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SAN FRANCISCO—MAY 1936

REPORT

of the

SAN FRANCISCO TERMITE SURVEY

By

A. A. BROWN, *Consulting Engineer*

*A publication destroyed by subterranean termites. Attached on
shelves of the Academy of Sciences, Golden Gate Park.*

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FOREWORD

Termites in San Francisco, as reported to the Department of Public Works by property owners, are apparently infesting homes in every district of the city. Judged by these reports, the damage to houses has been increasing in recent years due, seemingly, to the rapid building up of the city and the consequent multiplication of buildings and structures designed and constructed without regard to this menace. In order to ascertain the extent of the damage to property and to study the incidence of termite infestation in relation to any peculiar conditions which might be favorable to their increase and dissemination, the San Francisco Termite Survey was inaugurated by the City of San Francisco in cooperation with the Federal Emergency Relief Administration and the State Emergency Relief Administration. This survey provided an opportunity for the study of the effect of changed physical conditions in relation to this important problem. Technically trained men were assigned to this work from the relief rolls and given a course of training of about three months prior to their making field inspections.

Because of his extensive experience and knowledge of the termite problem, the City of San Francisco employed A. A. Brown, a consulting engineer who had been chairman of the Termite Investigations Committee, to direct the survey. His report of this survey is presented herewith in non-technical form for the benefit of lay readers and property owners.

ALFRED J. CLEARY,
*Chief Administrative Officer of the
City and County of San Francisco.*

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INTRODUCTION

The termite menace in the United States, until recently only vaguely appreciated, is as serious and widespread as it is inevitable. With more than fifty species of the insect native to the country, they are found in destructive and ever-increasing numbers in the forty-eight states of the Union. From their original useful function as forest scavengers, breaking down and restoring wood tissue to the soil and air, termites have become a significant economic problem as a result of the artificial accumulation and widespread distribution of their food supply in the form of timber in man-made structures. The result has been to facilitate the spread and the rapid increase in number of these insects. To date there have been no adequate control measures because the habits and activities of termites have been so little understood by the construction industry and the general public.

TERMITES NATIVE TO CALIFORNIA

The first impression to be corrected is the common idea that the observance of termite work for the first time in a neighborhood indicates an invasion. Professor S. F. Light, of the University of California, says:

"It cannot be too strongly emphasized that all the termites doing extensive damage in the United States, and, indeed, all except one, or possibly two, of the fifty-five species known to occur in the United States, are native species. We are not facing, therefore, any sudden invasion of new forms, as many have imagined, but simply an adjustment with species present for millions of years before man entered upon the scene."

There are nineteen species of termites native to California.* The three main habit groups into which the various species have been classified to be found in San Francisco are: (1) damp-wood termites (scientifically known as *Zootermopsis angusticollis* Hagen); (2) dry-wood termites (*Kaloterme minor* Hagen); and (3) subterranean termites (*Reticulitermes hesperus* Banks).

In nature, termites and their associated organisms have been the immemorial scavengers of forests, cleaning up the down timber and stumps, and returning such wood to the soil and atmosphere. With the settlement of our country, the land was subdivided and the boundaries usually marked by fences. Roads were built, paralleled on each side by fences. These roadways were used as rights-of-way for the erection of pole lines, and the poles, being placed in direct contact with the ground, provided a ready means for these insects to move from their natural habitat in forests to man-made structures in towns and cities.

Associated with termites in this biological scheme of breaking down wood fiber and returning it to the soil and atmosphere are the fungi (rot) which grow in wood. Conditions favorable for termites are also favorable for fungi. Fungus is a necessary element in the diet of termites. It is to them the equivalent of our beefsteak, and without it, their diet would be com-

*Report of the Termite Investigations Committee, *Termites and Termite Control*, University of California Press, 1934.

parable to our living entirely on starches. The wood made available to termites in man-made structures differs from their food supply in nature, as the tree from which lumber is cut is felled in the full flush of its activity when it is rich in food values, whereas in nature termites live on dead and decaying trees and stumps. In man's relation to their principal food supply, therefore, he has created a huge reservoir of food in the man-made structures of our cities which is far more desirable to termites than that which they find in nature. He has also provided them with shelter and warmth in our furnace-heated homes. All these factors are designed to stimulate their activity; and since they multiply by geometrical progression, it is to be expected that they will move in and occupy the available food supply. This is precisely what they are doing.

FACTORS CONTRIBUTING TO THE DISTRIBUTION OF TERMITES IN SAN FRANCISCO

Numerous factors contribute to the widespread infestation of buildings within the city limits of San Francisco. Approximately 81 per cent of all wood frame structures inspected were infested by one or more species of wood-destroying insects; 33 per cent of the Class C buildings were similarly infested, as were also 36 per cent of the Class A, and 37 per cent of the Class B buildings.

Termites in San Francisco are not confined to any particular area or district but are found throughout the city. The presence of dune sand has no doubt been a contributing factor to the high percentage of subterranean termites in certain districts, while our climate and proximity to the sea appear to have stimulated the spread of damp-wood termites. Higher elevations such as the Western Addition, and regions along the Bay shore such as Sea Cliff and the Presidio, show a higher percentage of infestation by damp-wood termites, while areas such as the Sunset, Richmond and Mission Districts show a predominance of subterranean termites.

In analyzing the distribution of these insects within the city limits it is well to resolve the problem into its constant and variable factors. In this analysis certain elements may be considered constant as they are always true, namely:

1. *Food*: Cellulose is the principal source of food for termites. Any material containing cellulose, therefore, such as wood, paper, clothing, wool, leather, and artificial materials containing a combination of these products, is subject to attack by these insects.

2. *Protozoa*: Protozoa are always found in the gut of termites. They are microscopic one-cell animals which make cellulose available to termites as food. This fact is an important element in certain methods of prevention and eradication since any substance which will destroy these organisms, will ultimately kill the termite.

3. *Fungi*: Fungi are always associated with termites. They provide the nitrogenous part of their diet which is necessary for their successful growth and development.

4. *Wood-dwelling termites* always make their home in wood. They are divided into two major groups, one commonly known as the dry-wood termite, and the other, the damp-wood termite. Both of these types leave characteristic seed-like fecal deposits, commonly referred to as pellets, which are distinctive in appearance and reveal the presence of the insects.

5. *Ground-dwelling termites* (commonly called subterranean termites), make their home in part in the ground, and always maintain a connection with a permanent moisture supply, which is usually found in the soil. These termites do not leave seed-like pellets, but their burrows contain distinctive marks from their liquid feces, together with a peculiar "frass" composed of earth and partly-digested wood, both of which aid in disclosing their presence in a structure. They frequently build covered runways over wood, brick, concrete, or metal surfaces to reach a food supply not in ground contact. These runways, which are made of earth and partly-digested wood and lead from the earth to wood or vice versa, are characteristic of the ground-dwelling termites.

In solving any problem, the difficulties are not in meeting situations presented by factors that are constant, but by those that vary. Therefore, as an aid to providing an adequate solution it is advisable to determine the limits within which these variables operate. Among these variables are:

1. *Moisture*: Subterranean termites are dependent upon a constant supply of moisture from some source. This is usually found in the soil. It is possible, however, for them to colonize without ground connection if they have other means of obtaining moisture. For example, an ocean liner at the dock in San Francisco was found to be infested by an oriental subterranean termite. In this instance they had colonized in the woodwork of a cabin and were obtaining their moisture supply from a leaky coffee urn.

Dry-wood termites are able to colonize in dry, seasoned wood which contains no free moisture. Any wood exposed to the atmosphere contains some moisture which it absorbs from the air. The only wood that can be considered free of moisture is that which has been oven-dried, and in a short time even this oven-dried wood will absorb moisture if exposed to air. Wood in which dry-wood termites were found contained 12.75 per cent of moisture by oven-dry weight. This latter percentage of moisture is commonly present in any wood exposed to air.

Damp-wood termites have an exceedingly wide range of tolerance to moisture once the colony is established. However, some free moisture appears necessary for the colonizing pair. These termites were found in wood containing as much as 220 per cent moisture (waterlogged), and also in wood containing as little as 13.35 percent moisture by dry weight.

2. *Temperature*: Termites are normally attracted to warm places. They thrive best in the tropics. Thirty years ago furnaces were not standard equipment in basements of flats and residences in San Francisco, while today the reverse is true. In fireproof concrete structures, subterranean termites are often found entering the furnace room, no doubt stimulated to activity by the presence of heat. A warm temperature, therefore, is a favorable contributing factor to termite activity, although the degree of temperature will vary greatly within structures.

3. *Distribution of types:* While there are three major habit types of termites found in San Francisco, it does not follow that all three may be grouped within the same structure. The distribution of these types (the two major wood-dwelling and the subterranean termites), is influenced by other variable factors.

4. *Soil Conditions:* Soil would appear to be an important contributing factor to the distribution of subterranean termites. Subsoils of San Francisco consist of clay and sand, and a mixture of the two, overlying the bedrock series of Franciscan sandstone, shale and serpentine. In certain of the lower areas there is made-ground and swamp materials. The possible moisture content of the soil depends upon the size and shape of the grains and the degree of sorting. The great number of particles in clay, for example, and their small size and shape, give it a high degree of hygroscopic content—that

(FIG. 2). Photograph of space between a wood frame building and a concrete structure, where the wood forms used in constructing the concrete building were left in ground contact. Subterranean termites heavily infested the wood forms and also the wood frame building.

is, moisture in the form of a thin film about each particle, which is not available as free moisture. Sand, on the other hand, due to the larger size of its grains, contains much more free capillary moisture. Clay may have a higher percentage of total moisture-content than dune sand, but the water in the former is principally locked in and not available, while the water in sand is free and available to termites. The capillary action of dune sand normally maintains free moisture relatively near the ground surface, presenting a condition most favorable for the colonizing of subterranean termites.

5. *Climate:* The climate in San Francisco appears to be an important element which contributes to the widespread distribution of damp-wood termites. These termites are found emerging on their nuptial flight beginning in August and extending sporadically through the fall and winter months. The

(FIG. 3). Photograph of a 10" x 10" raw wood column taken from the basement of a 6-story apartment house. The column, supported by stilts to show its length before the subterranean termites discovered it, was originally encased in metal lath and plaster. Processed lumber should be used under such conditions, and a steel plate extending beyond the plaster line should be placed under the column.

(FIG. 4). *Photograph of ends of raw timber joists taken from a Class C building demolished to provide space for approaches to the San Francisco-Oakland Bay Bridge. These joists were 4 feet above the ground, the ends resting in a concrete wall. Note damage to ends of joists by subterranean termites. The ends of such joists should be processed with non-water-soluble chemicals to render them immune to fungi or termite attack.*

early rains of the fall, beginning in September or early October, extend intermittently until about the first of June. June and early July are dry months, followed by fogs heavily laden with moisture during the latter part of July and August, when there is another brief period of fair weather before the early fall rains begin. This climatic condition is favorable for the colonizing of damp-wood termites, since they seem able to avail themselves of moisture in the air in addition to obtaining moisture by body processes from otherwise dry wood.

6. *Natural wood preservative*: It has been commonly observed that certain pieces of wood will resist the forces of decay longer than other pieces. This unequal resistance is due to the variance in distribution of nature's preservative in the tree from which the wood was taken, and probably accounts for the fact that termites select those pieces of wood that are less durable and where they can more readily grow fungi as an element for their diet.

7. *Construction*: Certain building practices commonly in use by the construction industry under existing ordinances provide ideal opportunities for infestation by one or more of the species of termites found within the city limits (figs. 2, 3, 4).

The above variable factors enter into the distribution of these two major habit types of termites, and, while specifically applicable to the City and County of San Francisco, are of broader significance and can be applied, with variations, to other communities. Hence it is reasonable to conclude that climatic and soil conditions, together with faulty methods of construction, are the three major variable factors influencing the distribution within the city limits of the two most important species of termites.

CHARACTERISTICS OF TYPES FOUND IN SAN FRANCISCO

Dry-wood termites: In this survey, dry-wood termites were found only in the region of Golden Gate Park, adjoining the Richmond District. These insects, if permitted to extend the boundaries of their present infestations, have great potential possibilities for doing damage. As their name implies, they live in the dry, sound wood of trees, poles, posts, and buildings. They rarely if ever enter the ground, and require no special moisture supply. These termites were found swarming in the middle of the day in bright sunshine, during the latter part of July. Their normal time to swarm is from eleven o'clock in the morning to three o'clock in the afternoon, the peak of their swarm occurring at the noon hour. The alates are brown, with lighter shaded wings, and slightly less than five-

(FIG. 5). Photograph of a group of individuals from a colony of the damp-wood termite, *ZOOTERMOPSIS ANGUSTICOLLIS*, natural size. Note the numerous nymphs, one soldier, and five winged reproductives, or alates, ready for swarming.

eighths of an inch in length from end to end including the wings. During their flight, they mate and seek new homes, entering cracks, nail holes or joints, or where these are not available, they dig into the solid wood.

The most common method of controlling these insects is by blowing poison dust into their runways. The poison adheres to the fine sensory hairs on their bodies, and, due to their constant habit of grooming, is spread rapidly

(FIG. 6). A 6" x 6" post gutted by damp-wood termites and fungi. Note the sound appearance of the exterior.

through the colony. Since these termites enter the wood directly at the swarming period, it is necessary to stop the colonizing pair from entering by protecting the wood. This can be done by the use of a toxic, penetrating, priming coat of paint, or by spraying with a penetrating toxic preservative that is not readily water-soluble.

Damp-wood termites: The winged damp-wood termites are about the same color as the dry-wood termites but are larger. From tip to tip alates measure about an inch (fig. 5). They are usually found flying in the late afternoon or early evening. They are commonly attracted to electric lights. Beginning about the middle of August and extending through the fall and winter months, these termites emerge at sporadic intervals on their nuptial flight. The colonizing pair appear to require some free moisture, such as is found in wood that has been dampened by rain, etc. Once established, however, they have a very wide range of tolerance to moisture, being found in wood piling at low tide line in a building in the vicinity of the San Francisco waterfront. Termites from this same building were placed in glass jars and

(FIG. 7). Section of a raw timber building-column infested by damp-wood termites. Spray treatments do not reach concealed colonies as shown in this photograph. Experimental methods illustrated in figures 22 and 23 can be satisfactorily adopted for eradication of termites under the conditions shown.

provided with a quantity of dry wood and a small amount of moist paper as an aid to their establishing a colony under new conditions. At the end of six months the colony was still healthy, and specimens of the wood then tested contained 16.08 per cent moisture by dry weight. These termites have been referred to as rotten-wood termites but are generally called damp-wood termites (fig. 6). Both of these terms, however, are subject to some restriction in use. The name "rotten-wood termite" implies that one would expect to find them in rotten wood. This is not necessarily true (fig. 7). As previously mentioned, fungi are always associated with termites, and since these insects live in damp wood and carry fungi with them, it naturally follows that they are frequently found in decaying wood; but this, it appears, is only the case where they are able to control the growth of fungi. Where conditions favor an excessive growth of fungi, it has been found that termites move to other parts of the structure where they can control its growth and development (see fig. 21). We found many instances where damp-wood termites had been present but appeared to have died out due to the excessive amount of decay that had taken place in the wood. On more careful examination, however, the investigator found that these termites had not died, but had abandoned the decayed wood and moved to sound wood where conditions were more favorable to their mode of living and where the growth of fungi could be controlled. These observations probably explain both the failure of workmen to locate such termite colonies, and the finding of termites in structures immediately following the completion of attempts at eradication

(fig. 8). Among the buildings inspected were a considerable number that had been repaired during the year 1935. Inspections were made in some instances within twenty-four hours after completion of the repairs, and in 77 per cent of these buildings termites were still present. The damp-wood

(FIG. 8). *Photograph of concealed damage by damp-wood termites in building illustrated in figure 9. The building appeared sound prior to removal of the exterior sheathing.*

termites are very destructive to property in San Francisco, being present in approximately 50 per cent of the structures inspected and found to be infested. While infestations by these termites are not quite as numerous as those of the subterranean variety, their damage to buildings, per infestation, is far greater. The cost of making repairs on a job where these termites are involved is usually much more expensive than in the case of ground-dwelling termites as they often extend their activity from the foundation to roof-rafters (fig. 9). In one instance they were found on the fifth-floor level of a fireproof structure (fig. 10).

Subterranean Termites: The winged subterranean termites are almost jet black with light gray wings, the wings being about twice as long as the body (fig. 11). From tip to tip they measure about half an inch in length. On the first sunny day following the first heavy rain in

(FIG. 9). The building illustrated in this photograph was recently razed, thus providing an opportunity for a thorough inspection of all parts of the structure. The degree of infestation by damp-wood termites is indicated by shading. The damage was greatest near the top, probably due to leaky roof and siding.

the fall, they emerge from the ground or from buildings in large numbers on their mating flight. Sporadic flights continue through the fall months. A minor flight occurs on bright, sunny days in the spring following a heavy period of rainfall. It is this variety that is commonly mistaken for flying ants. Since these termites nest in the ground at varying depths, the time required for moisture to reach the colony and stimulate the mating flight will vary. We found winged termites of this species in basements many feet below the street level as late as June, indicating that the time required for moisture to reach them was greatly delayed. After shedding their wings, they mate and seek new homes either in the ground, or in wood in contact with the ground, or in wood where free moisture is available. They frequently enter concrete structures through cracks, joints, defects, wood-block spreaders (fig. 12) that were embedded at the time the concrete was poured, or along pipes,

(FIG. 10). A housewife called the survey office to report that she had found a lot of seeds under a rug in her home. The photograph shows the seed-like fecal pellets left by the damp-wood termites which penetrated the flooring leaving a row of holes on the surface. The termites had also damaged the rug along the line of holes. This floor was approximately 10 feet above the ground.

conduits, etc., causing damage to stored material containing cellulose, or by building their characteristic covered runways (fig. 13) to reach such material. The most extreme case we found was where they had entered through joints in a concrete floor 25 feet below the street level, and constructed their covered runways to furnishings on the main floor above (fig. 14). Subterranean termites not only build covered runways over concrete, brick, etc., but they also erect coral-like structures (fig. 15) to reach wood not in contact with the ground. They appear unable to create moisture from wood to the

(FIG. 11). *Photograph of subterranean termite winged reproductives (alates) swarming in the basement of a fireproof building, near the furnace room on July 2, 1935. Termites gained entrance through a crack in the concrete floor.*

extent that wood-dwelling termites do, and therefore are more dependent on some exterior supply. These termites were present in approximately 67 per cent of the buildings inspected and found to be infested. (See fig. 16).

In the initial attack of wood-dwelling termites on a structure, we are dealing basically with the colonizing pair. Subterranean termites, however, have their nests in the ground, possibly some distance from the point of infestation, and these nests may contain thousands of individuals. Their attack therefore is made not by a pair of individuals, but literally by an army. They build galleries under the surface of the ground to wood in ground contact, or to wood placed away from ground contact, making it necessary in dealing with them, to provide a depth of treatment sufficient to destroy a colony rather than a pair of individuals.

BEETLES

Wood-boring beetles were found doing damage to structures and to furniture in approximately 11 per cent of the buildings that were inspected and found to be infested by wood-destroying insects (fig. 17). We found these adult beetles flying during the months of June, July and August. Mating takes place soon after emergence from the wood, and as the result of their ability to fly considerable distances, the females are enabled to spread

their attack to uninfested wood in the vicinity. Normally they shun the light, and are most active at dusk and during the night.

Late one evening I was called to the home of a man who explained that a day or two earlier he had purchased a cord of oak firewood which was stored in his furnace-room. Upon entering the furnace-room that same evening, he found a quantity of small black bugs emerging from the wood. Upon examining them, I found three different species of adult wood-boring beetles on their nuptial flight. The floor, walls and ceiling were thickly spotted with insects, and they had crawled under the door leading from the furnace-room and were finding their way to the woodwork in the upper part of the home. The firewood came originally from Sonoma County, and had been purchased from one of the local wood yards. Prompt action in this case probably prevented a home which had been built only a few months previous from being thoroughly infested by these pests.

Wood paneling in another home, which had been free of infestation for many years, was found during the summer of 1935 to be infested with beetles. In the basement of this home was stored a quantity of beetle-infested oak firewood, some of which had been there for about three years. The same species of beetle found in the firewood was found in the wood paneling. These instances indicate the need for controlling the sale of infested wood.

(FIG. 12). Subterranean termites gained entrance to the basement of an 8-story Class C building through a raw wood-block spreader left in place at the time the concrete wall was constructed. Termites constructed runways over the concrete to the raw wood joists above. Winged reproductives were swarming on June 4, 1935.

(FIG. 13). *Covered runways made of earth and partly-digested wood constructed by subterranean termites on a vertical concrete wall to reach the raw wood frame of the building above.*

Powder post beetles and death watch beetles are the types most frequently found in San Francisco (fig. 18). The adults of these beetles are small, being less than a quarter of an inch in length, and black in appearance. Their larvae are grublike. Beetles live for generation after generation in old, well-seasoned timber, honeycombing the wood and reducing it to a condition of powder, which plugs the old burrows or is expelled from time to time through small openings. The small shot-hole openings, and the powdered remnants of their workings in wood usually found on floors or ledges, indicate their presence and differentiate them from termite workings.

(FIG. 14). Oak partitions covered with frass and runways. These partitions had been stored for only 3 months in the basement of a fireproof office building. Some of the partitions were damaged beyond repair.

(FIG. 15). Coral-like towers and tubes made by subterranean termites to reach raw wood in a building, not in ground contact. All the towers parallel a hot-air duct.

(FIG. 16). Group of individuals from a colony of subterranean termites, *RETICULITERMES HESPERUS*, showing the appearance of workers when a colony is opened. Natural size.

Fumigation: In a number of instances which came to our attention, attempts had been made to eradicate beetle infestation by fumigation. Subsequent inspections made, however, showed that beetles were still infesting the wood. These observations confirm the report of Dr. Merle Randall, chairman of the Chemical Sub-Committee of the Termite Investigations Committee, which says:

"Most of the commonly used gas, liquids, and solid fumigating materials were tested and all were found toxic to termites. The great obstacle to the success of fumigation is the difficulty of reaching all the termites with the poisonous vapors. The vapors do not diffuse readily through the termite galleries, hence the termites were able to escape the effects of the vapors even during a fumigation period of reasonable length. The surviving fragments of the original colonies which remain defeat the purpose of fumigation."

(FIG. 17). Typical work of a powder post beetle in a Douglas fir floor joist. Note the small emergence holes.

FUNGI

Sagging floors, cracked plaster, jammed doors, and windows that are difficult to open and close, are common results of the failure of wood in buildings (fig. 19). Much wood failure is attributed to dry rot. In many instances the failure is actually due to termite attack, the fungus being introduced to

(a)

(b)

(FIG. 18). (a) *LYCTUS CAVICOLLIS* (Lec.) the commonest true powder post beetle in California. (b) *HADROBREGMUS GIBBICOLLIS* (Lec.), the most destructive native California death watch beetle. These beetles are about $3/16$ of an inch in length, natural size.

the wooden members by termites. Decay is caused by fungus, a plant growth which grows on and in wood and destroys its substance as it develops. Generally speaking, conditions which favor termite infestation also are favorable for the growth of fungi. The most important factor in eliminating their growth is moisture. Dry wood will not decay. Wood is food for fungi, but it cannot be used as food unless it contains at least 15 to 20 per cent moisture by dry weight (fig. 20). Neither can fungi use wood that is submerged in water. The spores of fungi are always floating in the air and some 33 different kinds were found by Dr. Esther C. Hendee to inhabit the burrows of termites of the Bay area.* Good drainage and adequate ventilation are essential in any program of eliminating damage to structures by fungi. Leaky roofs, walls, window frames, down spouts, plumbing fixtures, etc. (see appendix), all provide conditions favorable for the rapid growth of these organisms, as well as providing conditions favorable for infestation by termites.

*The Association of Termites and Fungi, Chap. 9, TERMITES AND TERMITE CONTROL.

BUILDING DETAILS WHICH CONTRIBUTE TO TERMITE INFESTATION

Among the species of raw wood commonly used in the construction of buildings in San Francisco, none were found to be immune to termite attack. It is important, therefore, that care be exercised in the construction and maintenance of any building in which raw wood or raw wood products are used.

Brick veneer buildings backed by wood framing are often found to be infested by termites. Brick veneer is not always watertight, and moisture reaches the wood backing behind the brick. Brick foundations are also a common source of difficulty as they draw moisture from the soil to the wood,

(FIG. 19). *Photograph of raw timber joists destroyed by fungi in a warehouse.*

making it thoroughly damp although placed as much as two feet from the ground. Where concrete or masonry walls are inadequately waterproofed, moisture reaches the wood frame on the inside and provides conditions favorable for the colonizing of wood-dwelling termites and fungi (fig. 21).

Certain methods of construction permissible under the present building ordinance preclude the possibility of any untreated wood giving a satisfactory use-life. In all classes and types of building wood floors are commonly nailed to sleepers overlying concrete which is in ground contact. As has been previously noted dune sand (which predominates in this city) draws moisture by capillary action close to the surface and creates a condition of dampness in this type of construction which is not only favorable to the development of

(FIG. 20). *Photograph of fungi growing on the wood frame of a building. Due to the presence of moisture and lack of ventilation, the structure was seriously damaged by fungi.*

fungi but also is necessary to subterranean termites. Defects in the concrete slab invariably provide a ready means of access for termites; and this, combined with conditions favorable to the development of fungi, results in a very short life for wood floors constructed over concrete in ground contact.

In discussing the necessity of renewing a wood floor built as described above, the manager of a building recently remarked that every four or five years he had found it necessary to replace the floor in question, and now felt that he had given wood a sufficient trial and was desirous of using a wood substitute. In this particular case, however, the wood flooring never had a chance. Instead of using wood that had been chemically treated to make it unavailable for either termites or fungi, he had been providing them with a new food supply every four or five years under the most favorable conditions for their use. The ordinance permitting the use of any material containing cellulose under such conditions should, in fairness to the lumber industry, be revised in line with our present knowledge of the dangers involved.

Small Building Lots: Over large areas of San Francisco buildings have been constructed on 25 foot lots, with adjoining structures built to within an inch of the property lines, thus making it impossible ever to get at the outside walls except from inside the basement. The wind-blown debris that accumulates in these small openings when dampened by rain water running down the sides of the buildings, provides ideal nesting places for termites. Of 67 closely-built wood frame buildings in one block, all but five were infested.

DIFFICULTIES ENCOUNTERED IN CONTROL MEASURES

The Termite Investigations Committee reports having found subterranean termites nesting in the ground and attacking wood 165 feet distant. The physical conditions prevailing in San Francisco—provided by ideal soil in the nature of dune sand, and small building lots causing structures to be built in solid rows—together with the ability of these insects to construct galleries under the ground for considerable distances, changes the problem from one in which only the individual property owner is concerned, to a community problem as well.

Property owners who are interested in eradicating termites from their buildings but find their neighbors careless or not at all interested in the subject, are presented with a difficult situation where infested buildings abut their property. During the course of the survey this difficulty was discussed by a number of property owners who desired to remove the

(FIG. 21). *Raw wood supports for concrete or brick porches and steps are frequently destroyed by termites and fungi. Such areas should be well ventilated, and wood used for the purpose should be chemically processed.*

menace from the neighborhood, but, under existing laws, there was nothing they could do about it. The problem presented, however, suggests the necessity for studying remedial legislation so that it might be possible for a majority of property owners in a neighborhood to institute a general program of eradication. In San Francisco we are not dealing with a theoretical problem that termites might infest structures, but with the reality that termites are widespread.

The hidden mode of life of all termites renders impracticable the control methods used for other insects, such as biological control by the use of enemies, poison bait as in the control of the common house ant, fumigation, spraying as in the control of orchard pests, or the poisoning of mosquito-breeding grounds. They live shut off from the light in enclosed passageways, either in the wood on which they feed, or partly within the wood and partly within the earth.

Inspection: In existing structures a careful and intelligent inspection by a person familiar with the building industry, and possessing a knowledge of the life-habits of the various kinds of insects and organisms that do damage to wood and its products, will prove of great aid in reducing the likelihood of termite infestation. The old adage, "An ounce of prevention is worth a pound of cure" is applicable to the termite situation. Inspections frequently reveal conditions favorable for termite infestation which, if immediately remedied, will avoid the necessity of future costly repairs. Termite damage is by no means confined to old buildings. Many of the older structures were better built than new homes constructed by speculative builders. During the boom days many homes were built with "Queen Anne fronts and Mary Ann backs." Such buildings, in which emphasis was placed upon appearance rather than upon substantial workmanship, are now paying the penalty for many careless and slipshod construction details. Wood-destroying organisms in one such home less than two years old caused such severe damage that an entire wall had to be replaced. As previously mentioned, new, fragrant lumber is more attractive to termites than old, dry, seasoned material. Consequently, any faulty condition in recently constructed buildings which may be disclosed by proper inspection should be promptly remedied.

A common means of locating the presence of wood-dwelling termites is by their characteristic fecal pellets. From time to time openings are made in the wood and these pellets discharged from the runways. The pellets of the dry-wood termite are smaller than those of the damp-wood termite, and have a characteristic shape and appearance. The pellets of the damp-wood termites also have a characteristic form but appear to vary in size owing to the presence of moisture. Where there is much moisture the pellets are larger than when they have colonized in relatively dry wood. All species of termites reveal their presence at the swarming time when the winged members of the colony emerge to mate. This always affords the alert property owner an opportunity to learn the extent, if any, of termite infestation in his building. Subterranean termites reveal their presence at the swarming period, and also by their characteristic covered runways, coral-like towers, and frass. These termites seal the cracks, joints or defects

in the wood with their frass as a means of controlling the circulation of air, and in this way leave the tell-tale evidence of their presence.

References are found in current literature suggesting the necessity of destroying the queen as a means of controlling termite infestation. There are certain species of termites where the queen develops essentially into an egg-laying factory and becomes immobile. The royal chamber in such circumstances is guarded by a large number of soldiers. In India, native termite experts who have keen hearing are able to locate the position of such queens by the characteristic noise made by the guarding soldiers. In the case of the three major types of termites doing damage in San Francisco, however, the royal pair are mobile and move from place to place, and should they be destroyed, each colony contains supplementary reproductives which in a period of from five to six weeks will produce a new king or queen, the latter more fecund than the original. When dealing with wood-dwelling termites in San Francisco, therefore, it is important that all members of a colony be destroyed, as any survivors after the relatively short period of a few weeks can re-establish themselves and continue their destructive activity. Where the nest is in the ground, as is generally the case with subterranean termites, the royal pair is rarely disturbed by the methods used for eradication.

Misinformation given to the public: Many high-pressure sales organizations prey upon property owners due to their ignorance of this important subject. Materials under ambiguous names are now being offered to home owners for the control and prevention of termites. We quote from a recent circular mailed by the manufacturer of one of these products to architects and engineers, in which the writer expressed impatience with laboratory methods used by research scientists in determining the efficacy of products offered for the purpose of termite control:

“For years architects, builders and home owners, in order to protect their buildings, have been obliged to follow a stereotyped rule laid down by some conscientious professor who never lived in a structure after his ideas of the proper termite control medium had been applied . . . His natural honesty of purpose, if backed with practical experience, would stop the use of poisonous materials that leach out killing plant life, pets and endangering the lives of children when applied under and around the outside of the house. However, his laboratory tests prove that this or that will kill termites, and it has been unfortunate for the real builders that laboratory and not practical standards have been in vogue.”

The material offered the public by this manufacturer depends largely upon cyanide for the asphyxiation of termites. In the opinion of Professor Frank T. Green, City Toxicologist, it constitutes a real menace to human health. In the circular the manufacturer of that product is criticizing the professor who objects to the use of materials which create a hazard to human life in dealing with this problem in the home. He goes on to say:

“Has this theoretical practice of years stopped termites? No. They are increasing in the proportion of each queen laying 86,400 eggs a day.”

We quote some of the misinformation contained in the circular of another manufacturer:

"The queen lays an egg every two and one-half seconds, night and day, for approximately ten years. Unlike humans, termites never rest. At this rate the colony increases 24 a minute, 1440 an hour, 34,560 a day, totaling 12,614,400 a year. In the spring and fall the alates take wings and swarm to form new colonies. This gives you an idea of just why they are so destructive."

Dr. A. L. Pickens, of the University of California, devoted his undivided attention for a number of years to the study of subterranean termites for the Termite Investigations Committee. He reports:

"Some of the largest supplementary queens can lay 60 to 80 eggs a day . . . Some of the African species it is estimated lay 4,000 eggs per day; and Dr. Emerson of the University of Chicago counted 7,000 eggs laid in one day by a queen of one of the African species."

In the literature of one of these sales organizations they have the queen producing 86,400 eggs in twenty-four hours, and in the other, 34,560 eggs in a day; whereas our scientists actually found that the subterranean

(FIG. 22). Portable equipment used for pressure-treating experimental building sections, using a refined creosote colored with an oil-soluble dye. Small holes $\frac{3}{32}$ of an inch in diameter were bored to within $\frac{1}{2}$ inch of the opposite side, into which a hollow screw was inserted, fitted with an Alemite connection. The holes were spaced about 18 inches on centers. All concealed joints were thoroughly coated with preservative. Pressures of from 200 to 250 pounds per square inch proved most satisfactory in treating Douglas fir.

(FIG. 23). Photograph of a 4" x 4" Douglas fir 4 feet 6 inches long, into which preservative was forced under pressure. Note the stain at the end showing that the oil had passed entirely through the post.

termites, with which we are dealing, may produce from 60 to 80 eggs a day. Such misinformation often creates a feeling of hysteria in the public mind against the use of wood and its products. If termites actually increased in the fantastic proportions mentioned above, they would long since have taken complete possession of our homes. It is advisable, therefore, for property owners to deal with well-established, reputable business houses when seeking advice and information for the control and eradication of these pests.

The use of a spray has almost assumed the proportions of a panacea; yet it is utterly impossible by such a method of control to reach termites deeply embedded in timbers (fig. 7). Methods adapted to the pressure-impregnation of lumber in place are available (fig. 22), the preservative being forced into the wood under pressures up to 300 or even as high as 500 pounds per square inch. In fig. 23 a preservative was forced through a 4" x 4" piece of Douglas fir 54" long. A small hole $\frac{3}{32}$ nds of an inch in diameter is drilled across the grain to within about $\frac{1}{2}$ inch of the opposite side, and a hollow screw fitted with an Alemite connection inserted. The preservative is then forced through the wood, directly entering any existing termite runways and destroying members of the colony. There is no panacea for the eradication of termite-infested homes, as conditions vary greatly both in structures and methods of attack by termites.

SCIENTIFIC FINDINGS OF BIOLOGISTS

Men of pure science are frequently criticized for the apparently impractical studies undertaken in their laboratories. The biological researches into the life and habits of termites made by these men, extending over many years, is now the groundwork upon which it is possible for architects, engineers and contractors to approach the problem with sufficient basic data to find a reasonable practical solution.

Among the many phases of research undertaken in the laboratory of Professor Charles A. Kofoed of the University of California was one dealing with the normal sexual development of the supplementary reproductives inhabiting termite colonies. It was found first that termites constantly groom themselves and each other, a custom which extends to the royal pair. Then, by experimenting, they found that the royal pair gave off a substance from their bodies which, upon being distributed through the colony by grooming, inhibited normal sexual development in the reproductive so long as that substance was available. This scientific fact standing alone meant little, but when interpreted in the light of experience in field observation, it explained the presence of secondary kings and queens in colonies which were apparently branches of an original colony that had become separated from the other members. Further application of this important basic fact disclosed the necessity when dealing with wood-dwelling termites of entirely destroying the colony and not merely the reproductive pair, since potential kings and queens are always available to replace the original royal pair.

It is a well-known fact that arsenic is a deadly poison to all forms of animal life including wood-destroying insects. Research studies made by Doctors Charles A. Kofoed, R. Stohler and Esther C. Hendee * in the biological laboratories of the University of California disclosed the interesting fact that certain fungi commonly found in soils of the Bay region and in termite colonies use arsenic in their metabolism and release an arsine gas. Arsenic has been commonly used by exterminators for ground treatment to prevent soil-dwelling termites from gaining access to a structure from their nest in the ground. Thus we find with these two organisms so closely associated, that what is poison to one becomes an aid in body processes to the other; again indicating the necessity for understanding the vast mass of scientific data now available before attempting the application of remedies. Too much cannot be said in praise of these men who have contributed years to the study of minute phases of termite life that are now proving of inestimable value when properly interpreted and applied to the problem of termite prevention and control. Such men often spend a lifetime studying one small phase of a problem apparently of little practical value but, when fitted into the entire picture, helps to make the whole possible, as one piece of tile does its bit to complete a beautiful mosaic. Such scientific facts are the products of many laboratories and the work of scientists in widely separated places. The limited space available in this report does not permit the listing of the many scientific facts recorded, instanced by those mentioned

**The Association of Termites with Arsine-producing Fungi*, TERMITES AND TERMITE CONTROL.

above, nor the correlation of one to the other, and their application to the practical phases of the problem of termite control. Suffice it to say that biologists have made available sufficient data for those in the field of applied science to successfully inaugurate a program of control. This is another instance of the ever-widening influence of the biologist.

ALTERED PHYSICAL CONDITIONS FAVOR TERMITE INFESTATION

It is an established scientific fact that wood which remains submerged in water has an indefinite life. Recognizing this fact, engineers endeavor to so cut the tops of wood piling, which provides support for many buildings in our city, that all the wood in the piling will be submerged at all times. The coming of automatic sewage ejectors, the need for garage space in basements, and many other changes in our mode of living have made necessary the use of more space below the ground in commercial structures. A few years ago, rain falling upon roofs was permitted to run to the streets and the soil. Following the earthquake and fire of 1906, the building ordinances were revised making it mandatory that all conductors of such waste water be connected with the sewer. The old cobblestone pavement which formerly lined our streets permitted rain water to reach the soil and replenish the underground supply. The hard asphalt surface now in use has completely altered that situation; so that today the combined effect of the physical change in the streets, the

(FIG. 24). *Damp-wood termites were found infesting waterlogged wood piling at low tide. Subsiding ground waters expose wood piling to the ravages of these pests.*

(FIG. 25). *Underpinning of an apartment house destroyed by subterranean termites. The top of the concrete foundation was approximately at ground level inside the basement. The entire area was littered with old lumber in ground contact, most of which was infested by termites.*

change in the building code, and the removal of ground waters to provide dry basements, have resulted in the lowering of the normal water table and exposing, in many instances, wood piling to the ravages of these pests (fig. 24).

San Francisco has experienced severe earthquakes in the past, and will probably experience others in the future. In such periods of testing, wood frame structures have demonstrated their ability to withstand the unusual strains put upon them. Termites in many instances center their attack near the foundation of buildings, often at very vital places, necessitating changes in the now accepted methods of wood frame construction if wood is to retain its present favored position. Says Dr. Charles A. Kofoid:

"There is no possibility of eradicating termites; they have existed for millions of years and will continue to exist despite anything man can do about it. But their major damage can be controlled."

He adds:

"Wood is the material best suited for homes in an earthquake country. It is economical to use. It is esthetically enjoyable. We love the feel of it. We enjoy its pattern and colors. It lends itself to the hand of the craftsman and to the human need of change. It can be safely used in the face of the termite menace. In a well-built city controlled by a proper building code, termite danger will be reduced, the spread of infestation will be checked, home investments conserved, and the earthquake hazard reduced."

SUGGESTIONS TO HOME OWNERS

1. Check the masonry or concrete foundations of your home, both inside and outside, to determine whether the top of the foundation at all points is above the ground line. It is desirable to have a minimum clearance of 6 inches. If you find the ground line at any point extending above the top of the foundation, inside or outside, it is advisable to consult some one familiar with the problem involved. It is often possible to avoid costly future repairs by taking immediate action (fig. 25).

2. Where homes have been constructed with no wood in contact with the ground but where, due to landscape gardening, the contour of the ground line has been raised at one or more points above the top of the concrete foundation, such change creates an unnecessary danger to the building and often contributes to termite infestation. Carefully survey your garden next to the house for such a condition.

3. While the city ordinance requires that all ground surface under the house be ratproofed with a thin coating of concrete, many instances were revealed by the Termite Survey where this work had not been done. On inclined lots where ratproofing has been omitted, the sandy top soil is often disturbed by individuals crawling or walking over it, causing it to slide down hill and lodge against the interior partitions or the outside wall on the low side, creating favorable conditions for termite infestation. Carefully inspect the interior piers, partitions and walls, particularly on the up

(FIG. 26). *Wood forms around concrete footing left in ground contact provided subterranean termites easy access to main floor above. The raw-timber girder, joists and flooring had to be replaced. Note the typical frass and hanging tubes.*

side of sloping ground, and make sure that the earth is not in direct contact with the wood frame of the building. In exposed positions, wind-blown sand is often found banked against the side of a wood frame building that had been constructed with ground clearance.

4. Do not leave stumps and roots of trees under your building. Neither should wood and rubbish be permitted to accumulate on the ground as they provide breeding places for termites. Good housekeeping in the basement of your building will prove to be a distinct aid in discouraging termites from entering your home. Any wood in ground contact attracts termites.

5. Wooden forms used in the construction of concrete piers and concrete foundations often provide termites with a ready means for entering the underpinning of your home (see fig. 26). In many instances wood forms have been left in place and embedded in ratproofing, these forms extending to ground contact. Carefully inspect all concrete walls or piers, both inside and outside, and if such wood forms are found they should be promptly removed.

6. Do not permit the wood framing around meter boxes or basement ventilators to come in contact with the ground.

7. If water enters your basement during the rainy season, every effort should be made to correct faulty drainage. Such damp conditions encourage infestation by termites and damage by fungi. Frequently the cause of moisture in basements can be traced to roof drains discharging against the house, or to refrigerator drains being permitted to empty onto the ground beneath the building. Every effort should be made to maintain the ground in basements free from moisture.

8. Good ventilation is a distinct aid in maintaining dry basements. Do not permit shrubbery in the garden to interfere with the free circulation of air through basement ventilators. A musty odor in the basement is a good indicator that all is not well with your home.

9. Many homes are built with beautiful brick steps and veneered brick entrances. Occasionally such brick work is supported by reinforced concrete, but generally it is supported by wood framing. In a very large percentage of homes the space under such steps and entrances is not properly ventilated; and since outside steps and entrance platforms are always exposed more or less to the elements, moisture leaks through and provides ideal conditions for the nesting of termites and the development of fungi (see fig. 19). This also applies to concrete steps and concrete platforms where they are supported by wood framing. The entrance is generally a decorative feature, but in a large percentage of the homes inspected the construction was very bad. Do not fail to inspect your home for such conditions and if necessary consult some one competent to advise you.

10. In constructing garages, the concrete foundation and wood frame are generally erected prior to the pouring of the concrete floor slabs. We frequently found that the frame to which the garage doors were hung extended into the floor slab in ground contact. Be sure that this condition does not prevail in your garage.

11. The basement concrete slab is often poured after the wood steps leading to the basement and the framing for basement partitions have been erected, and frequently the bottoms of such steps and wood partitions are encased in a concrete slab in ground contact. Inspect your house for such conditions; they should be corrected. This faulty construction has been an important contributing factor to termite infestation in homes.

12. Rear porches are a common source of termite infestation. Usually after such porches have been erected, the concrete slab or sidewalk is poured often encasing the wood in concrete. All framing and wood posts supporting porches should be cut off above the top of the concrete slabs. The bottom of posts that support wooden hand-rails should not be encased in concrete unless the wood has been chemically treated.

13. When a house and garage have been substantially completed it is customary to install the driveway to the garage. It is frequently necessary to adjust the ground surface to provide an even grade between the garage and the street, resulting in the raising of the ground surface adjoining the building. This often results in portions of the wood frame of the home being placed below the top of the concrete driveway, creating a condition which favors both termite infestation and damage by fungi.

14. Do not lay wood floors on concrete that is in ground contact unless the wood has been chemically treated. It is impossible to provide proper ventilation under such a floor, and the wood absorbs a certain amount of moisture from the concrete which, in turn, absorbs moisture from the ground beneath. Such concrete slabs usually crack, and these cracks provide ready access for subterranean termites.

15. There should be a space of at least 18 inches between the bottom of the floor joists and the top of the ground surface in the basement. In many homes this clearance has not been provided, making it exceedingly difficult to make a proper inspection; and should this condition prevail in your home, it may be advisable to employ an expert familiar with the termite problem to make a survey of your home.

16. Fence posts, clothes-line poles, and wood curbs in gardens are almost universally infested by termites. In a number of cases where the building itself was not infested we found termites infesting wood in ground contact in the garden, providing breeding places for these termites. This was without doubt the most common breeding-ground for termites uncovered in the San Francisco Termite Survey. Wood placed in ground contact should be chemically treated with a preservative that is not water-soluble, and which is known to be toxic to termites.

17. Poorly constructed window boxes commonly result in termite infestation and damage to buildings by fungi due to moisture leaking through and coming in contact with the wood frame of the house. A careful inspection of all window boxes should be made to determine their potential possibility for damage.

18. Conservatories in homes also frequently are the cause of excessive dry rot and termite damage. In watering plants, care should be exercised

to avoid creating a condition of permanent dampness in the wood frame of your building.

(FIG. 27). Bathroom floor 10 feet above the ground, seriously damaged by damp-wood termites. Bathrooms frequently provide conditions favorable for the colonizing pair of damp-wood reproductives.

19. Termites have been found penetrating brick walls which have been laid with a lime mortar. As they can easily dig through such mortar, it is advisable to be generous in the use of cement in laying brick.

20. Do not permit water from the shower-bath to strike the wood work or plaster on the walls of your bath room. Plaster is rarely watertight, and permits moisture to reach the wood backing causing the wood to rot, and frequently providing an available source of moisture for the colonizing pair of damp-wood termites.

Do not use an excessive amount of water in washing bath room floors covered with linoleum or tile (see fig. 27). Water thus used often reaches the wood below, causing damage by dry rot and damp-wood termites.

Leaky plumbing and sweating joints in water pipes are also a common source of trouble that leads to dry rot and termite infestation (Fig. 28).

(FIG. 28). *A sweating joint in a water-pipe attached to the ceiling in a basement provided damp-wood termites with the moisture required to establish a colony. The subfloor and joists were badly damaged by these insects.*

21. Store fronts are very commonly infested by termites. Usually there is a joint between the sidewalk and the concrete foundation at the building line. The frequent washing of windows and the hosing of sidewalks permits moisture to penetrate through this joint in the concrete to the soil below, providing ideal conditions for subterranean termites. Termites then find entrance through cracks in the slab inside the building where a wood frame supports the display-space in show-windows. Changes in construction methods and the use of a small quantity of chemically treated wood will usually avoid all such difficulties.

22. Do not purchase firewood that is infested with termites or wood-boring beetles. Both termites and beetles were found swarming from such infested firewood in basements, endangering the entire structure.

23. Chemicals that are dangerous to human beings or to pets that might get under the house should not be used for ground treatments to destroy termites in the soil. If in spite of this warning arsenic is used, the risk to the user as well as to the home owner should be recognized. Merely spraying the soil is inadequate; only a thorough drenching of it will provide any protection. Leaching may follow such drenching of the soil, and plants adjacent to the house are subjected to serious injury. A conspicuous permanent label on soil thus drenched should state: "*POISONED WITH ARSENIC.*" There are other products which do not present a hazard to

human life and which, although possibly more expensive than arsenic, will prove more effective. Soil treatments are not universally effective and too often create a feeling of false security.

Professor Frank T. Green, City Toxicologist, Dr. C. D. Leake, of the University of California Medical School, and Dr. Charles A. Kofoed, Chairman of the Department of Zoology of the University of California, have this to say:

"Since it has been demonstrated that certain fungi in wood and in termite burrows can and do utilize arsenic in their food without being killed thereby, and under these conditions release trimethyl arsine gas, an odorless deadly poison, it is advisable to avoid the use of all arsenical compounds either as sprays, ground treatment or wood preservatives in dwellings."

Dr. J. C. Geiger, Director of Public Health of San Francisco, provides a word of caution against the use of arsenic:

"Tri-Methyl Arsenic Gas.

"In view of the strenuous efforts exerted in the past and at present by various health agencies and agriculturists throughout the world in discouraging the use of arsenic and its compounds in any manner whereby it may affect the public health, it would indeed be a mistake to allow arsenic compounds to be used in the treatment of premises for extermination of termites. This is particularly important as the gas given off under particular circumstances can in no way be detected, and serious symptoms may follow the inhalations of very minute amounts."

24. In dealing with the termite situation, it is well to remember that it is not possible to get something for nothing. High-pressure salesmanship in neighborhoods often creates undue concern in the minds of property owners. It should be remembered always that termites do not create hazardous conditions over night. Hence it is well to investigate before taking hasty action.

25. Your property should be systematically inspected at least once a year, and preferably every six months. When repairs or remodeling are undertaken, every effort should be made to observe practices in construction which will minimize termite infestation. In other sections of this report your attention has been directed to the fact that subterranean termites build tubes or covered runways over masonry or concrete to reach raw wood not in contact with the ground (fig. 13). When making these systematic inspections, therefore, you should search carefully for the presence of such tubes or runways.

The above suggestions should prove of material aid to home owners and prospective purchasers. They by no means cover all the technique of inspection, but will prove helpful.

SUMMARY

Living as we are in a changing world, it becomes necessary from time to time to stop and take stock of these changes, and relate them to existing conditions. This has been the purpose of the San Francisco Termite Survey, limited to the influence of wood-destroying organisms on physical properties brought about by such changes. In this report it has been possible merely to indicate a few of the changes occurring within our memory. The influence of certain of these changes, and their contributing effect on the lowering of the ground waters, has been discussed. Another important change has been the installation of modern plumbing in our homes. We found in this survey that leaky plumbing, sweating joints, and poorly-protected shower baths have also been contributing factors to the infestation of structures by termites (fig. 28). The important element of moisture so necessary for the colonization of damp-wood termites and subterranean termites, is often found in otherwise well-built buildings, due to faulty plumbing.

Much of the damage being done by termites can be prevented by proper building requirements. Mention has been made of the fact that the practice of installing furnaces in homes stimulates termite activity. It has been said that man's greatest battle in the future will be fought with the insect world; but thus far we have entirely failed to take account of the destructive propensities of termites. To acquire esthetic effects, architects and builders, because of their lack of knowledge of this important subject, have created conditions most favorable to their development. The logical sequence now would seem to call for a study of building ordinances, with a view to amending them so that the mistakes of the past will not be repeated in the future. In correcting the many defective construction details in buildings, little if anything will be added to the ultimate cost of structures. In most instances the cost of building termites *out* of a structure should not add more than 1%, or at most 2%, to its cost, and would result in a better and more durable structure.

There are three major factors which appear mainly responsible for the widespread distribution of termites within the city limits and have made termite infestation inevitable. Unlike most great cities, San Francisco is founded on a peninsula, with a limited ground area available for subdivision purposes resulting in small building lots and a large percentage of structures being erected in solid rows. Soil conditions in San Francisco are most favorable for the nesting and propagation of subterranean termites, while the climate appears to provide ideal conditions for the colonizing of wood-dwelling termites.

In the past the building industry has failed to appraise the extent of the problem created by termites. Home ownership is considered one of the great stabilizing influences in American life. Prospective buyers are now questioning the advisability of investing their life savings in a home, having noted the difficulties and experiences of others caused by these insects. Such people often lack technical information, and usually are unaccustomed to employing technical advice to preserve their investments,

as are large corporations. It would seem timely, therefore, to establish rules through a revised building code governing new construction, and thus provide the small home owner with this needed information. *Caveat emptor!* Let the buyer beware, is becoming the watchword in real estate transactions. Here again we find the person of small means, unaccustomed to business transactions, failing to act prior to entering into a contract and then, often in anguish, seeking help. The new problem presented should be frankly faced, in the courageous manner that is typical of San Francisco. For these reasons I would recommend:

1. That the inherent danger created by the recession of the ground water level where buildings are supported on wood piling, be explored to determine its boundaries; and that the effect of the proposed construction of the Market Street Subway upon this important problem be considered also.

2. Emphasis on methods of prevention and control of termite damage is almost universally applied to infestations by subterranean termites, on the commonly-accepted assumption that subterranean termites constitute a predominating economic factor and that damp-wood termites are of minor importance. The survey of all structures in an area comprising some 662 acres disclosed the interesting fact that damp-wood termites are also of great economic importance to property owners in our city. The number of city-wide random inspections, however, was limited, and before it can be safely assumed that the conditions found in the district completely surveyed can be applied to the city as a whole, a more adequate sample survey should be undertaken by the City of San Francisco, or a new program instituted similar to the one upon which this report is based. Methods commonly used for the eradication of subterranean termites are not equally effective when applied to the damp-wood species.

3. A scientific study of our building ordinances in the light of this growing menace should be undertaken with a view to recommending methods which will minimize the present inherent danger and prevent damage to subsequent construction. The need for such a revision can be illustrated by citing an experience in one of our fireproof buildings: A concrete trough was constructed on the ground floor of this building to provide for the installation of conduits and pipes. These electric conduits were not thoroughly embedded in the concrete where they passed through the wall and entered the trough. Termites gained entrance along the conduits and did extensive damage to partitions, filing cabinets, and paper records. Had it been required in the building ordinance that tight metal collars be placed on the conduit within the concrete wall, the termites could not have entered. The cost of such a minor change in method is negligible, but the cost of the repairs to the building due to termite damage and the loss of records, was substantial.

4. The work of classifying the soil in detail throughout the city has not yet been completed and this phase of the work should be prosecuted to a conclusion.

5. The practice of selling insect-infested wood to householders should be controlled.

6. Every effort should be made to reduce the available food supply of termites. The present custom of burying form-lumber in the soil and of back-filling trenches in the streets, leaving the wood-lagging, should be avoided. This practice provides potential reservoirs of food for termites, which tends to increase the density of their population.

7. Further experimentation should be made in the use of lethal electric rays as a means of destroying larvae of beetles and of eradicating termites under certain conditions. There also is need for the development of sound equipment for detecting the presence of termites in concealed places.

ACKNOWLEDGMENTS

The relation of the Federal Government to the San Francisco Termite Survey was advantageously and helpfully represented by Dr. James B. Sharp, the State Coordinator of Statistical Projects of the Works Progress Administration; Ralph J. Wakefield, Supervisor of the Division of Employment; Mrs. Claya Budd, District Supervisor, Women's and Professional Projects, and Mrs. Florence Chemnick, Assistant Supervisor, Women's and Professional Projects. Their knowledge of governmental procedure and their desire to cooperate have very greatly facilitated the progress of the survey.

The cooperation of the City of San Francisco initiated by Alfred J. Cleary, the Chief Administrative Officer, has been continued by W. H. Worden, Director of Public Works, Clyde E. Healy, Chief Assistant City Engineer in charge of relief projects, Erle L. Cope, Superintendent of the Bureau of Building Inspection, and Dr. J. C. Geiger, Director of Public Health. These gentlemen gave liberally of their time and contributed many helpful suggestions which facilitated the conduct of the work. The Building Inspectors under the supervision of Mr. Cope were also of material aid. The members of the Fire Department and in particular, Fire Chief Charles J. Brennan and Captain Theodore Trivett of the Fire Prevention Bureau, made space available to the personnel of the survey in their fire houses, and in other ways materially aided the project.

The work of moisture determinations was undertaken in the City Laboratory under the supervision of Dr. C. L. Cook, City Chemist, and the preliminary studies of the hazard to human health created by the use of certain chemicals, were made in the laboratory of Professor Frank T. Green, City Toxicologist.

Dr. Charles A. Kofoed, Chairman of the Department of Zoology of the University of California, and Dr. C. D. Leake of the University of California Medical School, served as an advisory committee to the work done in the laboratory of the city toxicologist.

Several corporations contributed the time of their employees as well as furnishing equipment without charge. The Reilly Tar & Chemical Corporation of Indianapolis supplied equipment developed in its engineering laboratory, illustrated in figure 22, for experimental work in pressure-treating lumber in a building.

The General Electric X-Ray Corporation made available laboratory space, equipment and personnel for experiments in the use of Roentgen Rays, and short-wave apparatus for experiments using lethal electric rays for eradicating beetles and termites.

The Pacific Gas and Electric Company volunteered the services of J. P. Jollyman, an eminent electrical engineer, to assist in conducting experiments involving lethal electric rays.

The relation of the lumber industry to this important survey was advantageously served by John H. McCallum, president of the McCallum Lumber Company and M. I. Harris, president of the Van Arsdale-Harris Lumber Company.

Special mention should be made of the following members of the survey staff: E. Ross Ellis, Assistant Supervisor, Dr. Walter R. Shaw, Professor George Albers, Harry W. Abrahams, licensed architect, who were largely responsible for the educational program, and M. H. McCarthy, in charge of the photographic work.

APPENDIX

TABLE NO. 1

CLASSIFICATION AND NUMBER OF STORIES IN
BUILDINGS INSPECTED

Number of Stories	Number of Wood Frame Buildings Inspected	Number of Class "C" Buildings Inspected	Number of Class "B" Buildings Inspected	Number of Class "A" Buildings Inspected
1 story	227	182	14	1
1 story and basement.....	74	72	2	2
2 stories	131	116	8	8
2 stories and basement.....	167	115	18	4
3 stories	65	27	6	1
3 stories and basement.....	77	102	12	4
4 stories	4	16	2	2
4 stories and basement.....	14	56	5	3
5 stories	---	3	4	1
5 stories and basement.....	---	28	13	7
6 stories	---	7	2	1
6 stories and basement.....	---	25	14	3
7 stories	---	1	3	1
7 stories and basement.....	---	8	8	3
8 stories	---	---	1	---
8 stories and basement.....	---	2	5	3
9 stories and basement.....	---	---	2	---
10 stories and basement.....	---	1	4	3
11 stories and basement.....	---	---	---	2
12 stories	---	---	---	1
14 stories and basement.....	---	---	---	2
16 stories and basement.....	---	---	---	2
17 stories and basement.....	---	---	---	1
18 stories and basement.....	---	---	---	3
21 stories and basement.....	---	---	---	1
22 stories and basement.....	---	---	---	1
26 stories and basement.....	---	---	---	1
Lumber Yard	1	---	---	---
Rustic Bridge	1	---	---	---
Kezar Stadium	1	---	---	---
Rustic Horse Stalls	2	---	---	---
Rustic Pavilion.....	1	---	---	---
	765	761	123	61

TABLE NO. 2
SUMMARY OF BUILDINGS INSPECTED

In this area, comprizing approximately 662 acres, 100% of the buildings were inspected

KIND OF INFESTATION	Total Number Inspections	Class A ¹ Build- ings	Class B ² Build- ings	Class C ³ Build- ings	Wood Frame Build- ings
Number of inspections made..	1385	44	103	678	560
Number of damp-wood termite infestations		2	3	59	130
Number of damp-wood and beetle infestations		1	....	5	4
Number of subterranean termite infestations		2	13	115	163
Number of subterranean and beetle infestations		1	1	4	2
Number of subterranean and damp-wood termite infestations		2	4	16	122
Number of subterranean and damp-wood and beetle infestations .....		....	....	2	11
Number of damp-wood, dry-wood and beetle infestations .....		....	....	....	....
Number of infestations by beetles only		4	14	10	5
Number of buildings damaged by fungi only		1	8	111	52
Number of buildings where no kind of wood-destroying organisms were found		31	60	356	71
Per cent of buildings infested by wood-destroying insects..		27%	34%	31%	78%
Per cent of buildings infested by wood-destroying organisms		30%	42%	48%	87%
Per cent of infestations where damp-wood termites were present		42%	20%	39%	61%
Per cent of infestations where subterranean termites were present		42%	51%	65%	68%
Per cent of infestations where beetles were present.....		50%	43%	10%	5%

1, 2, 3—For definition of building types, see page 44.

TABLE NO. 3

SUMMARY OF CITY-WIDE RANDOM INSPECTIONS

KIND OF INFESTATION	Total Number of Inspections	Class A Build- ings	Class B Build- ings	Class C Build- ings	Wood Frame Build- ings	Grand Total of Build- ings Inspected
Number of inspections made	325	17	20	83	205	1710
Number of damp-wood ter- mite infestations		1	4	4	44	.....
Number of damp-wood and beetle infestations .....		....	....	....	5	.....
Number of subterranean ter- mite infestations		8	7	22	77	.....
Number of subterranean and beetle infestations .....		....	....	3	8	.....
Number of subterranean and damp-wood termite in- festations .....		....	....	3	32	.....
Number of subterranean, damp-wood and beetle infestations		1	....	1	9	.....
Number of damp-wood, dry- wood and beetle infesta- tions .....		....	....	....	2	.....
Number of infestations by beetles only .....		....	....	6	5	.....
Number of buildings dam- aged by fungi only .....		....	1	13	14	.....
Number of buildings where no kind of wood-destroy- ing organisms were found		7	8	31	9	.....
Per cent of buildings infested by wood-destroying insects		59%	55%	47%	89%	.....
Per cent of buildings in- fested by wood-destroy- ing organisms		59%	60%	63%	96%	.....
Per cent of infestations where damp-wood termites were present		20%	36%	20%	50%	.....
Per cent of infestations where subterranean termites were present		90%	64%	74%	69%	.....
Per cent of infestations where beetles were present		10%	....	26%	16%	.....

*RECAPITULATION OF TOTAL INSPECTIONS AND
INFESTATIONS SHOWING THE PERCENTAGE
OF INFESTATION IN EACH CLASS OF
BUILDING, TAKEN FROM TABLES
NO. 2 AND NO. 3*

Of 61 Class A Buildings, 22 or 36% were infested by wood-destroying insects.

Of 123 Class B Buildings, 46 or 37% were infested by wood-destroying insects.

Of 761 Class C Buildings, 250 or 33% were infested by wood-destroying insects.

Of 765 Wood Frame Buildings, 618 or 81% were infested by wood-destroying insects.

¹ Class "A" Buildings are defined by the San Francisco Building Laws as those having fireproof frames of steel and with all structural parts of incombustible materials. Walls shall be of brick, stone, concrete or reinforced concrete.

² Class "B" Buildings are defined by the San Francisco Building Laws, as those having a frame of reinforced concrete carrying all wall and floor loads. All structural parts shall be of incombustible material. Walls shall be of brick, stone or reinforced concrete.

³ Class "C" Buildings are defined by the San Francisco Building Laws, as those having exterior walls of brick, stone or concrete, and an interior frame of combustible material. The walls may be bearing or curtain walls, and the interior supports may be timber joists, timber or steel girders and timber, steel or cast iron columns, or timber studding.

TABLE NO. 4

LOCATION OF INFESTATIONS IN THE BUILDINGS
INSPECTED.

	Wood Frame	Class C	Class B	Class A
Buildings in ground contact *.....	416	615	103	61
Buildings where wood is placed within 1" to 3" of the ground	38	3	1	....
Buildings with termite-infested wood sills	274	32	....	1
Buildings with termite-infested wood posts	168	45	2	1
Buildings with termite-infested wood joists	192	45	2	1
Buildings with termite-infested wood studs	249	45	2	....
Buildings with termite-infested exte- rior walls	244	43	10	4
Buildings with termite-infested interior walls	80	32	7	3
Buildings with termite-infested stairs and porches	235	38	1	4
Buildings with stairs infested by fungi only	89	....	....	....
Buildings with termite-infested flooring..	196	69	6	3
Buildings with infested upper floors:				
Second floor	35	18	3	....
Third floor	14	7	2	....
Fourth floor	3	2	3	....
Fifth floor .....	....	4	1	1
Sixth floor .....	....	....	....	1
Seventh floor .....	....	....	1	....
Roof of a 10-story building .....	....	....	1	....
Termite-infested fences, posts, wood driveways, etc.	325	38	6	1

*Some of the wood in the frame buildings listed was in ground contact. Class A, B and C buildings having first-floor slabs in ground contact are included in this classification.

ADDITIONAL DATA COMPILED FROM INSPECTION REPORTS

Twenty-four buildings had been repaired during the year 1934 due to termite damage, and of this number 22 were found infested at the time the inspection was made.

Forty-four buildings had been repaired during the year 1935 due to termite damage, and of this number 34 were found infested at the time the inspection was made.

In 30 instances defective plumbing contributed directly to termite infestation.

In 37 cases termite infestation was traceable to concrete form-lumber left in place.

In 17 instances leaky roofs contributed to infestation by termites.

In many of the older Class C buildings, wooden elevator guides were used, and in 30 of such instances elevator guides and/or shafts were found infested by termites.

Permanent dampness caused primarily by poor drainage was found in the basements of 313 buildings.

In the basements of 442 buildings, debris, such as lumber, boxes, paper, etc. (all of which contribute to termite infestation) was found.

Termites were found entering concrete or masonry walls in Class A, B and C buildings through defective concrete, cracks in concrete or brick walls, cracks in concrete floor slabs, wood-block spreaders, loose steel tie-wires in concrete walls, and along water lines, sewer pipes and electric conduits.

In the basement of one Class C four-story building, subterranean termites gained entrance through wood spreaders left in the concrete walls, at 20 different locations and built covered runways to the wood joists above.

In a number of instances trees and old stumps in the yard were infested by termites, affording these insects with conditions favorable to the development of colonies adjacent to buildings.

Leaky sidewalk lights provided necessary dampness in basements for the colonizing of termites in paper cartons and newspapers piled five feet six inches above the floor.

See 2-1