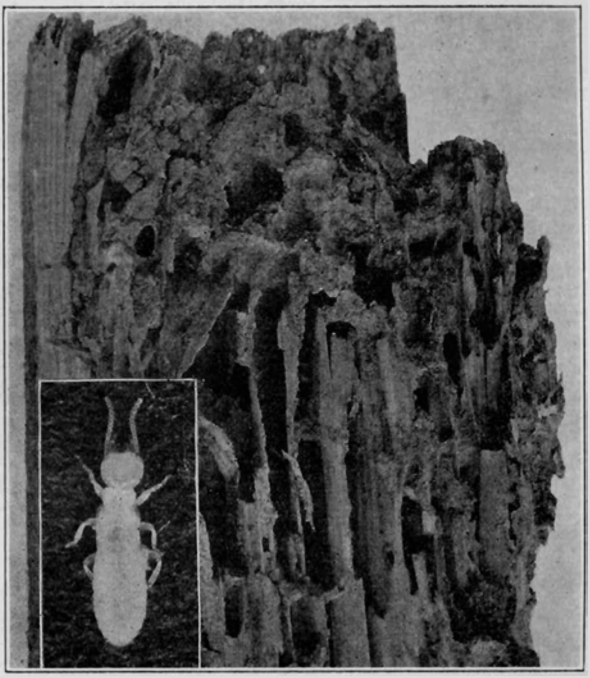
Bulletin 382 March, 1936

TERMITE CONTROL IN BUILDINGS IN CONNECTICUT

Neely Turner and James F. Townsend



Connecticut
Agricultural Experiment Station
New Haven

Printing by The Peiper Press, Inc., Wallingford, Conn.

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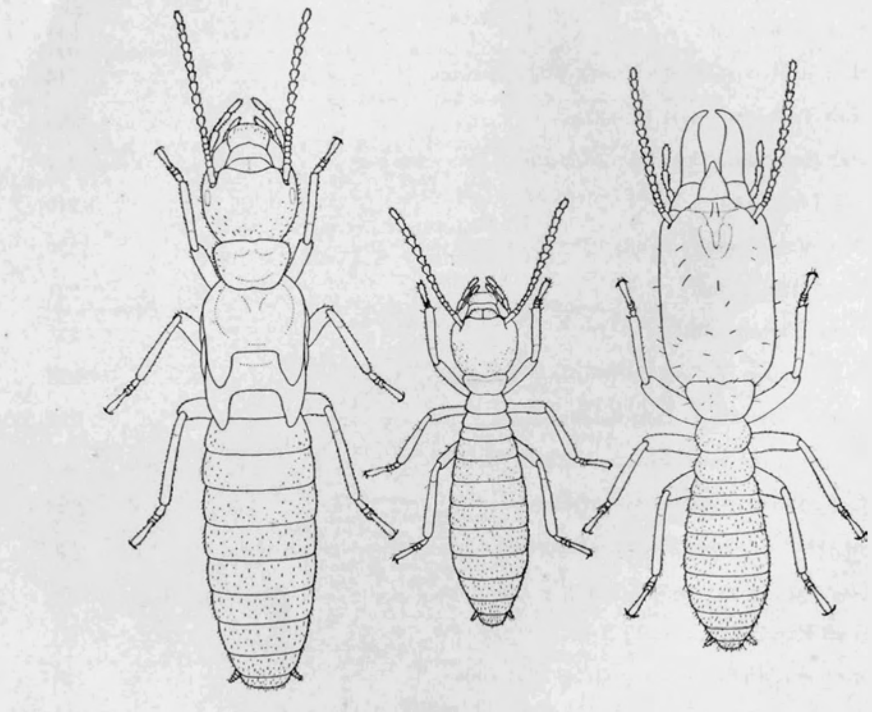

FIGURE 78. Supplementary queen (left), worker (center), and soldier (right). Eleven times natural size.

TERMITE CONTROL IN BUILDINGS IN CONNECTICUT

NEELY TURNER AND JAMES F. TOWNSEND

HISTORY OF THE TERMITE IN NEW ENGLAND

THE EASTERN subterranean termite (*Reticulitermes flavipes* Kollar), the only termite known to occur in Connecticut, has been common in stumps and logs for many years. It is a native insect which originally fed on dead wood in forests. While it is still found in woodlands, it is now appearing in large numbers in some urban sections as well and is doing an increasing amount of damage to buildings.

Termite injury was recognized in houses in this region as early as 1875, but never has the Experiment Station had so many cases reported as in the past three years. In 1935, 111 buildings were examined and found infested, and the necessary repair work amounted to thousands of dollars. What is the reason for this so-called outbreak?

Central heating is probably one answer. When our ancestors first cleared the land and erected wooden structures, termites attacked the new lumber. However, their inroads were limited to the warm months and they made a faint impression on the massive beams used by the settlers. When furnaces were installed, the insects had an opportunity to feed throughout the year.

Many other changes introduced by man have favored termites. Removal of trees has allowed more sunlight to warm the soil to higher temperatures. The concentration of sound wood in the ground, or easily accessible from the ground, has provided a more ample food supply than existed in the forests. Recently many new houses have been built in wooded country and some of these have been attacked. Dwellings of the same type, erected on cultivated land, have not been found infested.

According to Hagen[12*], termites were very abundant and were attacking buildings in the vicinity of Boston as early as 1876. Recent investigations indicate that similar trouble existed in Connecticut at an earlier date than records show. One old house at Easton required reënforcements in 1900 when new joists had been set beside the old ones. In 1934 it was discovered that termites had completely destroyed the old wood and had badly damaged the new. It is logical to conclude that they were responsible for the original trouble. A similar situation came up at Newtown. A remodeling job there was done in 1918 and 15 or 20 posts and several large cross beams had to be used to give the house adequate support. Both old and new beams were found ruined by termites in 1935, indicating that these insects had been present in the first place.

* For number references see bibliography on page 242

Since entomologists seldom examine buildings under repair, they did not discover the seriousness of the situation in Connecticut until specimens of wood and insects were sent to the Station for identification. For years carpenters had noticed the rotten condition of wood in certain houses, and had usually classified the entire trouble as dry rot. Hence termite damage went unrecognized and was much more common than anyone supposed.

Britton[2] reported termite damage to a building in South Norwalk in 1909. Other reports were received one each in 1915[4], 1925[6], 1927, 1928[7], 1930[8] and 1931[9]. In 1914 specimens of greenhouse-grown geranium plants were damaged by termites[3]. Hickory saplings were attacked in Old Lyme[20] in 1915, and specimens of infested phlox and geranium plants growing out-of-doors were received in 1923[5], 1931[9] and 1932[10]. Termites destroyed insulation on telephone wires in a building in New Haven in 1921[31]. And since 1931 termites have been found in a large number of houses[29].

Careful examination of about 300 infested buildings reveals wide variation in the amount of damage. In some places there is evidence that termites have been present for a long time with serious consequences. In others extensive termite injury occurred in the past, but at present no infestations can be found. The same condition holds for many wooden fences and fence posts where termites worked near the ground level but have not persisted. In some of these cases the wood seemed to be rotting too rapidly for the insects to survive. In a number of structures, from 50 to 100 years old, termites are known to have been present for at least 5 or 10 years but no extensive damage resulted. On the other hand, many buildings not more than 10 years old have been seriously injured, with large sections of the sills and lower parts of the studding ruined.

Nor do these insects confine their activities to buildings of one type. Severe termite damage has been seen in small garages, frame, stucco, masonry, brick and stone veneered buildings; small business buildings; masonry public buildings such as libraries and hospitals; masonry apartment houses, masonry office buildings and factories.

It is difficult to draw any specific conclusions from the evidence. Certainly it is true that termites have not found conditions favorable for growth in some locations, while they have developed very rapidly in others. But little is known of the factors involved or the reasons for differences in colony expansion.

At the present time it is impossible to estimate the future abundance of termites in general, or of a single termite colony. It is expected that their number will fluctuate, but whether the present outbreak will last 5 or 50 years is a matter of conjecture. It *is* known that, unless checked by natural or artificial means, termites *can* and *do* seriously injure wooden structures in Connecticut. The abundance of many other insects from season to season is determined by the presence of natural enemies, and by conditions of temperature and moisture, and it is logical to assume that termites are affected in the same way. It is also a fact that termite damage is a matter of years rather than days or weeks.

There is no occasion for exaggerated fears that all buildings are going to be seriously injured immediately. However, it is desirable for every property owner, architect and builder to be acquainted with the danger of termite attacks and the best methods of control.

This publication has been prepared to bring together the necessary facts of termite biology and habits, the significant results of research work in materials and methods of termite control, and the experience of disinterested workers in practical measures. On the basis of these findings, the authors offer their suggestions for the control of termites in Connecticut buildings. It is hoped that a better understanding of the problem will help to reduce the great economic waste now being caused by termites in Connecticut.

BIOLOGY OF TERMITES*

The eastern subterranean termite (Figure 79) is a social insect living in colonies with members divided into a number of castes. Each caste has certain definite functions to perform and is distinctive in appearance. Termites are commonly called "white ants". They are not ants; not all forms are white, and they do not have the abdominal constriction or "wasp-waist" which is characteristic of true ants.

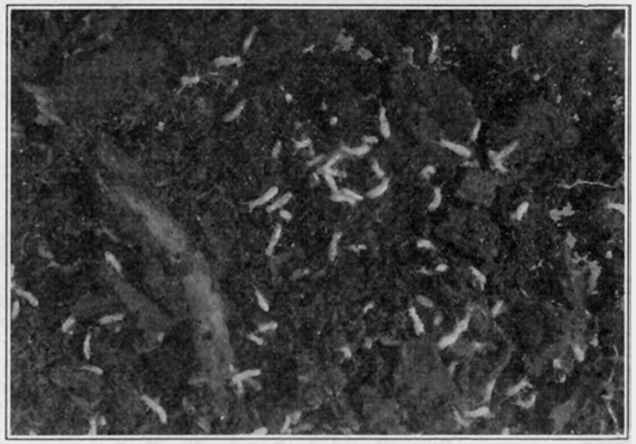

FIGURE 79. Some members of a termite colony: workers, supplementary queens and soldiers. Natural size.

The workers (Figure 78) are blind, grayish white, wingless and sexless, and live entirely under cover. They make all excavations in the ground or in wood, feed the young termite nymphs, soldiers, queen and males, and construct covered runways, or tubes of earth-like material, over the surface of objects that they cannot penetrate. These tubes may be built to obtain food or to serve as outlets for a swarm of winged adults. In heavy infestations, they are frequently built down from wood to obtain additional soil contacts for moisture.

The soldiers (Figure 78) are about the same color and size as the workers and are also blind and sexless, but have enlarged heads with strongly

* Most of the biological information given here has been taken from various publications of Dr. T. E. Snyder.

developed mandibles. Their sole function is to protect the colony from enemies, such as rival termite colonies and ants.

The queen has a black head and thorax but the abdomen is enlarged and partly white. She is usually accompanied by one or two true males and is found near the center of the colony. She deposits eggs which may produce workers, soldiers, or reproductive primary or secondary males and females. In addition to the primary queen, at least two forms of secondary reproductive females (Figure 78) occur in some termite colonies. These deposit eggs which produce true workers or secondary sexual forms, and are very important in causing a rapid increase in colony size. They are usually more or less isolated from the center of the colony.

At times, particularly in the spring, large numbers of dark brown, winged males and females, which develop from certain workers, (Figure 80) may appear in the colony. They usually swarm from cracks in infested wood and fly short distances from the point of exit. On alighting, the wings are broken off and the fertilized female, attended by a male, attempts to find a suitable place to start a new colony. She must find

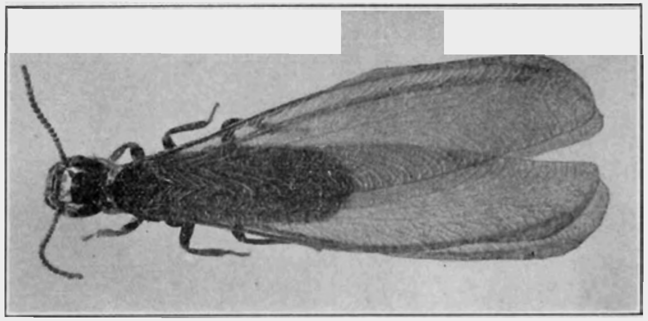

FIGURE 80. Winged termite. Eight times natural size. Swarms of these insects sometimes emerge from infested timbers in spring. After flight they discard their wings.

moist soil near a supply of food in ground not occupied by other termites. A large percentage of these males and females are unable to start new colonies. They are usually killed by birds, ants or by other colonies of termites. If a young queen survives, she mates and deposits from 6 to 12 eggs, and she and the male attend these until the nymphs are mature, a period lasting about a year. Then more eggs are laid and the workers take over the care of the brood. Until secondary females start producing, colony growth is very slow. Individual workers may live for five years but the reproductive rate is low and it takes a long time to build up a large colony.

As stated above, termites usually locate in moist soil near a supply of dead wood that is used as food. If the wood in which they are feeding is constantly moist, because it is buried in the ground or kept wet by leaks in houses, the colony may live in the wood itself. It is not necessarily a compact unit in a stable location but may be spread over a large area with several reproductive centers connected by a network of runways. It is not sharply defined by boundary limits and the location may be changed with variations in temperature and moisture. In winter

the colony, unless living in or under a heated house, moves below the frost line. It is usually difficult to find the center of a colony and practically impossible to destroy every individual belonging to it.

Termites are capable of persistent concerted action, with behavior bordering on intelligence. By constant searching they discover susceptible points in building construction. In several well-built houses termites have located the only evident point of entry. They seem to be continually exploring for new sources of food. Once established in a

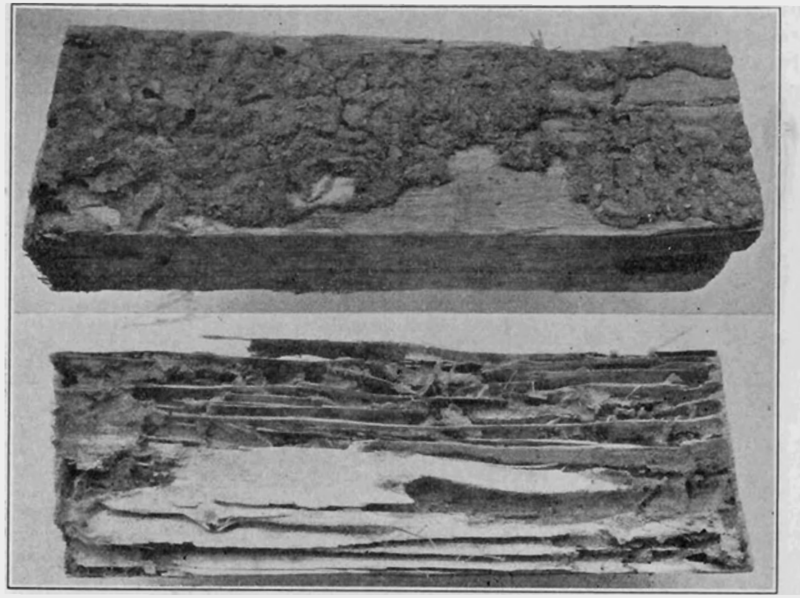

FIGURE 81. Above, external appearance of a block of infested wood. Below, section of the same block showing character of termite burrows.

building, if they are not checked by natural or artificial means, they continue their activities until the infested timbers are weakened.

SOURCES OF FOOD

The principal food of the termites is cellulose, obtained usually from damp wood that is invaded by fungi. There are records of termite damage to books and documents, wall board and other cellulose building materials, foodstuffs, cloth, shoes, paper and the like, stored in buildings. Sometimes they feed on living trees, field crops, nursery stock, flowers and greenhouse plants as pointed out in the introduction. Although they prefer damp wood in the early stages of decay, they are able to feed on sound, dry lumber by carrying moisture and fungi into the burrows, which are kept closed to the outside air. For this purpose they require a constant supply of moisture. Termites show a preference for certain woods but are able to feed on all those commonly used for houses in this section. The heartwood of redwood, red cedar and cypress is relatively unpalatable to them.[21]

HOW TO RECOGNIZE THE PRESENCE OF TERMITES

Examination of wood in contact with the ground, such as stumps, stakes, boards, lattices and steps outside a building, is frequently helpful in finding whether or not a property is infested. If present, some termites are usually found near the ground line. Additional information as to the population may be gained by setting stakes of unpainted white pine in the ground, or blocks of the same material on the ground, and examining them after a week or 10 days. Termites present on adjoining building lots or in nearby woodlands are a menace, but may or may not enter an uninfested building.

Susceptible wood construction such as cellar window frames, door jambs and posts extending into concrete floors, may be examined by

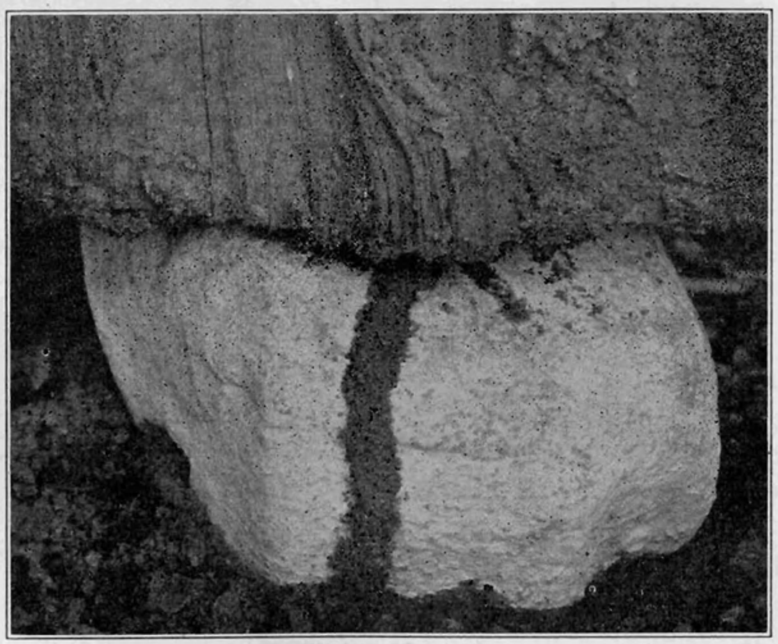

FIGURE 82. Termites constructed this shelter tube in the laboratory under artificial conditions. About two-thirds natural size.

punching with a sharp instrument such as a screwdriver. This may disclose the presence of termite burrows (see Figure 81).

In termite burrows, the outer shell and usually the harder parts of the annual growth of the wood are left intact. The burrows are kept closed and the high humidity maintained inside favors fungous growth. They often contain masses of a wood paste resembling commercial wood putty, and the walls frequently show small spots of the same material. This is one of the ways in which they may be distinguished from burrows of carpenter ants. The absence of "sawdust" is another distinction. Moreover, carpenter ants excavate more smoothly than termites. Wood-boring beetles work in individual tunnels, filling these with waste mater-

ials and casting "sawdust" from holes or cracks. Powder-post beetles form a very fine powder never present in termite burrows and the emerging insects leave small, round holes in the surface of the wood.

Brown, earth-like shelter tubes are frequently found on the inside basement walls of infested buildings (see Figures 82, 86, 87). They may also be built under porches and on masonry walls behind vines or dense shrubbery and around obstructions such as bricks, concrete or unpalatable timbers.

Large swarms (50 to several thousand) of dark brown, winged termites (see Figure 80) sometimes occur in or near infested buildings. These flights have been observed in Connecticut in late winter or spring. Flights

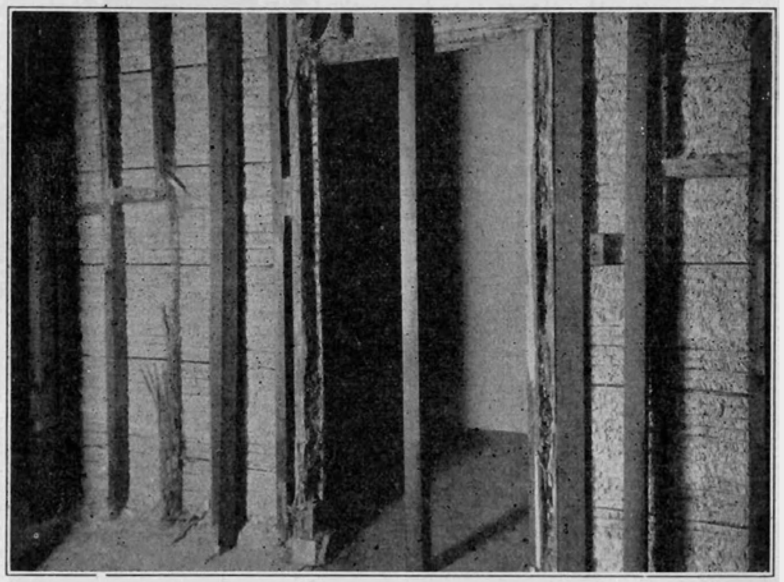

FIGURE 83. Termite damage to wooden basement partition in a large masonry building. Photograph shows four pieces of temporary shoring necessary to support wooden floor above.

are not likely to occur until a building has been infested for two or more years. The winged termites are not wasp-waisted like common ants. They usually shed their wings soon after emergence but ants are likely to retain theirs for some time. It is quite characteristic to find a large number of wings, about one-half inch long, shortly after termite flights. An occasional insect wandering around the house at other times is not likely to be a termite.

Structural failure of the wood due to termite excavations usually does not become evident until the building has been infested for several years. Soft spots in wood flooring laid over concrete or on soil, and weakening of wooden porch steps may indicate termite damage.

It is sometimes difficult for even an experienced worker to locate small infestations when little injury has been done.

HOW TERMITES INFEST BUILDINGS

Subterranean termites infest buildings in one or more of the following ways:

1. **Through direct contact between wood and soil** such as wooden porch steps and lattices, wooden posts, basement studding and partitions (Figure 83) extending through concrete floors, cellar window frames, cellar hatchways, and house sills in contact with fill under masonry terraces and porches (Figure 84).

2. **Through existing cracks or hollows in masonry** (Figure 85) or through channels that termites are able to excavate in lime mortar. These may give access directly to structural timbers or to built-in basement construction such as closets, wainscoting, partitions, door jambs, and furred, lathed and plastered construction through which structural timbers may be reached.

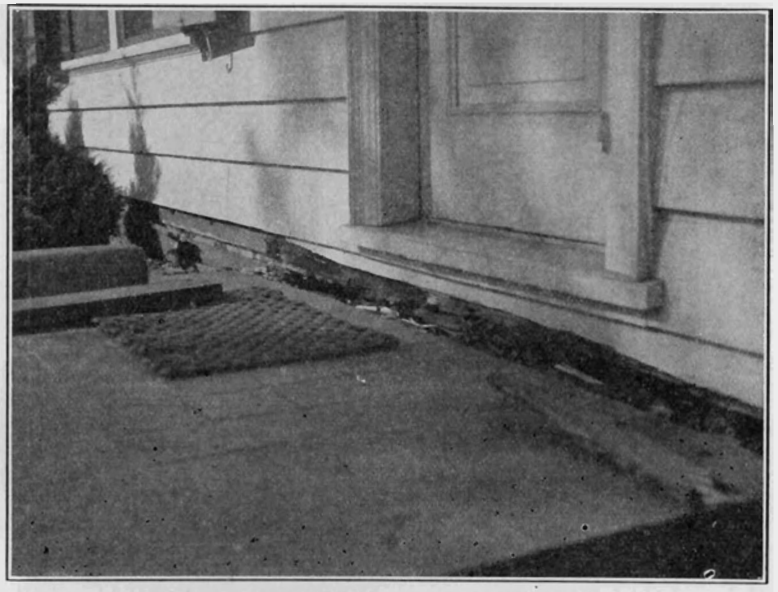

FIGURE 84. Termite damage to sill and sheathing adjoining masonry porch. Part of porch floor removed to make repairs.

3. **By means of covered runways or tubes** (Figure 86) built over the face of wood, masonry, pipes, etc., or for short distances vertically in the air, usually not more than one foot, although von Schrenk[40] has reported some several feet high. These tubes are usually built in sheltered places inside the foundation, but may be on the outside walls as well. In isolated cases termites have constructed such runways under vines on a masonry building from the ground to the second floor. Tubes are also frequently found in hollow tiles, sometimes as far as the second floor framework.

4. **By storage of infested wood.** It is possible to establish a termite colony by storing infested wood such as beams from an old building, or fireplace wood, in basements or on the ground under porches. Bentley and Rogers[1] have reported such a case in Tennessee. We have seen wood stored in basements damaged by termites, but the evidence in these cases indicated that the termites came from the building and not from the wood.

Subterranean termites do not infest buildings by crawling or flying in open doors or windows. The winged males and females can start a new colony only in moist soil.

TERMITE CONTROL: VARIOUS METHODS DISCUSSED

In the control of various insect pests, entomologists and chemists have developed many insecticides that either kill by contact, or act as internal poisons if consumed by insects. Termites are soft-bodied and have been killed by such mild chemicals as common table salt, borax,

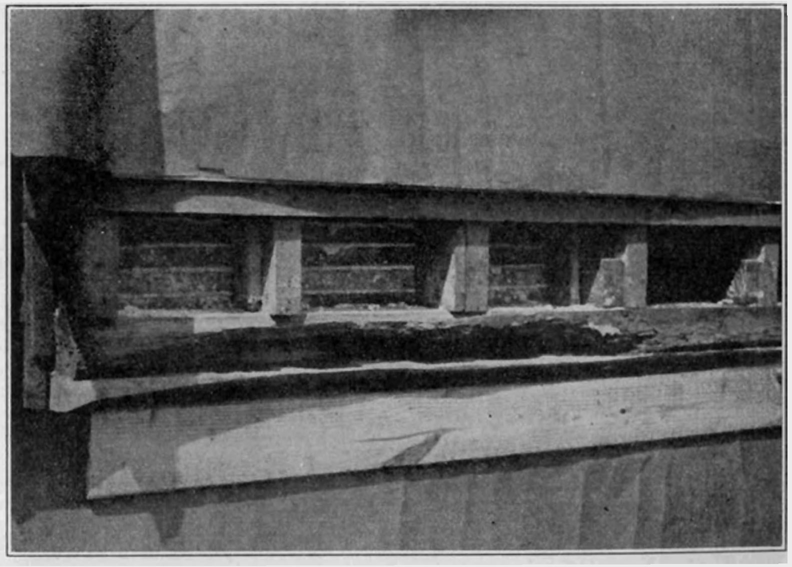

FIGURE 85. Termite damage to sill and studding of house. The entry was through hollows in the concrete block foundation (covered by building paper).

calomel and boric acid, but the protection afforded by their concealed life in burrows makes control difficult. Since colonies are spread out, extermination of all termites in the vicinity is not practicable. However, the population may be reduced by destruction of unnecessary sources of food and by use of soil treatments.

The methods commonly effective against other insects, such as spraying, trapping, use of poisoned baits or biological control, have not been employed successfully against subterranean termites[17]. Fumigation does not kill all termites in timbers and does not prevent reinfestation[17,23]. Heat (135° F. for 24 hours) is effective[19] but is not practicable for use in the ordinary building and does not prevent reinfestation. Poisons sprayed or brushed on timbers do not kill all termites working inside[17,23]. Injection of poison dusts in holes in wood is not a satisfactory method. It may be effective over a limited area but is not a permanent protection for a building[17]. Neither has the injection of toxic liquids into infested timbers been satisfactory. According to Snyder[23]: "*Due to the possible ramifications of termites in a building which has been infested*

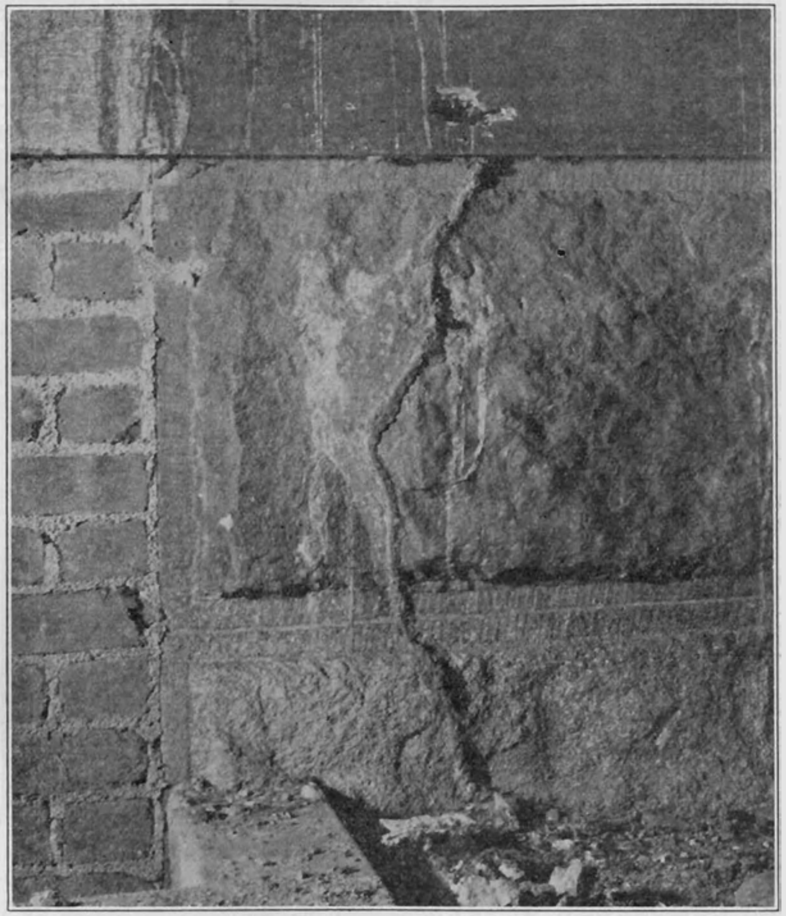

FIGURE 86. Termites constructed this shelter tube in a partly excavated area to gain entry to wood in this building.

for some little time and the protection which they have in their burrows concealed in the wood, no control worth while by fumigation or spraying has proved to be possible, and spraying even if applied under strong pressure at borings made at occasional points in eaten timbers, is unsatisfactory".

For a period of at least 35 years, the most practical and successful method of control has been to exclude termites from buildings by proper

construction. To do this intelligently, it is necessary to know the termite resistance of building materials.

Termites can penetrate the following materials:

1. Lime mortar, which usually disintegrates after a few years. Moreover, it is said that termites secrete an acid which makes penetration possible[17].
2. Masonry work of brick, stone or other units as commonly laid up[30]. Such masonry usually contains vertical and horizontal hollows which may allow termite entry.
3. Termites of species not found in Connecticut have penetrated lead telephone cables[20], hard paint films, poisoned bitumen paint and two-ply roofing felt with two coats of asphalt paint[17]. It should not be assumed that our termites cannot do the same. Von Schrenk[30] says, "Asphaltic compounds are of no use whatever" (to keep out termites) and Snyder states, "Tar is no protection for wood"[23]. In one case in Connecticut, termites penetrated asphalt-treated building paper in many places.

Termites cannot penetrate the following materials:

1. Timbers treated by a standard pressure process or open tank process using coal-tar creosote[21]. However, they can construct shelter tubes over such treated timbers to reach untreated wood above. There is no evidence that termites cannot construct tubes over timbers treated with any wood preservative.
2. Solid concrete or solid unit masonry laid in cement mortar with well-filled joints. They can construct shelter tubes over such materials to reach woodwork above. If concrete or masonry is used as a barrier, it must be constructed without cracks and protected against the formation of cracks at a later date.
3. Non-corrosive sheet metal, such as copper. Moreover, they cannot construct shelter tubes up over the edges of properly installed sheet metal shields.

SOIL TREATMENT

Various investigators have made attempts to find a satisfactory soil treating material to kill the termites present, or to act as a barrier against their access to a structure. Literally hundreds of substances have been proposed for such use and the search still continues. Readers interested in this phase of the subject should consult *Termites and Termite Control*, University of California Press, for a list of materials including proprietary compounds. Randall and Doody[17], of the California Termite Investigations Committee, were unable to find that any such treatment was a standard practice, or that there were available conclusive experimental data or field observations supporting any such treatment. They stated that many investigators have abandoned former recommendations and now favor control by construction methods. Snyder says in this connection: "The use of soil poisons is, however, still very much in the experimental stage and on present information cannot be recommended as a permanent remedy." [23]

Soil treatments that have been found effective in other parts of the country may not be suited to Connecticut conditions. For instance, paradichlorobenzene, considered promising in California tests, is apparently ineffectual here on account of lower soil temperatures. Snyder[23] holds crude liquid orthodichlorobenzene the most promising soil poison. Although it has not been thoroughly tested in New England, in one instance it failed to prevent termite entry. The use of water-soluble compounds such as copper sulfate and borax is not considered practical in Connecticut because of the leaching action of the soil moisture. Soluble arsenical compounds should not be used for soil poisoning because (1) soil fungi acting on them may free the highly toxic arsine gases, and (2) they may poison wells and streams. Also there is no indication that such treatments are of permanent value. Manufacturers of proprietary compounds containing arsenic claim that a fungicide is included to prevent formation of arsine. So far as we know, there is no evidence gathered by unbiased workers either confirming or disproving this claim.

A proprietary self-emulsifying compound, known as Phinotas oil, was used for soil treatment by O'Kane and Osgood[19] in New Hampshire with satisfactory results. It was applied at the bottom of a trench at the rate of one gallon in 200 gallons of water, and the trench was filled with cinders. This treatment apparently made the ground unsuitable for termites for two years. Phinotas oil might be used along foundation walls and piers in trenches about 30 inches deep, and again near the ground level after the soil has been replaced. If it is impractical to dig a deep trench around the foundation, penetration to the proper depth might be obtained by digging a shallow ditch, perforating the bottom with crowbar holes not more than one foot apart, and flooding it with quantities of diluted oil. A thorough saturation of the soil is necessary. The application should be made when the ground is fairly dry.

The use of soil treatments in the absence of structural changes must be considered as a temporary expedient in the protection of buildings. They have an important place in supplementing construction methods in that they may be used in cases of severe infestation to reduce the termite population. They are particularly useful if wood scraps cannot be removed from the soil around the foundation. In cases of light infestation, soil treatments may be used to keep out termites, with full knowledge that such procedure is temporary.

Apparently the thickness of the treated soil layer is more important than the concentration of poison in the solution[17]. Therefore large quantities of treating materials should be used.

All chemicals now known to control termites in the ground are toxic to vegetation and may injure shrubbery growing near the treated area. Plants set close to buildings may be moved beyond the poison zone. The spread of the poison may be controlled by trenching, and treating the excavated earth before it is replaced.

Anyone planning to use soil poison should consider the fire hazard, dangers of handling, and possibilities of undesirable odors or toxic fumes.

POISONING MASONRY WALLS

Poisoning of masonry foundation walls is sometimes attempted to create a barrier against termites. There is very little information available as to the effectiveness of such methods. Snyder[26] suggests that orthodichlorobenzene may be poured through holes bored in hollow unit masonry foundations at the rate of one gallon in 10 linear feet, if it is practical to cap them. The method of impregnating masonry walls has the obvious limitation that the chemicals may bleed through paint or plaster on the cellar walls and may cause objectionable odors.

WOOD TREATMENT

Any wood treatment for use in termite control should prevent fungous growth and make the wood toxic to termites. Of all the preservatives available, coal-tar creosote has given the most satisfactory service in actual use, especially under conditions of heavy infestation and exposure to weather. Its performance has also been outstanding in experimental tests in which treated posts were set in the ground out-of-doors. The disadvantages which limit its use are as follows[14]: (1) Its odor, which may be objectionable to some persons, especially in places where foodstuffs are to be stored. However, Hunt[14] states: "Creosoted wood can undoubtedly be used in sills and foundation timbers, floor sleepers embedded in or resting on concrete, and even subflooring with little danger of the odor becoming noticeable." (2) Its color and the fact that it is difficult to paint creosote-treated wood. In house construction these facts limit the use of such wood to framework. (3) The difficulty of obtaining properly treated wood without delay. At present it is necessary to wait for open tank treated lumber to season, or to send lumber to a pressure-treating plant. Therefore it is necessary to make arrangements for treatment well in advance of the time of starting a building.

Creosote penetrates wood only a short distance, even if applied under pressure, and the durability of the creosote treatment depends on the thickness of this treated shell. According to Snyder[21], the full cell pressure process renders wood set in the ground resistant to termites for at least 25 years. The open tank method, if properly used, is effective for at least 15 years. Spraying or painting timbers with several coats of creosote will add from two to five years to the life of the wood. Snyder[24] states that wood for use in buildings may be treated by the pressure process or the open tank method. The American Wood-Preservers' Association specifications for materials and methods should be followed. The spraying and painting methods are not considered satisfactory in preventing termite damage. While such treatments are not entirely worthless, they cannot be depended upon for lasting protection.

All wood should be well seasoned and framed (cut to size) before treatment. Seasoning of creosoted wood after open tank treatment is advisable because the excess creosote will cause slight burns on the hands of workmen, and may bleed through plastered walls if used in framework. Pressure-treated timbers usually lose most of the excess creosote in the process. The coated shell must be well protected in all handling of the lumber because if it is broken termites can penetrate the wood. In case it is necessary to cut treated wood, the exposed portions should be painted with two or three coats of hot creosote.

Zinc chloride has been recommended for treating lumber to be used in the framework of houses. It is odorless, creates no fire hazard and is paintable. However, it is water-soluble and will leach if exposed to weather or if placed in contact with wet masonry walls[14]. This preservative might be used satisfactorily on finished lumber exposed to weather if kept protected by a coating of paint. The full cell pressure process is preferred for application, and brush treatments are not worth while[15].

One group of proprietary preservatives has been developed to provide a treatment that leaves the wood clean, paintable and odorless. Hunt[14] says of these: "Such preservatives have a considerable field of usefulness in the treatment of flooring, furniture, and millwork exposed to termite attack, window sash and frames, automobile woodwork, and miscellaneous lumber for various other purposes. The user of such preservatives should insist upon knowing the nature and amount of the effective chemicals in the mixture."

Of proprietary materials in general Hunt[14] states: "The literature advertising some of the proprietary preservatives not infrequently contains extravagant claims as to their properties and their effectiveness. Obviously such claims should be greatly discounted. There are very few, if any, proprietary preservatives for general use, regardless of price, that have shown themselves to be better or more generally satisfactory than straight coal-tar creosote and zinc chloride in their respective classes."

Treatment of Timbers in Place in a Building

The literature on wood preservation contains very little information on this subject. Randall and Doody declare that brushing or spraying timbers in place in a building with wood preservatives is unsatisfactory[17]. The statement of Snyder, quoted on page 218, does not definitely specify wood preservatives. Some commercial companies working on termite control in infested buildings apply the material under pressure through holes bored in timbers. In the absence of any statement from an unbiased source, it is impossible to pass judgment on this method. However, certain disadvantages are very apparent. (1) The preservatives cannot penetrate wood that is wet. (2) In actual practice it is very difficult for even the most careful operator to reach all parts of all timbers needing treatment. (3) The amount of toxic material introduced must be relatively small because a large amount of carrier is necessary to assure adequate penetration. (4) Some woods, according to Hunt[15], are very difficult to penetrate. (5) Some of these materials contain a more or less inflammable solvent, the use of which constitutes a fire hazard.

Crude creosote is not suitable for this type of treatment in dwelling houses. The odor of fresh creosote will persist for long periods of time and the fire hazard is also considerable until the volatile portions of the creosote have evaporated. Moreover, any excess material may bleed through plastered walls and stain painted boards.

Arsenicals as Wood Preservatives

As in the case of soil, preservatives containing arsenic should be used with caution on lumber or other building material designed for houses. In wood also, the growth of certain fungi is liable to liberate arsine gas[17]. As stated above, manufacturers of some of these compounds add fungicides which are claimed to obviate the risk.

Proprietary Treatments

The chief exponents of chemical methods are commercial companies sponsoring proprietary compounds and special methods of application. In many cases it has apparently been the policy of these companies to guard their processes and materials in such a way that observation by disinterested scientific investigators has been impossible. Some of the advertising literature has contained statements that are difficult to reconcile with published records of unbiased investigators. This is unfortunate, because there is a field of usefulness for chemical treatments of demonstrated value. They may be less effective than structural changes, but they have a place when the expense of reconstruction does not seem warranted.

METAL TERMITE SHIELDS

Termite shields were devised in the tropics to prevent termites from building tubes over the face of walls or other objects to gain entrance to the wooden structure of buildings. Froggatt[11], writing in Australia in 1905, stated, "......on the top of each [pile] a tin or zinc cap should be placed, for, though not everlasting, they help to keep the pests out of all other woodwork." Jack[16], in South Africa in 1913, suggested the use of a "zinc ant course", consisting of strips of zinc laid on the first course of bricks and projecting one inch on each side of the wall. "This effectually prevents the termites from ascending the wall." Snyder[24] suggests that such shields be used "in regions of excessive termite damage". Von Schrenk[30] recommends their use in his specifications for termite-resistant construction.

Nevertheless, there is considerable controversy over the effectiveness of metal shields, carried on particularly by companies using chemical methods of control. Snyder has stated[17] that termites have never been known to build tubes up over a properly installed metal shield. In correspondence with the authors he reiterated this statement as late as October 28, 1935. In some cases where termites were able to enter buildings at points where there was no shield protection[17], however, they have built shelter tubes down over shields.

We believe that the evidence is overwhelmingly in favor of the effectiveness of metal shields and recommend them as furnishing the most complete protection against termites.

Kinds of Shields

Termite shields may be of two forms. The first is a sheet of non-corrosive metal placed in or on the foundation between the ground level and the first floor framework, extending completely through or over the foundation. This type prevents termite entry through vertical cracks or hollows in foundations as well as by means of covered runways built on the surface. The second kind is in the form of a strip firmly inserted in the face of the foundation and designed to prevent tube building over the surface. Obviously this type will not keep the insects out of masonry cracks and it is our opinion that its use should be limited to heavy concrete or masonry foundations free from fissures of any sort.

Shields should be made with two-inch projecting edges (Figures 91, 92) bent down at an angle of 45°[23]. New buildings can be designed so that the shield will be inconspicuous. The upper side may be concealed

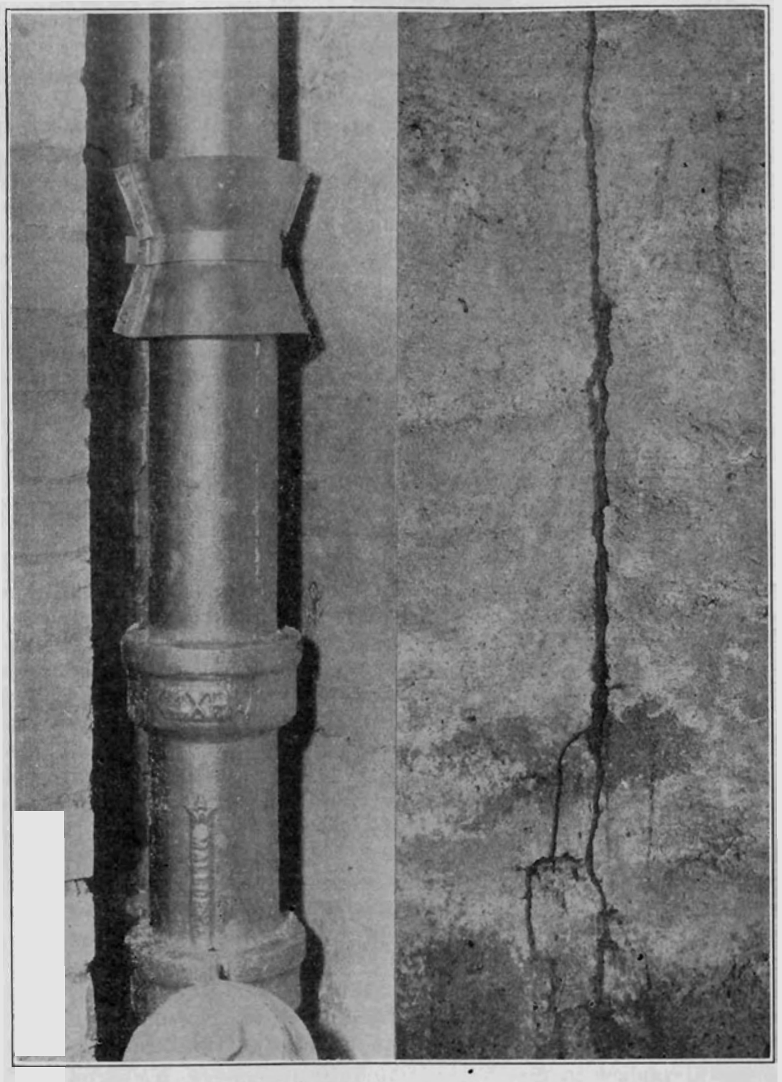

FIGURE 87. Metal shield on soil pipe in chase. Top funnel filled with plastic coal-tar pitch. Main shield (not shown) protects the chase. Right, shelter tube built down from sill to basement floor to secure additional moisture.

by a simple change in certain types of frame buildings, or under a belt course or water table in masonry buildings. In certain cases, such as finished basement rooms, prominent and exposed places outside a building, or frequented parts of a house where beauty is important, architects

and home owners may prefer to use a smaller extension or to bend it down flat against the wall. (See Hamilton[13]). Even where the shield does not project, it forces the termites to the edges, where they may be seen. Their activity may then be stopped by supplementary measures such as the local application of chemicals to foundation and soil.

In our opinion, shields of either of these types will be satisfactory if the owner recognizes the limitations of the protection afforded and is willing to make frequent inspections. In hidden places where this is difficult or likely to be neglected, at least a two-inch, and preferably a five-inch, projection should be used.

The shield must be continuous, without holes or cracks, and should be installed with some such provision as a lock joint, to allow expansion and contraction without cracking at the joints. If it is necessary to insert a bolt through a termite shield, great care must be taken to make an absolutely tight joint. A close fitting metal washer may be used for this purpose. It should be remembered that in wet places deterioration may occur by electrolysis if dissimilar metals are used.

All partitions, piers, posts, pipes (Figure 87), and other structures reaching from the basement to the wooden structures above should be provided with shields. Outside pipes such as leaders may need protection.

If shields are not properly installed, they will not be satisfactory. Every detail must be carefully checked to see that no cracks or openings are left. Except in the most simple construction, it is advisable to employ a competent sheet metal worker who also understands the requirements of shield construction.

To insure permanent protection, the sheet metal selected must be non-corrosive for existing conditions which vary according to the building. Practical men in the building trades claim that certain metals may be attacked, particularly in the presence of moisture, by soft coal smoke, by fumes from industrial plants, and by acids present in building materials, as in some kinds of cedar or cypress shingles, or cinders used in filling and in cinder concrete. Shields exposed to such conditions may be protected by coating the side next to the corroding materials with asphalt paint. A layer of concrete between shield and cinders will protect those under masonry porches. Snyder[23] has suggested the use of the following metals for termite shields: "Copper, or zinc, or an alloy composed of 28 per cent of copper, 67 per cent of nickel and 5 per cent of iron, manganese and silicon".

The question of the efficacy of partial shielding is frequently raised. In the case of buildings susceptible at many points and now badly infested by termites, installation of short sections of metal frequently forces termite entry at an unprotected point. However, in many infested buildings of highly resistant construction, it is a logical procedure to insert short shields at the few susceptible points, such as adjoining masonry porches, susceptible cellar hatchways and above wooden basement window frames. The ends should be embedded in solid masonry or extended to points where they can be seen. At the same time there should be thorough application of soil poisons around unshielded places. This method applies particularly to buildings set high on good foundations. It is also a desirable way of protecting places where frequent inspection is difficult or impossible, such as partially excavated extensions and built-in basement construction which covers the foundation walls. Use of partial shielding is entirely logical in new structures, assuming that the plans follow termite-resistant specifications in other respects. Here, again, the need is for shielding places that cannot be inspected.

The usual method of shield installation in an infested building is as follows: (1) Use of shoring to take the weight of the building; (2) removal of the top part of the foundation; (3) placing the shield, and (4) replacement of the foundation. If this work is skillfully done, no cracks or settling should occur. There are many difficult points in fitting shielding around pipes, in corners and where changes in level of the shield are required. In these spots considerable ingenuity must be used to design a shield that termites cannot cross.

After the installation of a shield in an infested house, frequent inspections should be made to see that the termites do not find a new way to enter, or that they are not continuing their activities by obtaining moisture from leaks. Termite flights above the shield, or attempts to construct shelter tubes down over the shield, indicate that the infestation is still going on. Shelter tubes built on the foundation wall below a properly installed shield are not an evidence of shield failure, and are not a menace to the wood above the shield. However, if the building owner considers them undesirable, the termite activity can be stopped by use of soil poisons.

CONSTRUCTION OF TERMITE-RESISTANT BUILDINGS

On the basis of the known facts stated above, it is practical and feasible to construct buildings which cannot be penetrated by termites. Termite-resistant construction makes use of all the common building materials and in the main the methods are accepted practices that are well-known in the building trades. No untreated wood is used in contact with the ground, and no vertical or horizontal cracks are left in or between any materials to allow termites hidden access to wood. Suggested details are given in the Appendix (see pages 232 to 239).

TERMITE CONTROL IN INFESTED BUILDINGS

Establishing an effective barrier in an infested building accomplishes the double purpose of *preventing further entry* and of *exterminating termites* actually in the building. This is true because termites must not only gain access to edible wood but must maintain a constant route of travel between their food supply and a source of moisture, usually soil, but occasionally wood kept moist by leaks. After construction of an effective barrier, additional measures to kill the termites in the structure are not needed and are a waste of effort. Details of alterations are included in the Appendix (see pages 232 to 239).

EVIDENCE IN REGARD TO CONTROL METHODS

Speaking of infested buildings, H. von Schrenk, consulting timber engineer of St. Louis, Mo. declares: "There are two possible methods of attack, one which involves structural changes made for the purpose of discovering the point of entrance and the other is to attempt, in some way or another to poison both the wood, foundation walls and soil by the use of toxic substances. Personally, I have for more than 30 years followed the practices of determining the point of entrance and made such structural changes in the building as would give reasonable assurance that the termites would hereafter fail to find a point of entrance."[30]*

Snyder states: "The means of stopping termite injury in a building are substantially the same as those to be employed in new construction to prevent the entry of termites...... The most lasting and effective remedy, as already indicated, is in the replacement of wood in or near the basement of the building with concrete. Second, in order of effectiveness and durability, is in replacement of such wood with treated wood or timbers, and, in regions of excessive termite damage, to employ under both methods protective shields. By this means contact between colony and building is permanently broken and relief from termite damage is assured....... This type of construction insures the fullest protection, and has been given first importance by the Department for 25 to 30 years."[23]

Dr. Kofoid, Professor of Zoölogy in the University of California, makes a similar statement: "Structural methods are here made available to the builder, architect, and engineer, which if used and supplemented by inspection and maintenance, will greatly reduce and even ultimately render insignificant the loss due to termite attack."†

The executive committee of the California Termite Investigations Committee, composed of scientists, lumbermen and an engineer, issued in December, 1934, a 13-page printed report on *General Recommendations for the Control of Termites*. These recommendations emphasize proper structural methods to prevent termite injury to buildings, including the pressure treatment of wood, "......with a final retention of not less than eight (8) pounds of No. 1 grade of coal-tar creosote per cubic foot of wood, the grade of creosote and the method of treatment being in accordance with specifications of the American Wood-Preservers' Association, or......lumber which is impregnated by a pressure treatment with such other equivalent preservative and equivalent method as may hereafter be approved."** In regard to chemical soil treatments they state: "The evidence before the Committee is insufficient to recommend specific chemicals for soil treatments."

These authorities, representing both scientific institutions and commercial organizations, are in accord in recommending the use of structural methods for termite control.

A careful search of the literature for authentic information on termite protection of existing buildings by chemical means alone has revealed little except of negative value. Even with the great number of experiments performed in various parts of the world during the past 30 years, with a wide variety of materials, there is still no definite proof that soil poisoning can be depended upon for sure and lasting protection against termites. The small amount of information from disinterested sources

* von Schrenk, H. Termites and Methods for Combating Them. In Proc. Amer. Wood-Pres. Assn. for 1934. Quoted by permission of the American Wood-Preservers' Association, Washington, D. C.

† Kofoid, C. A. et al. Termites and Termite Control. p. 12, Univ. of Cal. Press. 1934. Quoted by permission of the University of California Press.

** Brown, A. A. et al. General Recommendations for the Control of Termite Damage. p. 540 and 542. In Termites and Termite Control. Univ. of Cal. Press. 1934. Quoted by permission of the University of California Press.

regarding results of chemically treating timbers in place is mainly of an unfavorable nature.

RECOMMENDATIONS FOR CONNECTICUT

As it is a matter of only four years that termites have been known as a serious menace to Connecticut buildings, it is too soon to pass judgment on the long-term effectiveness of control measures on the basis of our own experience. Conclusions from observation must be limited to the statement that certain methods have apparently proved successful and that others have already shown evidence of failure. Under these circumstances it seems best to rely on the judgment of workers of longer experience in the field.

Two experts, Snyder and von Schrenk, have worked on this problem for 30 years and have definite records of success over long periods of time. In our opinion their support of structural control methods outweighs the arguments in favor of chemical methods without such records of service. **Therefore we suggest that the main reliance be placed on structural methods to exclude termites from buildings.** Included in these structural methods are: Keeping the wood from contact with the ground; the use of adequately treated lumber; the use of impenetrable concrete or masonry; planning and carrying out details of construction to prevent hidden access of termites; and, for the most complete protection, the use of a metal termite shield. Supplementary measures which we consider valuable are: Keeping the termite population at a minimum, and keeping the structural wood in sound, dry condition. We believe that soil treatments with chemicals are a promising aid in connection with structural changes, but as yet they are unproved under Connecticut conditions.

It is granted that other methods may have given satisfactory control of termites in certain cases, and that improved methods or materials may be developed.

We suggest that if chemical control measures are used, they should be accompanied by removal of the more susceptible points of entry by structural changes.

In cases of severe termite attacks it is advisable to make use of all available means to reduce the hazard of damage on account of chance failure at any point. No method of termite control can be depended upon unless the work is carefully performed with intelligence and thoroughness in details.

TO WHAT EXTENT IS TERMITE-RESISTANT CONSTRUCTION JUSTIFIED?

The question as to what extent termite control measures are justified in Connecticut is a very important one. This is a practical question confronting the building owner and is one that everyone must decide after considering all the facts, just as he does in the case of fire, or other hazards. It is our opinion that termites are abundant and destructive enough in Connecticut to justify the use of termite-resistant construction in all permanent new buildings. If many termites are known to infest a building site or nearby buildings, or if the owner desires the most complete and lasting protection from termite attacks, the use of a metal termite shield should be considered. It is much less expensive to use proper construction methods in the first place than to remodel after the building is completed. The average additional expense is estimated at from 1 to 2 per cent of the total building cost if the work is done during erection.[27]

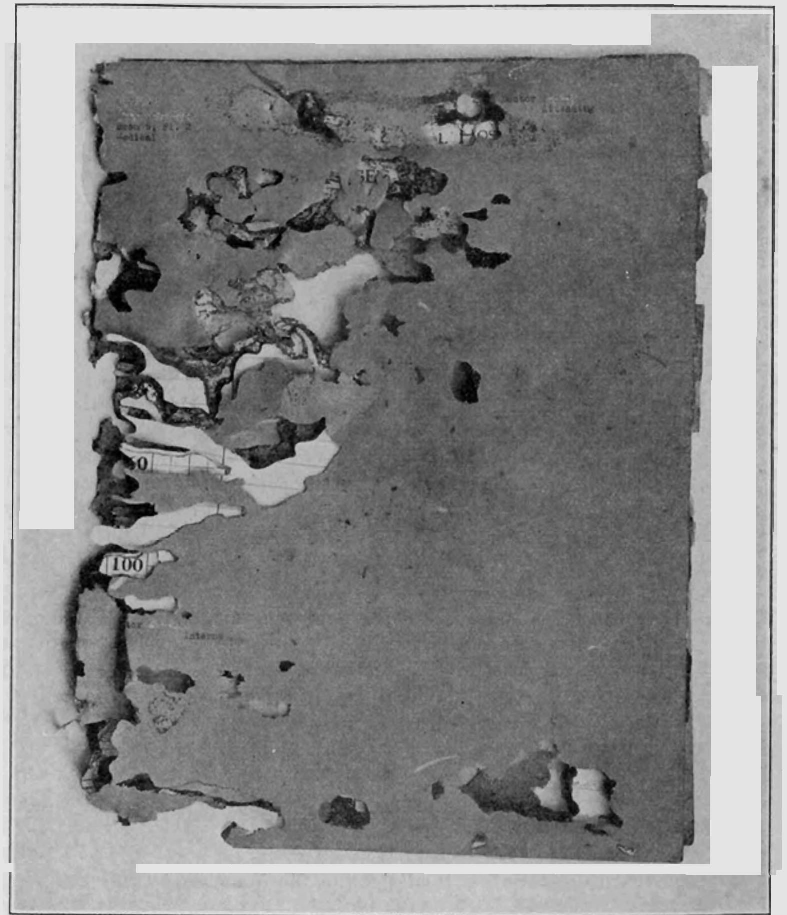

FIGURE 88. Termite damage to records stored in the basement of an infested building.

The amount of expenditure justified in an existing building that is infested by termites depends on: (1) The permanency of the building, (2) the termite population, (3) the type of construction and (4) the quality of the construction. A great many buildings, especially certain types used for industrial and business purposes, are of more or less temporary nature. In such structures only small outlay is justified for termite control. The plan generally adopted has been to insure structural safety, use soil treatments, and look forward to replacement of the building within a few years.

The abundance of termites present is the important factor in determining the amount of expenditure justified in the case of permanent buildings. A large population and serious injury call for complete termite-resistant construction for lasting protection. A small infestation causing little damage, in wooden porches or window frames in contact with the soil, requires protection at these points of entry. The difficult cases are those occurring between the extremes just mentioned, due to the fact that the cost of complete protection is large in proportion to the value of the building. It is hard to decide in any specific instance whether the insignificant injury occurring now will seriously increase within a few years. Termites are not uniformly distributed throughout the State, and even in the same locality exhibit great variability in the choice of buildings infested and in the severity of the attack. As previously mentioned, there is no way of predicting their future abundance except that there seems to be a general upward trend throughout the United States.

It would seem wise for owners of buildings showing moderate infestations to study the type and quality of construction and base their decision on these factors. For instance, buildings on high, uncracked, concrete foundations can usually be made relatively termite-resistant at moderate cost. Buildings on hollow-unit or poorly laid masonry foundations are more difficult to protect, as are those lying close to the ground. This is a matter for individual judgment and no general rules can be laid down.

In regard to buildings not known to be infested, particularly in an area where termites are scarce, it is questionable how much expense is justified for preventive measures. It is undoubtedly easier to keep termites out of a building than to eradicate them after they have entered. Therefore if any repairs are being made in such buildings, it would seem wise to make them on termite-resistant lines. This may be done at once or as the repairs are necessary. Many of the susceptible points are wood in actual contact with the ground. As this rots, replacement should follow the above principles.

PROCEDURE FOR TERMITE CONTROL IN BUILDINGS

1. Study the termite population to determine the amount of protection desired.
   - A. Heavy infestations of termites on building sites are indicated by:
     - (1) Large numbers of termites in stumps, logs and waste wood on the building site.
     - (2) Termite damage to unpainted white pine blocks or stakes used to attract termites (see also page 213).
     - (3) Presence of heavily infested buildings in the immediate vicinity.
   - B. Heavy infestations of termites in buildings are indicated by:
     - (1) Occurence of large swarms of winged adults.
     - (2) Abundance of covered runways on basement walls.
     - (3) Serious damage to the wooden structure.
     - (4) Large numbers of termites in waste wood or stored materials (see also page 231).

2. Plan new buildings to be of termite-resistant construction and study old buildings to determine how they can be altered to remove the susceptible places. It often requires considerable ingenuity to adapt preventive measures to existing buildings without excessive cost. Since termite damage occurs comparatively slowly, there is no need of great haste in taking action. A delay of a few months in carrying out preventive measures will not result in much additional injury. It is much better to plan carefully in order to do adequate work than to rush into the task and overlook protection of some important point of entry. The only instance requiring immediate action occurs when structural timbers are so weakened that buildings are unsafe.

   As previously stated, eradication of termites from an infested structure is accomplished by cutting them off from their usual source of moisture, the damp soil, or any other moisture, as from a leak. It is not necessary to do anything more to kill the termites in the wood as they cannot live without moisture[23].

3. Remove unnecessary sources of termite food.
   - A. **Remove and destroy all stumps,** roots, waste wood, etc., in or on the ground under and around the building.
   - B. **Remove all wooden forms** from concrete work and keep all waste wood out of fills. One-half cubic foot of such wood can support a colony of 4,000 termites[17]. The concentration in such waste materials around the base of foundations has been one of the chief causes of severe infestations in relatively new buildings. If it is impractical to remove this wood, the soil should be poisoned thoroughly.
   - C. **Remove or repair trees that are hollow** or have scarred areas at the bases if they are infested by termites. Snyder[28] states that "Properly executed tree surgery may sometimes be effective in repairing damage to valuable old trees". He also suggests the use of a soil fumigant such as carbon disulfide poured in a shallow trench about a foot away from the trunk and covered with earth. This liquid forms a toxic and inflammable gas, and must be handled with great care. Badly decayed trees that are infested should be cut down and burned and the stumps destroyed.
   - D. Construct all trellises, arbors, etc., of termite-resistant materials such as treated wood, concrete or metal.

4. Inspect a new building annually for the presence of termites and an infested building at least once a month for about six months, and thereafter twice a year, after termite-resistant reconstruction. Large colonies of termites will make persistent efforts to re-enter the building, especially by means of covered runways or tubes. These tubes should be destroyed and the soil from which they come should be thoroughly poisoned.

IS A TERMITE EXPERT REQUIRED?

Satisfactory termite control can be directed by anyone who understands building construction and a few essential facts about termites. He should know how the insects live, how they infest buildings and the type of measures (structural and chemical) that check or prevent their entry. Experience in examination of infested buildings, determining the points of entry and altering construction to exclude termites is valuable but not essential.

STORAGE OF CELLULOSE-CONTAINING MATERIALS

Owners of fire-proof buildings made of concrete or masonry, with concrete floors, frequently believe that termites cannot damage their property. Actually the insects can do no structural harm but they may still be serious pests by eating cellulose-containing materials stored in such buildings. This happens rather frequently, especially if materials remain undisturbed for long periods of time. Books, records (Figure 88), surgical dressings and paper towels have been injured in Connecticut. Snyder[20] has recorded damage to electrotype blocks, rolls of cloth, clothing, shoes and food stored in basements. Anything of value that is susceptible to termite attack should not be kept in basements unless adequate protection is provided. A cheap and effective form of protection is the construction of short piers, each capped with a termite shield, on which materials may be stored (see Figure 89).

APPENDIX

DETAILS OF TERMITE-RESISTANT CONSTRUCTION

For years Snyder has advocated the adoption of building codes containing mandatory regulations for termite-resistant construction.[22] Until such codes are accepted in Connecticut it will be necessary for

FIGURE 89. Records stored on termite-proof rack in basement of an infested building.

individuals to insist on proper methods and materials in their buildings. It is hoped that building officials will give serious consideration to the termite problem and that such special methods as may seem warranted will be adopted as standard practice and incorporated in local building codes.

Many useful and practical suggestions can be obtained from Snyder's publications[22,23,25,26]; the California Termite Investigations Committee Report,[17] (especially the sections dealing with subterranean termites); the article by von Schrenk[30] and the informative articles of Hamilton[14] written from the architectural standpoint. To fill a temporary need for more detailed treatment of construction and repairs as applied to Connecticut buildings, the following section has been pre-

pared. It is based largely on such recommendations of the authorities mentioned above as seem applicable, and contains additional suggestions based on our own observations. The details given merely illustrate the principles of termite-resistant construction and are not offered to

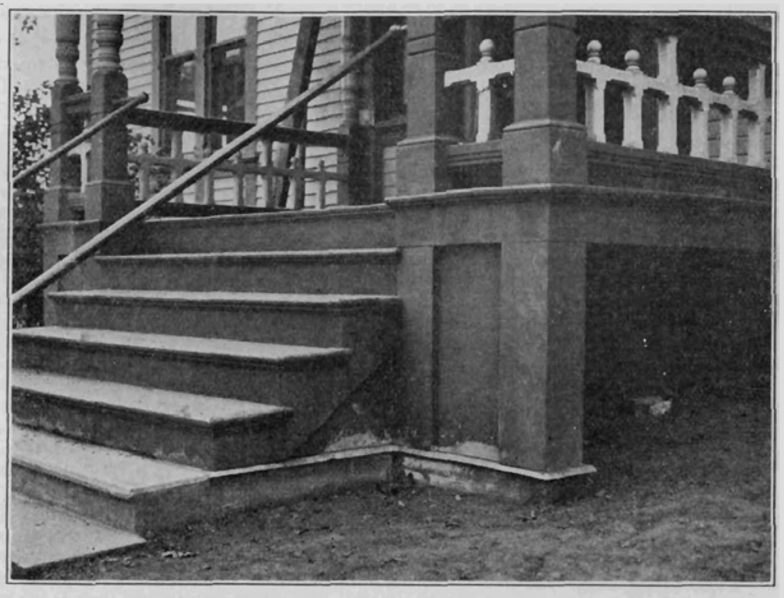

FIGURE 90. Wooden porch steps placed on concrete base and also shielded.

take the place of specific recommendations that may be made by competent authorities of the building industry.

In the following columns are listed some of the structural defects found in buildings and the contrasting termite-resistant construction. Few of the infested buildings examined had many of these defects, but each had at least one.

Structural Defects in Buildings of Various Ages	**Termite-Resistant Construction**
1. Stumps, waste wood, concrete forms, etc., on the ground or buried under fill beneath and around the building.	1. No wood left in such locations. All form boards and waste wood removed before filling.
2. Wood in contact with the ground. (Porch steps, lattices, cellar hatchways and door frames, houses set on wood piers, etc.)	2. No wood in contact with the ground. Snyder[23] recommends treatment of all wood within 18 inches of the ground.
3. Porches with untreated wood less than 18 inches above the ground, with steps and lattices in contact with the ground or so close to it that termites find hidden access when leaves or litter accumulate. Lattices set close to piers allowing termites to ascend in the crack between lattice and pier. Porches supported on wood posts, or piers of poorly laid masonry.	3. Wood framework less than 18 inches from ground treated, or excavations made for clearance. Steps supported on a solid stone or concrete base six inches high (Figure 90)[17]. Lattices at least 6 inches above ground (if lower, inspect frequently) and 1 inch from any pier, supported from top and removable for inspection. Metal shields may be used, at least 6 inches above ground and below all woodwork; or all framework may be of treated wood. Piers concrete or masonry, laid solid in cement mortar. Small porches may be separated from house by a metal shield.
4. Porches built with stucco veneer on wood framework extending into the ground. Inadequate ventilation under porch.	4. House foundations extended under porches, stucco applied to foundation. Treated wood used for porch framework. Adequate cross-ventilation provided.
5. Earth-filled masonry porches built so that there is actual contact between the fill and wood structure of the house (Figure 91a), or a crack between the porch slab and foundation leading up to the wood. Over 50 per cent of infested modern houses examined showed entry under masonry porches (both wood frame and masonry buildings.)	5. Foundations adjoining masonry porches built solid, preferably of reinforced concrete. Joists in masonry buildings supported on metal hangers or shelf; not inserted into wall. For frame buildings special foundation and sill construction; metal shields for most effective protection (Figures 91b, c & e.)
6. Cellar hatchways in contact with ground or resting on cracked foundation. Crack between hatchway and house foundation frequently allows termite entry.	6. Cellar hatchways with foundations and cheeks of solid reinforced concrete without cracks or hollows, built as integral part of main house foundations; no wood closer than six inches to ground. Doors and casing of treated wood or separated from house by metal shield. Wooden hatchways may be separated from house by a metal shield (Figure 92).
7. Foundations with cracks or voids that may allow termite entry. Hollow unit masonry as commonly laid offers many hazards of both horizontal and vertical penetration by termites.	7. Solid foundations laid on adequate footings. Concrete reinforced at corners where walls join foundation, and near porches. Hollow masonry units avoided or special protection given, such as solid capping (4-inch reinforced concrete[14]) or a metal shield.
8. Lime mortar used in masonry foundations disintegrates and may be penetrated by termites.	8. Masonry laid solid in cement mortar: 1 part Portland cement, 3 parts sand. Hydrated lime not to exceed 10 per cent of weight of cement may be added.[24]
9. Cellar window frames and door jambs set in rough-finished openings so that there is a crack between the wood and foundation.	9. All cellar window and door openings plastered with cement mortar. Metal frames used. If door frames are of treated wood, concrete plinths used.
10. Pipes set loosely in basement walls or floors. Pipes set too close to walls to allow inspection. Pipes in chases allowing hidden access to timbers above.	10. Pipes set tightly in concrete where passing through basement walls or floor. Pipes far enough from walls to allow inspection. Pipes in chases provided with metal shields.
11. Cracks in cellar floors that may allow termite entry. Cracks due to poor construction; cracks between adjacent slabs, or between floor and wall due to shrinkage of concrete in ageing.[29]	11. Well-laid floors with special reinforcing under partitions, stairways, etc. Expansion joints located in open for inspection where possible. Crack between floor and wall prevented: (1) by inserting floor into groove in wall; (2) by metal expansion joint or (3) by V-shaped joint filled with coal-tar pitch.[30] A sanitary base and cove[23], or a concrete base formed by the upper part of the footing* (Figure 91b), may be used with any of these methods.
12. Wood floors laid over porous concrete or cinders, sleepers and flooring of untreated wood. (Difficult to give absolute protection with this type of construction.)	12. Wood floors laid over solid concrete paving with protected expansion joints. Sleepers and rough floor of treated wood, finish floor treated by a process not discoloring wood. Additional protection, such as metal shields, for any built-in construction.
13. Built-in cellar construction such as furred, lathed and plastered walls, and other construction covering outside cellar walls offering opportunity for hidden termite entry through foundations and floor.	13. Built-in cellar construction covering outside walls made termite-resistant by use of treated wood or metal, and the framework above protected by a metal shield. Closets and shelving not extending full ceiling height.
14. Basement partitions with wood framework or furring, wood posts, stairways, etc., built over cracked concrete, over unprotected expansion joints or extending into concrete basement floor. Partitions and posts difficult to protect at point of contact with cellar walls.	14. All basement wood partitions, wood posts and other construction of adequately treated wood set on concrete footings extending six inches above the floor level. Partitions separated from outside wall by a concrete pilaster, with special protection such as a metal expansion joint to prevent crack formation at junction of pilaster and footing. Snyder[23] suggests that wherever possible no wood be used in basement construction.
15. Untreated wood used in damp locations, favoring decay and termite attack.	15. Wood kept in sound, dry condition or treated wood used.
a. Frame houses set on foundations at or near grade level.	a. Frame houses set on foundations 18 inches above grade level, or adequately protected against rot and termite entrance.

* Suggested by a New Haven architect and used with his permission.

b. Timbers under enclosed porches and unexcavated portions with no ventilation.	b. Timbers in such locations at least 18 inches from the ground and adequate cross-ventilation provided.
c. Wood furring and studding in contact with damp masonry walls (common in well-built masonry buildings and stucco applied on wood framework in cheap construction.)	c. Waterproof masonry construction. Metal or creosote-treated furring and studding.
d. Sills partly enclosed in mortar. Ends of joists enclosed in mortar in supporting slots in masonry.	d. Sills not enclosed in mortar and ends of joists set in slots with adequate ventilation, or in metal hangers.
e. Moisture from leaks in roof, walls, or plumbing, or from condensation on cold surfaces, particularly in cellars or under unventilated roofs. May provide sufficient moisture so that control by usual method of cutting off termites from moist soil is not effective.	e. All leaks prevented or repaired. Condensation prevented by adequate ventilation under roofs, or by use of insulation. Excessive moisture on cold pipes prevented by insulation. Treated wood used in cellar or other places where wood is in contact with damp masonry walls or metal.
16. Books, records, letter files, paper, wood and other cellulose-containing materials stored in damp vaults or basement storage rooms.	16. Adequate ventilation provided in such places. All cellulose-containing materials in basements stored on shielded supports (Figure 89).
17. Buildings with ceiled basements, inaccessible unexcavated areas and porches make inspection difficult. Unless inspection is provided for, it is frequently necessary to break into finished basement construction to find whether or not termites are present. Joists closely paralleling foundations, preventing inspection of sill, common in thick wall construction. Rough dark masonry in unfinished basements, making it difficult to see shelter tubes.	17. Provisions made for inspection in buildings not completely protected from termites. Removable panels provided: (1) where finished ceilings join outside basement walls; (2) at base of unprotected wooden basement partitions and where they join outside walls; (3) over inclosed pipe chases. Where joists closely parallel foundations, first joist may be replaced by short joists extending from sill to second joist.[13] In unfinished basements, partly excavated areas and under porches, walls and piers whitewashed or painted light color so that shelter tubes may be seen readily.
18. Dense shrubbery planted close to frame houses preventing the wood from drying out. Vines covering foundations and offering opportunity for construction of concealed shelter tubes.	18. Shrubbery planted far enough away so that wood may dry out. Vines started on termite-resistant trellises set at least 4 inches away from foundations.

The only radical difference in construction is: For the most complete protection, use of a termite shield of non-corrosive metal inserted between the foundation and the wood framework, and on all partitions, pillars, supports and pipings which extend to the framework.

From an examination of the foregoing it will be noted that the chief differences between methods ordinarily used and termite-resistant construction are in connection with the permanent parts of the building

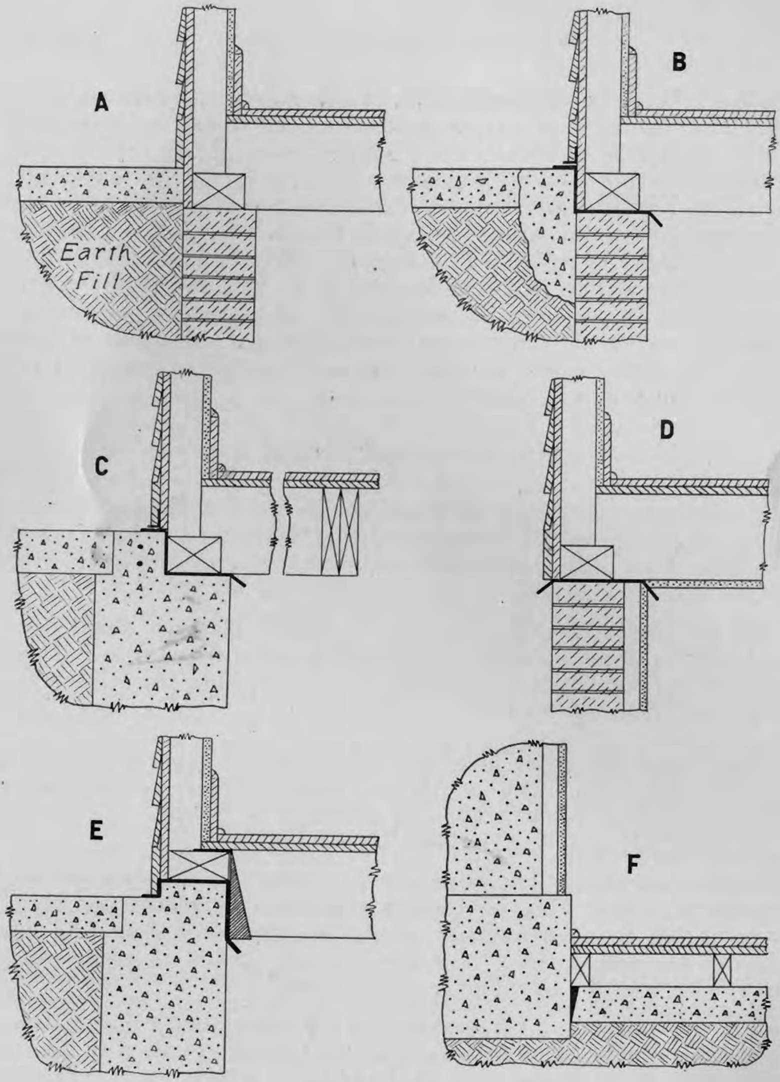

FIGURE 91.

A. Usual type of filled masonry porch which allows termites to enter the sheathing and sill.

B. Reconstruction of usual type of porch, showing the metal shield protected by a layer of concrete. May also be used in new buildings. (Wooden pilasters should be protected by shield.)

C. Shows foundation with extra thickness adjoining masonry porch, (adapted from Kofoid[17]) used with or without shield as shown. Also illustrates the use of short joists at right angles to the sill to facilitate inspection.

D. Metal shield used to protect woodwork above furred-out basement walls.

E. House foundation raised higher than porch floor; extra thickness of foundation as in C; wooden base extending down to porch floor level. If wooden base is raised about three inches above porch floor, or replaced by a concrete base cast as part of foundation, the extra thickness of the foundation may be omitted. May be used with or without metal shields. The floor joists may be hung in metal stirrups as shown, or supported on a shelf formed by the rear of cellar wall, as illustrated by Hamilton.[12]

F. Finished basement construction showing use of expansion joint filled with plastic coal-tar pitch and concrete base formed by upper part of footing.

in contact with or near the ground. Such construction must not only perform its regular function as heretofore, but must exclude termites as well. It is now a problem in Connecticut building construction to guard against termites building shelter tubes over the face of foundations or in the cracks between adjacent structural members regardless of materials.

Thorough and painstaking workmanship is essential. Examination of a large number of infested buildings has revealed a surprising amount of faulty construction and carelessness that has materially increased the susceptibility to termite infestation. Competent supervision is particularly needed at the present time when the essentials of termite-resistant construction are not generally understood or regarded as important in the building trades.

ALTERATION OF BUILDINGS

In general the alteration of buildings should be planned to comply with the requirements for termite-resistant construction given on pages 234 to 236. (See also Snyder[26]). Certain points require special treatment and examples of possible changes are given below.

Wood in contact with ground. Contact between wood and the ground may be broken: (1) by cutting off wooden structures and placing on concrete or solid masonry footings; (2) by raising the structures and placing on a concrete foundation or footing; or (3) by lowering the grade level.

In some cases the grade level can be lowered by making sunken areas with retaining walls, such as those commonly built around basement windows extending below grade. If drainage is possible, such a trench may be used along the entire side of a building.

Masonry porches. The most effective way to alter masonry porches is usually to install a metal termite shield as illustrated on page 237. This operation requires removal of part of the porch floor and usually the top of the foundation. The metal shield should be protected from contact with the fill by a layer of concrete.

Cellar hatchways. On account of the fact that cellar hatchways usually have cracked foundations, the most simple method of protection is to separate the hatchway from the building by a metal shield (Figure 92).

Foundations. In many old buildings the foundation walls were laid up with lime mortar, the joints were not well filled, and cracks have resulted from settling. Such walls offer an easy way for termites to reach sills, joists or built-in cellar construction. It may be necessary to rebuild the upper part of the foundations, using cement mortar. Walls may be plastered inside and out with cement mortar to prevent termites passing horizontally through them. This does not stop entry through vertical hollows. Foundations may be protected with a reinforced concrete cap, to prevent vertical entry. In most instances it is only slightly more expensive and much more effective to install a termite shield than to make extensive reconstruction of the foundation. (Methods of shield installation are given on page 226).

Cellar floors. Cracks[7] in cellar floors may be enlarged and filled with coal-tar pitch. Badly cracked floors should be rebuilt. Wooden floors over cracked or porous concrete should be relaid as in new construction, or replaced by a concrete floor.

Built-in cellar construction. At present there seems to be no method of protecting susceptible construction covering outside basement walls except rebuilding as in new construction. Wooden basement partitions and posts may be cut off 6 inches above the basement floor level and concrete bases installed.

Large masonry buildings. People are apt to be misled by the appearance of massive construction and solidity and do not realize that such buildings may be just as susceptible to termites as smaller ones. For instance, sidewalks and driveways adjoining business buildings may provide a means of hidden entrance for termites in the same way as masonry porches on dwellings, and the corrective measures are similar. Large buildings frequently have cracked basement floors and foundation walls which allow termite entry. Two cases of very serious injury to large masonry buildings have been investigated. In both the termites were entering through cracks in the foundation and in the concrete floors, which gave them access to wood in partitions. Other cases of less serious injury have been investigated. In two, termite flights from cracks in concrete floors have been observed. In one modern structure every wooden partition and all wooden furring on the outside walls was infested. In such an instance the use of a metal termite shield seems to be the only satisfactory remedy at present.

Many industrial buildings have wooden floors laid over cinder concrete and the sleepers or screeds are frequently attacked by termites. It is difficult to protect a floor in such locations without completely rebuilding it. In some older industrial buildings, large wood posts were used for structural support of upper floors. These should either be replaced by metal posts or set on a concrete pier extending at least 6 inches above the floor level. A small amount of injury to such a wood post may be serious, especially if it supports heavy machinery.

Houses of Early American type. Houses of Early American type are particularly susceptible to termite infestation as they are usually set on low foundations with roughly laid masonry walls and have large stone chimneys that offer easy access to house timbers at many points. In reconstructing such buildings, it is important that thorough methods of termite-proofing be used. Again the metal termite shield appears to be the most practical way of securing permanent safety. The large chimneys are particularly difficult problems. On account of the well-known serious fire hazard of such chimneys, as well as the termite risk, it may be advisable to rebuild them. Unexcavated extensions built on poor foundations are frequently infested. It is usually necessary to excavate at least 18 inches under such places, rebuild the foundation and install a metal shield.

ACKNOWLEDGMENTS

The writers wish to express their appreciation to the University of California Press for permission to quote material published in *Termites and Termite Control*; to the American Wood-Preservers' Association for

permission to quote from the article by Dr. Hermann von Schrenk published in their 1934 Proceedings; to Mr. B. H. Walden for all photographs used as illustrations in this report; to Mr. M. P. Zappe and Dr. R. B. Friend of this department for use of information gathered in examining

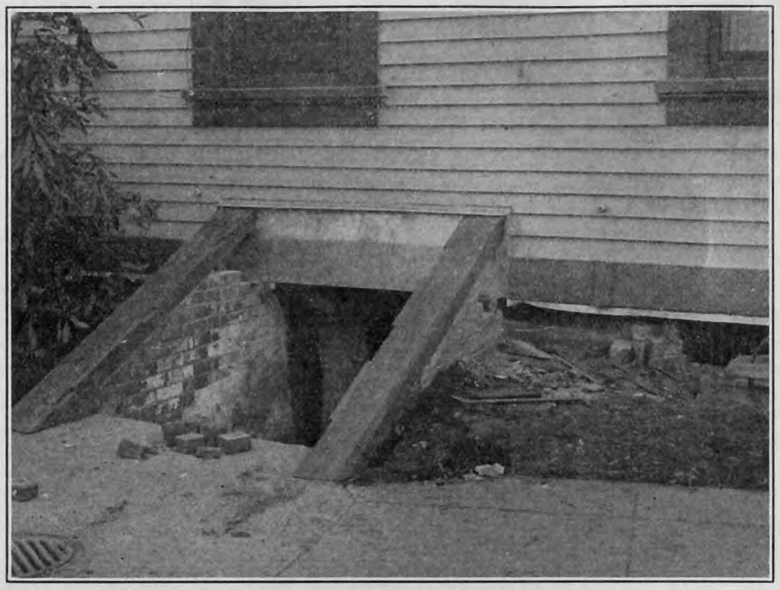

FIGURE 92. Susceptible cellar hatchway shielded from a house.

termite-infested buildings, and to Dr. Friend for valuable suggestions for organization of the material and careful criticism of the manuscript; to Dr. William F. Clapp of Duxbury, Mass., for sharing his information on termite conditions and control work in New England; and to Dr. Thomas E. Snyder and Dr. R. A. St. George of the Federal Bureau of Entomology for valuable information given in an extensive correspondence. The drawings in Figure 78 were made by Mrs. Elizabeth Kaston, and in Figure 91 by James F. Townsend.

SUMMARY

Eastern subterranean termites are native insects living in colonies usually located in moist soil. There are several castes, each of which performs a definite function in the social scheme. Their food consists of cellulose, obtained from wood and a variety of other materials, and they require a constant supply of moisture which is generally taken from the soil.

Reports of termite damage in Connecticut have been increasing in numbers since 1931. All types and ages of building have been found infested.

Termites work entirely under cover. Their presence is recognized by their characteristic burrows, by shelter tubes built over impenetrable

objects or by the emergence of winged swarms. They enter buildings through: (1) direct contact between wood and the soil, (2) cracks or hollows in masonry or concrete, or (3) covered runways or tubes.

Methods of control effective against other insect pests have not been satisfactory for termites. The most practical and successful measure has been to construct buildings in such a way that the termites cannot enter. The materials which they can penetrate are listed in this bulletin. They *cannot* penetrate adequately treated wood, solid concrete, solid unit masonry or non-corrosive sheet metal, and they cannot construct shelter tubes up over the edges of properly installed metal shields.

Soil treatments have not been generally effective and their use is still in the experimental stage.

For wood to be used out-of-doors or in the framework of buildings, the most effective preservatives are coal-tar creosote applied by the pressure or open tank methods. Zinc chloride, applied by the pressure process, may be used for wood not exposed to the weather.

At present there is no information from unbiased sources available as to the effectiveness of treating timbers already in place in a building.

The requirements and methods of metal shield installation are given.

On the basis of the facts presented, termite-resistant buildings can be erected and infested buildings can be altered to exclude the pests. Cutting termites off from their source of moisture exterminates those actually in a building and no other measures are necessary.

Dr. T. E. Snyder, entomologist of the U.S.D.A., Mr. H. von Schrenk, consulting engineer, and the California Termite Investigations Committee, all advise structural methods of control.

Recommendations for Connecticut are that the main reliance be placed on structural methods to exclude termites from buildings and that chemicals be used as a supplementary measure.

Termites are abundant and destructive enough in the State to warrant the use of termite-resistant construction in all permanent new buildings. The amount of expenditure justified in an existing building depends on its permanency, the termite population and the type and quality of the construction.

A procedure is given for termite control in new construction and existing buildings.

Stored materials containing cellulose may be protected by a simple, inexpensive method.

The appendix gives suggested details for termite-resistant construction and possible methods of alteration of buildings.

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