, particularly for cigarette tobaccos. It is seldom applied on cigar tobaccos just prior to manufacture or on cigars, because the odor may persist for several weeks.

A 1:9 mixture of ethylene oxide and carbon dioxide is often used for cigars and cigar tobaccos. Although it does not leave any objectionable odor, it is not always effective, especially at temperatures below 60° F.

Methyl bromide has been employed to a limited extent and is a good insecticide, but obnoxious odors have developed in tobacco fumigated with it. Furthermore, handling of tobacco fumigated with methyl bromide may be very dangerous for several days after fumigation, small quantities of absorbed gas being given off by the bales of tobacco.

A 1:1 mixture of acrylonitrile and carbon tetrachloride has recently become known as a tobacco fumigant. This gas is less dangerous than methyl bromide or hydrogen cyanide, leaves no objectionable odor, is an effective insecticide, and has not been known to injure tobacco. However, it creates a fire hazard.

Much tobacco is fumigated in vacuum during the fall, winter, and spring, when the temperature of tobacco is below 70° F. At such temperatures it is necessary to increase the dosage of fumigant and the results are erratic, perhaps because the insects are less active and therefore more resistant.

Exposure of infested tobacco to vacuum alone for practical lengths of time is relatively ineffective in controlling stored-tobacco pests. Tests showed that continuous exposure to a high vacuum (above 28 inches) for 3 days killed all stages of the tobacco moth and all stages of the cigarette beetle except the egg. An exposure of 10 days was required to destroy the eggs of the beetle. However, even a 3-day exposure is impractical under most conditions.

The following dosages of fumigants are recommended for the vacuum fumigation of tobacco at an exposure of 3 to 4 hours:

Fumigant and type of tobacco:	*Pounds per 1,000 cubic feet at—*	
	70° F. or above	*35° to 69° F.*
Hydrogen cyanide:		
Flue-cured	4	5
Turkish	4	5
Cigar filler or binder	4	5
Cigar wrapper	5	----------
Ethylene oxide-carbon dioxide:		
Cigar filler or binder	60	----------
Cigar wrapper	65	----------
Cigars	45	----------
Acrylonitrile-carbon tetrachloride:		
Flue-cured	4	5
Turkish	4	5
Cigar filler or binder	4	5

CONTROL IN TOBACCO FACTORIES

Preventing Infestation

An important source of factory infestation has always been the flight of cigarette beetles from storage warehouses nearby. The various processes—stemming, blending, bulking, handling, and manu-

facturing—need as much light as possible. In the past large windows permitted entrance of the beetles. Fluorescent lighting and air conditioning have eliminated this problem in some modern buildings with screened air intakes. Unfortunately, however, only a few factories are so equipped.

Probably the greatest source of infestation in factories is tobacco that is already infested when brought into the building. Because tobacco is often held for hours or even days before it is processed, great care should be taken not to bring infested tobacco into the manufacturing plant. In cigarette manufacture the hogsheads of tobacco almost always receive a thermal-vacuum treatment to moisten and condition the tobacco so it can be handled without breaking. This process raises the temperature of the tobacco high enough to kill all stages of the cigarette beetle and tobacco moth. However, it is important that the hogsheads move directly into the processing chambers as they are brought in from the warehouse; otherwise there is always danger of infesting the factory. Tobaccos that do not receive the thermal-vacuum treatment should be fumigated in vacuum or atmospheric chambers before being brought into the factory. If it is necessary to bring untreated tobacco into a manufacturing plant and hold it for even a short time, it should be placed in a receiving room screened with 20-mesh wire.

In factories that are not air conditioned all doors, windows, and ventilators should be screened with 20-mesh wire. Home owners more than a mile from any tobacco storage or factory have complained of large invasions of cigarette beetles. Unscreened doors and windows are an open invitation to this insect.

Insect Traps

One or more suction light traps should be installed on each floor of a factory, preferably one in each room where tobacco is handled or stored. They should be operated continuously. The catches will reduce the number of beetles flying in the factory, and provide early information as to the start of an infestation. They also offer an opportunity for determining what rooms or floors are sources of infestation.

Fumigation of Manufactured Tobacco

Cigarettes leaving the factory for channels of trade are not fumigated. With the precautions taken in modern factories it is seldom necessary. Moreover, a package of cigarettes is so tightly sealed that effective fumigation is impractical. However, cigarettes sometimes become infested while in the hands of wholesalers or retailers; they are returned to the manufacturer. Some of the tobacco in such cigarettes can be cleaned and reclaimed, but infested cigarettes should be fumigated, preferably in vacuum, before they enter the factory. The cartons of cigarettes should be opened and, if possible, the wrapping on the packages should be broken before fumigation.

Cigars need protection from the time they are made until they are shipped out of the factory. This interval may be as long as 40 days or even longer. If it is not possible to keep the cigars in cool storage or an insect-tight room, it is desirable to fumigate in vacuum with

ethylene oxide-carbon dioxide fumigant before shipment, particularly in summer. When fumigating cigars it is advantageous to do so before wrapping in cellophane.

Pipe and chewing tobaccos are rarely fumigated after manufacture. Therefore they must be protected during storage if losses are to be prevented. Adequately sealed packages are valuable in this respect. All returned goods should be fumigated before being received into the factory for cleaning and salvage.

Heat Treatment and Cold Storage

As has been stated, the redrying process for leaf tobacco should kill all stages of the tobacco moth and cigarette beetle. This is not necessarily true for the redrying of flue-cured strips, the laminae of the leaves after the midribs have been removed. Strips are redried at lower temperatures and for shorter periods than is leaf tobacco; consequently the treatment is not always entirely effective.

In manufacturing cigarette or pipe tobacco, the shredded, granulated, or chopped-up tobacco is heat conditioned. In all such processes observed the temperatures have not been high enough or maintained long enough to give appreciable insect mortality.

Cold or cool storage is of great value in preventing or checking an insect infestation. Flue-cured tobacco for export is sometimes held in storage at 50° to 60° F. to prevent loss of color and excessive fermentation. As the threshhold of activity for the moth and the beetle is 60° to 65°, a lower temperature will check activity and arrest insect development.

Cool storage is also widely used in the cigar industry to prevent cigarette beetle infestation. Cigars are often stored in rooms at 45° to 55° F. No insect infestation occurs at this temperature. The cigarette beetle is killed by continuous exposure to 40° for 33 days, to 36° for 16 days, to 25° for 7 days, or to 15° for 3 days.

AN INSECT-CONTROL PROGRAM IN TOBACCO WAREHOUSES

The question of when and where to fumigate is sometimes difficult to answer. The problem may be complicated by the type or age of the tobacco, the degree of infestation, whether one or both species of insects are involved, and previous treatment. As a rule it is advisable to fumigate a warehouse 1 to 2 weeks after the peak of emergence of an insect brood. However, where the tobacco moth is known to be present, fumigation as early in the spring as appreciable emergence occurs is desirable.

Complete kills of insects are rare in the fumigation of tobacco warehouses. For this reason it is important to keep a constant record of insect populations in warehouses by means of suction light traps, and to time fumigation to follow the emergence of beetles and moths. When full grown, tobacco moth larvae move to the surface of the tobacco or leave it entirely. Large numbers of cigarette beetles also migrate to near the surface of the tobacco. The adult moths and most of the adult beetles stay out of the tobacco to mate and lay eggs. As the eggs of both insects are laid on or near the surface of the tobacco,

the very young larvae are usually near the surface also, and little penetration of gas is required to kill adults, eggs, pupae, and many larvae. With careful timing the largest possible proportion of moths and beetles can be killed.

Suction light traps should be installed and placed in operation before the earliest spring emergence. This date ranges from March 1 in eastern South Carolina to April 15 at Richmond, Va., and probably May 1 in eastern Pennsylvania.

Applications of a pyrethrum-oil spray containing 0.2 percent of pyrethrins in a cigarette-tobacco warehouse should start when suction light traps show 10 tobacco moths a week. If or when traps show a catch of 10 cigarette beetles a week, a spray containing 1 percent of pyrethrins should be used. Should the spray fail to control the cigarette beetle, the warehouse should be fumigated as soon as possible after the peak of emergence. Under such conditions the minimum infestation that would probably justify fumigation of cigarette tobacco would be indicated by a weekly catch of 200 to 300 beetles. In warehouses of cigar tobacco fumigation might be justified by a much lighter infestation. If necessary, the fumigation should be repeated.

If a spray is not used, two to four fumigations a year are needed, depending on the degree of infestation. At Richmond, Va., the most desirable times for such fumigations have usually been May 15 to 31, June 25 to July 5, August 10 to 25, and September 15 to 30.

In all fumigation of tobacco, the gas should be applied only by a person especially trained for the work. For warehouse or factory fumigation it is best to employ a licensed pest-control operator. An employee especially trained should be solely responsible for atmospheric or vacuum-chamber fumigation.

COST OF INSECT CONTROL

The cost of insect control varies from year to year with the price of labor, insecticides, and other things. Cost figures are available for cigarette tobaccos only. For 1948 the cost of treating tobacco warehouses with pyrethrum-oil spray to control the tobacco moth ranged from 8 to 13 cents a hogshead. It cost about 18 cents a hogshead to spray for control of the cigarette beetle. The cost of warehouse fumigation ranged from 17 to 32 cents a hogshead and averaged about 26 cents for each fumigation. In 1949 the costs of both spraying and fumigation were substantially higher.

Vacuum fumigation may range from $1.00 to $3.00 a hogshead. The charge for custom fumigation in vacuum at Newport News, Va., in 1950 was about $1.25 a hogshead of flue-cured tobacco. This included the cost of the fumigant, labor, electric power, and amortization of equipment.

SAFEGUARDS IN FUMIGATION

Carelessness is responsible for most of the accidents in industrial fumigation. The following precautions should always be taken:

Employ only trained men, preferably licensed pest-control operators, in the fumigation of warehouses and factories. Operators must abstain from intoxicants while working.

Except where electric fans are to be used, disconnect all electric lines and telephone lines into the building or chamber—preferably outside the building. Use only sparkproof and explosion-proof electric fans.

Keep all persons and domestic animals outside the building or chamber when it is finally closed and sealed for fumigation. Post placards in prominent places on the building or chamber, warning that it is being fumigated with poison gas.

Keep guards and night watchmen on duty to see that no person or domestic animal approaches a building under fumigation.

Wear or carry gas masks equipped with the proper canisters at all times when handling gas.

Local authorities should be notified of the intention to fumigate and any necessary permits obtained from them. These officials should be notified again when the fumigation is completed and the building has been properly ventilated.

Before fumigation, the interested fire insurance underwriters should be notified, and their approval of the procedure obtained.

SUGGESTIONS FOR FURTHER READING

ALFIERI, A.
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