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ABSTRACT

The manual presents material designed to acquaint housing inspectors and their supervisors with the crigin of public concern about housing problems; the past, present, and new approaches to housing code administration; the expanded role of the inspection function in the neighborhood improvement effort; and the general nature of their role and responsibilities. The first chapter, Trends in Housing, deals with all aspects except for role and responsibilities. That aspect is developed through the succeeding six chapters as individual elements of housing inspection are considered in detail: the housing code, health and sanitary elements, building aspects, plumbing elements, heating and environmental control, and electrical aspects. The manual contains numerous illustrations depicting materials, equipment, and assembly. Terms and procedures are defined and explained. (AG)

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# TRAINING MANUAL FOR INSPECTION FOR DECENT, SAFE, AND SANITARY HOUSING



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U.S. DEPARTMENT OF TRANSPORTATION
Federal Highway Administration
Office of Right-of-Way and Environment
Relocation Assistance Division

April 1975

## Chapter 1
## TRENDS IN HOUSING

Members of countless communities throughout America are raising critical questions about the adequacy and effectiveness of local housing code enforcement programs. These critics feel deep concern over the fact that 1966 found "some four million urban families living in homes of such disrepair as to violate decent housing standards."(1) For this reason, they insist everything possible be done to guarantee that present and future inspection efforts lead to rapid and adequate upgrading of the substandard but salvageable housing in each community and that the neighborhoods be made more desirable places in which to live.

In order to meet these demands effectively, inspectors of housing and their supervisors should first acquaint themselves with the origin of public concern about housing problems; the past, present, and new approaches to housing code administration; the expanded role of the inspection function in the neighborhood improvement effort; and the general nature of their role and responsibilities.

### I THE HISTORY OF HOUSING

The first public policies on housing in this country were established during the Colonial period. Many of the early settlers built houses with wooden chimneys and thatched roofs which were the causes of frequent fires. Consequently, several of the colonies passed regulations prohibiting these. One of the first was the Plymouth Colony, which in 1626 passed a law stipulating that new houses should not be thatched but roofed with either board or pale and the like. In 1648 wooden or plastered chimneys were prohibited on new houses in New Amsterdam, and chimneys on existing houses were decreed to be inspected regularly. In Charlestown in 1740, following a disastrous fire, the general assembly passed an act that declared that all buildings should be of brick or stone, that all 'tall' wooden houses must be pulled down by 1745, and that the use of wood was to be confined to window frames, shutters, and to exterior work. This law was obviously unenforceable because, as we learn from other publications during that period, more Charlestown houses were made of timber than of brick.

Social control over housing was exerted in other ways. Early settlers in Pennsylvania frequently dug caves out of the banks of the Delaware River and used these as primitive-type dwellings. Some of these shelters were still in use as late as 1687 when the Provincial Council ordered inhabitants to provide for themselves other habitations. in order to have the said caves or houses destroyed. In some New England communities. around the turn of the 18th century. standards were raised considerably higher by local ordinances. In East Greenwich, it had been the custom to build houses 14 feet square with posts 9 feet high; in 1727 the town voted that houses shall be built eighteen feet square with posts fifteen feet high with chimneys of stone or brick as before.

During the early days of this country, basic sanitation was very poor, primarily because outdoor privies served as the general means of sewage disposal. The principal problems created by the use of these privies involved their nearness to the streets and their easy accessibility to hogs and goats. In 1652, Boston prohibited the building of privies within 12 feet of the street. The Dutch of New Amsterdam in 1657 prohibited the throwing of rubbish and filth into the streets or canal and required the householders to keep the streets clean and orderly.

After the early Colonial period we pass into an era of very rapid metropolitan growth along the eastern seashore. This growth was due largely to the immigration of people from Europe. Frequently these immigrants arrived without money or jobs and were forced to move in with friends or relatives. This led to severe overcrowding. Most of the information available pertains to New York City, because the situation there was worse than that in any other city in the country. It received the majority of the immigrants, many of whom were unable to move beyond the city. The most serious housing problems began in New York about 1840 when the first tenements were built. These provided such substandard housing and such unhealthy, crowded living conditions that a social reform movement was imminent in New York.

During the early part of the 19th century, the only housing control authority was that vested in the fire wardens, whose objective was to prevent fires, and the health wardens, who were charged with the enforcement of general sanitation. In 1867, with the passing of the Tenement House Act, New York City began to face the problem of substandard housing. This law represented the first comprehensive legislation of its kind in this country. The principal features of the act are summarized as follows: for every room occupied for sleeping in a tenement or lodging house, if it does not communicate directly with the external air, a ventilating or transom window to the neighboring room or hall; a proper fire escape on every tenement or lodging house; the roof to be kept in repair and the stairs to have bannisters; water closets or privies—at least one to every twenty occupants for all such houses; after July 1, 1867, permits for occupancy of every cellar not previously occupied as a dwelling; cleansing of every lodging house to the satisfaction of the Board of Health, which is to have access at any time; reporting of all cases of infectious disease to the Board by the owner or his agent; inspection and, if necessary, disinfection of such houses; and vacation of buildings found to be out of repair. There were also regulations governing distances between buildings, heights of rooms, and dimensions of windows. The terms "tenement house," "lodging house," and "cellar" were defined.

Although this act had some beneficial influences on overcrowding, sewage disposal, lighting and ventilation, it did not correct the evils of crowding on lots and did not provide for adequate ventilation for inner rooms. In 1879, a second tenement act, amending the first, was passed adding restrictions on the amount of lot coverage and providing for a window opening of at least 12 square feet in every room. Several attempts in 1882, 1884, and 1895 were made to amend this original act and provide for occupancy standards, etc., but they were relatively unenforceable. While these numerous acts remedied only slightly the serious problems of the tenements, they did show the city's acknowledgment of the problems.(1) This public acknowledgment, however, was seldom shared by the owners of the tenements, or, in some cases, by the courts. The most famous case, in 1892, involved Trinity Church, at that time one of the largest owners of tenements in New York City. In the case, the City of New York accused Trinity Church of violating provisions of the Act of 1882 by failing to provide running water on every floor of its buildings. A district court levied a fine of $200 against the Church, which in turn appealed to the Court of Common Pleas to have the law set aside as unconstitutional. Incredibly, the court agreed unanimously to uphold the landlord's position, stating there is no evidence nor can the court judicially know that the presence and distribution of water on the several floors will conduce to the health of the occupants... there is no necessity for legislative compulsion on a landlord to distribute water through the stories of his building; since if tenants require it, self-interest and the rivalry of competition are sufficient to secure it... now, if it be competent for the legislature to impose an expense upon a landlord in order that tenants be furnished with water in their rooms instead of in the yard or basement, at what point must this police power pause?...a conclusion contrary to the present decision would involve the essential principle of that species of socialism under the regime of which the individual disappears and is absorbed by a collective being called the 'state' a principle utterly repugnant to the spirit of our political system and necessarily fatal to our form of liberty. Fortunately, 3 years later, the city health department was granted an appeal from the court order, and eventually the constitutionality of the law was upheld.

Jacob A. Riis, Lawrence Veiller, and others did much during this period to champion the cause of better living conditions. Their efforts resulted in the Tenement House Act of 1901, a milestone in housing and an extremely comprehensive document for its time. It began with concise definitions of certain terms that were to become important in court actions. It contained provisions for protection from fire, requiring that every tenement erected thereafter, and exceeding 60 feet in height, should be fireproof. In addition, there were specific provisions regarding fire escapes on both new and existing houses. More light and ventilation were required; coverage was restricted to not more than 70 percent on interior lots and 90 percent on corner lots. There were special provisions governing rear yards, inner courts, and buildings on the same lot with the tenement house. At least one window of specified dimensions was required for every room, including the bathroom. Minimum size of rooms was specified as were certain characteristics for public halls. Significantly included were provisions concerning planning for the individual apartments in order to assure privacy. One of the most important provisions of the Tenement Act was the requirement for running water and water closets in each apartment in new tenement houses. Special attention was given to basements and cellars, the law requiring not only that they be dampproof but also that permits be obtained before they were occupied. One novel section of this act prohibited the use of any part of the building as a house of prostitution.

The basic principles and methodology established in the Tenement Act of 1901 still underlie much of the housing efforts in New York City today. Philadelphia, a city that can be compared with New York from the standpoint of age, was fortunate to have farsighted leaders in its early stage of development. Since 1909, with the establishment of the Philadelphia Housing Association, the city has had almost continual inspection and improvement.

Although Chicago is approximately two centuries younger than New York, it enacted housing legislation as early as 1889 and health legislation as early as 1881. Regulations on ventilation, light, drainage, plumbing of dwellings, etc., were put into effect in 1896. Many of the structures, however, were built of wood, were dilapidated and constituted serious fire hazards.

Before 1892, all government involvement in housing was at a local level. In 1892, however, the Federal Government passed a resolution authorizing investigation of slum conditions in cities containing 200,000 or more inhabitants. At that time these included the cities of Baltimore, Boston, Brooklyn, Buffalo, Chicago, Cincinnati, Cleveland, Detroit, Milwaukee, New Orleans, New York, Philadelphia, Pittsburgh, St. Louis, San Francisco, and Washington. Much controversy surrounded the involvement of the Federal Government in housing. The Commissioner of Labor was forced to write an extensive legal opinion concerning the constitutionality of expenditures by the Federal Government in this area. The result was that Congress appropriated only $20,000 to cover the expenses of this project. The lack of funds limited actual investigations to Baltimore, Chicago, New York, and Philadelphia and did not cover housing conditions in toto within these cities. Facts obtained from the investigation were very broad, covering items such as the number of saloons per number of inhabitants, number of arrests, distribution of males and females, proportion of foreign-born inhabitants, degree of illiteracy, kinds of occupations of the residents, conditions of their health, their earnings, and the number of voters.

The twentieth century started off rather poorly in the area of housing. No significant housing legislation was passed until 1929 when the New York State legislature passed its Multiple Dwelling Law. This law continued the Tenement Act of New York City but replaced many provisions of the 1901 law with less strict requirements. Other cities and states followed New York State's example and permitted less strict requirements in their codes. This decreased what little emphasis there was in enforcement of building laws so that during the 1920's the cities had worked themselves into a very poor state of housing. Conditions in America declined to such a state by the 30's that President Franklin D. Roosevelt's shocking report to the people was "that one-third of the nation is ill-fed, ill-housed, and ill-clothed." With this the Federal Government launched itself extensively into the field of housing. The first Federal housing law was passed in 1934. One of the purposes of this act was to create a sounder mortgage system through the provision of a permanent system of government insurance for residential mortgages. The Federal Housing Administration was created to carry out the objectives of this act.

Many other Federal laws followed, the Veterans Administration becoming involved in guaranteeing of loans, the Home Loan Bank Board, Federal National Mortgage Association, Communities Facilities Administration, Public Housing Administration, Public Works Administration, etc. With the U.S. Housing Act of 1937, the Federal Government entered the area of slum clearance and urban renewal, requiring one slum dwelling to be eliminated for every new unit built under the Housing Administration program. It was not until the passage of the Housing Act of 1949 that the Federal Government entered into slum clearance on a comprehensive basis.

The many responsibilities in housing administered by various agencies within the Federal Government proved to be unwieldy. Hence, in 1966 the Department of Housing and Urban Development was created to have prime responsibilities for the Federal Government's involvement in the field of housing.

## II TRENDS IN HOUSING INSPECTION

Historically, local provisions for the inspection of housing have been completely inadequate. Usually the function has been split among two or more agencies, and the pertinent code sections have been spread among several local ordinances.

Following the work of C. E. A. Winslow, minimum code standards were made available and resulted in the passing of housing codes. This consolidation of housing requirements resulted in the field of housing inspection. Originally much of the work was devoted to complaint and referral inspections.

## A Complaint and Referral Inspections

In most communities the housing inspectors are expected to center their efforts primarily on complaint and referral inspections. This approach satisfies the persons making the complaints and referrals and helps improve some of the municipality's substandard housing. However, it does little to bring about general improvements in any section of the community and actually constitutes an inefficient way of using the available inspection manpower because the men have to spend so much time traveling from one area to another.

Many supervisors and inspectors realize this unsystematic method not only wastes time but also is an ineffective way of upgrading housing and curbing blight. First, on complaint inspections the inspectors are usually instructed to confine their investigations to the dwelling unit specifically involved unless the general conditions are so bad that an inspection of the entire building is deemed necessary. This means most complaint inspections are piecemeal and do not ordinarily bring entire dwellings up to code standards. Second, even though numerous complaints are unwarranted, inspectors are often given so many to check each day that they do not have time to inspect other obviously substandard houses in the vicinity of those complained about. Consequently, these "rotten apples" are left to spoil the block, while the house that has been improved stands alone.

Too often inspection agencies have found they did not have enough facts on hand about the extent and distribution of the substandard housing in their communities. Thus, they were unable to convince their superiors and the public about the inadequacy of complaint inspections as the major method of uncovering violations and checking residential blight in neighborhoods. It is the consensus of housing officials that area inspections are the most effective way of doing both.(2) Fortunately, in the 1960's, as one city after another began developing the comprehensive community renewal plans provided for in the Housing Act of 1959, this information finally started to become available. It verified the need for systematic inspections on a neighborhood basis. Congress further emphasized the importance of this new approach by including Section 301 in the Housing Act of 1964. This required all cities engaged in urban renewal to have comprehensive area inspection programs in operation by March 1967, and thereafter, in order to remain eligible for national renewal funds.

## B Neighborhood Inspection Technique

The area of neighborhood inspection technique is a more recent type of inspection and one which begins to face up to the problems of saving neighborhoods from urban blight. While this is a step forward, it is merely one of several steps required if urban blight and its associated human suffering are to be minimized or controlled.

Throughout this manual the terms "area" or "neighborhood" are used interchangeably and refer to a readily indentifiable portion of a community. Whether this consists of so many blocks, an entire neighborhood, or a section thereof. it should be of such size as to permit the local code enforcement team to inspect and systematically effect minimum housing standards within a manageable time.

This means that area inspection programs involve systematic cellar-to-roof, house-to-house, block-to-block inspections of all properties within the specific area and include all the follow-up work required to bring the substandard housing up to code standards within a reasonable period. By the putting of major emphasis on this type effort instead of on the complaint-oriented approach, blight is checked and an overall upgrading of residential sections is achieved in one portion of a community after another. Thus, systematic area inspection is both a longer lasting and a much more effective method of improving housing and stabilizing property values than the traditional complaint method.

Usually a municipality combines its area work with some complaint and referral inspections. This is not objectionable so long as major emphasis is given to the area programs, and the inspectors move through the various sections of town systematically. Only in this way can a community's housing inspection program contribute adequately to the municipal efforts to upgrade all substandard housing and stem the deterioration of individual homes and neighborhoods. A percentage of the inspection force should, however, be primarily assigned to complaint and referral work so that prompt action can be taken on all cases in which the problems are too severe to await action in connection with the area inspections.

While the area-wide or neighborhood inspections will correct violations of the housing code, this is all they will accomplish. Once these neighborhoods are brought up to standard, inspectors will move on to other neighborhoods but be forced to return at a later time and repeat the process.

If a neighborhood has declined to the extent that there is a large amount of housing violations, then it is obvious that something or someone or both have caused the neighborhood to deteriorate. Any effort that does not also eliminate the cause for deterioration can only be a token effort and frequently a wasted effort. Unless a housing program evaluates the total neighborhood for both housing violations and for environmental stresses within the neighborhood that may have caused the deterioration of the housing, then the inspectional effort has not been complete.

What then are these "environmental stresses"? Environmental stresses are the elements within a neighborhood that influence the physical, mental, and emotional well-being of the occupants. They include items such as noise, glare, excessive land covering, nonresidential land uses, extensive traffic problems, etc. If a housing program is to be complete, these stresses must be identified and assessed. Then efforts must be made in conjunction with other departments within the city to program capital improvement budgets to alleviate or minimize these stresses.

These two types of inspection are the field involvement of the housing inspector. He must inspect not only the houses for violations but also the neighborhoods for environmental stresses. This will provide him with knowledge of physical conditions within the neighborhood. As mentioned previously, however, this is not the whole problem in most neighborhoods. Generally, the very difficult problem of the human element is involved. Many buildings and neighborhoods deteriorate because of apathy upon the part of the neighborhood inhabitants. Efforts must be made to motivate the slum dweller to work towards a better living environment. Experience by the PHS in motivational training has shown it to be very effective in raising the living standards of neighborhood populations.

In summary then, a housing inspection effort should be made up of three parts: First, a neighborhood or area-wide housing inspection procedure; second, a neighborhood analysis procedure to identify, assess, and eventually control environmental stresses; and third, a program of motivational training for slum dwellers to raise the living standards of the neighborhood.

## III ROLE OF HEALTH AGENCIES IN HOUSING

Up until the end of WW II, most local housing hygiene programs were carried on by the health departments. After WW II, health agencies began to drift away from the field of housing hygiene. This gap was filled by a variety of other city agencies including building departments, police departments, fire departments, and more recently created departments of licenses and inspections. Regardless which department administers the housing code, the health department, if it is to live up to its responsibilities of protecting the public health, must have an involvement in housing. A general statement of PHS policy is that the basic responsibility of health agencies with regard to housing is to see to it that local and State governments take action to ensure that all occupied housing meets minimum public health standards. This basic responsibility falls upon Federal, State, and local health agencies alike.

Several kinds of governmental action are required. These include: (1) adoption of minimum health standards in housing, (2) conduct of a program to achieve and maintain these standards, (3) periodic evaluation of the standards to ensure their current adequacy, and (4) monitoring of the standards enforcement effort to guarantee that public health values are provided. Health agencies, in order to meet their responsibilities, must accept the role of either stimulating or carrying out these four required kinds of governemental action.

In communities that have neither standards nor program, the health agency has the responsibility of initiating both by stimulating the required governmental action. Stimulation may be direct, through elected or appointed officials, or indirect, by generating public support that will trigger official action.

## IV SUMMARY

Several basic thoughts are contained in this chapter.

A Housing is an old, well-established, but often overlooked topic within this country. Indications are, however, that the broad field of housing will receive much more attention from the policymakers throughout the country within the coming years.

B No single agency can eliminate urban blight. A concentrated effort of all city departments, private concerns, and political bodies must be focused on small sections (neighborhoods) to minimize or control urban blight and its associated human sufferings.

C A housing effort cannot be successful if it is merely an inspection of houses for code compliance. There must also be a united effort to eliminate environmental stresses within the neighborhood and instill motivation in slum dwellers to desire and work towards improving their environment.

## REFERENCES

1 President Lyndon B. Johnson's "Demonstration Cities" message to Congress, January 26, 1966.

2 "Enforcement of Housing Codes." Harvard Law Review, Vol. 78, No. 4. Feb. 1965, p. 807.

## Chapter 2

## THE HOUSING CODE

Any housing code, regardless of who promulgates it, is basically an environmental health protection code. The hygiene of housing, correspondingly, is the area of environmental health that deals with man's most intimate living environment - his home and his neighborhood. Into the fabric of housing hygiene is woven a wide variety of health, safety, economic, social, and political factors.

Early housing codes primarily considered protecting only man's physical health; hence, they were enforced only in slum areas. More recently the realization has been made that if urban blight and its associated human suffering are to be controlled, the housing codes must consider both physical and mental health and must be administered uniformly throughout the community.

In preparing or revising the housing code, local officials must maintain a level of standards that will not merely be "minimal." These standards should maintain a living environment that contributes positively to healthful individual and family living. The fact that a small portion of housing fails to meet a desirable standard is hardly a legitimate reason for retrogressive modification or abolition of a standard. A housing code is merely a means to an end. The end is the eventual elimination of all substandard conditions within the home and neighborhood. This end cannot be reached if the community adopts an inadequate housing code. The adoption of a housing ordinance that establishes low standards for existing housing serves only to legalize and perpetuate an unhealthy living environment. Wherever local conditions are such that immediate enforcement of some standards within the code would cause undue hardship upon some individuals, it is better to provide a time interval for compliance than to eliminate an otherwise satisfactory standard.

### I DEFINITIONS

The following definitions of terms have been excerpted from "APHA - PHS Recommended Housing Maintenance and Occupancy Ordinance" and will be used throughout this Manual. (1)

1 Accessory Structure shall mean a detached structure located on or partially on any premise and not used or not intended to be used for living or sleeping by human occupants.

2 Approved shall mean approved by the local or State authority having such administrative authority.

3 Appropriate Authority shall mean that person within the governmental structure of the corporate unit charged with the administration of the appropriate code.

4 Ashes shall mean the residue from the burning of combustible materials.

5 Chimney shall mean a vertical masonry shaft of reinforced concrete or other approved non-combustible, heat-resisting material enclosing one or more flues, for the purpose of removing products of combustion from solid, liquid, or gas fuel.

6 Central Heating System shall mean a single system supplying heat to one or more dwelling unit(s) or more than one rooming unit.

7 Dormitory shall mean a room in any dwelling used for sleeping purposes by four or more unrelated persons.

8 Dwelling shall mean any enclosed space that is wholly or partly used or intended to be used for living or sleeping by human occupants, provided that temporary housing as hereinafter defined shall not be regarded as a dwelling.

9 Dwelling Unit shall mean any room or group of rooms located within a dwelling and forming a single habitable unit with facilities that are used or intended to be used for living, sleeping, cooking, and eating.

10 Extermination shall mean the control and elimination of insects, rodents, or other pests by eliminating their harborage places; by removing or making inaccessible materials that may serve as their food; by poisoning, spraying,

fumigating, trapping, or by any other recognized and legal pest elimination methods approved by the local or state authority having such administrative authority.

11 Family shall mean one adult person plus one or more persons legally related to said person and residing in the same dwelling unit with said person.

12 Flush Water Closet shall mean a toilet bowl flushed with water under pressure with a water sealed trap above the floor level. Such toilet bowls shall have a smooth, easily cleanable surface.

13 Garbage shall mean the animal and vegetable waste resulting from the handling, preparation, cooking, serving, and nonconsumption of food.

14 Guest shall mean any person who shares a dwelling unit in a nonpermanent status for not more than 30 days.

15 Habitable Room shall mean a room or enclosed floor space used or intended to be used for living, sleeping, cooking, or eating purposes, excluding bathrooms, water closet compartments, laundries, furnace rooms, pantries, kitchenettes and utility rooms of less than 50 square feet, foyers or communicating corridors, stairways, closets, storage spaces, and workshops, hobby, and recreation areas in unsealed or uninsulated parts of structure below ground level or in attics.

16 Health Officer shall mean the legally designated health authority of the (name of corporate unit) or his authorized representative. (If the legally designated health authority has a title other than "Health Officer" the title of this authority should be substituted for "Health Officer" in this section and all other sections of this ordinance.)

17 Heated Water shall mean water heated to a temperature of not less than 120°F.

18 Household shall mean a family and/or one or more unrelated persons, including servants and not more than two boarders, who share the same dwelling and use some or all of its cooking and eating facilities.

19 Infestation shall mean the presence within or around a dwelling of any insects, rodents, or other pests.

20 Kitchen shall mean any room containing any or all of the following equipment, or area of a room within 3 feet of such equipment: sink and/or other device for dishwashing, stove or other device for cooking, refrigerator or other device for cool storage of food, cabinets and/or shelves for storage of equipment and utensils, and counter or table for food preparation.

21 Meaning of Certain Words. Whenever the words "dwelling," "dwelling unit," "rooming house," "rooming units," "premises," or "structure" are used in the ordinance, they shall be construed as though they were followed by the words "or any part thereof." Words used in singular include the plural, and the plural the singular; the masculine gender includes the feminine, and the feminine the masculine.

22 Multiple Dwelling shall mean any dwelling containing more than two dwelling units or rooming units or both.

23 Occupant shall mean any person, over 1 year of age, living, sleeping, cooking, eating in, or actually having possession of a dwelling unit or a rooming unit; except that in dwelling units a guest will not be considered an occupant.

24 Operator shall mean any person who has charge, care, control, or management of a building, or part thereof, in which dwelling units or rooming units are let.

25 Ordinary Summer Conditions shall mean a temperature 10° F below the highest recorded temperature in the locality for the prior 10-year period.

26 Ordinary Winter Conditions shall mean a temperature 15°F above the lowest recorded temperature in the locality for the prior 10-year period.

27 Owner shall mean any person who, alone or jointly or severally with others:

a shall have legal title to any dwelling or dwelling unit, with or without accompanying actual possession thereof, or b shall have charge, care, or control of any dwelling or dwelling unit as owner or agent of the owner, or as an executor, administrator, trustee, or guardian of the estate of the owner. Any such person thus representing the actual owner shall be bound to comply with the provisions of this ordinance and of rules and regulations adopted pursuant thereto, to the same extent as if he were the owner.

28 Permissible Occupancy shall mean the maximum number of persons permitted to reside in a dwelling unit or rooming unit.

29 Person shall mean and include any individual, firm, corporation, association, or partnership.

30 Plumbing shall mean and include all of the following supplied facilities and equipment: gas pipes, gas-burning equipment, water pipes, garbage disposal units, waste pipes, water closets, sinks, installed dishwashers, lavatories, bathtubs, shower baths, installed clothes-washing machines, catch basins, drains, vents, and any other similar supplied fixtures, together with all connections to water.

31 Privacy shall mean the ability of a person or persons to carry out a commenced activity without interruption or interference, either by sight or sound, by unwanted persons.

32 Premises shall mean a platted lot or part thereof or unplatted lot or parcel of land or plot of land, either occupied or unoccupied by any dwelling or non-dwelling structure, and includes any such building, accessory structure, or other structure thereon.

33 Refuse shall mean all putrescible and nonputrescible solids (except human body wastes) including garbage, rubbish, ashes, and dead animals.

34 Rooming Unit shall mean any room or group of rooms forming a single habitable unit used or intended to be used for living and sleeping but not for cooking purposes.

35 Rooming House shall mean any dwelling or that part of any dwelling containing one or more rooming units, one or more dormitory rooms, or both.

36 Rubbish shall mean nonputrescible solid wastes (excluding ashes) consisting of either.

a combustible wastes such as paper, cardboard, plastic containers, yard clippings, and wood; or

37 Safety shall mean the condition of being free from danger and hazards that may cause accidents or disease.

38 Space Heater shall mean a self-contained heating appliance of either the circulating type or the radiant type and intended primarily to heat only one room.

39 Supplied shall mean paid for, furnished by, provided by, or under the control of the owner or operator.

40 Temporary Housing shall mean any tent, trailer, mobile home, or any other structure used for human shelter that is designed to be transportable and that is not attached to the ground, to another structure, or to any utility system on the same premises for more than 30 consecutive days.

## II BACKGROUND OF HOUSING CODES IN THE UNITED STATES

To assist municipalities with the development of legislation necessary to regulate the quality of housing, the Committee on the Hygiene of Housing, American Public Health Association, prepared and in 1952, published a proposed housing ordinance. This provided a prototype on which such legislation might be based and has served as the basis for countless housing codes enacted in the United States since that time. Some municipalities enacted it without change. Others made revision by omitting some portions, modifying others, and sometimes adding new provisions.

In the ensuing 15 years, the control of housing through administrative law developed to the point where the proposed ordinance needed revision. In 1967, the American Public Health Association and the Public Health Service's National Center for Urban and Industrial Health jointly undertook the job of rewriting and updating this model ordinance. The new document, entitled "APHA-PHS Recommended Housing Maintenance and Occupancy Ordinance," is the most recent model ordinance available. This new ordinance is one of several model ordinances available to communities to consider when they are interested in adopting a housing code.

One must keep in mind when considering the adoption of any model code that the code is, as stated, merely a model. The community should read and consider each element within the model code to determine its applicability to that community. As previously stated, however, a housing code is merely a means to an end. The end is the eventual elimination of all substandard conditions within the home and the neighborhood. This end cannot be reached if the community adopts an inadequate housing code.

## III OBJECTIVES OF A HOUSING CODE

The Housing Act of 1949 gave new impetus to existing local, state, and Federal housing programs directed towards the elimination of poor housing and the production of sound and decent housing. In passing this legislation, Congress defined a new national objective by declaring that the general welfare and security of the nation and the health and living standards of its people...require a decent home and a suitable living environment for every American family. This mandate generated an awareness that the quality of housing and residential environment has an enormous influence upon the physical and mental health and the social well-being of each individual and, in turn, upon the economic, political, and social conditions in every community. Consequently, public agencies, units of government, professional organizations, and others sought ways to ensure that the quality of housing and the residential environment did not depreciate or deteriorate.

It soon became apparent that a new type of legislation was needed, namely, ordinances that regulate the supplied facilities and the maintenance and occupancy of dwellings and dwelling units, or as they are more commonly called, "housing codes." The objective of a housing code is to establish minimum standards essential to make dwellings safe, sanitary, and fit for human habitation by governing the condition and maintenance, the supplied utilities and facilities, and the occupancy.

## IV LIMITATIONS

A housing code is limited in its effectiveness by several factors. First, if the housing code does not contain standards that adequately protect the health and well-being of the individuals, it cannot be effective. The best trained soldier, if armed only with a pea shooter, can accomplish little positive action in a battle. Similarly, the best trained housing inspector, if not armed with an adequate housing code, can accomplish little good in the battle against urban blight.

A second factor affecting the quality of the housing administration effort is the budget of the housing group. If the housing effort is directed, because of limitations of funds and personnel, to the fire-fighting efforts of complaint answering, then the community can expect to lose the battle against urban blight. It is only through a systematic enforcement effort by an adequately sized staff of properly trained inspectors that the battle can be won.

A third factor that can affect the housing effort is the attitude of the political bodies within the area. A properly administered housing program will require the upgrading of substandard housing throughout the community. Frequently, this results in political pressures' being exerted to prevent the enforcement of the code in certain areas of the city. If the housing effort is backed properly by all political elements, blight can be controlled and eventually eliminated within the community. If, however, the housing program is not permitted to choke out the spreading influence of substandard conditions, urban blight will spread like a cancer, engulfing greater and greater portions of the city. Similarly, an effort directed only at the most serious blocks in the city will merely upgrade those blocks while the blight spreads elsewhere. If a cancer is to be controlled, it must be cut out in its entirety. If urban blight is to be controlled, it also must be cut out in its entirety.

A fourth element that limits the ability of a housing program is whether or not the housing program is supported fully by the other departments within the city. Regardless of which city agency administers the housing program, the other city agencies must support the activities of the housing program. In addition, great effort should be expended to obtain the support and cooperation of the community as a whole towards the housing effort.

and updating this model ordinance. The new document, entitled "APHA-PHS Recommended Housing Maintenance and Occupancy Ordinance," is the most recent model ordinance available. This new ordinance is one of several model ordinances available to communities to consider when they are interested in adopting a housing code.

One must keep in mind when considering the adoption of any model code that the code is, as stated, merely a model. The community should read and consider each element within the model code to determine its applicability to that community. As previously stated, however, a housing code is merely a means to an end. The end is the eventual elimination of all substandard conditions within the home and the neighborhood. This end cannot be reached if the community adopts an inadequate housing code.

## III OBJECTIVES OF A HOUSING CODE

The Housing Act of 1949 gave new impetus to existing local, state, and Federal housing programs directed towards the elimination of poor housing and the production of sound and decent housing. In passing this legislation, Congress defined a new national objective by declaring that the general welfare and security of the nation and the health and living standards of its people---require a decent home and a suitable living environment for every American family. This mandate generated an awareness that the quality of housing and residential environment has an enormous influence upon the physical and mental health and the social well-being of each individual and, in turn, upon the economic, political, and social conditions in every community. Consequently, public agencies, units of government, professional organizations, and others sought ways to ensure that the quality of housing and the residential environment did not depreciate or deteriorate.

It soon became apparent that a new type of legislation was needed, namely, ordinances that regulate the supplied facilities and the maintenance and occupancy of dwellings and dwelling units, or as they are more commonly called, "housing codes." The objective of a housing code is to establish minimum standards essential to make dwellings safe, sanitary, and fit for human habitation by governing the condition and maintenance, the supplied utilities and facilities, and the occupancy.

## IV CONTENT

What then are the general items which should be included in a housing code? Although all comprehensive housing codes or ordinances contain a number of common elements, the provisions of any two or more communities on the same element or elements usually will vary to some extent. This is true whether the codes be national or state models, those of a northern, eastern, southern or western municipality, or even of two or more communities within the same state or region. These variations stem from differences in local policies, preferences, and to a lesser extent, on needs. They are also influenced by the standards set by the related provisions of the diverse building, electrical, and plumbing codes in use in the municipality.

Within any housing code there are generally five major sections. These sections are listed and discussed in more detail both in the following pages and to a degree in the Legal Aspects chapter of this manual. The five major features are:

A Definitions of terms used in the code.

B Administrative provisions showing who is authorized to administer the code and the basic methods and procedures that must be followed in implementing and enforcing the sections of the code. The administrative sections deal with such items as: reasonable hours of inspections; when service of violation notices is and is not required; how to notify (a) the absentee owner when he can or cannot be contacted in person or through a legally responsible agent and (b) the resident-owner or tenant; how to process and conduct hearings; the rules to be followed in processing dwellings alleged to be unfit for human habitation; occupancy or use of dwellings finally declared fit.

C Substantive provisions specifying the various types of health, building, electrical, heating, plumbing, maintenance, occupancy and use conditions that constitute violations of the housing code. These provisions also can be and often are grouped into three main categories; namely, (1) minimum facilities and equipment for dwelling units, (2) adequate maintenance of dwellings and dwelling units as well as their facilities and equipment, and (3) the occupancy conditions of dwellings and dwelling units.

D Court and penalty sections outlining the basis for court action and the penalty or penalties to which the alleged violator will be subjected if he is proven guilty of violating one or more provisions of the code.

E Enabling conflict and unconstitutionality clauses providing for: the date a new or amended code will take effect, prevalence of more stringent provision in cases where there is a conflict of two codes, and severability of any part of the ordinance that might be found unconstitutional and retention of all other parts in full course and effect. In any city following the format of the APHA-PHS Housing Ordinance, the Health Officer or other supervisor in charge of housing inspections also will adopt appropriate housing rules and regulations from time to time to clarify or further refine the provisions of the ordinance. This has been done, for example, by the Commissioners of Health in Baltimore, Maryland and Milwaukee, Wisconsin and by the District of Columbia's Department of Licenses and Inspections. In contrast, some municipalities such as Fort Worth, Texas, St. Louis, Missouri, and Chicago, Illinois have tended to make their housing codes broader in the first place and subsequently have relied more on amendments to their ordinances rather than numerous rules and regulations. Either method has its advantages, so local practice will often help determine which is used.

Where the rules and regulations method is used, care should be taken that the department is not overburdened with a number of minor rules and regulations. similarly, a basic housing ordinance which encompasses all rules and regulations might have difficulty because any amendments to it requires action by the political element of the community. Some housing groups, in attempting to obtain amendments to the ordinance, have had the entire ordinance thrown out by the political bodies.

REFERENCE

1 PHS-APHA Recommended Housing Maintenance and Occupancy Ordinance. PHS Publication #1935.

## Chapter 3

## HEALTH AND SANITARY ELEMENTS OF A HOUSING INSPECTION

### I BACKGROUND FACTORS

Benjamin Franklin said "Sir, I respectfully submit that we can give advice but we cannot give conduct."

In dealing with the public we must give to our fullest capacity. Sometimes what we believe are frustrations peculiar to inspectors of housing are actually the same frustrations experienced by inspectors in many other fields. In dealing with the public, it is our duty to perform officially, teach where possible, and use the big stick only when necessary. Our manner must be forthright and that of a tutored professional. A housing inspector represents the key person in a local housing hygiene program since he is the local representative dealing with the grass root problems. Unless the inspector is a sanitarian, he is not prepared or expected to function as a sanitarian. There must, however, be a rapport between the housing inspector and the sanitarian to achieve the united action that will result in the achievement of greater health, safety, and welfare of the community. This is brought about by joint and supporting actions of the housing inspector and the sanitarian. Ordinarily more referrals will go from the former to the latter, because the regular work of the housing inspector brings him into contact with health problems more often than the work of the average sanitarian does. If both parties wish to do their respective jobs well, then they should develop an arrangement of mutual support and assistance.

### II MAJOR HEALTH AND SANITARY FACTORS

A comprehensive housing ordinance or code includes minimum requirements for adequate heat, light ventilation, sanitation, space, and occupancy. Various studies have provided evidence of the relationship between insanitary conditions, overcrowding, inadequate heat, light and ventilation and health problems such as the transmission of various diseases, infections, etc. Studies to evaluate the effects of conditions within man's living environment upon his mental health and emotional stability are being undertaken by the United States Public Health Service.

Within all comprehensive housing ordinances, there are appropriate standards for the important health and sanitation factors.

#### A Heat

Minimum inside heating temperatures vary little throughout the country except for the marked difference between the localities with very mild or very cold climates. Some state and local housing codes have set 70° F as the minimum standard. They vary, however, on the outside temperature that must prevail before the inside standard of 70° F must be met. The APHA Housing Code, for example, required it to be maintained under ordinary minimum winter conditions. Of necessity, therefore, you must be guided by your local code for quantitative standards. If there are no quantitative standards in your local code, Table No. 1 in Chapter 26 of the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE), Handbook of Fundamentals, gives minimum design temperatures for different areas of the country under winter conditions. The publication is readily available from most public libraries.

The APHA-PHS Housing Code states that a temperature of at least 68°F at a distance of 18 inches above floor level should exist. ASHRAE states that the temperature should be measured at the breathing line 5 feet above the floor or at the seating level 30 inches above the floor in a location where the temperature-sensing device is not exposed to a condition of abnormal heat gain or heat loss. Local code requirements should, however, prevail. If the local code does not give a specific statement, any of the previously mentioned methods may be used, but every housing inspector in the community should measure the temperature in the same way.

#### B Thermal Environment

One of the basic requirements in healthful housing is maintenance of a thermal environment that will avoid undue heat loss from the human body. While the so-called comfort level varies from person to person, it is generally conceded that for normal household activities a minimum temperature of 70°F throughout the room is necessary to protect the body from undue heat loss. Heat loss from the body results in lowered resistance, particularly to respiratory tract infections, and to some extent, all other infections.

Room temperatures vary considerably from floor to ceiling. Since hot air rises, the coolest temperature will be found near the floor and the warmest near the ceiling. The temperature of 70°F maintained near the ceiling might be far from adequate for protection required. Therefore, as mentioned earlier, the APHS-PHS Code specifies that temperature measurements for the determination of compliance with requirements be made at a level approximately 18 inches from the floor. This ensures that children, even the younger children who are most active, are in an area where the temperature is sufficiently warm to give them the protection they need. It also assures the less active adults a location in an area where the temperatures are at a desirable level.

C Natural Light

Most municipalities require at least one window or skylight facing directly to the outdoors for every habitable room. They are also in general agreement that this window area or skylight area be 10 percent of the total floor area of the room. Note here that a window located less that 3 feet from an outside wall or other structure that extends above the ceiling level of the room is not deemed to face directly to the outdoors. A window that faces directly into a completely enclosed court is counted as facing directly to the outdoors as long as the court is greater that 3 feet in its least dimensions.

Daylight should be used as fully as possible in all buildings no matter how adequate other forms of light may be. Satisfactory natural illumination depends upon the intensity of daylight or sky brightness and the amount, distribution, and quality of this light in a room. Natural light is particularly important in low-income housing where artificial lighting will be held to a minimum. Light is important in showing up dirt and thus leads to more cleanliness within the home. The bactericidal effect of light transmitted through glass is questionable. The bright, naturally lit room is, however, certainly more conductive to healthy mental attitudes than a dim, dark room lit only by artificial sources.

In different parts of the country different standards of window size are possible. For instance, in a sunny climate, such as that found in the southwestern desert, a smaller window area would supply adequate illumination and may be desirable to prevent excessive glare in a room. In a climate in the northern part of the country, however, 10 percent of the floor area should be a minimum for window area in consideration of the reduced amount of sunlight present, especially in the winter time.

The lighting requirements shall be deemed satisfactory if every habitable room has one window facing directly to the outdoors and the total window area in each habitable room is at least 10 percent of the floor area of that room. In computing window areas no deduction is made for sashes and trim used to hold the glass panes in place. If a skylight type of window on the ceiling of the habitable room serves as the only window in the room, the area of the horizontal projection of the skylight should also be at least 10 percent of the total floor area of the room. In a room with both a window and a skylight the total area of both should be at least 10 percent of the floor area.

D Artificial Light

It is a common requirement that every habitable room have two separate floor- or wall-type convenience outlets or else one such convenient outlet and one supplied ceiling-type electrical light fixture. It is also required that public halls and stairways be sufficiently lighted at all times in such a manner as to allow safe travel back and forth. The 1967 APHA-PHS Housing Code states that the electrical service and outlets of an existing house must be capable of providing at least 3 watts of power per square foot of total floor area in the house. It also provides that every habitable room and nonhabitable room used for food preparation shall have one wall-type electric convenience outlet for each 60 square feet or fraction thereof of total floor area and in no case less than two such outlets.

Every water closet compartment, bathroom, kitchen or kitchenette, laundry room, furnace room, and public hall shall contain at least one supplied ceiling or wall-type electric light fixture. Convenient switches or equivalent devices for turning on one light for each room or passageway shall be located so as to permit the area ahead to be lighted.

Every public hall and stairway in a multiple dwelling shall be adequately lighted by natural or electric light or both at all times so as to provide in all parts at least 6 foot candles of light at the tread or floor level. If the structure contains not more than two dwelling units this light may be controlled by a switch and be turned on when needed instead of being turned on full time.

Electricity is as essential to the modern home as heating or ventilation. It has long replaced gas, kerosene, and other utilities for lighting because it is more economical and, when properly used, safer. It has, probably more than any other single item, made practical the use of labor-saving devices for household tasks and thereby promoted the cleanliness of both the dwelling and the person.

Since the mid-1930's, electricity has been provided even to the most remote areas. Individual electrical generating units are available for use in places where industry or government has not provided electricity to the homeowner. Only the most backward and most primitive areas of this country are today without service of this utility. Certainly, all metropolitan areas have electricity, and there is no reason why this servant of mankind should not be available in the home.

The 1967 APHA-PHS Code allows a dwelling that is located more than 300 feet from the nearest electrical source to be without this service; however, there are very few dwellings left in the populated areas of this country that do not have, within 300 feet, the lines of the local electric utility.

Although electricity is a valuable servant, it can also be a severe safety hazard. Among the most common faults in providing electrical service is the furnishing of inadequate outlets. This results in overloading of the lines, causing possible overheating of wires and fixtures and subsequent fire hazards. Improperly installed facilities and outlets furnish a fire hazard, as well as a safety hazard, particularly to small children.

When inadequate outlets are provided there is a tendency, particularly among the poorly educated, to connect many high-wattage items such as toasters, irons, televisions, and other similar items to a single outlet.

Kitchen, living rooms, and rooming units are most likely to contain several electrical appliances in addition to the lighting fixtures. This is not necessarily true in toilet rooms, laundry rooms, furnace rooms, and public hallways. It is very important, therefore, that rooms most likely to have a large number of appliances be required to have an adequate number of outlets in order to prevent overloading of circuits and installation of amateurish and possibly hazardous extension wiring.

E Ventilation

The code requirement for the total openable window area in every habitable room is 45 percent of the minimum window area except where an approved mechanical means of ventilation is installed.

Adequate ventilation is essential in meeting many of the fundamental needs in housing. Among these are the maintenance of a thermal environment that will permit adequate heat loss from the human body, provision of an atmosphere of reasonable chemical purity, and provision of possibilities for esthetic satisfaction in the home and its surroundings.

The factors controlling heat loss in the body are air temperature, mean radiant temperature of surrounding surfaces, relative humidity, and air movement. It is particularly important that cool, moving air be made available in sleeping rooms since the impact of cool air is of great value in promoting healthful sleep. Moreover, odors given off by the body exert a definitely harmful influence on appetite and therefore upon health. There can be no doubt that the well-ventilated home, like the well-illuminated home, is more conducive to healthful mental attitudes than a poorly ventilated or poorly illuminated home.

Every bathroom and toilet room should comply with the housing code's light and ventilation requirements for habitable rooms except that windows or skylights should not be required if the ventilation system is adequate. Many codes state that mechanical means must provide at least two to six changes of air per hour.

As has been previously mentioned, light promotes cleanliness. This is particularly important in bathrooms and toilet rooms, where cleanliness is essential to sanitation and proper attitudes are essential to cleanliness. Ventilation is also necessary in these rooms because they are subject to a high concentration of body odors and humidity. Since these rooms are frequently located, for economical construction reasons, within the inner part of the structure and away from the exterior walls, windows and skylights are not always practical. The provision of artificial light sources and mechanical ventilation will, therefore, accomplish the basic purposes of light and ventilation requirements and at the same time meet practical standards of construction.

F Space and Occupancy

The maximum density of occupancy for any dwelling unit has been set by the APHA-PHS Code at 150 square feet of total habitable room area per person. In the event of single-person occupancy, this requirement is lowered to 100 square feet of total habitable room area. The code further requires that the total number of persons allowed may not be more than twice the number of habitable rooms in the dwelling unit.

If more than one family plus two occupants unrelated to the families, not including guests or domestic employees, are to occupy a dwelling unit, a permit for a rooming house must be granted by the appropriate local authority.

The ceiling height of any habitable room is set at a minimum of 7 feet except in rooms under a sloping ceiling. In those instances at least one half of the floor area must have a minimum ceiling height of 7 feet. The floor area located under the portion of the room where the ceiling height is less than 5 feet may not be used in computing total floor area of the room when the maximum permissible occupancy is being determined.

Space located partially or totally below the grade of the ground may not be used as a habitable room unless:

1 The floor and those portions of the wall below the grade are of waterproof and damp-proof construction.

2 The minimum window area is equal to at least 10 percent of the total floor area; the window area is located entirely above the grade of the ground adjoining it, or if windows are located wholly or partially below the grade, a properly drained window well has been constructed with an open area equal to or greater than the area of the masonry opening for the window; the bottom of the window well is below the top of the impervious masonry construction of this window, and the minimum horizontal distance at a right angle from any point of the window well is equal to or greater than the vertical depth of the window well as measured from the bottom of the masonry opening for the window. Where adequate artificial illumination is supplied no window is necessary.

3 The total openable window area in each room is equal to at least 45 percent of the total window area except where other approved devices affording adequate ventilation and humidity control are supplied.

4 There are no pipes, ducts, or other obstructions less than 6 feet 8 inches above the floor that interfere with the normal use of the room or area.

In dwelling units of two or more rooms, each sleeping room must contain at least 72 square feet of floor space for the first occupant, and at least 68 square feet of floor space for each additional occupant.

Dwellings or dwelling units containing two or more sleeping rooms must have a room arrangement that permits access to the bathroom or water closet without passage through another sleeping room.

Other space requirements state that each dwelling unit shall have at least 4 square feet of floor-to-ceiling-height closet space for the personal effects of each permissible occupant. If this space is lacking, in whole or in part, an amount of square footage equal to the space deficiency shall be subtracted from the computed area of habitable room space used in determining permissible occupancy.

Overcrowding in housing is one of the greatest contributing factors in the transmission of diseases, particularly those of the respiratory tract. In addition, crowding violates one of the basic maxims of healthful housing–the need for privacy of the individual. Privacy in the home and privacy in the use of sleeping, bath, and toilet rooms dictate that the user must be able to use these facilities without violating the privacy of another person or without having his privacy violated by another. Crowding makes proper cleansing and maintenance difficult and less likely to be done.

Rooms, to be considered habitable, must be of a size sufficient for use by normal-size people. Any room in which half the total floor area is usable only with difficulty, in which the ceiling is too low, or in which a person has problems moving around can hardly be considered habitable.

The use of below-the-grade space as habitable rooms in dwelling units is allowed basically to permit use of the so-called English Basement and Garden Apartment, which would otherwise meet the code requirements, since it conforms to the other provisions of the code for habitable rooms. Obviously, any room that is extremely damp, dark, and poorly ventilated would not be conducive to healthful occupancy by any human being.

G Sanitation: Cleanliness

Obviously, if a house and its premises are clean and maintained in a sanitary manner, they are not likely to harbor or breed disease-carrying vectors. In homes, however, where clean premises are not maintained, vectors that are commonly a problem include roaches, flies, mosquitoes, and rodents.

The roach may travel 2,200 feet when disturbed. During this travel it goes through many pools or pockets of filth. As it later passes through foodstuffs, and over dishes, pots, and pans, it leaves a path well filled with potential disease deposits. The daily travels of an ordinary house fly may encompass stops on garbage cans, dead animals, privies, manure piles, or other places of filth. Then at the first opportunity it comes in the house. If it feeds on food, it must regurgitate in order to be able to ingest it. Thus it leaves a trail of filth and disease potential brought from its earlier travels. Mosquitoes, when allowed to breed, are potential carriers of malaria, encephalitis, dengue fever, yellow fever, or other diseases. Rats, mice, squirrels, and other rodents carry fleas that can carry plague and other diseases to man.

These pests can exist only on premises where they are tolerated. Rats, mice, and roaches are shy creatures, which, when exposed to the light, usually scamper for the protection of the dark. Only hunger brings them out in the open. In a slum area, for instance, a rat may creep into the bed of a very young child because it is attracted by the milk or food left on the child's unwashed face. The rat will feed on these food traces until the child attempts to brush it away. This situation is, of course, extremely dangerous to the child, especially an infant. To prevent rodent infestation, points of entry, places of harborage, and feeding grounds must be eliminated.

In far too many cases, these dangerous disease-carrying vectors are disregarded until they have gained an almost complete mastery of their surroundings. At that point they become costly as well as difficult to eliminate. In addition to its quest for food, a rat destroys an average of $30 worth of property per day as he gnaws to keep his teeth short. Thus in slum areas where the people cannot afford exterminators, these vectors of disease soon take over.

H Sanitation: Infestation

When a building, structure, or dwelling becomes infested, the only solution is to call in a qualified exterminator to do a thorough job and then employ him on a regular basis to keep the situation under control. The inspection list of violations should note this and call for initial extermination and continued control. It goes without saying that housing codes do not allow accumulation of improperly stored garbage, trash, or other types of refuse in or around dwellings. Adequate, securely covered garbage and refuse containers should be standard equipment for every dwelling and dwelling unit.

The housing inspector should be able to identify correctly the spiders, mosquitoes, houseflies, mice, insects, and other vermin or rodents. He should be able to distinquish between the comparatively harmless flying ant and the destructive or dangerous termite for which the former is often mistaken. It is also important for him to recognize the bedbug, flea, and rat on sight so that he can give the owner or occupant accurate instructions about the type of pest or pests to be exterminated.

In addition to his general knowledge about the troublesome and insanitary nature of these common household pests, the inspector of housing should know the following facts and prepare to inform the public about the importance of eliminating and controlling infestation by these insects, rodents, and vermin:

1 Bedbug and flea - These bloodsucking vermin multiply rapidly and cause itchy welts, and it is a difficult and obnoxious process to free a person of them once he becomes infested.

2 Fly and mosquito - Both are vectors of disease, for if they pick up germs in their travels, they can contaminate directly or indirectly or infest food or persons they contact, bite, or sting. For example, flies help spread cholera and trachoma; mosquitoes are known transmitters of encephalitis, malaria, dengue fever, yellow fever, and other diseases.

3 Roach - These pests eat food, soap, garbage, starchy materials, and various forms of debris and also enjoy the wheat paste commonly used to glue on wallpaper. They will travel 1,200 feet or more in search of food. Since roaches are basically nocturnal creatures, it is usually an indication that the premises are heavily infested if they are seen in daylight. They pick up and carry bacteria and viruses from any contaminated or infected material they consume or contact. For example, roaches transport hookworm, whipworm, and amoebic dysentery. They can also acquire and transmit Coxsackie virus—which is said to be one of the viruses responsible for nonparalytic poliomyelitis—from infected sewage and excreta. Roaches can be carried into a home with the groceries but they are usually present because of poor housekeeping. Some common types of roaches and their chief characteristics are:

a Common house roach—is light brown, approximately 5/8 of an inch in length, and has black stripes running lengthwise on its back. This type is generally found in bathrooms and kitchens.

b American cockroach—is reddish to dark brown in color. The adults are about $1\frac{1}{2}$ to 2 inches long. They breed in damp basements and sewers as do the dark brown or black Oriental cockroaches.

c Brown banded cockroach or southern cockroach—is light brown, and the adults are $1\frac{1}{2}$ inches in length. These might live any place in the building.

d Australian cockroach—is reddish to dark brown with yellow marking and streaks. The adults are about 1 inch long. They are usually found in warm damp places in or out of doors.

4 Rat - These belong to the rodent family. The word rodent stems from the Latin word rodere, which means to gnaw, and the rat must gnaw continually to prevent its teeth from growing so long it cannot walk. Rats are cannibalistic, dangerous, and carriers of diseases such as rat bite fever, tularemia, salmonellosis, amoebic dysentery, and tapeworm. Aside from their actual bite, rats spread disease through the fleas they carry, their urine, feces, and falling hairs. The drop 25 to 150 pellets daily and constantly shed hair.

The rattus norvegicus, or Norway rat, is grayish brown on top and lighter in color on the underside of its body; has a heavy build; is 8 to 9 inches long, with a tail shorter than the body; and has teeth averaging $3\frac{1}{2}$ inches in length.

5 Termite - These have whitish, opaque wings, are black or dark brown, and have thick waist unlike the wasplike one of a flying ant. Some signs of termite infestation are clusters of their discarded wings or tubes of dried mud leading from a crack in the foundation or the ground to the wood structure of a house. Since cellulose is their principal food, the wood in buildings provides them with a ready-made food supply if any part of the wood structure is in contact with the ground. They devour

every bit of wood in their paths and are seldom discovered until major damage has been done.

Proper sanitation is the best preventive medicine for all these pests except the termite, for which termite shields, vapor barriers, or soil poisons are a must.

I Sanitation: Water Supply and Temperature

Some housing codes specify only that dwelling units have hot and cold water supply at all times. Other codes, however, specify a minimum rate of flow for hot and cold water of 1 gallon per minute from each fixture. The temperature generally requested and accepted for hot water is a maximum of 120°F. Any temperature higher than 120°F could cause sever burns of the body if it were not tempered with cold water. This is especially hazardous for older persons and young children.

J Sanitation: Septic Tanks

There are 17 million people in the United States who use septic tanks as a means of sewage disposal. It is important, therefore, for an inspector of housing to have a basic understanding of their construction and use.

Before a septic tank can be installed it must be determined that there is a correct location for a disposal field. Since 1927 the method has been the Percolation Test, a method credited to Henry Ryan. A hole, 1 foot square, is excavated to a depth of a proposed disposal trench. The hole is thoroughly saturated with water, then filled with water to a depth of 6 inches, and the time required for the water to drop 1 inch is measured. This was later revised by others to use the average time per inch for the water to drop 6 inches. This method of testing is intended to indicate the relative absorptive capacities of the various soils tested. Because of time-consuming difficulties in excavating a hole 1 foot square to the desired or required depth, the United States Public Health Service came to the conclusion that an easier method of making percolation tests would be as follows:

1 Bore a 4-inch (auger) hole instead of the 1-foot-square dug hole.

2 Make a reasonable number of tests and use the average rate for estimating absorption capacity of the soil.

3 Fill test holes with water and allow the soil to soak thoroughly before tests are made.

The conventional septic tank sewage and disposal system consists of two main parts—a septic tank and an absorption field or seepage pit. The tank settles, stores, and digests the solids (sludge and scum). As sewage enters the tank, the heavier solids settle to the bottom and become sludge, and the lighter particles, including mostly grease, rise to the top of the liquid and remain as scum. The organic matter contained in both sludge and scum is decomposed by action of certain anaerobic bacteria (the type of bacteria that thrive in absence of air). These bacteria gain their life-processing oxygen by reducing complex organic substances. They then extract oxygen, leaving liquids, solids, and gases. The gases are vented to atmosphere, and liquids are discharged to the disposal field.

Digestive action by the bacteria takes time, and so the tank must be of sufficient capacity to store solids for the required time. As raw sewage enters the tank, an equal amount of liquid effluent is discharged so that the liquid level remains fairly constant. The tank inlet has a baffle to divert the incoming sewage downward. An outlet baffle or pipe fitting retains solids but allows discharge of liquid to the absorption or disposal field. Recommended retention period of solids ranges from 8 to 48 hours. In normal operation, scum and sludge must be removed from tank by mechanical means.

The Public Health Service report shows that two or more solids retention compartment tanks are far more efficient than one. Rectangular compartment tanks are as good as any, and change in tank shapes to oval, or others offers no special advantages. In brief, then, the flow from the septic tank goes to a distribution box and then into the absorption field to allow liquids to be dissipated in the soil at a uniform rate.

K Sanitation: Drainage

The dangers of puddles and pools of stagnant water can be great depending on the location, the depth, and amount of the stagnant water. Stagnant water, whether it be on the ground or in receptacles such as old tin cans, bottles, rubber tires, etc., can be a major health hazard in any area of the country. Mosquitoes use these pools as breeding grounds. Female mosquitoes lay their eggs in water, and the eggs hatch into a larval stage. The larvae later change to a pupal stage and remain in the water-filled container until they change into adult mosquitoes and begin the fourth stage of their life cycle. It is in this fourth or adult stage that mosquitoes can carry diseases to man. The elmination of ponds, puddles, and other sources of stagnant water is the best way of eliminating mosquito hazards. If the pond or pool is large enough, it can also be a safety hazard for small children who may stumble into the water and drown.

Poor drainage may create another hazard if electricity is nearby. The obvious danger of being electrocuted exists when water and electricity are both present. The inspector should always look for evidence of water near the main fuse box in the house and for broken or frayed electrical wires in the kitchen, bathroom, water closet compartment, or laundry room.

Excessive dampness caused by puddles and other small bodies of stagnant water or leaking plumbing fixtures can cause structural damage to a house. The water itself can cause rotting of main structural members or can offer the campground needed by subterranean termites for their attack on wooden structures.

L Sanitation: Rubbish and Garbage Storage

Every occupant of a dwelling must maintain the part of the dwelling unit that he occupies and controls. The storage and disposal of rubbish and garbage in a safe and sanitary manner is considered the responsibility of the occupant insofar as the garbage and trash is generated in his portion of the structure. It is the owner's responsibility to see that arrangements are made by the tenant for the adequate removal of this refuse.

In a structure containing three or more dwelling units it is also the owner's responsibility to supply containers for the storage of refuse and to make provisions for its safe and sanitary removal as often as is necessary to maintain a sanitary structure.

In the case of a single- or two-family dwelling, it shall be the responsibility of the occupant to furnish facilities or containers. This does not preclude any agreement, whether written or oral, between owner and occupant for other types of disposal practices; however, any other type of disposal practice must be safe and sanitary.

As previously stated, avoiding the attraction of insects and rodents is essential to the public health. Refuse furnishes food and harboring places for rodents and tends to attract them to areas where they have not previously been present. The same is true of insects. The requirement that the proper facilities for the storage of rubbish be provided is to fix responsibility for maintenance and use of these facilities with a particular party whether it be the owner or the occupant of the dwelling. In the case of single-family or two-family dwellings, it is possible for the appropriate department to fix the responsibility for improper use and maintenance of rubbish storage facilities. Such is not the case, however, for multiple-family dwellings, and the responsibility for this use is therefore placed on the owner or operator.

M Sanitation: Kitchen Facilities

All Kitchens or kitchenettes should contain a kitchen sink, cabinets or shelves, (or both) a stove, and a refrigerator. Without these items the unit is not a dwelling unit but a rooming unit. If one of these items is missing, the health of the occupants is in jeopardy because of poor food sanitation. The kitchen sink should be an approved type and not a hand-washing sink. It should be large enough to hold a reasonably sized dish or pot. The sink should be connected to the hot- and cold-water systems. It is preferable, but not mandatory, to have a mixing faucet for safety reasons. The drain should be connected to the waste line and should include a trap. If the local plumbing code calls for a grease trap, it should be installed.

The purpose of a kitchen sink is the correct washing of dishes used in preparing and consuming meals. The diseases that can be caused by improperly washed dishes include food poisoning by salmonellae, shigellae, and staphylococci.

All kitchens should be supplied with adequate cabinets or shelves for the storage of eating, drinking, and cooking equipment. These may also be used to store foodstuffs that do not require refrigeration. It is important that newly cleaned eating and cooking equipment be stored on a clean surface so that contamination does not occur.

A stove or similar device for cooking food is necessary for maintaining adequate nutrition of the inhabitants. A diet of only cold food soon becomes boring and of doubtful nutritional value.

A refrigerator or similar device for storing food is also required in all kitchens. The refrigerator should be capable of storing food at temperatures between 32°F and 50°F under ordinary maximum summer conditions. An ice box would not meet the requirements, because it cannot keep the temperature below 50°F at all times during the summer. A freezer compartment is not necessary in this refrigerator, but it is always desirable because of the large amount of frozen foods now on the market. The purpose of a refrigerator is to protect the occupants of a dwelling unit from poisoning caused by improperly stored food. An economic factor is also involved since it is more expensive to buy food for one meal at a time.

## IV INSPECTION PROCEDURES

A Although inspection procedures vary from city to city, there are several common items that the inspector can and should check. These include:

1 Rodents - Look for possible harborage, entry points, tail marks, droppings feet marks, or signs of gnawing.

2 Roaches - Try to detect these through practice by their oily odor and by the obvious smell of commerical repellents used by home owners. Moreover, when open garbage bags or cans are in the kitchen, give them a shake and stand back.

3 Bedbugs - In touring a house, notice bed linen and blankets and be alert to urine odor. If children are at home when you call, casually observe the younger ones for bites on face and arms. Bedbugs have a distinctive odor.

4 In general, look for rubbish, garbage, and food leavings in or on sinks or strewn on floors. Observe any domestic animal beds or droppings.

5 Lifting, peeling, or flaking paint should be ordered removed, and the place should be repainted with lead-free paint, to prevent possible lead poisoning to children

6 Cracked and broken floor covering provides a nest for household pests. It should be ordered removed, the floor should be cleaned, and new covering put down. Kitchen and bathroom floor coverings should be impervious to water.

7 Cracks around bathtubs, in toilets, or in sinks are also unsanitary.

8 Back siphonage possibilities should be checked thoroughly. Make sure there is a proper air gap between the spill rim of basin, sink, or tub and the lowest point of the faucet.

9 Make sure kitchens are equipped with approved garbage containers with tight-fitting lids.

10 Make sure outside garbage cans are in good repair and have tight-fitting lids.

11 Keep alert for evidence of coal gas, sewer gas, and escaping cooking gas.

12 Order all unvented home space heaters removed in your presence.

13 Check legality of any community kitchens you may find since they are often a source of disease.

14 Check all windows for proper screening, where required, during the period called for in your code.

B The inspector will also find that there are other items he should check, and that, wher these conditions are found, they should be referred to the appropriate local authority. These include:

1 Reports by occupant of bites by rodents, roaches, or bedbugs.

2 Broken sewage disposal lines, also referred to as sanitary waste-water lines.

3 Stopped-up toilets.

4 Accumulation of weeds, garbage, or trash on premises.

5 Any obvious rashes, sores, etc., on occupants.

Although he is empowered to and should order corrective action on most, if not all, of these problems, he should also refer these sources or evidences of disease to the health agency.

C Appropriate Tools

The inspector should always carry a flashlight, thermometer, and a measuring tape. Moreover, when infestation is present, it would also be well for him to carry repellent so that he does not transport pests. Other equipment will be carried according to local department requirements.

D Reminder

In carrying out the health and sanitary aspects of housing inspections, the inspectors must keep in mind that responsibility is there for them to assume. They cannot do "just their job." They must do the "extra" that puts them above an automation and raises them to the class of dedicated, trained guardians of public health, and safety, and welfare.

## Chapter 4

## BUILDING ASPECTS OF A HOUSING INSPECTION

The principal function of a house is to furnish protection from the elements. In its current stage, however, our civilization requires that a home provide not only shelter but also privacy, safety, and reasonable protection of our physical and mental health. A living facility that fails to offer these essentials through adequately designed and properly maintained interiors and exteriors cannot be termed "healthful housing."

### I BACKGROUND FACTORS

For the purpose of this chapter, a building will be considered in terms of its major components exclusive of the mechanical elements namely, heating, plumbing, and electrical systems. Each of these items will be examined in detail in future chapters. Attention will be given in this chapter to the portions or a building not visible upon completion of the ceiling, roof, and interior and exterior walls in order to give the reader an understanding of generally accepted construction practices. Emphasis, however, will be placed upon the visible interior and exterior parts of a completed dwelling that have a bearing on the soundness, state of repair, and safety of the dwelling both during intended use and in the event of a fire. These are some of the elements that the housing inspector must examine when making a thorough housing inspection.

### II HOUSING CONSTRUCTION TERMINOLOGY KEY TO COMPONENT PARTS NUMBERED IN FIGURE 1.

A Fireplace

1 Chimney - You have known about this ever since Santa Claus days.

2 Flue Liner - The flue is the hole in the chimney. The liner, usually of terra cotta, protects the brick from harmful smoke gases.

3 Chimney Cap - This top is generally of concrete. It protects the brick from weather.

4 Chimney Flashing - Sheet-metal flashing provides a tight joint between chimney and roof.

5 Firebrick - An ordinary brick cannot withstand the heat of direct fire, and so special fire brick is used to line the fireplace.

6 Ash Dump - A trap door to let the ashes drop to a pit below, from where they may be easily removed.

7 Cleanout Door - The door to the ash pit or the bottom of a chimney through which the chimney can be cleaned.

8 Chimney Breast - The inside face or front of a fireplace chimney.

9 Hearth - The floor of a fireplace that extends into the room for safety purposes.

B Roof

1 Ridge - The top intersection of two opposite adjoining roof surfaces.

2 Ridge Board - The board that follows along under the ridge.

3 Roof rafters - The structural members that support the roof.

4 Collar Beam - Really not a beam at all. A tie that keeps the roof from spreading. Connects similar rafters on opposite side of roof.

5 Roof Insulation - An insulating material (usually rock, wool, or fiber glass) in a blanket form placed between the roof rafters, for the purpose of keeping a house warm in the winter, cool in the summer.

6 Roof Sheathing - The boards that provide the base for the finished roof.

7 Roofing - The wood, asphalt, or asbestos shingles—or tile, slate, or metal—that form the outer protection against the weather.

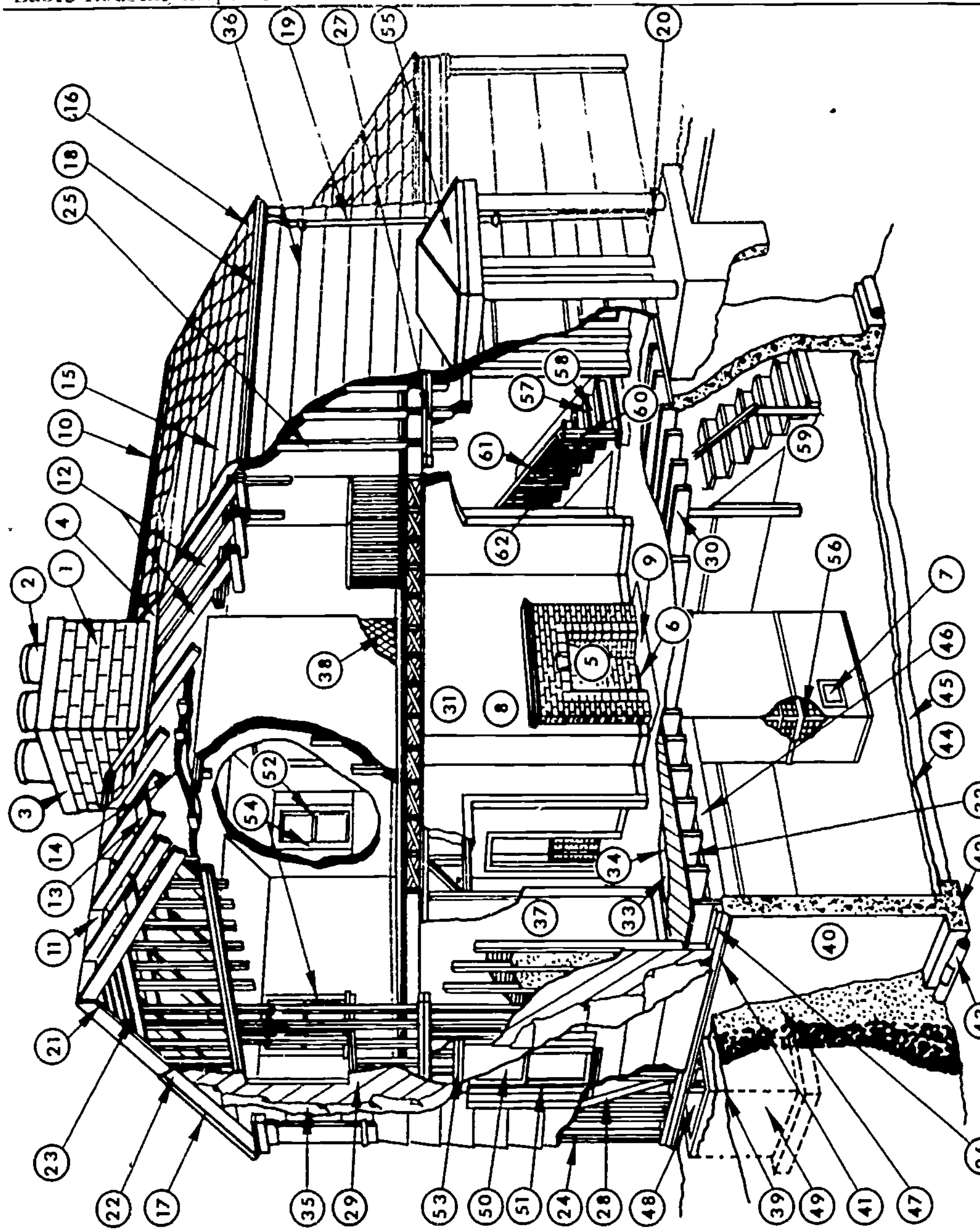



Figure 1. Housing construction terminology.

8 Cornice - A decorative element made up of molded members usually placed at or near the top of an exterior or interior wall.

9 Gutter - The trough that gathers rain-water from a roof.

10 Downspouts - The pipe that leads the water down from the gutter.

11 Storm-Sewer Tile - The underground pipe that receives the water from the downspouts and carries it to the sewer.

12 Gable - The triangular end of a building with a sloping roof.

13 Barage Board - The fascia or board at the gable, just under the edge of the roof.

14 Louvers - A series of slanted slots arranged to keep out rain, yet allow ventilation.

C Walls and Floors

1 Corner Post - The vertical member at the corner of the frame, made up to receive inner and outer covering materials.

2 Studs - The vertical wood members of the house, usually 2 × 4's generally spaced every 16 inches.

3 Sill - The board that is laid first on the foundation, and on which the frame rests.

4 Plate - The board laid across the top ends of the studs to hold them even and rigid.

5 Corner Bracing - Diagonal strips to keep the frame square and plumb.

6 Sheathing - The first layer of outer wall covering nailed to the studs.

7 Joist - The structural members or beams that hold up the floor or ceiling, usually 2 × 10's or 2 × 12's spaced 16 inches apart.

8 Bridging - Cross bridging or solid. Members at the middle or third points of joist spans to brace one to the next and to prevent their twisting.

9 Subflooring - The rough boards that are laid over the joist. Usually laid diagonally.

10 Flooring Paper - A felt paper laid on the rough floor to stop air infiltration and, to some extent. noise.

11 Finish Flooring - Usually hardwood, of tongued and grooved strips.

12 Building Paper - Sometimes placed outside the sheathing, not as a vapor barrier, but to prevent water and air from leaking in. Building paper is also used as a tarred felt under shingles or siding to keep out moisture or wind.

13 Beveled Siding - Sometimes called clapboards, with a thick butt and a thin upper edge lapped to shed water.

14 Wall Insulation - A blanket of wool or reflective foil placed inside the walls.

15 Metal Lath - A mesh made from sheet metal onto which plaster is applied.

D Foundation and Basement

1 Finished Grade Line - The top of the ground at the foundation.

2 Foundation Wall - The wall of poured concrete (shown) or concrete blocks that rests on the footing and supports the remainder of the house.

3 Termite Shield - A metal baffle to prevent termites from entering the frame.

4 Footing - The concrete pad that carries the entire weight of the house upon the earth.

5 Footing Drain Tile - A pipe with cracks at the joints to allow underground water to drain in and away before it gets into the basement.

6 Basement Floor Slab - The 4- or 5-inch layer of concrete that forms the basement floor.

7 Gravel Fill - Placed under the slab to allow drainage and to guard against a damp floor.

8 Girder - A main beam upon which floor joists rest. Usually of steel, but also of wood.

9 Backfill - Earth, once dug out, that has been replaced and tamped down around the foundation.

10 Areaway - An open space to allow light and air to a window. Also called a light well.

11 Area Wall - The wall, of metal or concrete, that forms the open area.

E Windows and Doors

1 Window - The wonderful invention that lets us see through a wall.

2 Window Frame - The lining of the window opening.

3 Window Sash - The inner frame, usually movable, that holds the glass.

4 Lintel - The structural beam over a window or door opening.

5 Window Casing - The decorative strips surrounding a window opening on the inside.

F Stairs and Entry

1 Entrance Canopy - A roof extending over the entrance door.

2 Furring - Falsework or framework necessary to bring the outer surface to where we want it.

3 Stair Tread - We put our foot down here.

4 Stair Riser - The vertical board connecting one tread to the next.

5 Stair Stringer - The sloping board that supports the ends of the steps.

6 Newel - The post that terminates the railing.

7 Stair Rail - The bar used for a hand hold when we use the stairs.

8 Balusters - Vertical rods or spindles supporting a rail.

## III BASIC ELEMENTS OF A RESIDENTIAL STRUCTURE

### A Foundation

The word foundation is used to mean:

1 Construction below grade such as footings, cellar or basement walls, etc.

2 The composition of the earth on which the building rests.

3 Special construction such as pilings, piers, and so on, used to support the building.

The foundation bed may be composed of solid rock, sand, gravel, or unconsolidated sand or clay. Rock, sand, or gravel are the most reliable foundation materials. Unconsolidated sand and clay, though found in many sections of the country, are not as desirable, because they are subject to sliding and settling.

The footing (see Figure 4-2) distributes the weight of the building over a sufficient area of ground so as to ensure that the foundation walls will stand properly. Footings are usually constructed of a masonry-type material such as concrete; however, in the past wood and stone have been used. Some older houses have been constructed without footings.

Although it is usually difficult to determine the condition of a footing without excavating the foundation, a footing in a state of disrepair or lack of a footing will usually be indicated either by large cracks or by settlement in the foundation walls (see Figure 3).

Foundation wall cracks are usually diagonal, starting from the top, the bottom, or the end of the wall. Cracks that do not extend to at least one edge of the wall may not be caused by foundation problems. Such wall cracks may be due to other structural problems and should also be reported.

The foundation walls support the weight of the structure and transfer this weight to the footings. The foundation walls may be made of stone, brick, concrete, or concrete blocks and should be moisture proofed with either a membrane of waterproof material or a coating of portland cement mortar. The membrane may consist of plastic sheeting or a sandwich of standard roofing felt joined and covered with tar or asphalt. The purpose of water-proofing the foundation walls is to prevent water from penetrating the wall material and leaving the basement or cellar walls damp.

Holes in the foundation walls are a common finding in many old houses. These holes

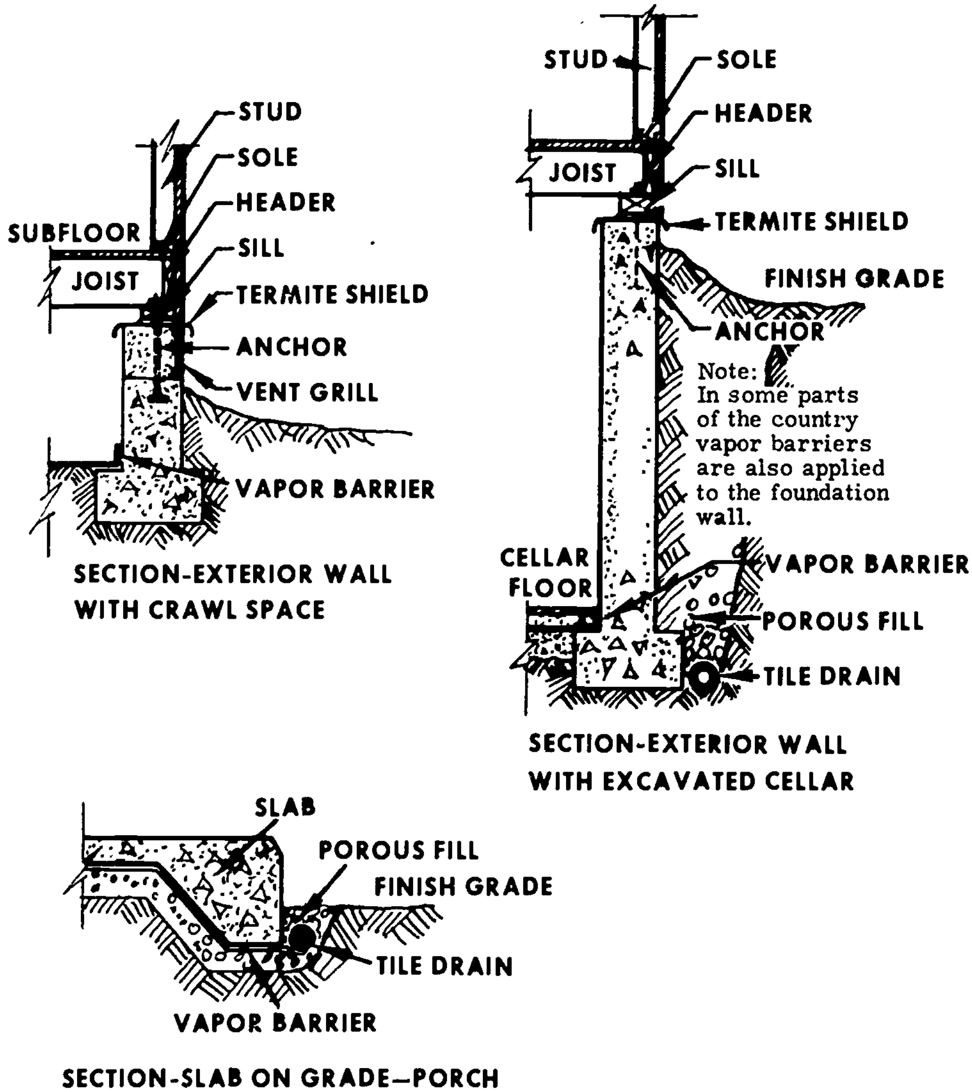



Figure 2. Foundation details

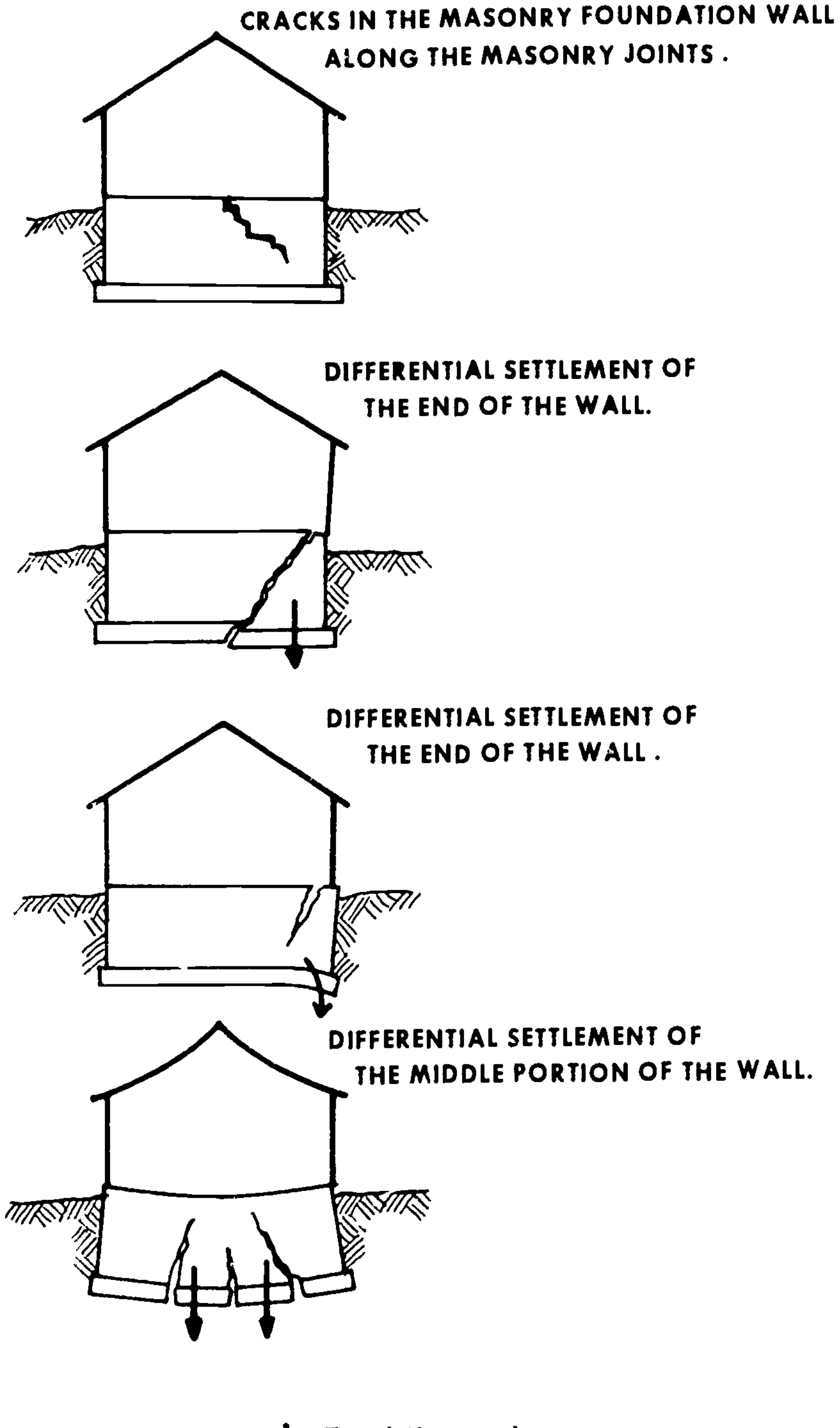



Figure 3. Foundation cracks

may be caused by missing bricks or blocks. Holes and cracks in a foundation wall are undesirable because they make a convenient entry for rats and other rodents and also indicate the possibility of further structural deterioration. These holes should not be confused with adequately installed vents in the foundation wall that permit ventilation and prevent moisture entrapment.

The basement or cellar floor should be made of concrete placed on at least 6 inches of gravel. The purpose of a concrete floor is to protect the basement or cellar from invasion by rodents or from flooding. The gravel distributes ground water movements under the concrete floor, reducing the possibility of the water's penetrating the floor. A waterproof membrane, such as plastic sheeting, should be laid before the concrete is placed, for additional protection against flooding.

The basement or cellar floor should be gradually but uniformly sloped towards a drain or a series of drains from all directions. These drains permit the basement or cellar floor to be drained if it becomes flooded.

Evidence of ineffective waterproofing or moisture proofing will be indicated by water or moisture marks on the floor and walls.

Cellar doors, hatchways, and basement windows should be weathertight and rodent proof. A hatchway can be inspected by standing at the lower portion with the doors closed; if daylight can be seen, the door probably needs repair.

B Framing

Many different types of house-framing systems are found in various sections of the country; however, the majority of the members in each framing system are the same. They include:

1 Foundation Sills: (see Figure 4 and 5). The purpose of the sill is to provide support or a bearing surface for the outside walls of the building. The sill is the first part of the frame to be placed and rests directly on the foundation wall. It is bolted to the foundation wall by sill anchors.

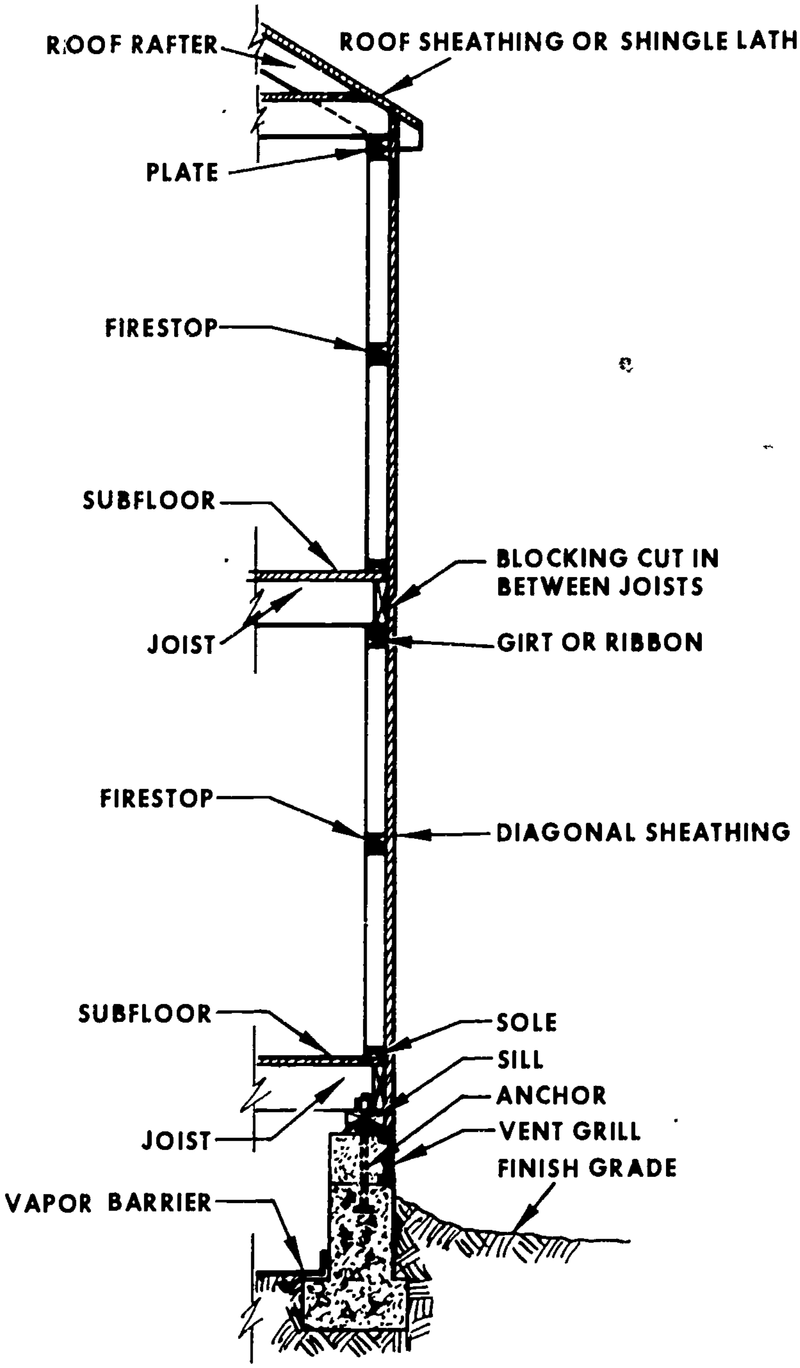
It is good practice to protect the sill against termites by extending the foundation wall to at least 18 inches above the ground and using a noncorroding metal shield continuously around the outside top of the foundation wall.

2 Flooring Systems: (see Figure 5). The flooring system is composed of a combination of girders, joists, subflooring, and finished flooring that may be made up of concrete, steel, or wood. Joists are laid perpendicular to the girders, at about 16 inches on centers, and are the members to which the subflooring is attached. When the subfloor is wood, it may be nailed at either right angles or diagonally to the joists.

As shown in Figure 5, a girder is a member that in certain framing systems supports the joists and is usually a larger section than the joists it supports. Girders are found in framing systems where there are no interior bearing walls or where the span between bearing walls is greater than the joists are capable of spanning. The most common application of a girder is to support the first floor in residences. Often a board known as a ledger is applied to the side of a wood girder or beam to form a ledge for the joists to rest upon. The girder, in turn, is supported by wood posts or steel "lally columns" which extend from the cellar or basement floor to the girder.

3 Studs: (see Figure 4 and 5). Wall studs are almost always 2 by 4 inches; studs 2 by 6 inches are occasionally used, to provide a wall thick enough to permit the passage of waste pipes. There are two types of walls or partitions: bearing and nonbearing. A bearing wall is constructed at right angles to and supports the joists. A nonbearing wall or partition acts as a screen or enclosure; hence, the headers in it are often parallel to the joists of the floor above.

In general, studs like joists are spaced 16 inches on center. In light construction such as garages and summer cottages where plaster is omitted, or some other material is used for a wall finish, wider spacing of studs is common.




SECTION-JOISTS AT RIGHT ANGLES
TO EXTERIOR WALL WITH CRAWL SPACE

Figure 4. Wall framing

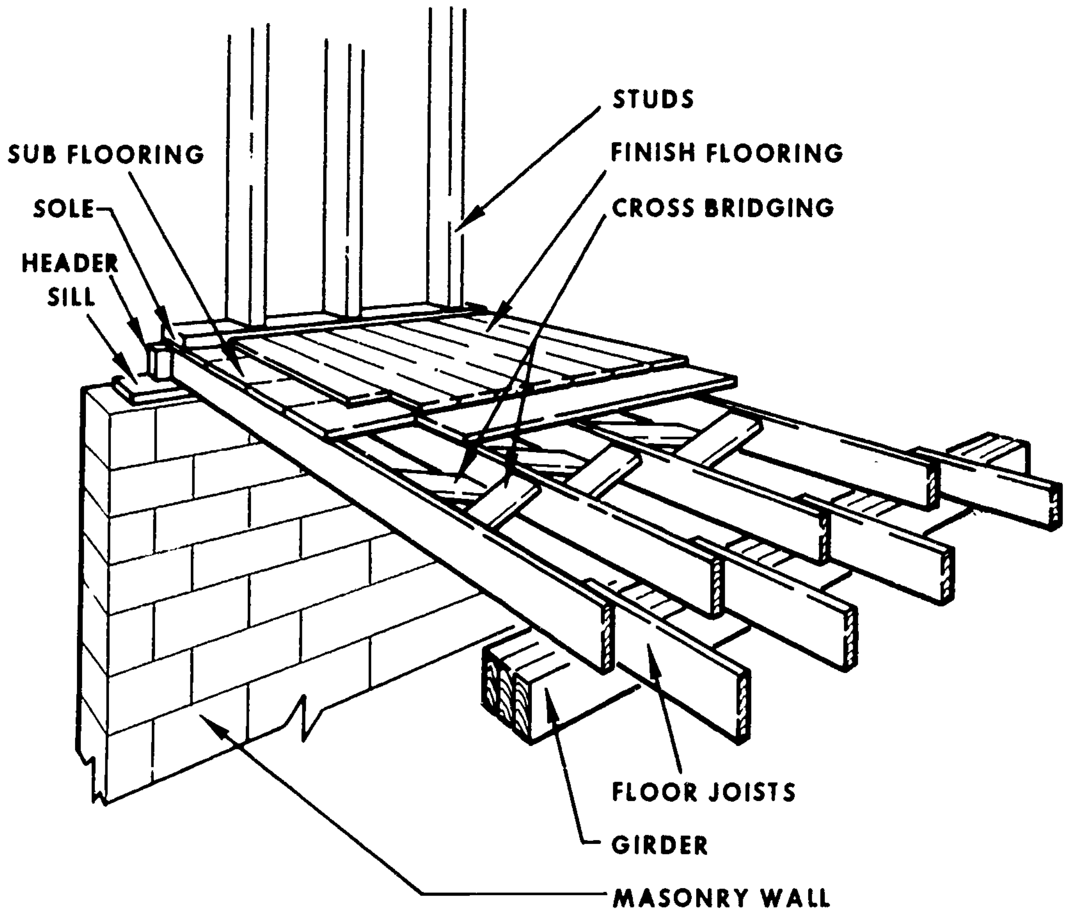



Figure 5. Floor construction

Openings for windows or doors must be framed in studs. This framing consists of horizontal members called "headers," vertical members called "trimmers," and short studs called "crippels" (see Figure 1).

Since the vertical spaces between studs can act as flues to transmit flames in the event of a fire, "fire stops" are important in preventing or retarding fire from spreading through a building by way of air passages in walls, floors, and partitions. Fire stops are wood obstructions placed between studs or floor joists to prevent fire from spreading in these natural fluespaces.

4 Interior Wall Finish: Many types of materials are used for covering interior walls and ceilings, but the principal types are plaster and dry-wall construction. Plaster is a mixture, usually gypsum, sand, and water, applied in two or three coats to lath to form a hard-wall surface. Dry-wall finish is a material that requires little, if any, water for application. More specifically, dry-wall finish may be gypsum board, plywood, fiberboard, or wood in various sizes and forms.

Gypsum board is a sheet material composed of a gypsum filler faced with paper. Sheets are usually 4 feet wide and can be obtained in lengths up to 12 feet. In dry-wall construction, gypsum boards are fastened to the studs either vertically or horizontally and then painted. The edges along the length of the sheet are recessed to receive joint cement and tape.

A plaster finish requires a base upon which plaster can be spread. Wood lath at one time was the plaster base most commonly used, but today gypsum-board lath is more popular. It has paper faces with a gypsum filler. Such lath is 16 by 48 inches and $\frac{1}{2}$ or 3/8 inches thick. It is applied horizontally across the studs. Gypsum lath may be perforated to improve the bond and thus lengthen the time the plaster can remain intact when exposed to fire. The building codes in some cities require that gypsum lath be perforated. Expanded-metal lath may also be used as a plaster base. Expanded-metal lath consists of sheet metal slit and expanded to form innumerable openings to hold the plaster. Metal lath is usually 27 by 96 inches and is fastened to the studs.

Plaster is applied over the base to a minimum thickness of $\frac{1}{2}$ inch. Because some drying may take place in wood-framing members after the house is completed, some shrinkage can be expected, which, in turn, may cause plaster cracks to develop around openings and in corners. Strips of lath imbedded in the plaster at these locations prevent cracks.

On the inside face of studs that form an exterior wall, vapor barriers are used to prevent condensation on the wall. The vapor barrier is an asphalted paper or metal foil through which moisture-laden air cannot travel.

5 Stairways: (see Figure 6). The general purpose of the standards for stairway dimensions is to ensure that there is adequate headroom, width, and uniformity in riser and tread size of every step to accommodate the expected traffic on each stairway safely.

Interior stairways should be not less than 44 inches in width. The width of a stairway may be reduced to 36 inches in one- and two-family dwellings. Stairs with closed risers should have maximum risers of $8\frac{1}{4}$ inches and a minimum tread of 9 inches plus $1\frac{1}{4}$-inch nosing. Basement stairs are often constructed with open risers. These stairs should have maximum risers of $8\frac{1}{4}$ inches and minimum treads of 9 inches plus $\frac{1}{2}$-inch nosing. The headroom in all parts of the stair enclosure should be no less than 80 inches.

Exterior stairway dimensions should be the same as those called for in interior stairways, except that the headroom requirement does not apply.

6 Windows: The four general classification of windows for residences are:

a Double-hung sash window that moves up or down, balanced by weights hung on chains or ropes, or springs on each side.

b Casement window sash is hinged at the side and can be hung so that it will swing outward or inward.

c Awning window—usually has two or more glass panes that are hinged at the top and swing about a horizontal axis.

d Sliding Window—usually has two or more glass panes that slide past one another on a horizontal tract.

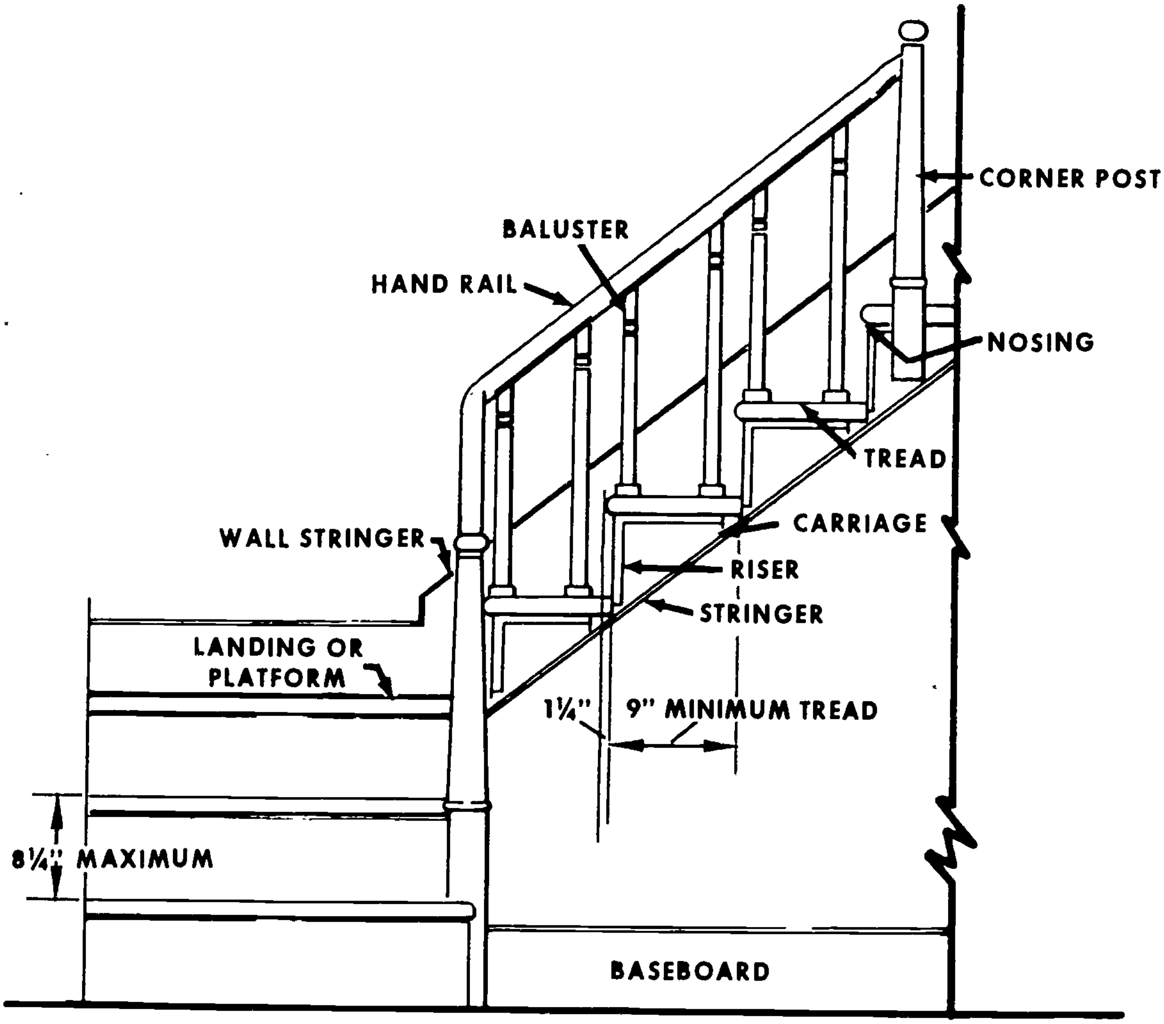



Figure 6. Stairway

The principal parts of a double-hung window (see Figure 4-7) are the lights, the top rail-framing members, bars or muntins that separate the lights, stiles–side-framing members, bottom rail, sash weights, and sash cords or chains. (All rails are horizontal, all stiles vertical.) The casement window's principal parts include: top and bottom rails, muntins, butt hinges, and jamb. All types of windows should open freely and close securely.

The exterior sill is the bottom projection of a window. The drip cap is a separate piece of wood projecting over the top of the window and is a component of the window casing.

7 Doors: There are many styles of doors both for exterior and interior use. Interior doors should offer a reasonable degree of privacy. Exterior doors must, in addition to offering privacy, protect the interior of the structure from the elements. The various parts of a door have the same definitions as the corresponding parts of a window.

The most common types of doors are:

a Batten door: This consists of boards nailed together in various ways. The simplest is two layers nailed to each other at right angles, usually with each layer at 45 degrees to the vertical.

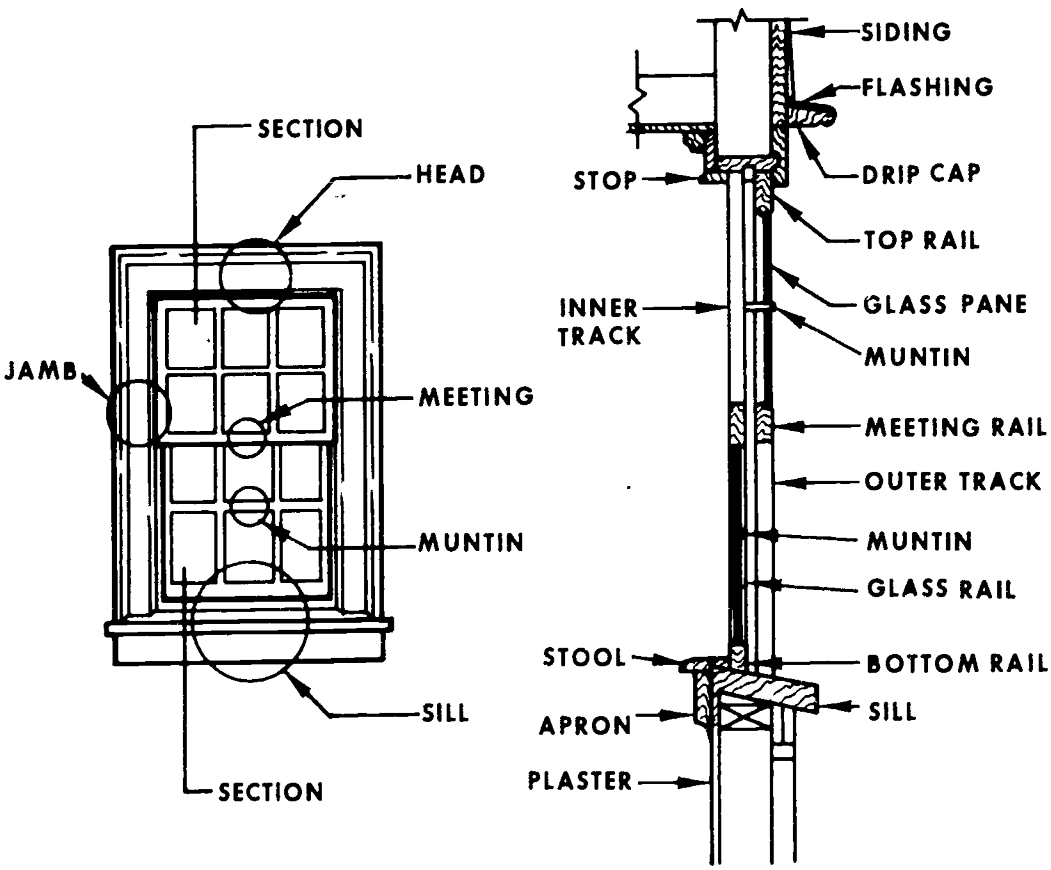



Figure 7. Window details

Another type of batten door consists of vertical boards nailed at right angles to several (two to four) cross strips called ledgers, with diagonal bracing members nailed between ledgers. If vertical members corresponding to ledgers are added at the sides, the verticals are called frames.

Batten doors are often found in cellars and other places where appearance is not a factor and economy is desired.

b Flush doors: Solid flush doors are perfectly flat, usually on both sides, although occasionally they are made flush on one side and paneled on the other. Flush doors sometimes are solid planking, but they are commonly veneered and possess a core of small pieces of white pine or other wood. These pieces are glued together with staggered end joints. Along the sides, top, and bottom are glued 3/4-inch edge strips of the same wood, used to create a smooth surface that can be cut or planed. The front and back faces are then covered with a 1/8- to $\frac{1}{4}$-inch layer of veneer.

Solid flush doors may be used on both the interior and exterior.

c Hollow-core doors: These, like solid flush doors, are perfectly flat, but unlike solid doors, the core consists mainly of a grid of crossed wooden slats or some other type of grid construction. Faces are 3-ply plywood instead of one or two plies of veneer, and the surface veneer may be any species of wood, usually hardwood. The edges of the core are solid wood and are made wide enough at the appropriate places to accommodate locks and butts. Doors of this kind are considerably lighter than solid flush doors.

Hollow-core doors are usually used as interior doors.

d Paneled doors: Most doors are paneled, with most panels consisting of solid wood or plywood, either "raised" or "flat," although exterior doors frequently have one or more panels of glass, in which case they are called "lights." One or more panels may be employed although the number seldom exceeds eight. Paneled doors may be used both on the interior or exterior.

In addition to the various types of wood doors, metal is often used as a veneer or for the frame.

In general, the horizontal members are called rails and the vertical members are called stiles. Every door has a top and bottom rail, and some may have intermediate rails. There are always at least two stiles, one on each side of the door.

The frame of a doorway is the portion to which the door is hinged. It consists of two side jambs and a head jamb, with an integral or attached stop against which the door closes.

Exterior door frames are ordinarily of softwood plank, with side rabbitted to receive the door in the same way as casement windows. At the foot is a sill, made of hardwood to withstand the wear of traffic, and sloped down and out to shed water.

Interior door frames are similar to exterior, except that they are often set directly on the hardwood flooring without a sill.

Building codes throughout the country call for doors in various locations within the structure to be fire resistant. These doors are often covered with metal or some other fire-resistant materials, and some are completely constructed of metal. Fire-resistant doors are usually located between a garage and a house, stairwells and hallways, and all boiler rooms. The fire resistance rating required for various doors differs with local fire codes.

C Roof Framing (see Figures 4-1, 4-4, 4-8, and 4-9)

Rafters serve the same purpose for the roof as joists do for floors, i.e., providing support for sheathing and roofing material. Rafters are usually spaced 20 inches on center.

1 Collar Beam: Collar beams are ties between rafters on opposite sides of the roof. If the attic is to be used for rooms, the collar beam may double as the ceiling joist.

2 Purlin: A purlin is the horizontal member that forms the support for the rafters at the intersection of the two slopes of a gambrel roof.

3 Ridge Board: A ridge board is a horizontal member against which the rafters rest at their upper ends; it forms a lateral tie to make them secure.

4 Hip: Like a ridge except that it slopes. The intersection of two adjacent, rather than two opposite, roof planes.

5 Roof Boards: The manner in which roof boards are applied depends upon the type of roofing material. Roof boards may vary from tongue-and-groove lumber to plywood panels.

6 Dormer: The term dormer window is applied to all windows in the roof of a building, whatever their size and shape.

D Exterior Walls and Trim (see Figure 4 and 9)

Exterior walls are enclosure walls whose purpose is to make the building weather-tight. In most one- to three-story buildings

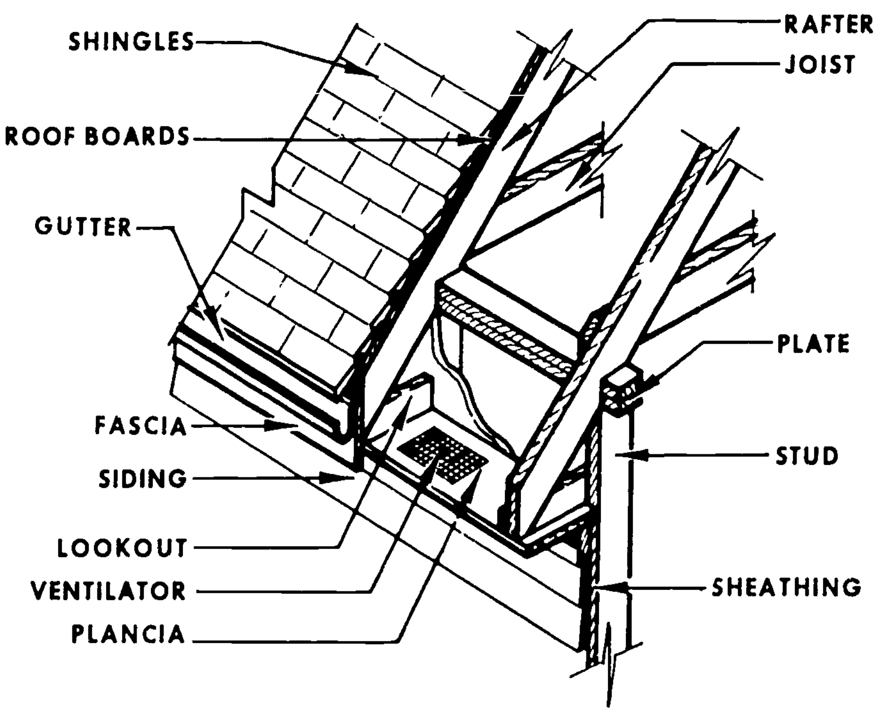



Figure 8. Cornice construction

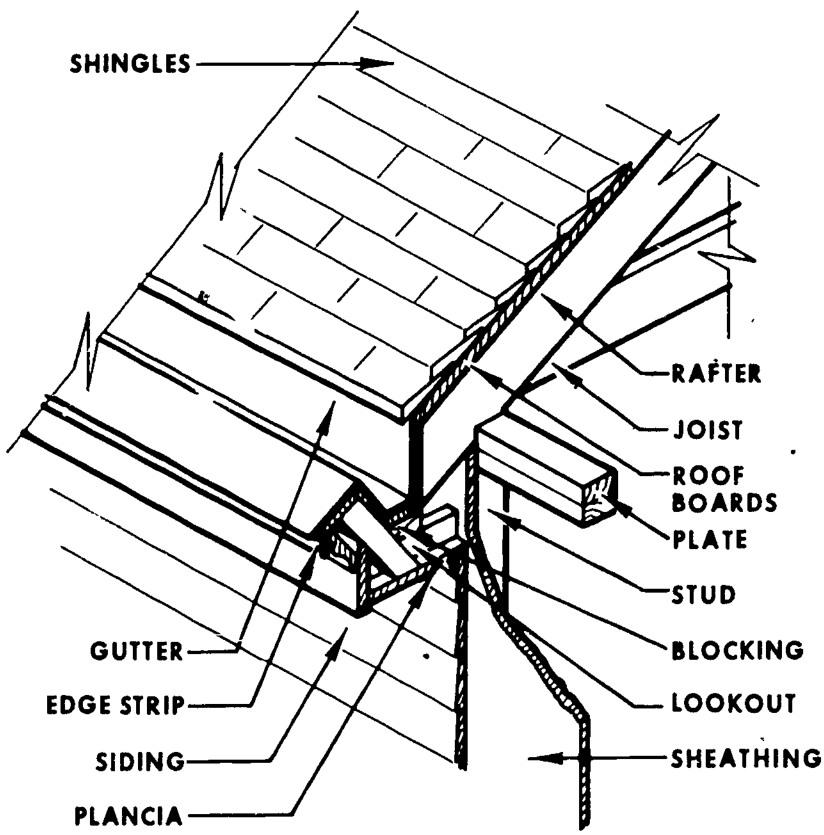



Figure 9. Cornice construction

they also serve as bearing walls. These walls may be made of many different materials.

Frequently used framed exterior walls appear to be of brick construction. In this situation, the brick is only one course thick and is called a brick veneer. It supports nothing but itself and is kept from toppling by ties connected to the frame wall.

In frame construction the base material of the exterior walls is called "sheathing." The sheathing material may be square-edge, shiplap, or tongue-and-groove boards.

In recent construction there has been a strong trend toward the use of plywood or composition panels.

Sheathing, in addition to serving as a base course for the finished siding material, stiffens the frame to resist sway caused by wind. It is for this reason that sheathing has been applied diagonally on frame buildings.

The finished siding may be clapboard, shingles, aluminum, brick asphalt, wood, and so forth, or a combination thereof. Good aluminum siding has a backer board that serves as added insulation and affords rigidity to the siding. Projecting cornices are a decorative trim found at the top of the building's roofline. A parapet wall is that part of the masonry wall that extends up and beyond the roofline and is capped with a noncombustible material. It helps prevent spread of fire, provides a rest for fire department ladders, and helps prevent people on the roof from falling off.

Many types of siding, shingles, and other exterior coverings are applied over the sheathing. Wood siding, cedar, and other wood shingles or shakes, clapboard, common siding (called benel siding), composition siding, asbestos, cement shingles, asbestos-cement siding, and the aforementioned aluminum siding are commonly used for exterior coverings. Clapboard boards and common siding differ only in the length of the pieces. Clapboard boards are 4 feet long while panel siding comes in lengths from 60 to 16 feet. Composition siding (felt and asphalt are often shaped to look like brick.) Asbestos and cement shingles are rigid and produce a covering that is fire resistant. Cedar wood shingles are also manufactured with a backer board that gives insulation and fire-resistant qualities. Asbestos cement siding made of asbestos fiber and portland cement has good fire-resistant qualities and is a rigid covering.

E <u>Roof Coverings (Flexible Material Class)</u>

1 Asphalt Shingle: The principal damage to asphalt shingle roofs is caused by the action of strong winds on shingles nailed too high. Usually the shingles affected by winds are those in the four of five courses nearest the ridge and in the area extending about 5 feet down from the edge or rake of the roof.

2 Asphalt Built-up Roofs: These may be unsurfaced, the coating of bitumen being exposed directly to the weather, or they may be surfaced having slag or gravel imbedded in the bituminous coating. The use of surfacing material is desirable as a protection against wind damage and the elements. This type of roof should have enough pitch to drain water readily.

3 Coal Tar Pitch Built-up Roofs: This type roof must be surfaced with slag or gravel. Coal tar pitch built-up roof should always be used on deck pitched less than ½ inch per foot; that is, where water may collect and stand. This type roof should be inspected on completion, 6 months later, and then at least once a year, preferably in the fall. When the top coating of bitumen shows damage or has become badly weathered, it should be renewed (rigid material class).

4 Slate Roofs: The most common problem with slate roofs is the replacement of broken slates. Roofs of this type normally render long service with little or no repair.

5 Tile Roofs: Replacement of broken shingle tiles is the main maintenance problem. This is one of the most expensive roofing materials. It requires very little maintenance and gives long service.

6 Copper Roofs: Usually are of 16-ounce copper sheeting and applied to permanent structures. When properly installed, they require practically no maintenance or repair. Proper installation allows for expansion and contraction with changes in temperature.

7 Galvanized Iron Roofs: Maintenance is done principally by removing rust and keeping roof well painted. Leaks can be corrected by renailing, caulking, or replacing all or part of the sheet or sheets in disrepair.

8 Wood Shingle Roofs: The most important factors of this type roof are its pitch and exposure, the character of wood, kind of nails used, and preservative treatment given shingles. Creosote and coal tar preservative are satisfactory for both treated and untreated shingles.

9 Flashing: Valleys in roofs that are formed by the junction of two downward slopes; may be finished, open, or closed. In a closed valley the slates, tiles, or shingles of one side meet those of the other, and the flashing below them may be comparatively narrow. In an open valley, the flashing, which may be made of zinc, copper, or aluminum, is laid in a continuous strip, extending 12 to 18 inches on each side of the valley, while the tiles or slates do not come within 4 to 6 inches of it.

The ridges built up on a sloping roof, where it runs down against a vertical projection, like a chimney or a skylight, should be weatherproofed with flashing.

Metal flashings are generally used with slate, tile, metal, and wood shingles. Failure of roof flashing is usually due to exposed nails that have come loose. The loose nails allow the flashing to lift with leakage resulting.

10 Gutters and Leaders: Gutters and leaders should be of noncombustible materials. They should be securely fastened to the structure and spill into a storm sewer if the neighborhood is so provided. When there is no storm sewer, a concrete or stone block placed on the ground beneath the leader prevents water from eroding the lawn. This store block is called a splash block. Gutters will not become plugged if protected against clogging of leaves and twigs. Both should be checked every spring and fall and then cleaned out if necessary.

## IV DISCUSSION OF INSPECTION TECHNIQUES

A serious building defect may often be observed during a housing inspector's routine examination. In many cases it is beyond the scope of the housing inspector's background to analyze the underlying causes and to recommend a course of action that will facilitate repair in an efficient and economical manner. In situations such as this, it is important that the inspector realize his limitations and refer the matter to the proper expert.

A prime example of a technically complex situation that a housing inspector might observe is a leaning, buckling, or bulging foundation or bearing wall. This problem may be the result of a number of hidden or interacting problems. For example, it may be the result of differential building settlement or failure of a structural beam or girder. It is beyond the scope of the housing inspector's responsibilities to discover the cause of the defect, but it is his responsibility to note the problem and refer it to the proper authority. In this case the proper authority would be a building inspector.

In the aforementioned situation where a bulging foundation wall was discovered, this would obviously constitute a violation of the housing ordinance and should be written up as such by the housing inspector. Since the housing inspector is generally not qualified to determine whether the house should be evacuated because it is in danger of imminent collapse, he should seek the advice of a building inspector.

A question that frequently arises is which violations should be referred to an expert. Needless to say, circumstances that obviously fall within the jurisdiction of another department should be referred to the department. The housing inspector should discuss with his supervisor any situation in which he feels inadequate to make a decision. In all cases the inspector should inform his supervisor before referring a problem to another agency or expert.

Another reason for referral to other departments is that when a remedial action is completed the other department will be in a better position to determine whether the job is satisfactory.

This principle of referral should be applied to every portion of the inspection, whether it deals with health, heating, plumbing, gas, or electrical as well as structural defects.

Certain structural items should be recognized as unsafe by the housing inspector. For example, a beam that has sagged or slanted may cause a portion of or an entire floor to sage or slope. Where a sagging or sloping floor is found, examine the ceiling of the room below or the basement for a broken or drooped girder or joist.

Doors and windows that are out of level will not close completely. It may be possible to see outside light through openings around window rails and door jambs. If an inspector detects such a situation, the condition of the supporting girders, grits, posts, and studs should be questioned, since this condition is evidence that some of these members may be termite infested or rotted and may be causing the outside wall to sag. Glass panes in doors and windows should be replaced if found to be broken or missing. Windows should also be checked for proper operation, and items such as broken sash cords or chains noted.

If the roof of the structure appears to be sagging, the inspector should make a special effort to examine the rafters, purlin, collar beams, and ridge boards if these members are exposed as in unfinished attics. The condition of the roof boards may be examined while he is in the attic. If light can be seen between these boards the roof is unsound. Evidence of a leaking roof will be indicated by loose plaster or peeling or stained paint and wall paper. Areas of the roof where flashing occurs, such as around the chimney are frequent origins of roof leaks. It is essential that the leak be found and repaired, not only to prevent the entrance of moisture into the building, but also to prevent the loosening of the plaster, rotting of timbers, and extension of damage to the remainder of the house.

Gutters and rain leaders should be placed around the entire building to insure proper drainage of water. This will lessen the possibility of seepage of water through siding and window frames, and entrance of water into the cellar or basement. Lack of or leaking gutters may result in rotting of the siding or erosion of the exposed portion of the cellar or basement walls. This situation commonly exists where the mortar between bricks or concrete blocks in foundation walls is found to be heavily eroded. Gutters should be free from dirt and leaves.

The exterior siding should be in sound, weathertight condition. Peeled or worn paint on wood siding will expose the bare wood to the elements and result in splitting and warping of siding. This condition will eventually lead to the entrance of rain water with resultant rotting of the sheathing and studs as well as inside dampness and falling plaster. Sound and painted siding will prevent major repairs and expenses in the future. This condition will often be particularly prevalent on the north face of the structure.

Roof and chimneys should be inspected for tilting, missing bricks, deterioration of flashing and pointing of chimney bricks. In addition, roof covering should be checked for broken spots and missing shingles or tiles. Roof doors should be metal clad, self-closing, tight fitting, and unlockable. The roof should also be examined for weather-tightness and broken TV antennas.

Porches should be carefully examined for weakened treads, missing or cracked boards, holes and holes covered with tin plates, railing rigidity, missing posts, handrail ridigity, condition of the columns that support the porch roof, and the condition of the porch roof itself. The open section beneath the porch should be inspected for broken lattice-work. Check under the porch for accumulation of dirt and debris that can offer a harborage for vermin and rodents.

Loose plaster and missing or peeling wallpaper or paint should be noted. Bugs and cockroaches eat the paste from the wallpaper while living behind loose paper.

The basic parts of a stairway that a housing inspector should be able to identify correctly are the following:

A Riser

B Tread

C Nosing

D Handrail

E Balustrade and Balusters, the Vertical Members that Support the Handrail, and

F The Soffit, Underpart of the Stairway.

In the examination of a stairway (be careful to turn the light on) initially check the underside, if visible, to see if it is intact. Then proceed slowly up the stairs placing full weight on each tread and checking for loose, wobbling, or uneven treads and risers. Regardless of the size of the treads or risers they should all be of uniform size. For all stairs that rise 3 or more feet, a handrail should be present and in a sound and rigid condition.

Any fireplace should conform to the requirements of the local code. An unused fireplace that has its opening covered with wallpaper or other material should have a solid seal behind the paper. Operable fireplaces should have a workable damper, fire screen, and should be clean.

Garages and accessory structures should be inspected in the same manner as the main building.

Sidewalks and driveways, whether constructed of flagstone, concrete, or asphalt, should be checked for creaking, buckling, and other conditions dangerous to pedestrian travel.

Stone, brick, or concrete steps should be inspected for cracks, deterioration, and pointing.

Fences should be in a sound condition and painted. Fire escapes should be checked for paint condition, loose or broken treads and rails, proper operating condition, and proper connection to the house.

## Chapter 5

## PLUMBING ELEMENTS OF A HOUSING INSPECTION

Plumbing may be defined as practice, materials, and fixtures used in the installation, maintenance, and alteration of all piping, fixtures, appliances, and appurtenances in connection with sanitary or storm drainage facilities, the venting system, and the public or private water-supply systems. Plumbing does not include the trade of drilling water wells, installing water softening equipment, or the business of manufacturing or selling plumbing fixtures, appliances, equipment or hardware. A plumbing system consists of three separate parts: An adequate potable water supply system; a safe, adequate drainage system; and ample fixtures and equipment.

### I BACKGROUND FACTORS

The generalized inspector of housing is concerned with a safe water supply system, an adequate drainage system, and ample and proper fixtures and equipment. This chapter covers the major features of a residential plumbing system and the basic plumbing terms the inspector must know and understand to identify properly housing code violations involving plumbing and the more complicated defects that he will refer to the appropriate agencies.

### II DEFINITIONS

1 Air Chambers - Air Chambers are pressure absorbing devices that eliminate water hammer. They should be installed as close as possible to the valves or faucet and at the end of long runs of pipe.

2 Air Gap (Drainage System) - The unobstructed vertical distance through the free atmosphere between the outlet of waste pipe and the flood level rim of the receptacle into which it is discharging.

3 Air Gap (Water Distribution System) - The unobstructed vertical distance through the free atmosphere between the lowest opening from any pipe or faucet supplying water to a tank, plumbing fixture or other device and the flood level rim of the receptacle.

4 Air Lock - Air lock is the accumulation, in the piping, of a quantity of air so located that a back pressure is induced to balance sufficiently the forward pressure, and thus greatly reduce flow from outlets.

5 Backflow - Backflow is the flow of water or other liquids, mixtures, or substances into the distributing pipes of a potable water supply from any source or sources other than the intended source. Back siphonage is one type of backflow.

6 Back Siphonage - Back siphonage is the flowing back of used, contaminated, or polluted water from a plumbing fixture or vessel into a potable water supply due to a negative pressure in such a pipe.

7 Branch - A branch is any part of the piping system other than the main, riser, or stack.

8 Branch Vent - A vent connecting one or more individual vents with a vent stack or stack vent.

9 Building Drain - The building (house) drain is the part of the lowest piping of a drainage system that receives the discharge from soil, waste, or other drainage pipes inside the walls of the building (house) and conveys it to the building sewer beginning 3 feet outside the building wall.

10 Cross Connection - Any physical connection or arrangement between two otherwise separate piping systems, one of which contains potable water and the other either water of unknown or questionable safety or steam, gas, or chemical whereby there may be a flow from one system to the other, the direction of flow depending on the pressure differential between the two systems. (See Backflow and Back siphonage.)

11 Disposal Field - An area containing a series of one or more trenches lined with coarse aggregate and conveying the effluent from the septic tank through vitrified clay pipe or perforated, non-metallic pipe, laid in such a manner that the flow will be distributed with reasonable uniformity into natural soil.

12 Drain - A drain is any pipe that carries waste water or water-borne waste in a building (house) drainage system.

13 Flood Level Rim - The top edge of a receptacle from which water overflows.

14 Flushometer Valve - A device that discharges a predetermined quantity of water to fixtures for flushing purposes and is closed by direct water pressures.

15 Flush Valve - A device located at the bottom of the tank for flushing water closets and similar fixtures.

16 Grease Trap - See Interceptor

17 Hot Water - Hot water means potable water that is heated to at least 120°F and used for cooking, cleaning, and washing dishes.

18 Insanitary - Contrary to sanitary principles-injurious to health.

19 Interceptor - A device designed and installed so as to separate and retain deleterious, hazardous, or undesirable matter from normal wastes and permit normal sewage or liquid wastes to discharge into the drainage system by gravity.

20 Leader - An exterior drainage pipe for conveying storm water from roof or gutter drains to the building storm drain, combined building sewer, or other means of disposal.

21 Main Vent - The principal artery of the venting system, to which vent branches may be connected.

22 Main Sewer - See Public Sewer.

23 Pneumatic - The word pertains to devices making use of compressed air as in pressure tanks boosted by pumps, etc.

24 Potable Water - Water having no impurities present in amounts sufficient to cause disease or harmful physiological effects and conforming in its bacteriological and chemical quality to the requirements of the Public Health Service drinking water standards or meeting the regulations of the public Health authority having jurisdiction.

25 P & T (Pressure and Temperature) Relief Valve - A safety valve installed on a hot water storage tank to limit temperature and pressure of the water.

26 P Trap - A trap with a vertical inlet and a horizontal outlet.

27 Public Sewer - A common sewer directly controlled by public authority.

28 Relief Vent - An auxiliary vent that permits additional circulation of air in or between drainage and vent systems.

29 Septic Tank - A watertight receptacle that receives the discharge of a building's sanitary drain system or part thereof and is designed and contructed so as to separate solid from the liquid, digest organic matter through a period of detention, and allow the liquids to discharge into the soil outside of the tank through a system of open-joint or perforated piping, or through a seepage pit.

30 Sewerage System - A sewerage system comprises all piping, appurtenances, and treatment facilities used for the collection and disposal of sewage, except plumbing inside and in connection with buildings served, and the building drain.

31 Soil Pipe - The pipe that directs the sewage of a house to the receiving sewer, building drain, or building sewer.

32 Soil Stack - The vertical piping that terminates in a vent in a roof and carries off the vapors of a plumbing system.

33 Stack Vent - An extension of a solid or waste stack above the highest horizontal drain connected to the stack. Sometimes called a waste vent or a soil vent.

34 Storm Sewer - A sewer used for conveying rain water, surface water, condensate, cooling water, or similar liquid waste.

35 Trap - A trap is a fitting or device that provides a liquid seal to prevent the emission of sewer gases without materially affecting the flow of sewage or waste water through it.

36 Vacuum Breaker - A device to prevent backflow (back siphonage) by means of an opening through which air may be drawn to relieve negative pressure (vacuum).

37 Vent Stack - The vertical vent pipe installed to provide air circulation to and from the drainage system and that extends through one or more stories.

38 Water Hammer - The loud thump of waste in a pipe when a valve or faucet is suddenly closed.

39 Water Service Pipe - The pipe from the water main or other sources of potable water supply to the water-distributing system of the building served.

40 Water Supply System - The water supply system consists of the water service pipe, the water-distributing pipes, the necessary connecting pipes, fittings, control valves, and all appurtenances in or adjacent to the building or premises.

41 Wet Vent - A vent that receives the discharge waste other than that from water closets.

42 Yoke Vent - A pipe connecting upward from a soil or waste stack to a vent stack for the purpose of preventing pressure changes in the stacks.

## III MAIN FEATURES OF AN INDOOR PLUMBING SYSTEM

The primary functions of the plumbing system within the house are as follows:

1 To bring an adequate and potable supply of hot and cold water to the users of the dwelling

2 To drain all waste water and sewage discharged from these fixtures into the public sewer, private septic tank, or in rare cases, the cesspool serving the structure

It is, therefore, very important that the housing inspector familiarize himself fully with all elements of these systems so that he may recognize inadequacies of the structure's plumbing as well as other code violations. In order to aid the inspector in understanding the plumbing system, a series of drawings and diagrams has been included at the end of this chapter.

## PLUMBING

### A Supply System

1 Water Service: The piping of a house service line should be as short as possible. Elbows, bends, etc., should be kept to a minimum since these reduce the pressure and therefore the supply of water to fixtures in the house.

The house service line should also be protected from freezing. The burying of the line under 4 feet of soil is a commonly accepted depth to prevent freezing. This depth varies, however, across the country from north to south. The local or State Plumbing Code should be consulted for the recommended depth in your area of the county.

A typical house service installation is pictured in Figure 1.

The materials used for a house service may be copper, cast iron, steel or wrought iron. The connections used should be compatible with the type of pipe used.

a Corporation stop - The corporation stop is connected to the water main. This connection is usually made of brass and can be connected to the main by use of a special tool without shutting off the municipal supply. The valve incorporated in the corporation stop permits the pressure to be maintained in the main while the service to the building is completed.

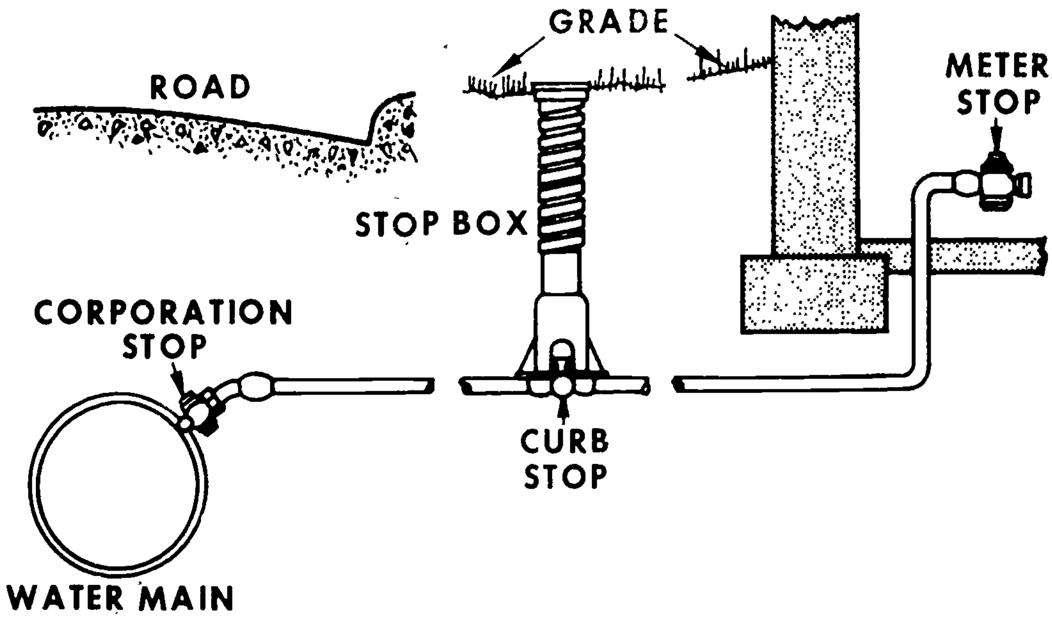



Figure 1. House service installation

b Curb stop - The curb stop is a similar valve used to isolate the building from the main for repairs, nonpayment of water bills, flooded basements, etc.

Since the corporation stop is usually under the street and would necessitate breaking the pavement to reach the valve, the curb stop is used as the isolation valve.

c Curb stop box - The curb stop box is an access box to the curb stop for opening and closing the valve. A long-handled wrench is used to reach the valve.

d Meter stop - The meter stop is a valve placed on the street side of the water meter to isolate the meter for installation, maintenance, etc. Many codes require a gate valve on the house side of the meter to shut off water for house plumbing repairs. The curb and meter stops are not to be used frequently and can be ruined in a short time if used very frequently.

e Water meter - The water meter is a device used to measure the amount of water used in the house. It is usually the property of the city and is a very delicate instrument and should not be abused.

Since the electric system is usually grounded to the water line, a grounding loop-device should be installed around the meter. Many meters come with a yoke that maintains electrical continuity even though the meter is removed.

2 Hot- and Cold-Water Main Lines: The hot- and cold-water main lines are usually hung from the basement ceiling and are attached to the water meter and hot-water tank on one side and the fixture supply risers on the other.

These pipes should be installed in a neat manner and should be supported by pipe hangers or straps of sufficient strength and number to eliminate sagging.

Hot- and cold-water lines should be approximately 6 inches apart unless the hot water line is insulated. This is to insure that the cold water line does not pick up heat from the hot water line.

The supply mains should have a drain valve or stop and waste valve in order to remove water from the system for repairs. These valves should be on the low end of the line or on the end of each fixture riser.

a <u>The fixture risers start at the basement main and rise</u> vertically to the fixtures on the upper floors. In a one-family dwelling, riser branches will usually proceed from the main riser to each fixture grouping. In any event the fixture risers should not depend on the branch risers for support but should be supported with a pipe bracket.

b <u>Each fixture is then connected to the branch riser</u> by a separate line. The last fixture on a line is usually directly to the branch riser. Figure 2 is a diagram of a typical single-family residence water supply system.

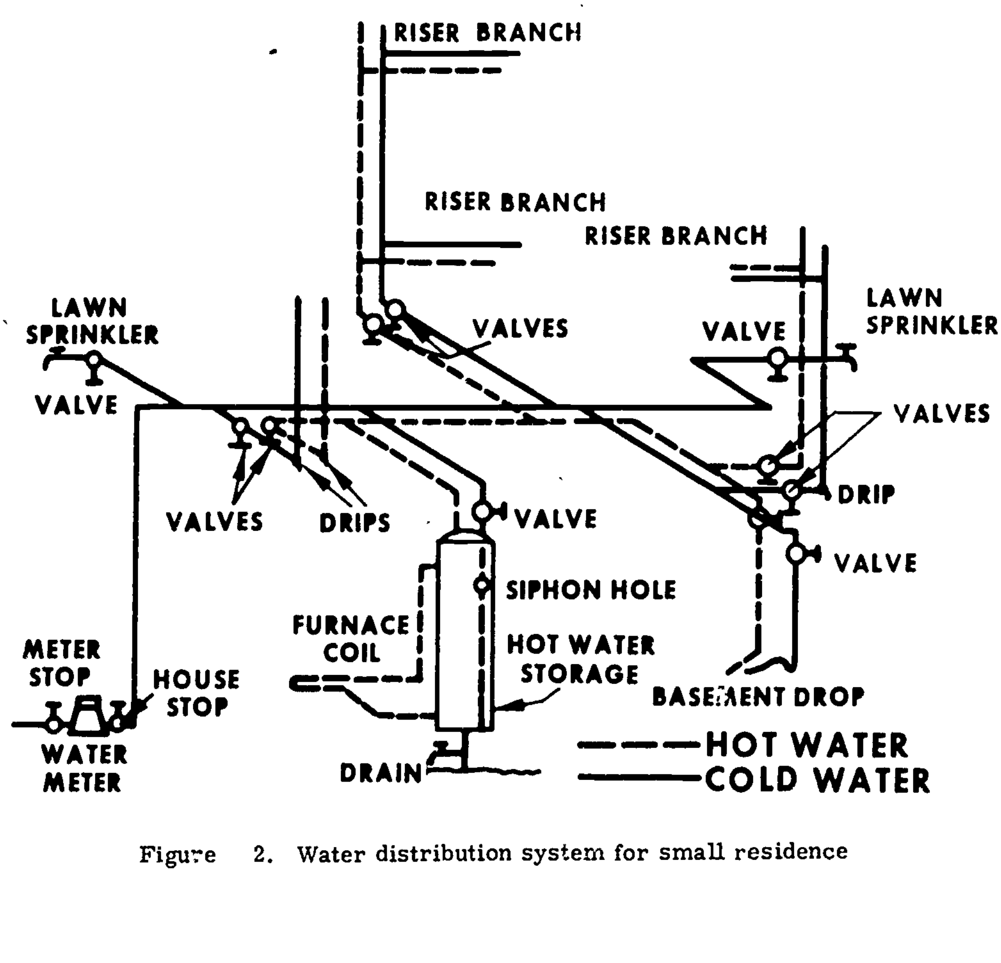



Figure 2. Water distribution system for small residence

3 Hot Water Heaters: Hot water heaters are usually powered by electricity, fuel oil, gas, or in rare cases, coal or wood. They consist of a space for heating the water and a storage tank for providing hot water over a limited period of time.

No matter what is used for fuel all hot-water heaters should be fitted with a temperature-pressure relief valve.

This valve will operate when either the temperature or the pressure becomes too high owing to an interruption of the water supply, a faulty thermostat, etc.

Figure 3 shows the correct installation of a hot-water heater.

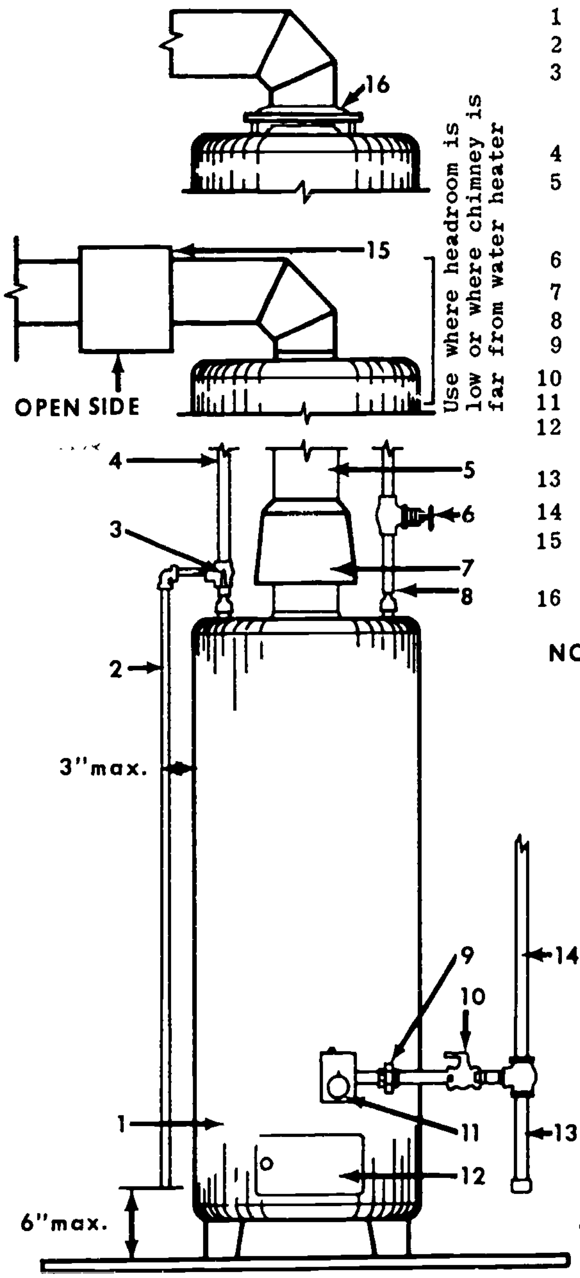
4 Pipe Sizes: The size of basement mains and risers depend on the number of fixtures supplied. However, a 3/4 inch pipe is usually the minimum size used. This allows for deposits on the pipe due to hardness in the water, etc., and will usually give satisfactory volume and pressure.

B Drainage System

The water supply brought into the house and used is discharged through the drainage system. This system is either a sanitary drainage system carrying just interior waste water or a combined system carrying interior waste and roof and patio runoff. The sanitary system will be discussed first.

1 Sanitary Drainage System: The proper sizing of the sanitary drain or house drain depends on the number of fixtures it serves. The usual minimum size is 6 inches in diameter. The materials used are usually cast iron, vitrified clay, plastic, and in rare cases, lead. For proper flow in the drain the pipe should be sized so that it flows approximately one-half full. This ensures proper scouring action so that the solids contained in the waste will not be deposited in the pipe.

a Sizing of house drain - The Uniform Plumbing Code Committee has developed a method of sizing of house drains in terms of "fixture units." One "fixture unit" equals approximately 7-$\frac{1}{2}$ gallons of water per minute. This is the amount of water discharged from a wash basin in 1 minute. All other fixtures have been related to this unit.




1 HOT-WATER HEATER
2 DRIP LEG (RELIEF VALVE)
3 COMBINATION TEMPERATURE AND PRESSURE RELIEF VALVE WITH TRY-LEVER
4 HOT-WATER LINE
5 FLUE PIPE* MUST BE NOT LESS THAN 28 GAUGE GALVANIZED SHEET METAL
6 COLD-WATER SHUT-OFF VALVE
7 DRAFT HOOD
8 COLD-WATER LINE
9 UNION
10 SHUT-OFF VALVE (GROUND JOINT)
11 THERMOSTAT
12 PILOT LIGHT AND BURNER ACCESS DOOR
13 DRIP LEG (GAS LINE)
14 GAS SUPPLY LINE
15 HORIZONTAL DRAFT HOOD (SQUARE)
16 LOW PROFILE DRAFT HOOD

**NOTE: TRY LEVER SHOULD BE INSTALLED ON HOT-WATER SIDE UNLESS OTHERWISE SPECIFIED BY MANUFACTURER.**

***MUST BE PROTECTED IF WITHIN 12" OF COMBUSTIBLE MATERIALS.**

Proper Water Heater Installation

Department of Community Development, Middletown, Ohio

Figure 3

A table of fixture unit values is shown in Table 1.

Table 1. FIXTURE UNIT VALUES

| Fixture | Units |
|---|---|
| Lavatory/wash basin | 1 |
| Kitchen sink | 2 |
| Bathtub | 2 |
| Laundry tub | 2 |
| Combination fixture | 3 |
| Urinal | 5 |
| Shower bath | 2 |
| Floor drain | 1 |
| Slop sinks | 3 |
| Water closet | 6 |
| One bathroom group (water closet, lavatory, bathtub, and shower; or water closet, lavatory, and shower) | 8 |
| 180 Square Feet of roof drained | 1 |

The maximum number of fixture units attached to a sanitary drain is shown in Table 2.

b Grade of house drain - A house drain or building sewer should be sloped toward the sewer to ensure scouring of the Drain. Figure 4 shows the results of proper and improper pitch of a house drain.

The usual pitch of a house or building sewer is $\frac{1}{4}$ inch fall in 1 foot of length.

c House drain installation - A typical house drain installation is shown in Figure 5. Typical branch connections to the main are shown in Figure 6.

Table 2. SANITARY DRAIN SIZES

| | Maximum number of mixture units | | |
|---|---|---|---|
| Diameter of pipe, in. | Slope 1/8"/Ft. | Slope $\frac{1}{4}$"/Ft. | Slope $\frac{1}{2}$"/Ft. |
| $1\frac{1}{4}$ | 1 | 1 | 1 |
| $1\frac{1}{2}$ | 2 | 2 | 3 |
| 2 | 5 | 6@ | 8@ |
| 3 | 15@ | 18@ | 21@ |
| 4 | 84 | 96 | 114 |
| 6 | 300 | 450 | 600 |
| 8 | 990 | 1,392 | 2,220 |
| 12 | 3,084 | 4,320 | 6,912 |

*A water closet must enter a 3 inch diameter drain and no more than 2 water closets may enter a 3 inch horizontal branch.

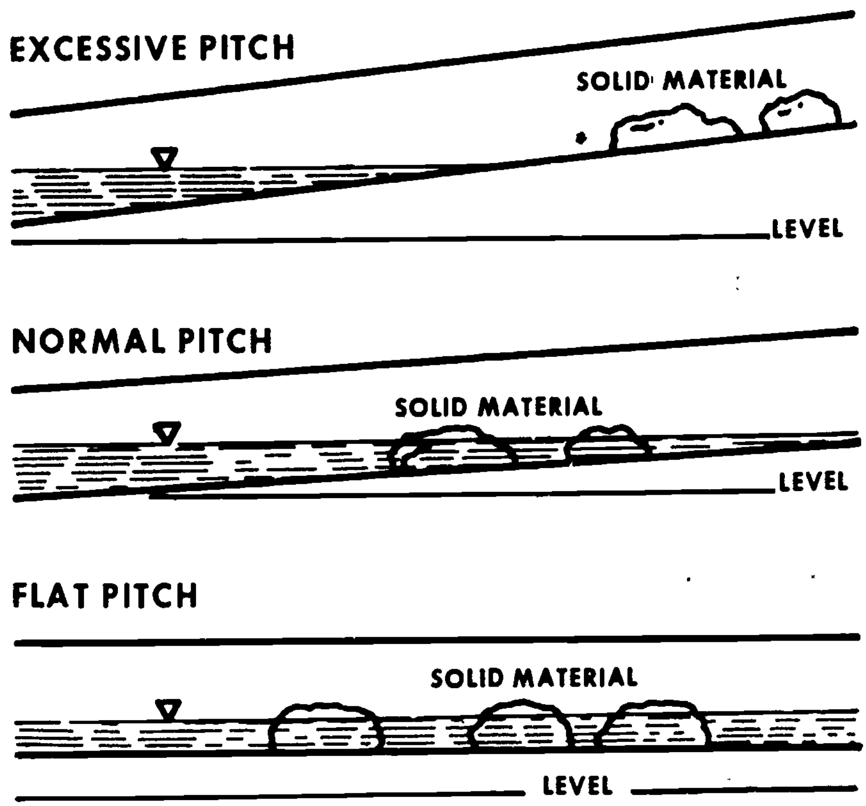



Figure 4. Results of proper and improper pitch of a house drain

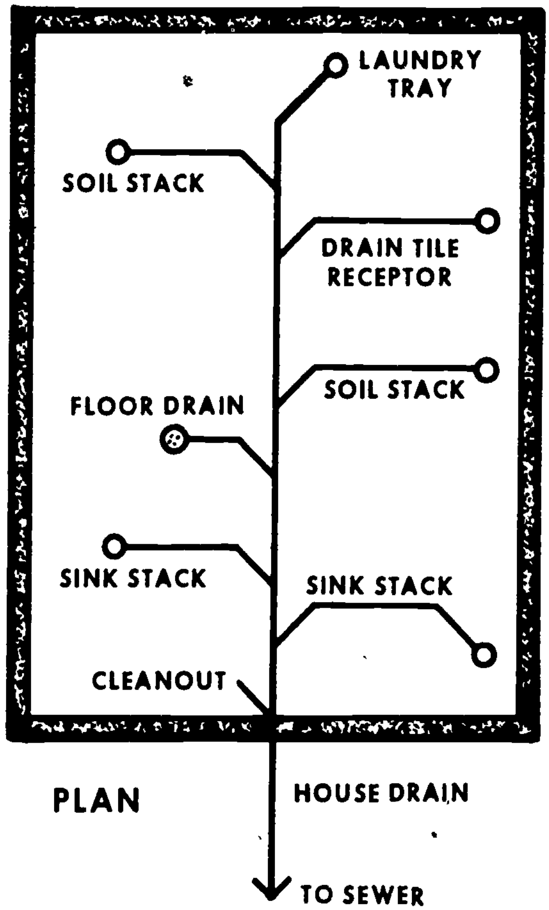



Figure 5. Typical house drain installation

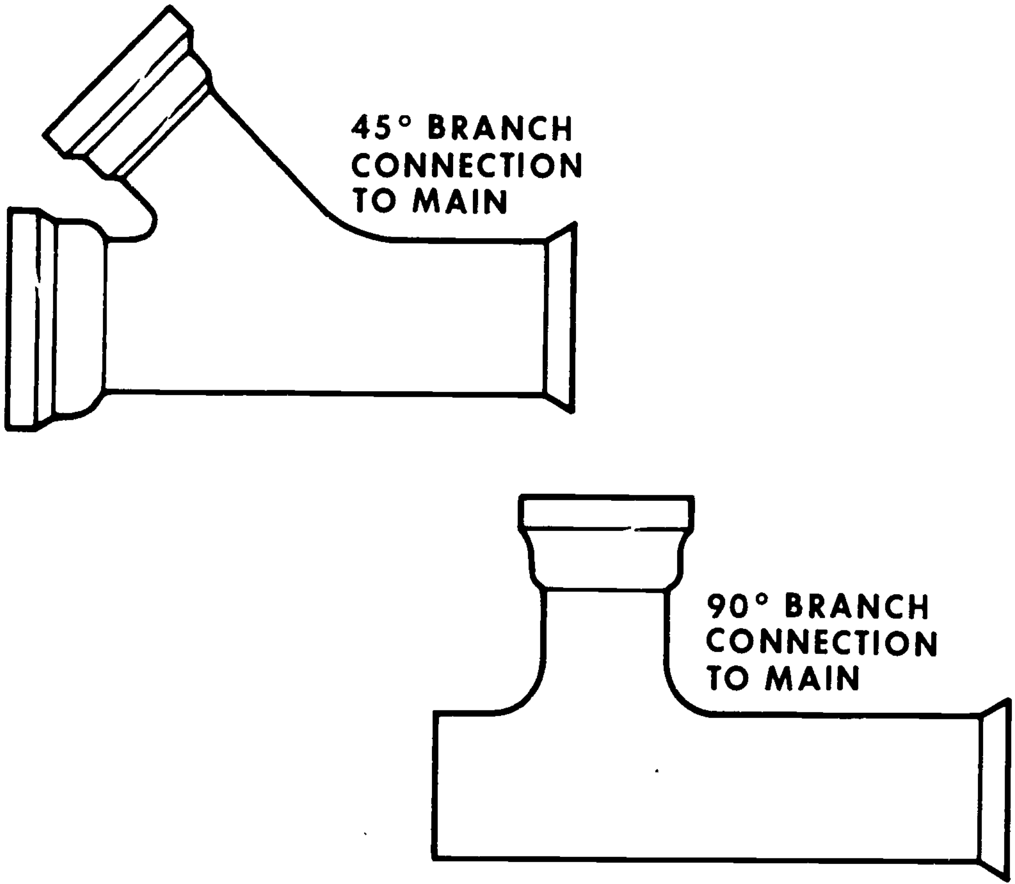



Figure 6. Typical branch connections to the main

d Fixture and branch drains - A branch drain is a waste pipe that collects the waste from two or more fixtures and conveys it to the building or house sewer. They are sized in the same way as the house sewer the fact being taken into account that all water closets must have a minimum 3-inch-diameter drain, and only two water closets may connect into one 3-inch drain.

All branch drains must join the house drain with a "Y"-type fitting as shown in Figure 6. The same is true for fixture drains joining branch drains.

The "Y" fitting is used to eliminate, as much as possible, the deposit of solids in or near the connection. A build-up of these solids will cause a blockage in the drain.

The recommended minimum size of fixture drain is shown in Table 3.

e Traps - A plumbing trap is a device used in a waste system to prevent the passage of sewer gas into the structure and yet not hinder the fixture's discharge to any great extent. All fixtures connected to a household plumbing system should have a trap installed in the line.

Table 3 MINIMUM FIXTURE SERVICE

| Fixture | Supply line, in. | Vent line, in. | Drain line, in. |
|---|---|---|---|
| Bathtub | ½ | 1½ | 1½-2 |
| Kitchen sink | ½ | 1½ | 1½ |
| Lavatory | 3/8 | 1¼ | 1¼ |
| Laundry sink | ½ | 1½ | 1½ |
| Shower | ½ | 2 | 2 |
| Water closet (tank) | 3/8 | 3 | 3 |

The effect of sewer gases on the human body are known; many are extremely harmful. Since certain sewer gases are explosive, a trap will prevent these gases from passing into the structure.

1) "P" trap - The most common trap found today is the "P" trap. Figure 7 is a drawing of a "P" trap.

   The depth of the seal in a trap is usually 2 inches. A deep seal trap has a 4-inch seal.

   As was mentioned earlier, the purpose of a trap is to seal out sewer gases from the structure. Since a plumbing system is subject to wide variations in flow, and this flow originates in many different sections of the system, there is a wide variation in pressures in the waste lines. These pressure differences tend to destroy the water seal in the trap.

   To counter act this problem mechanical traps were introduced. It has been found, however, that the corrosive liquids flowing in the system corrode or jam these mechanical traps. It is for this reason that most plumbing codes prohibit mechanical traps.

   There are many manufactures of traps, and all have varied the design somewhat. Figures 8 and 9 show various types of "P" traps. The "P" trap is usually found in lavatories, sinks, urinals, drinking fountains, showers, and other installations that do not waste a great deal of water.

2) Drum trap - The drum trap is another water seal-type trap. They are usually used in the 4- × 5-inch or 4- × 8-inch sizes. These traps have a greater sealing capacity than the "P" trap and pass large amounts of water quickly. Figure 10 shows a drum trap.

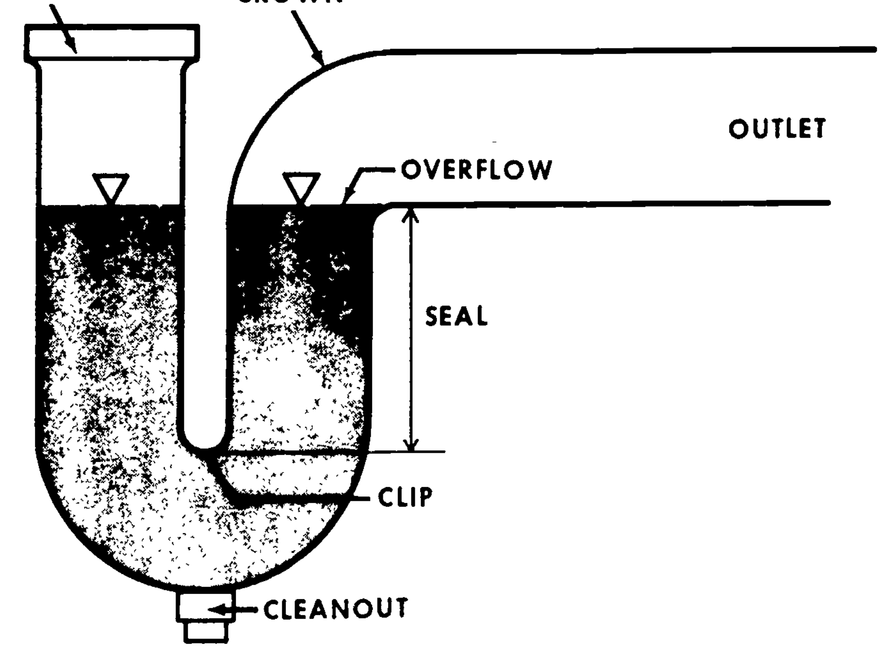



Figure 7. Diagram of a "P" trap

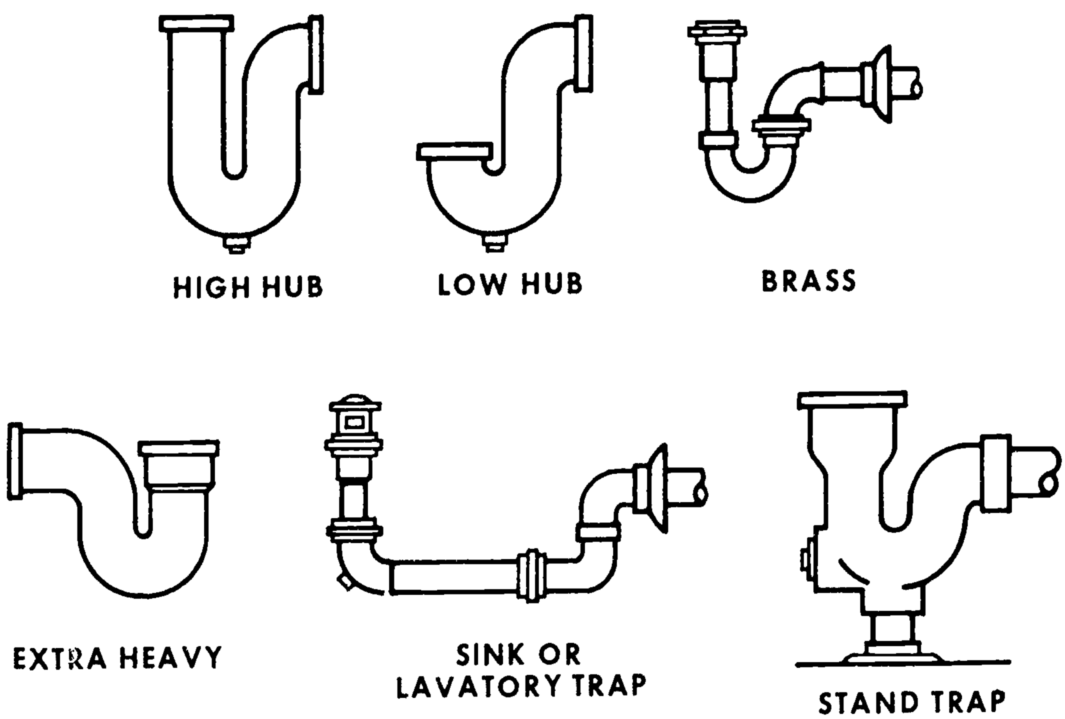



Figure 8. Various types of "P" traps

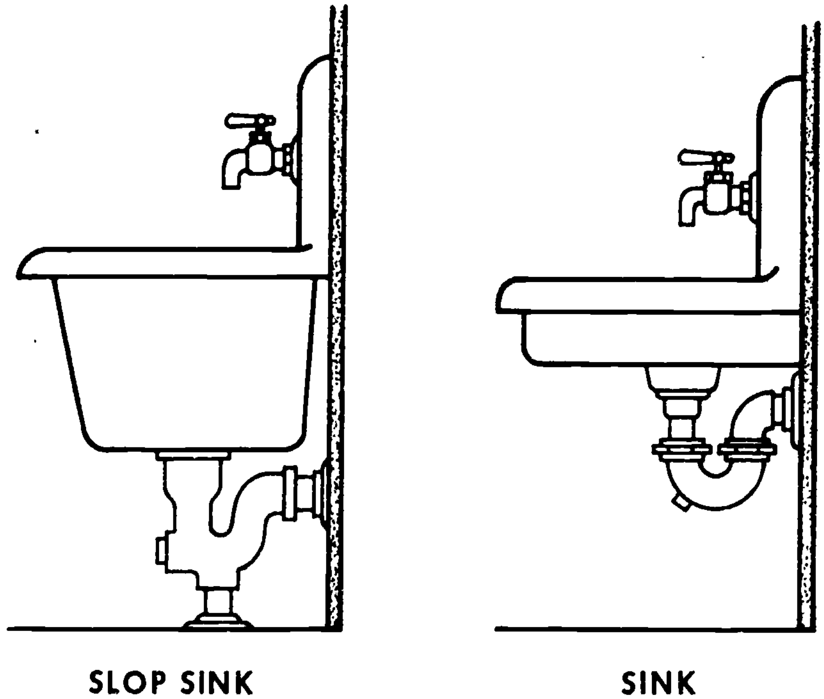



Figure 9. Traps on wall-hung fixtures

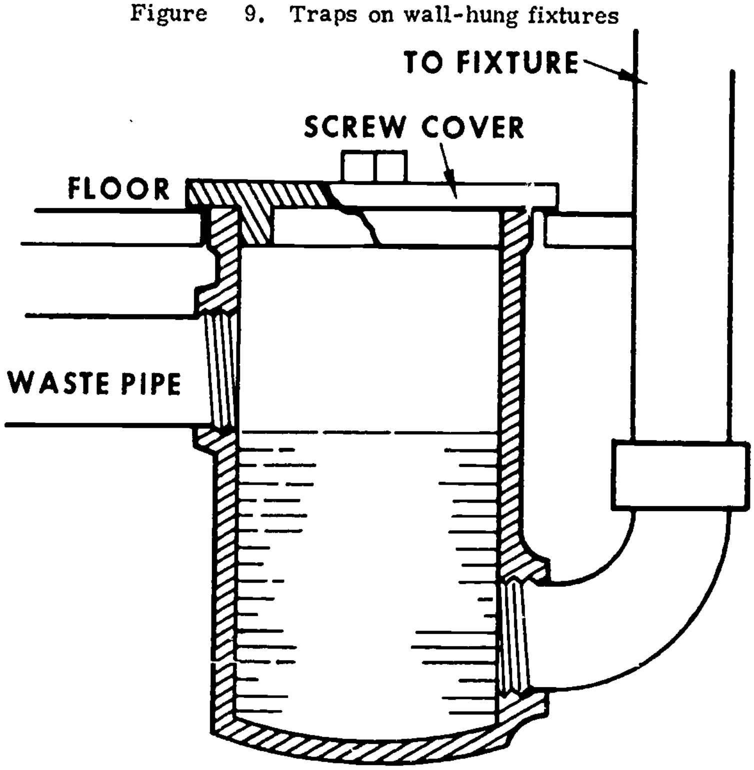
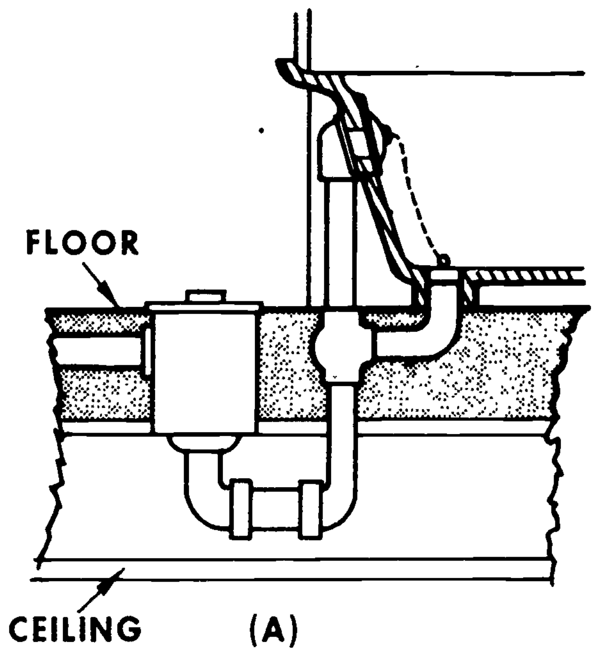



Figure 10. Four- by 8-inch drum trap

Drum traps are commonly connected to bathtubs, foot baths, sitz baths, and modified shower baths.

Figure 11 shows a drum trap connected to a bathtub and shower.



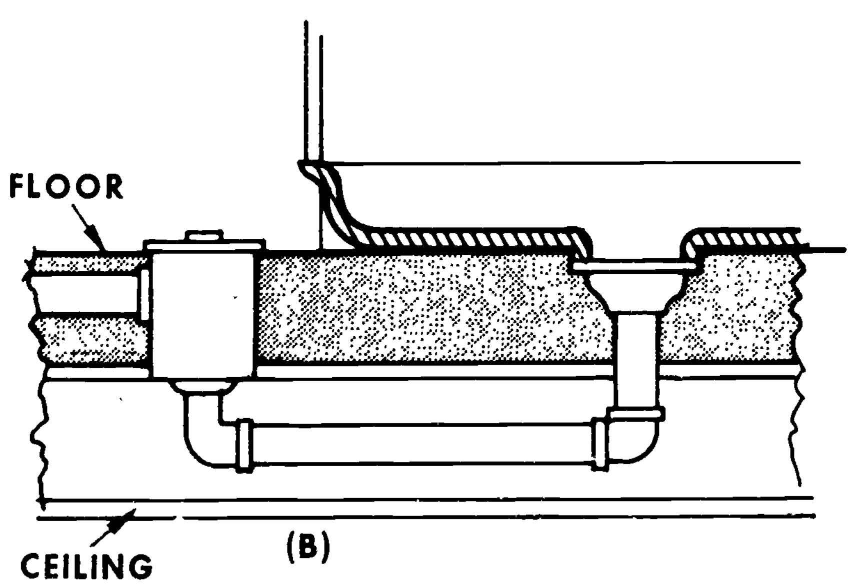




Figure 11. (A) Drum trap on bathtub outlet
(B) Drum trap on shower installation

3) Objectionable traps - The "S" trap and the 3/4 "S" trap should not be used in plumbing installations. They are almost impossible to ventilate properly, and the 3/4 "S" trap forms a perfect siphon.

The bag trap, an extreme form of "S" trap, is seldom found. Figure 12 shows these types of "s" traps.

Figure 13 shows one type of mechanically sealed trap. Any trap that depends on a moving part for its effectiveness is usually inadequate and has been prohibited by the local plumbing codes.

Figure 14 shows various types of internal partition traps. These traps work, but their construction usually results in their being higher priced than the "P" or drum traps.

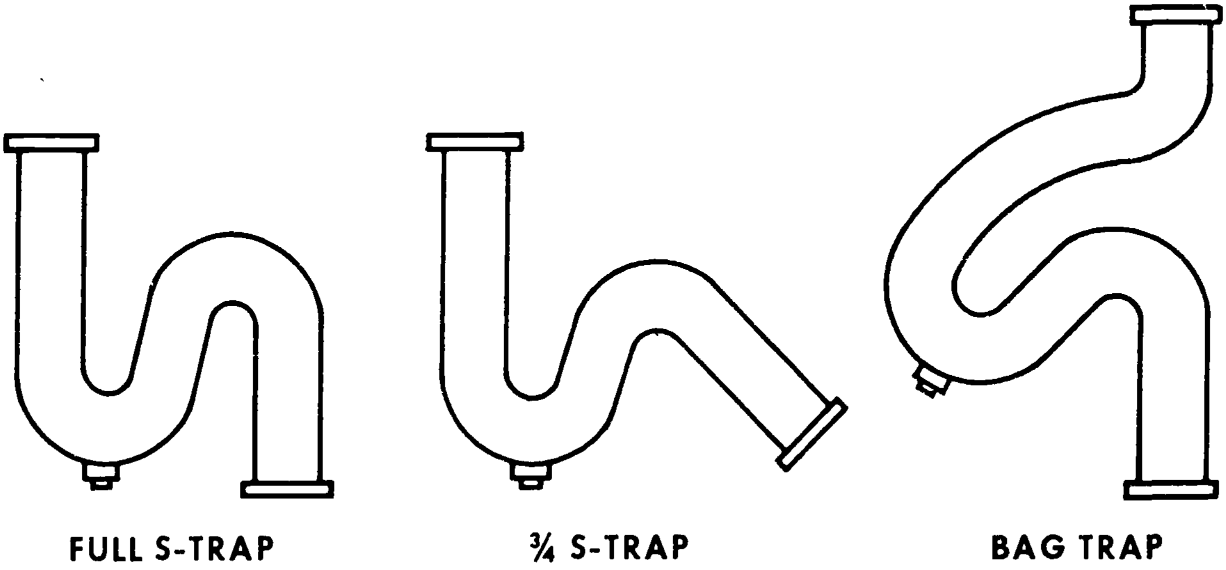



Figure 12. Types of "S" traps

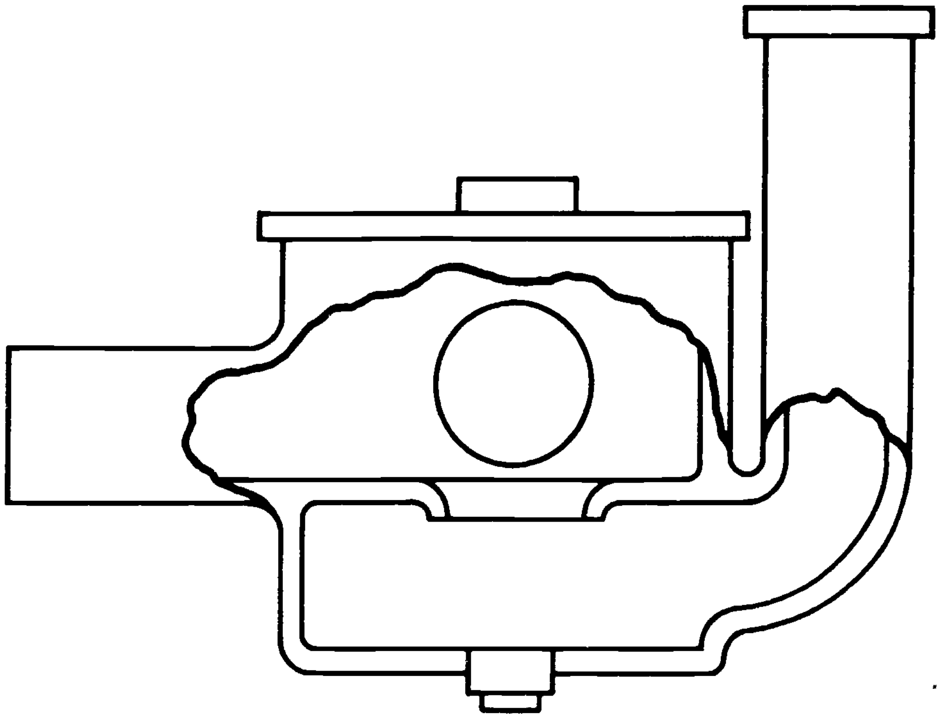


Figure 13. Mechanically sealed trap

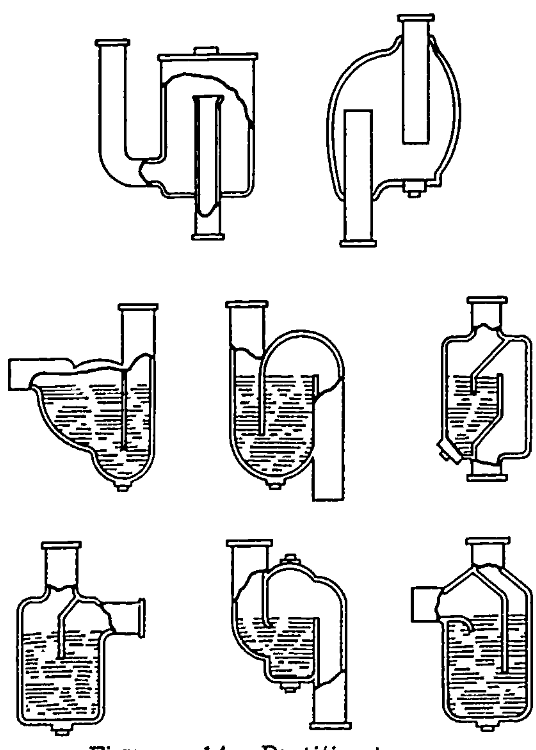


Figure 14. Partition traps

It should be remembered that a trap is used only to prevent the escape of sewer gas into the structure. They do not compensate for pressure variations. Only proper venting will eliminate pressure problems.

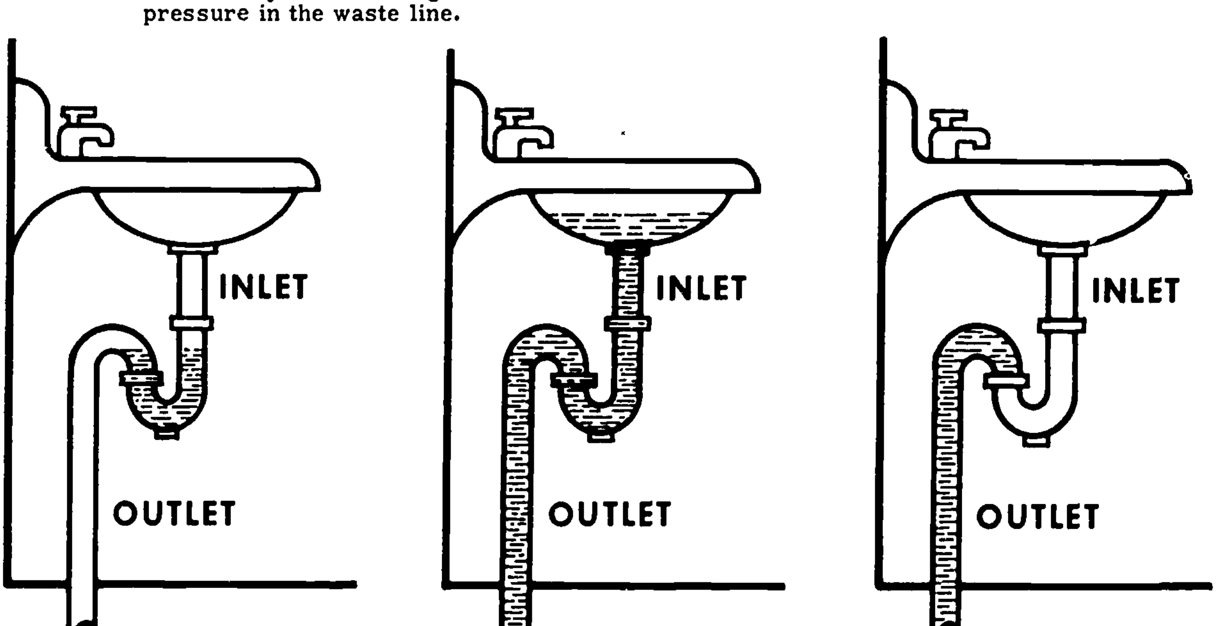
f Ventilation - A plumbing system is ventilated to prevent trap seal loss, material deterioration, and flow retardation.

1) Trap seal loss - The seal in a plumbing trap may be lost due to: Siphonage (direct and indirect or momentum), back pressure, evaporation, capillary attraction, or wind effect. The first two named are probably the most common causes of loss.

If a waste pipe is placed vertically after the fixture trap, as in an "S" trap, the waste water continues to flow after the fixture is emptied and clears the trap. This is caused by the pressure of air on the fixture water's being greater than the pressure of air in the waste pipe. The action of the water discharging into the waste pipe removes the air from that pipe and thereby causes a negative pressure in the waste line.

In the case of indirect or momentum siphonage, the flow of water past the entrance to a fixture drain in the waste pipe removes air from the fixture drain. This reduces the air pressure in the fixture drain, and the entire assembly acts as an aspirator such as the physician uses to spray an infected throat. Figures 15 and 16 show examples of siphonage.

2) Back pressure - The flow of water in a soil pipe varies according to the fixtures being used. A lavatory gives a small flow and a water closet a large flow. Small flows tend to cling to the sides of the pipe, but large ones form a slug of waste as they drop. As this slug of water falls down the pipe the air in front of it becomes pressurized. As the pressure builds it seeks an escape point. This point is either a vent or a fixture outlet. If the vent is plugged or there is no vent the only escape for this air is the fixture outlet. The air pressure forces the trap seal up the pipe into the fixture. If the pressure is great enough the seal is blown out of the fixture entirely. Figures 17 and 18 illustrate this type of problem.




Figures 15. Examples of direct siphonage: (a) Seal intact, (b) fixture discharging, (c) loss of seal

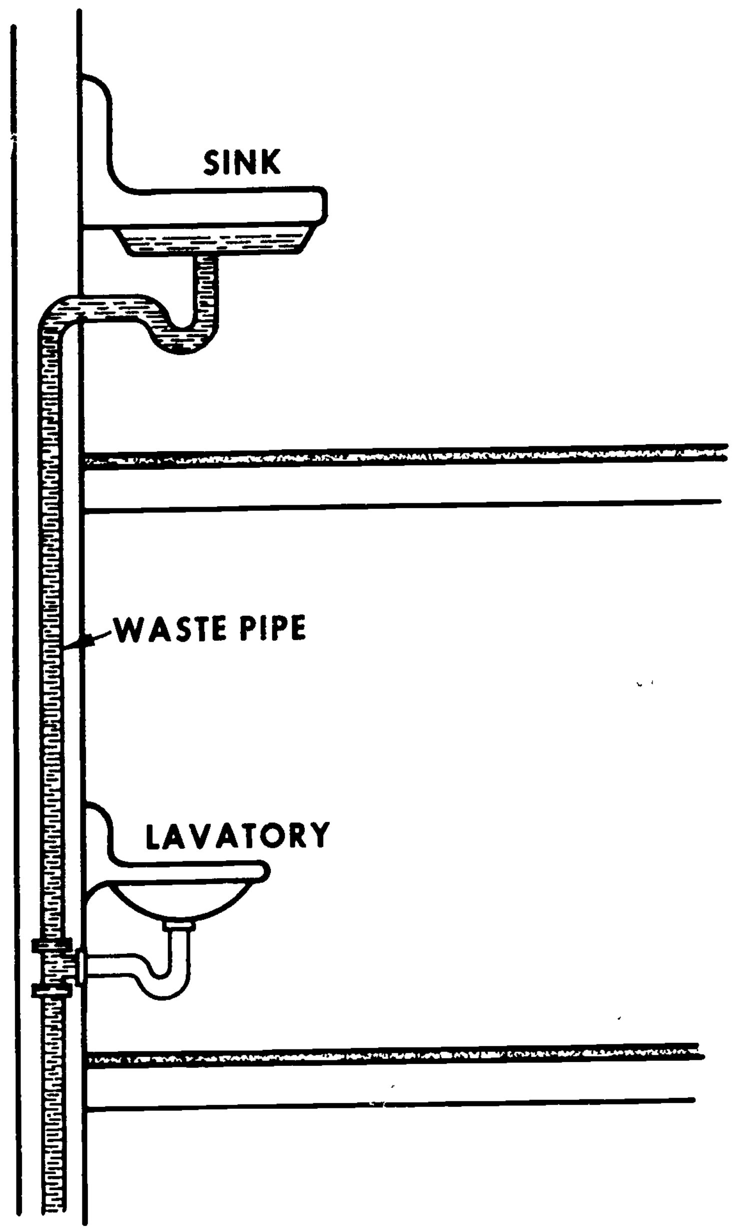



Figure 16. Loss of trap seal by indirect siphonage

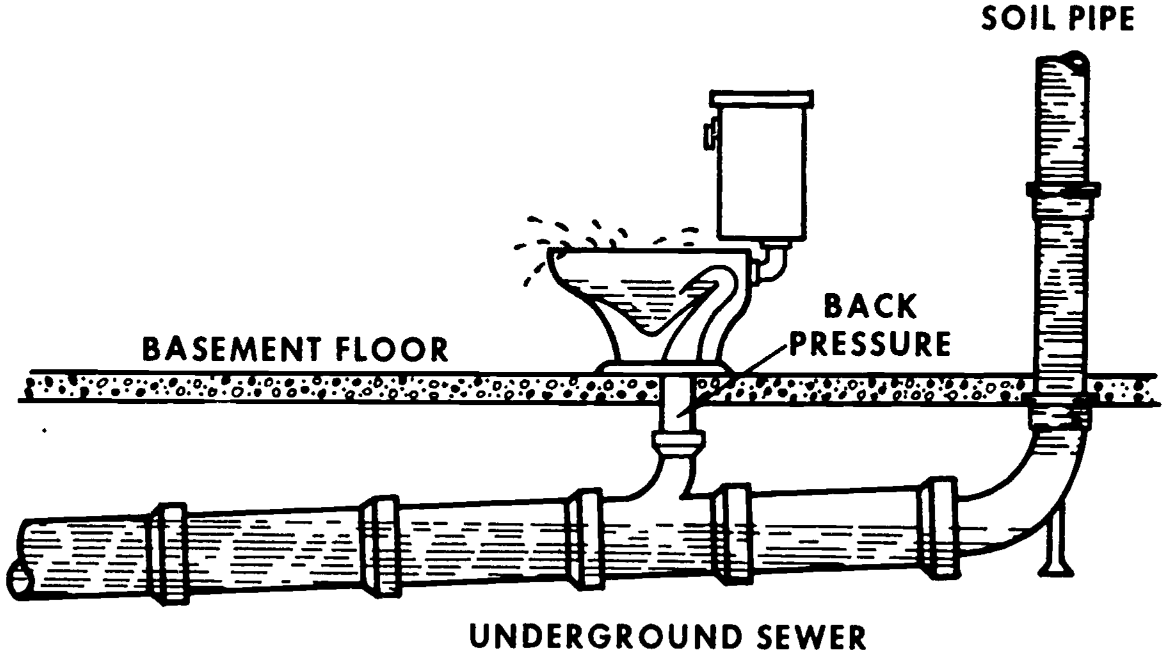



Figure 17. Loss of trap seal as a result of back pressure

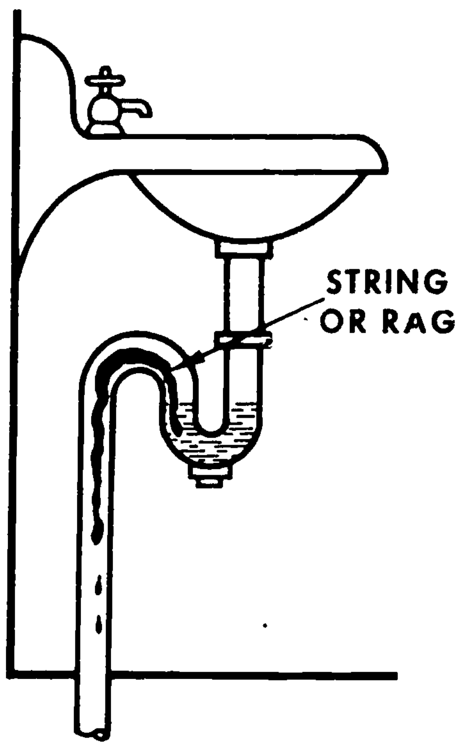



Figure 18. Loss of trap seal by capillary attraction

3) Vent sizing - Vent pipe installation is similar to that of soil and waste pipe. The same fixture unit criteria are used. Table 3 shows minimum vent pipe sizes.

   Vent pipes of less than $1\frac{1}{4}$ inches in diameter should not be used. Vents smaller than this diameter tend to clog and do not perform their function.

4) Individual fixture ventilation - Figures 19 shows a typical installation of a wall-hung plumbing unit. This type of ventilation is generally used for sinks, lavatories, drinking fountains, and so forth.

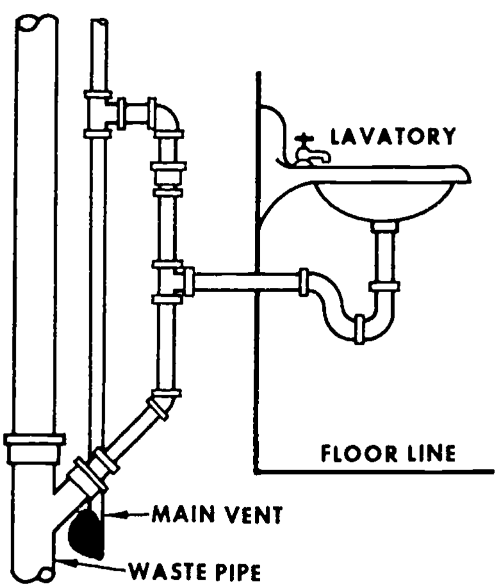



Figure 19. Individual ventilation of lavatories, sinks, drinking fountains, etc.

Figure 20 shows a typical installation of a bathtub or shower ventilation system.

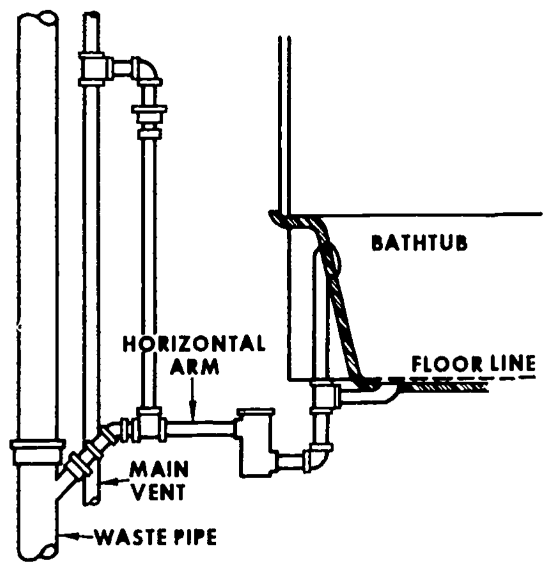



Figure 20. Individual ventilation of bathtubs, showers and urinals

Figure 21 shows the proper vent connection for a water closet or slop sink. The water closet can be either a tank type or a flushometer valve type.

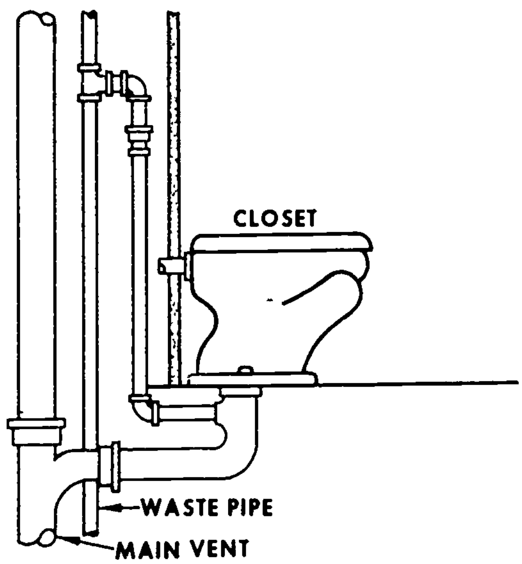



Figure 21. Individual ventilation of water closets, clinic sinks, slop sinks, etc.

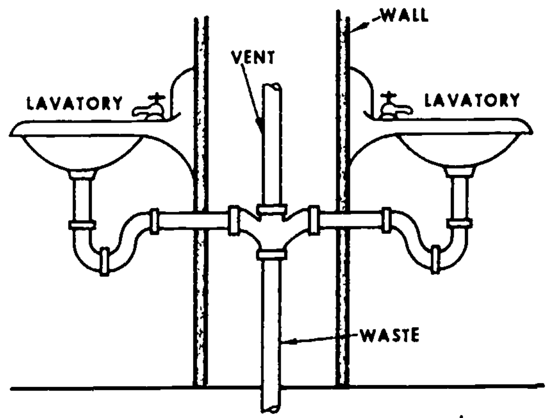



Figure 22. Unit vent method of ventilating wall-hung fixture traps

5) Unit venting - Figures 22 to 24 picture a back-to-back ventilation system for various common plumbing fixtures. The unit venting system is commonly used in apartment buildings. This type of system saves a great deal of money and space when fixtures are placed back to back in separate apartments.

Figure 25 shows a double combination "Y" used for joining the fixtures to the common soil pipe. The deflectors are to prevent waste from one fixture flowing back up into the waste in the attached fixture on the other side of the wall.

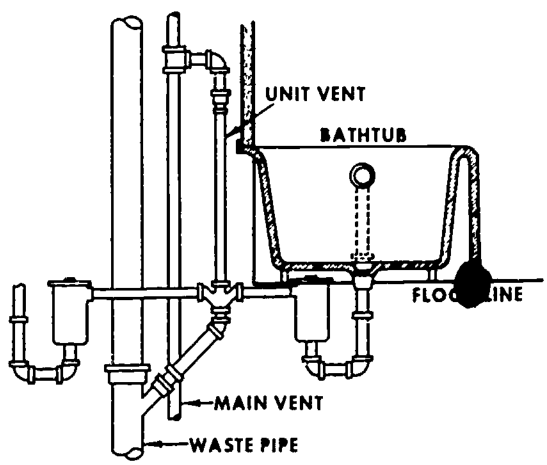



Figure 23. Unit vent used in bathtub installation

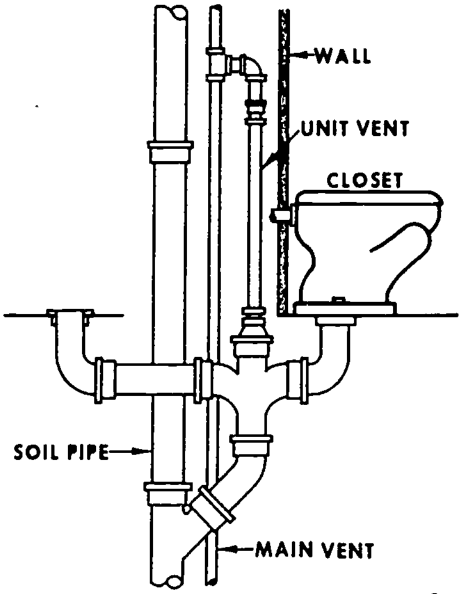



Figure 24. Unit vent used in water closet installation

6) Wet venting - Wet venting of a plumbing system is common in household bathroom fixture grouping. It is exactly what the name implies: the vent pipe is used as a waste line. Figure 26 shows a typical wet-vent installation in a home.

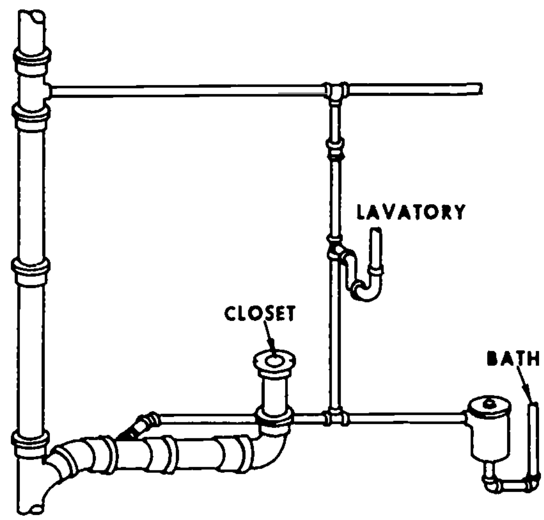



Figure 26. Wet vent used in connection with bathroom group of fixtures

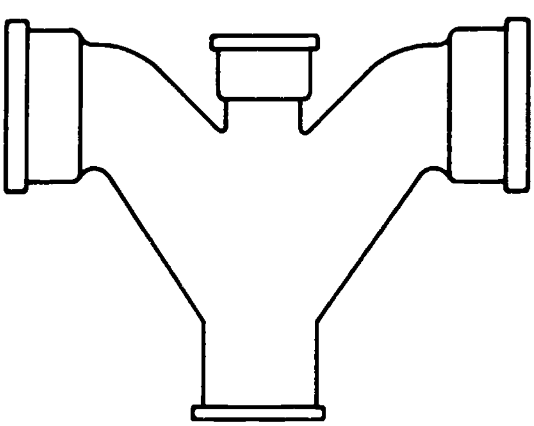


Figure 25. Double combination Y and 1/8 bend with deflectors

7) Total drainage system - Up to now we have talked about the drain, soil waste, and vent systems of a plumbing system separately. For a working system, however, they must all be connected. Figures 27 through 32 show some typical drainage systems that are found in homes and small apartment buildings.

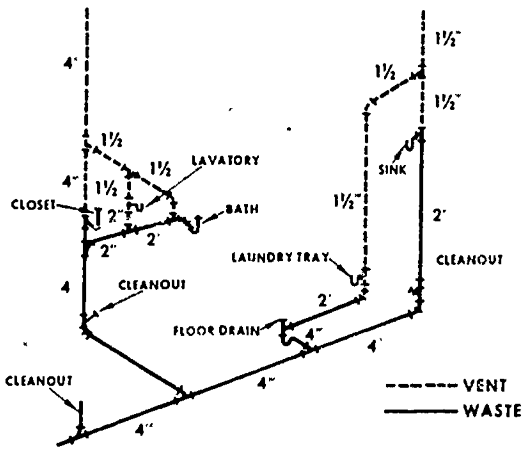



Figure 27. Drain soil waste and vent pipe layout

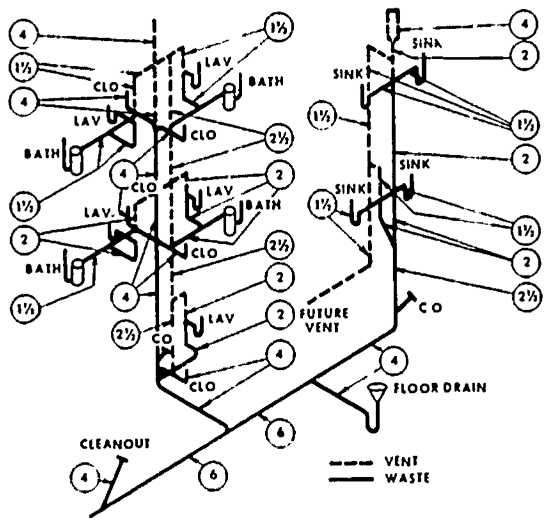



Figure 29. Typical plumbing layout for a two-story apartment building

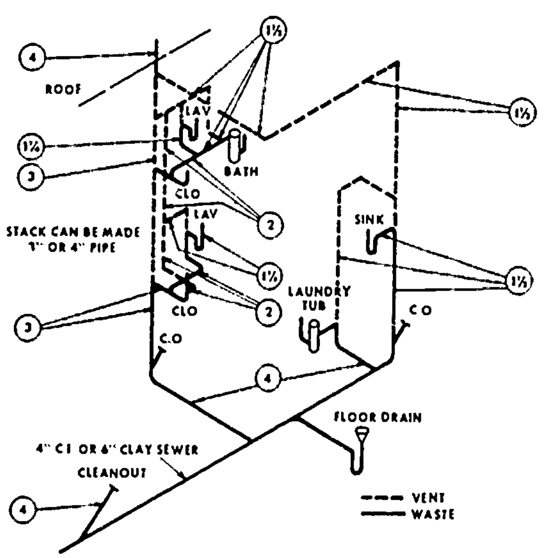



Figure 28. Plumbing layout for a two-story residence, showing individual ventilation of fixtures

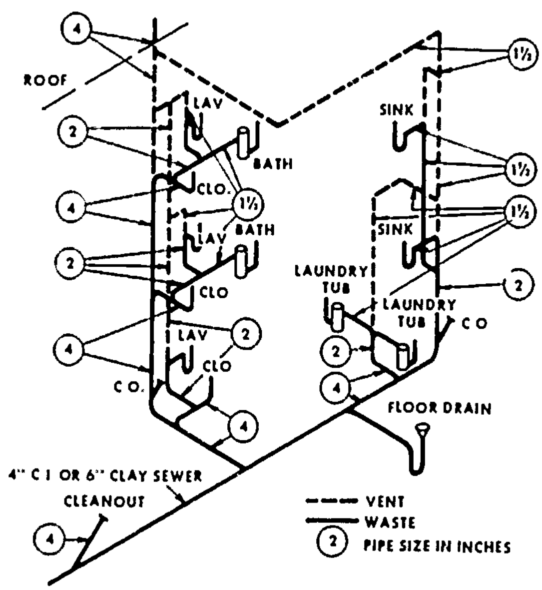



Figure 30. Plumbing layout for a duple:: residence

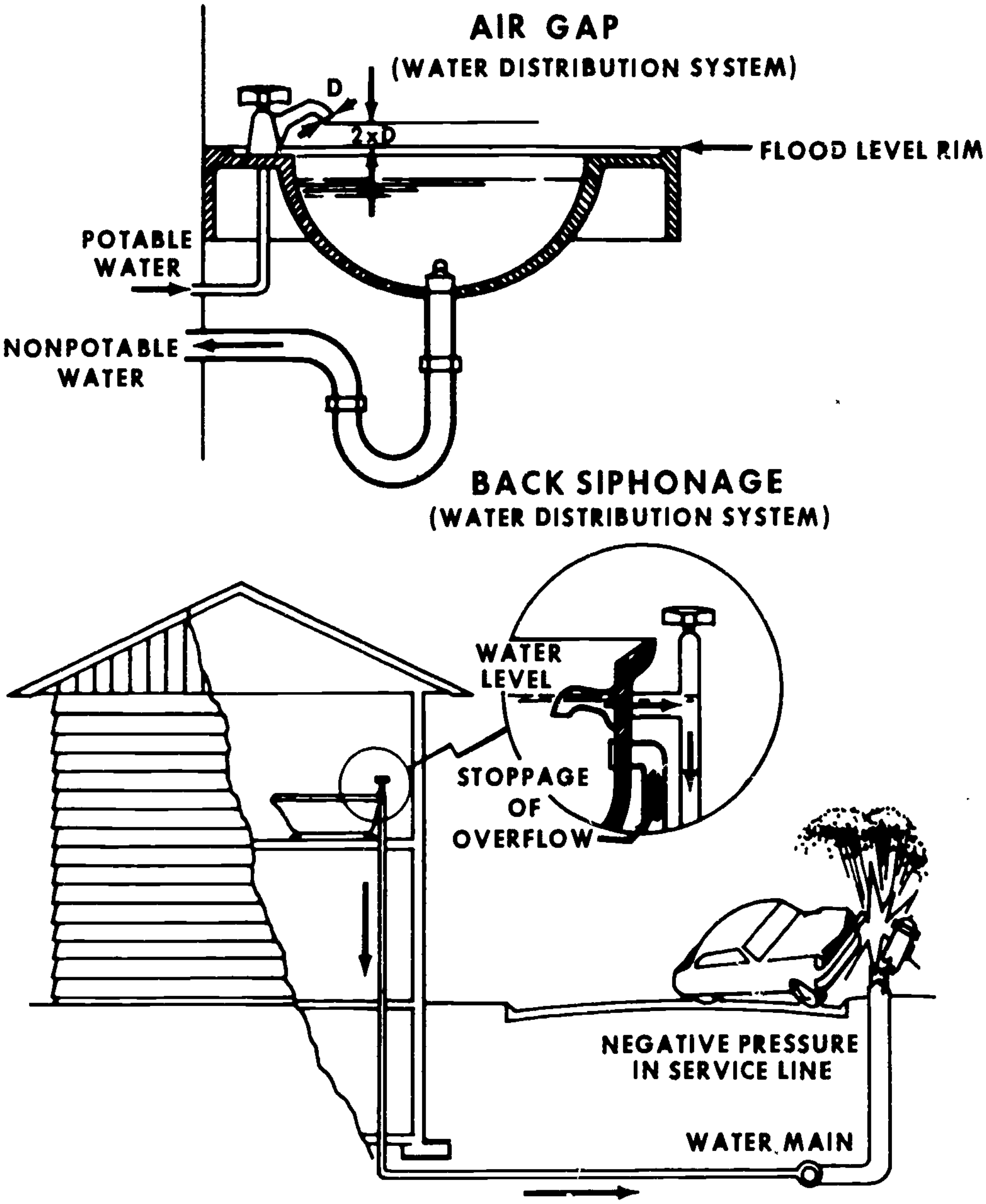



Figure 31. Cross Connection

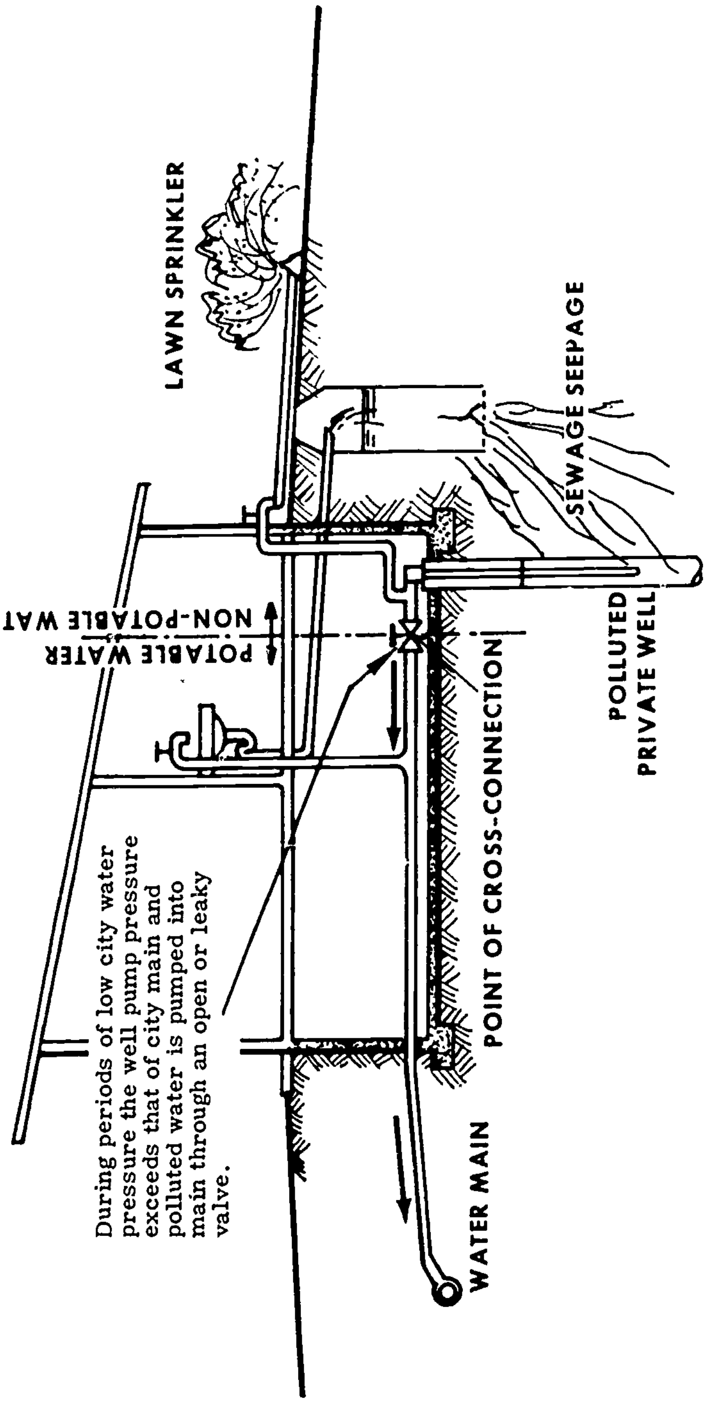



Figure 32. Direct Cross Connection

Chapter 6

# HEATING AND ENVIRONMENTAL CONTROL

## I INTRODUCTION

The function of a heating system is to provide for human comfort. To attain this comfort a constant rate of body heat loss must be maintained. The variables to be controlled are temperature, air motion, and relative humidity. Temperature must be maintained uniformly throughout the heated area. Field experience indicates a variance from 6 to 10 degrees F from floor to ceiling. The adequacy of the heating device and the tightness of the structure or room determine the degree of personal comfort within the dwelling.

Coal, wood, oil, gas, and electric are the main sources of heat energy. Heating systems commonly used are steam, hot water, and hot air. The housing inspector should have a knowledge of the various heating fuels and systems to be able to determine their adequacy and safety in operation. To cover fully all aspects of the heating system, the entire area and physical components of the system must be considered.

## II DEFINITIONS

A Anti-flooding Control - A safety control that shuts off fuel and ignition when excessive fuel accumulates in the appliance.

B Appliance:

1 High-heat - a unit that operates with flue entrance temperature of combustion products above 1,500°F.

2 Medium heat - same as high-heat, except 600°F.

3 Low heat -same as high heat, except below 600°F.

C Boiler:

1 High pressure - a boiler furnishing pressure at 15 psi or more.

2 Low pressure - (hot water or steam)—a boiler furnishing steam at a pressure less than 15 psi or hot water not more than 30 pounds.

D Burner - A device that provides the mixing of fuel, oxygen, and ignition in a combustion chamber.

E Chimney - A vertical enclosure containing one or more passageways.

1 Factory-built chimney - a tested and accredited flue for venting gas appliances, incinerators, and solid- or liquid-fuel-burning appliances.

2 Masonry chimney - a field-constructed chimney built of masonry and lined with terra cotta flue or fire brick.

3 Metal chimney - a field-constructed chimney of metal.

4 Chimney Connector - A pipe or breeching that connects the heating appliance to the chimney (smoke pipe).

F Clearance - The distance separating the appliance, chimney connector, plenum, and flue from the nearest surface of combustible material.

G Central Heating System - A boiler or furnace, flue connected, installed as an integral part of the structure and designed to supply heat adequately for the structure.

H Controls:

1 High-low limit control - an automatic control that responds to liquid level changes and pressure or temperature changes and that limits operation of the appliance to be controlled.

2 Primary safety control - the automatic safety control intended to prevent abnormal discharge of oil at the burner in case of ignition failure or flame failure.

3 Combustion safety control - a primary safety control that responds to flame properties, sensing the presence of flame and causing fuel to be shut off in event of flame failure.

I Convector - A convector is a radiator that supplies a maximum amount of heat by convection, using many closed-spaced metal fins fitted onto pipes that direct hot water or steam and thereby heat the circulating air.

1 Conversion - a boiler or furnace, flue connected, originally designed for solid fuel but converted for liquid or gas fuel.

2 Damper - a valve for regulating draft. Generally located on the exhaust side of the combustion chamber usually in the chimney connector.

3 Draft Hood - a device placed in and made a part of the vent connector (chimney connector or smoke pipe) from an appliance, or in the appliance itself, that is designed to (a) ensure the ready escape of the products of combustion in the event of no draft, back-draft, or stoppage beyond the draft hood; (b) prevent backdraft from entering the appliance; (c) neutralize the effect of stack action of the chimney flue upon appliance operation.

4 Draft Regulator - a device that functions to maintain a desired draft in oil-fired appliances by automatically reducing the chimney draft to the desired value. Sometimes this device is referred to, in the field, as air-balance, air-stat, or flue velocity control.

5 Fuel Oil - a liquid mixture or compound derived from petroleum that does not emit flammable vapor below a temperature of 125°F.

6 Heat - the warming of a building, apartment, or room by a stove, furnace, or electricity.

7 Heating Plant - the furnace, boiler, or the other heating devices used to generate steam, hot water, or hot air, which then is circulated through a distribution system. It uses coal, gas, oil, or wood as its source of heat.

8 Limit Control - a thermostatic device installed in the duct system to shutoff the supply of heat at a predetermined temperature of the circulated air.

9 Oil Burner - a device for burning oil in heating appliances such as boilers, furnaces, water heaters, ranges, etc. A burner of this type may be a pressure-atomizing gun type, a horizontal or vertical rotary type, or a mechanical or natural draft-vaporizing type.

10 Oil Stove - a flue-connected, self-contained, self-supporting oil-burning range or room heater equipped with an integral tank not exceeding 10 gallons, or it may be designed to be connected to a separate oil supply tank.

11 Plenum Chamber - an air compartment to which one or more distributing air ducts are connected.

12 Pump, Automatic Oil - a device that automatically pumps oil from the supply tank and delivers it in specific quantities to an oil-burning appliance. The pump or device is designed to stop pumping automatically in case of a breakage of the oil supply line.

13 Radiant Heat - a method of heating a building by means of electric coils, hot water, or steam pipes, etc., installed in the floors, walls, or ceilings.

14 Register - a grille-covered opening in a floor or wall through which hot or cold air can be introduced into a room. It may or may not be arranged to permit closing of the grille.

15 Room Heater - a self-contained, free-standing heating appliance intended for installation in the space being heated and not intended for duct connection (space heater).

16 Smoke Detector - a device installed in the plenum chamber or in the main supply air duct of an air-conditioning system to shutoff the blower automatically and close a fire damper in the presence of smoke.

17 Tank - a separate tank connected, directly or by pump, to an oil-burning appliance.

18 Thimble - a term applied to a metal or terra cotta lining for a chimney or furnace pipe.

19 Valve - Main Shut-off Valve - a manually operated valve in an oil line for the purpose of turning on or off the oil supply to the burner.

20 Vent System - the gas vent or chimney and vent connector, if used, assembled to form a continuous, unobstructed passageway from the gas appliance to the outside atmosphere for the purpose of removing vent gases.

## III FUELS

### A Coal

Classification and composition—the five types of coal are: Anthracite, semi-anthracite, bituminous, semi-bituminous, and sub-bituminous.

Coal is prepared in many sizes and combinations of size. The combustible portions of the coal are fixed carbons, volatile matter (hydrocarbons), and small amounts of sulfur. In combination with these are non-combustible elements composed of moisture and impurities that form ash. The various types differ in heat content. The heat content is determined by chemical analysis and is expressed in British Thermal Units (Btu) per pound.

The type and size of coal used are determined by the availability and by the equipment in which it is burned. The type and size of coal must be proper for the particular heating unit; that is, the furnace grate and flue size must be designed for the particular type of coal. Excessive coal gas can be generated through improper firing as a result of improper fuel or improper furnace design, or both.

The owner should be questioned about his procedure for adding coal to his furnace. It should be explained that a period of time must be allowed to pass before dampening to prevent the formation of excessive coal gas. This should also be done before dampening for the night or other periods when full draft is not required.

Improper coal furnace operations can result in an extremely hazardous and unhealthful occupancy—the inspector should be able to offer helpful operational procedures. Ventilation of the area surrounding the furnace is very important in order to prevent heat buildup and to supply air for combustion.

### B Fuel Oil

Fuel oils are derived from petroleum, which consists primarily of compounds of hydrogen and carbon (hydrocarbons) and smaller amounts of nitrogen and sulfur.

Classification of fuel oils—Domestic fuel oils are controlled by rigid specifications. Six grades of fuel oil are generally used in heating systems, the lighter two grades being used primarily for domestic heating.

These grades are:

1 Grade Number 1 - A volatile, distillate oil for use in burners that prepare fuel for burning solely by vaporization (oil-fired space heaters).

2 Grade Number 2 - A moderate-weight, volatile, distillate oil used for burners that prepare oil for burning by a combination of vaporization and atomization. This grade of oil is commonly used in domestic heating furnaces.

3 Grade Number 3 - A low-viscosity, distillate oil used in burners wherein fuel and air are prepared for burning solely by atomization.

4 Grade Number 4 - A medium-viscosity oil used in burners without preheating. (Small industrial or apartment house applications.)

5 Grade Number 5 - A medium-viscosity oil used in burners with preheaters that require an oil of lower viscosity than Grade Number 6. (Industrial or apartment house application.)

6 Grade Number 6 - A high-viscosity oil for use in burners with preheating facilities adequate for handling oil of high viscosity. (Industrial applications.)

7 Heat content - Heating values of oil vary from approximately 152,000 Btu per gallon for Number 6 oil to 136,000 Btu per gallon for Number 1.

Oil is more widely used today than coal and provides a more automatic source of heat and comfort. It also provides more complicated systems and controls.

If the oil supply is used within the basement or cellar area, certain basic regulations must be followed (see Figure 1). No more than two 275-gallon tanks may be installed above ground in the lowest story of any one building. The tank shall not be closer than 7 feet horizontally to any boiler, furnace, stove, or exposed flame. Fuel oil lines should be embedded in a concrete or cement floor or protected against damage if they run across the floor. Each tank must have a shutoff valve that will stop the flow from each tank if a leak develops in the line to or in the burner itself.

The tank or tanks must be vented to the outside, and a gauge showing the quantity of oil in the tank or tanks must be tight and operative. Tanks must be set off the floor and on a stable base so as to prevent settlement or movement that may rupture the connections.

A buried outside tank installation is shown in Figure 2.

C Gas

Commercial gas fuels are colorless gases. Some have a characteristic pungent odor, while other are odorless and cannot be detected by smell. Although gas fuels are easily handled in heating equipment, they are generally toxic and their presence in air in appreciable quantities becomes a serious health hazard. Gases diffuse readily in the air, making explosive mixtures possible. (A proportion of combustible gas and air that is ignited burns with such a high velocity that an explosive force is created.) Because of these characteristics of gas fuels, precautions must be taken to prevent leaks, and care must be exercised when gas-fire equipment is lit.

Classification of gas - Gas is broadly classified as natural or manufactured.

1 Manufactured Gas - This gas as distributed is usually a combination of certain proportions of gases produced by two or more processes as obtained from coke, coal, and petroleum. Its Btu value per cubic foot is generally closely regulated, and costs are determined on a guaranteed Btu basis, usually 520 to 540 per cubic foot.

2 Natural Gas - This gas is a mixture of several combustible and inert gases. It is one of the richest gases and is obtained from wells ordinarily located in petroleum-producing areas. The heat content may vary from 700 to 1,300 Btu's per cubic foot with a generally accepted average figure of 1,000 Btu's per cubic foot. Natural gases are distributed through pipe lines to point of utilization and are often mixed with manufactured gas to maintain a guaranteed Btu content.

3 Liquified Petroleum Gas - Principal products of liquified petroleum gas are butane and propane. Butane and propane are derived from natural gas or petroleum refinery gas and are chemically classified as hydrocarbon gases. Specifically, butane and propane are on the borderline between a liquid and a gaseous state. At ordinary atmospheric pressure butane is a gas above $33^{\circ}$F and propane a gas at $-42^{\circ}$F. These gases are mixed to produce commercial gas suitable for various climatic conditions. Butane and propane are heavier than air. The heat content of butane is 3,274 Btu's per cubic foot while that of propane is 2,519.

The gas burner should be equipped with an automatic cutoff in case the flame fails. Shutoff valves should be located within 1 foot of the burner connection and on the output side of the meter.

CAUTION - Liquified petroleum gas is heavier than air; therefore, the gas will accumulate at the bottom of confined areas. If a leak should develop, care should be taken to ventilate the appliance before lighting.

D Electricity

Electricity is gaining popularity in many regions, particularly where costs are competitive with other sources of heat energy. With an electric system, the housing inspector should rely mainly on the electrical inspector for proper installation. There are a few items, however, to be concerned with to ensure safe use of the equipment. Check to see that the units are accredited testing agency approved and installed according to the manufacturer's specifications. Most

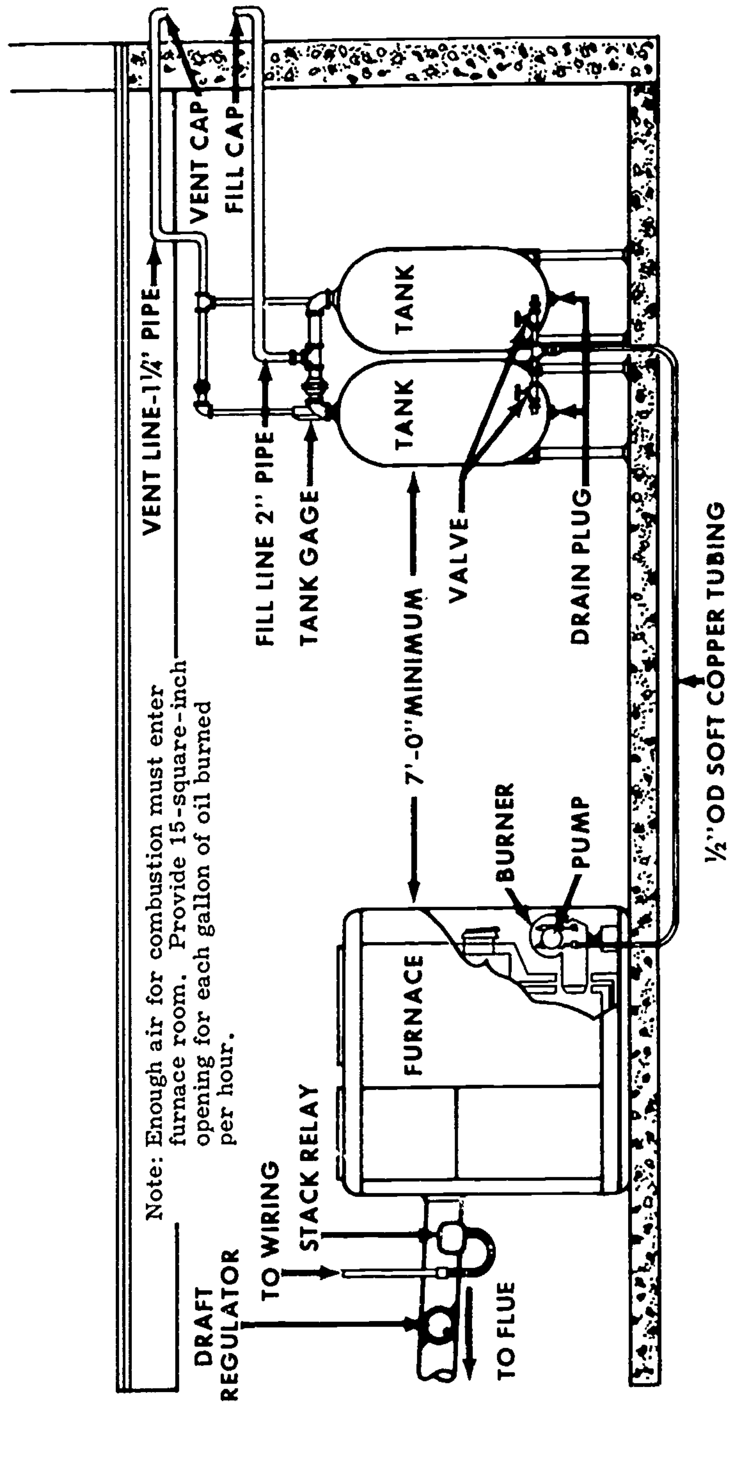



Figure 1. Piping hook-up for inside tank installation.

Note:
Enough air for combustion must enter furnace room. Provide 15-square-inch opening for each gallon of oil burned per hour.

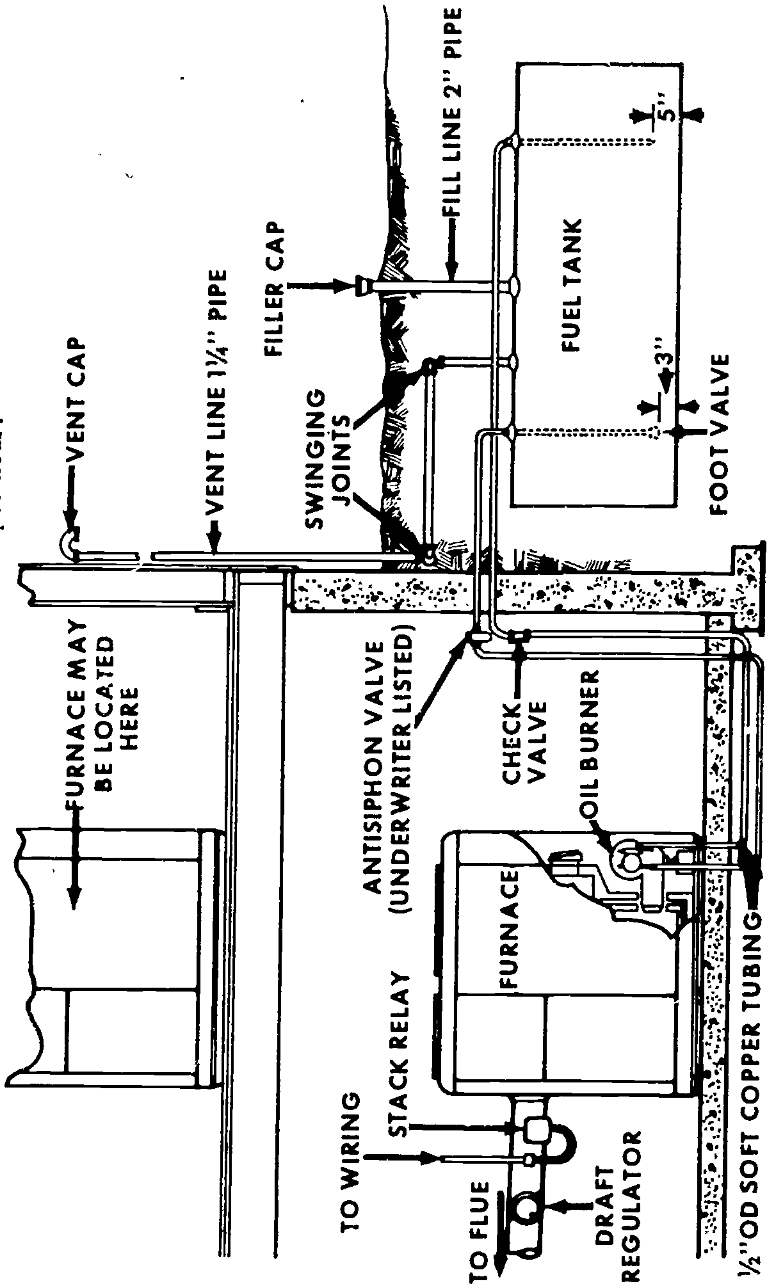



Figure 2. Piping hook-up for buried outside tank.

convector-type units are required to be installed at least 2 inches above the floor level, not only to ensure that proper convection currents are established through the unit, but also to allow sufficient air insulation from any combustible flooring material. The housing inspector should check for curtains that extend too close to the unit or loose, long pile rugs that are too close. A distance of 6 inches on the floor and 12 inches on the walls should separate rug or curtains from the appliance.

Radiant heating plastered into the ceiling or wall is technical in nature and not a part of the housing inspector's competence. He should, however, be knowledgeable about the system used. These systems are relatively new. If wires are bared in the plastering they should be treated as open and exposed wiring.

## IV CENTRAL HEATING UNITS

The boiler should be placed in a separate room whenever possible; in new construction this is usually required. In most housing inspections, however, we are dealing with existing conditions; therefore, we must adapt the situation as closely as possible to acceptable safety standards. In many old buildings the furnace is located in the center of the cellar or basement, and this location does not lend itself for practical conversion to a boiler room.

### A Boiler Location

Consider the physical requirements for a boiler room.

1 Ventilation - More circulating air is required for the boiler room than for a habitable room, in order to reduce the heat buildup caused by the boiler or furnace as well as to supply oxygen for combustion.

2 Fire Protection Rating - As specified by various codes (fire code, building code, insurance underwriters, etc.) the fire regulations must be strictly adhered to in areas surrounding the boiler or furnace. This minimum dimension from which a boiler or furnace is to be spaced from a wall or ceiling is shown in Figure 3.

Many times the enclosure of the furnace or boiler creates a problem of providing adequate air supply and ventilation for the room. Where codes and local authority permit, it may be more practical to place the furnace or boiler in an open area. The ceiling above the furnace should be fire protected to a distance of 3 feet beyond all furnace or boiler appurtenances and this area should be free of all storage material.

The furnace or boiler should be set on a firm foundation of concrete if located in the cellar or basement. If the codes permit furnace installations on the first floor, then the building code must be consulted for proper setting and location.

### B Heating Boilers

Boilers may be classified according to several kinds of characteristics. The material may be cast iron or steel. Their construction may be section, portable, fired-tube, water-tube, or special. Domestic heating boilers are generally of low-pressure type with a maximum working pressure of 15 pounds per square inch for steam and 30 pounds per square inch for hot water.

All boilers have a combustion chamber for burning fuel. Automatic fuel-firing devices help supply the fuel and control the combustion. Handfiring is accomplished by the provision of a grate, ash pit, and controllable drafts to admit air under the fuel bed and over it through slots in the firing door. A check draft is required at the smoke pipe connection to control chimney draft. The gas passes from the combustion chamber to the flue passages (smoke pipe) designed for maximum possible transfer of heat from the gas. Provisions must be made for cleaning flue passages.

The term boiler is applied to the single heat source that can supply either steam or hot-water boiler is often called a heater.

Cast iron boilers are generally classified as:

1 Square or rectangular boilers with vertical sections.

2 Round, square, or rectangular boilers with horizontal pancake sections.

Cast iron boilers are usually shipped in sections and assembled at the site.

## MINIMUM CLEARANCE FOR VARIOUS TYPES OF CENTRAL HEATING SYSTEMS

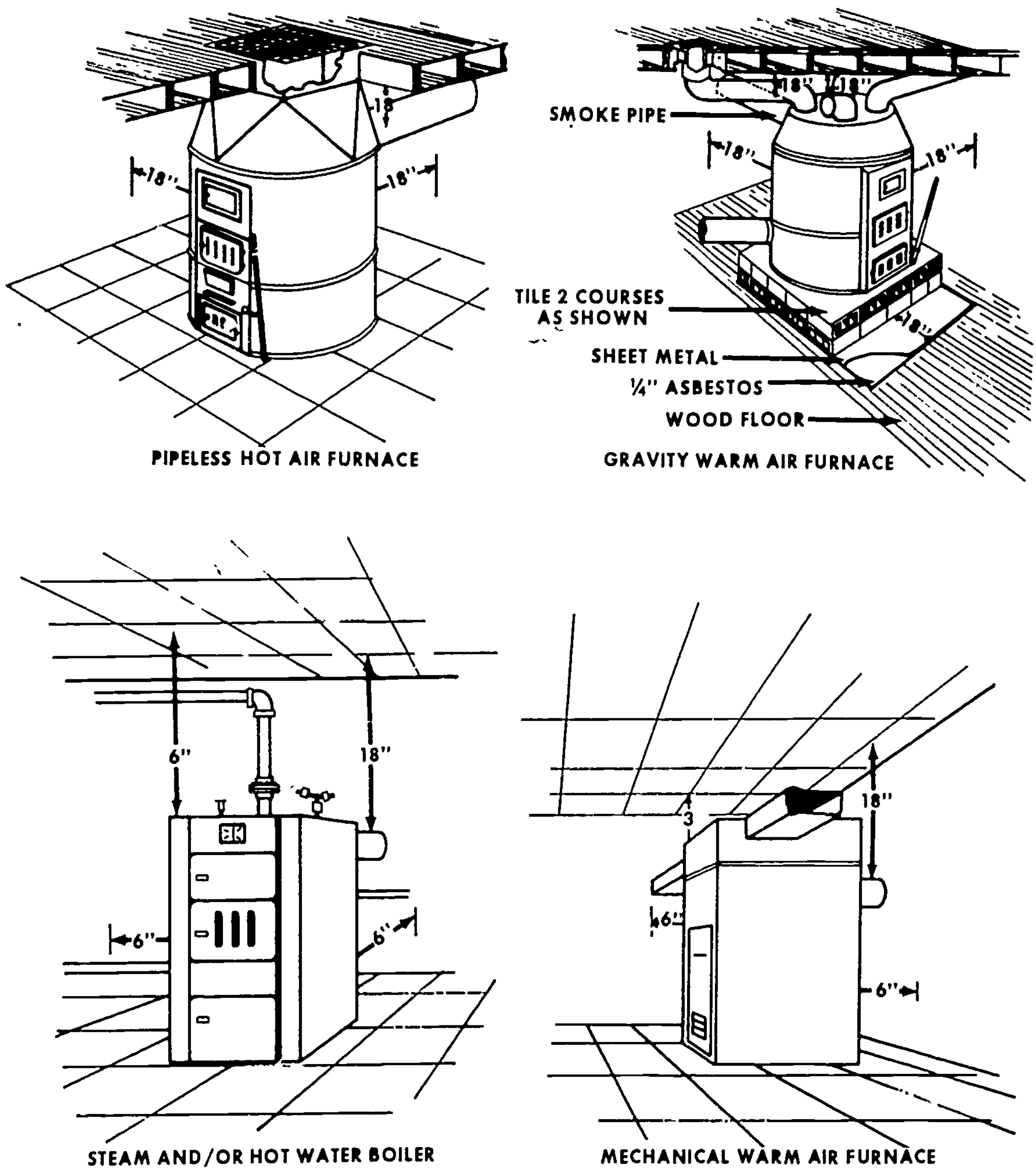



Figure 3. Minimum clearance for various types of central heating systems.

C Steel Boilers

Most steel boilers are assembled units with welded steel construction and are called portable boilers. Larger boilers are installed in refractory brick settings built on the site. Above the combustion chamber a group of tubes are suspended, usually horizontally, between two headers. If flue gases pass through the tubes and water surrounds them, the boiler is designated as the fire-tube type. When water flows through the tubes, it is termed water tube. Fire tube is the predominant type.

D Heating Furnaces

Heating furnaces are the heat sources used when air is the heat-carrying medium. Whe air circulates because of the different densitites of the heated and cooled air, the furnace is a gravity type. A fan may be included for the air circulation; this type is called a mechanical warm-air furnace. Furnaces may be of cast iron or steel and burn various types of fuel.

V FUEL-BURNING PROCEDURES AND AUTOMATIC FIRING EQUIPMENT

A Coal - Many localities throughout the nation still use coal as a heating fuel.

1 Hand Stoking - In many older furnaces, the coal is stoked or fed into the fire box by hand.

2 Automatic Stokers - The single-retort, underfeed-type bituminous coal stoker is the most commonly used domestic-type steam or hot water boiler (see Figure 4). The stoker consists of a coal hopper, a screw for conveying coal from hopper to retort, a fan that supplies air for combustion, a transmission for driving coalfeed and fan, and an electric motor for supplying power. The air for combustion is admitted to the fuel through tuyeres at the top of the retort. The stoker feeds coal to the furnace intermittently in accordance with the temperature or pressure demands.

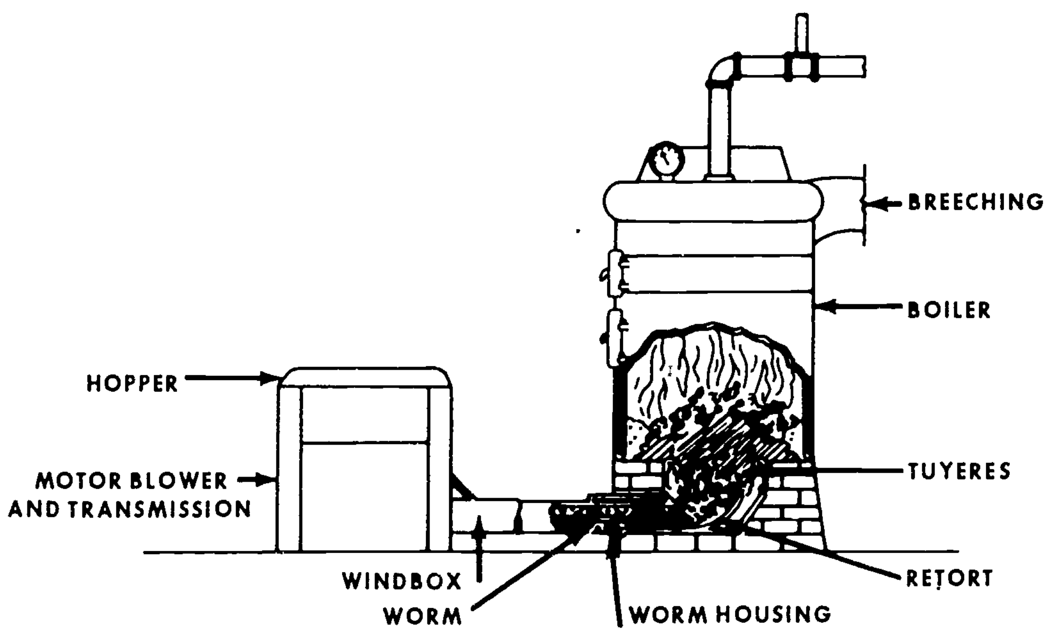



Figure 4. Typical underfeed coal stoker installation in small boiler.

B Oil Burners - Oil burners are broadly designated as distillate, domestic, and commercial or industrial. Distillate burners are usually found in oil-fired space heaters. Domestic oil burners are usually power driven and are used in domestic heating plants. Commercial or industrial burners are used in larger central-heating plants for steam or power generation.

1 Domestic Oil Burners - These vaporize and atomize the oil, and deliver a predetermined quantity of oil and air to the combustion chambers. Domestic oil burners operate automatically to maintain a desired temperature.

a Gun-type burners - These burners atomize the oil either by oil pressure or by low-pressure air forced through a nozzle.

The oil system pressure atomizing burner (see Figure 5) consists of a strainer, pump, pressure-regulating valve, shutoff valve, and atomizing nozzle. The air system consists of a power-drive fan and an air tube that surrounds the nozzle and electrode assembly. The fan and oil pump are generally connected directly to the motor. Oil pressures normally used are about 100 pounds per square inch, but pressures considerably in excess of this are sometimes used.

The form and parts of low-pressure air-atomizing burners (see Figure 5), are similar to high-pressure atomizing burners except for addition of a small air pump, and a different way of delivering air and oil to the nozzle or orifice.

b Vertical rotary burners - The atomizing-type burner, sometimes known as a radiant or suspended-flame burner, atomizes oil by throwing it from the circumference of a rapidly rotating motor-driven cup. The burner is installed so that the driving parts are protected from the heat of the flame by a hearth of refractory material at about the grate elevation. Oil is fed by pump or gravity, while the draft is mechanical or a combination of natural and mechanical.

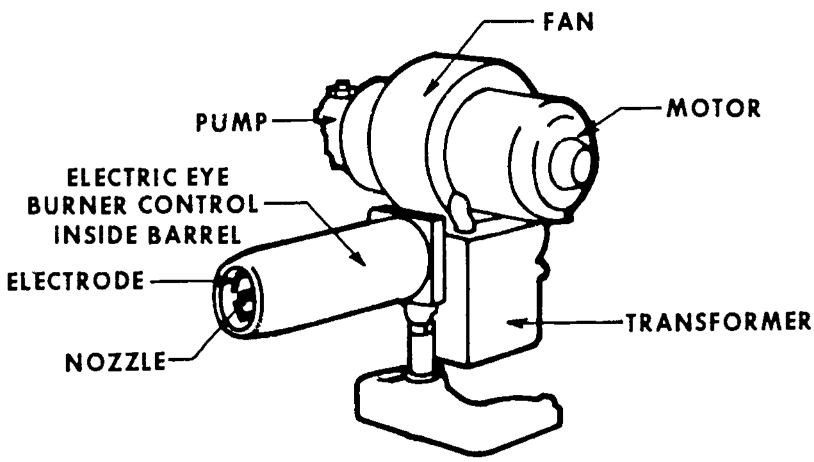



Figure 5. Cut-away of typical high-pressure gun burner.

c Horizontal rotary burners - These were originally designed for commercial and industrial use but are available in sizes suitable for domestic use. In this burner, oil is atomized by being thrown in a conical spray from a rapidly rotating cup. Horizontal rotary burners employ electric-gas or gas-pilot ignition and operate with a wide range of fuels. The vertical rotary burner and the gun-type burner operate primarily with Numbers 1 and 2 fuel oil. Primarily safety controls for burner operation are necessary. An anti-flooding device must be a part of the system so that, if ignition in the burner should fail, the oil will not continue to flow. Likewise, a stack control is necessary to shut-off the burner if the stack temperatures become excessive. A reset button on the older stack control units releases if excessive (predetermined) temperatures are exceeded and thus cuts off all power to the burner. This button must be reset before starting can be attempted. The newer models now use electric eye-type control on the burner itself.

2 Ignition - On the basis of the method employed to ignite fuels, burners are divided into five groups as follows:

a Electric - A high-voltage electric spark is blown in the path of an oil and air mixture and causes ignition. This electric spark may be continuous or may be in operation only long enough to ignite the oil. Electric ignition is almost universally used. Electrodes are located near the nozzles (see Figure 5) but not in the path of the oil spray.

b Gas pilot - A small gas pilot light that burns continuously is frequently used. Gas pilots usually have expanding gas valves that automatically increase flame size when motor circuit starts. After a fixed interval, the flame reverts to normal size.

c Electric gas - An electric spark ignites a gas jet, which in turn ignites the oil-air mixture.

d Oil pilot - A small oil flame is used.

e Manual - A burning wick or torch is placed in the combustion space through peepholes and thus ignites the charge. Operator should stand to one side of the fire door to guard against injury from chance explosion.

VI REFRACTORY

The refractory lining or material should be an insulating fireproof brick-like substance. Never use ordinary firebrick. The insulating brick should be set on end so as to build a 2 inch-thick wall in the pot. Size and shape of the refractory pot vary from furnace to furnace (see Figure 6 for various shapes). The shape can be either round or square, whichever is more convenient to build. It is important to use a special cement having properties similar to that of the insulating refractory-type brick.

VII HEATING SYSTEMS

A Steam Heating Systems - Steam heating systems are classified according to the pipe arrangement, accessories used, method of returning the condensate to the boiler, method of expelling air from the system, or the type of control employed. The successful operation of a steam heating system consists of generating steam in sufficient quantity to equalize building heat loss at maximum efficiency, expelling entrapped air, and returning all condensate to the boiler rapidly. Steam cannot enter a space filled with air or water at at pressure equal to the steam pressure. It is important, therefore, to eliminate air and to remove water from the distribution system. All hot pipe lines exposed to contact by residents must be properly insulated or guarded.

Steam heating systems are classified according to the method of returning the condensate to the boiler.

1 Gravity One-pipe Air-vent System - The gravity one-pipe air-vent system is one of the earliest types used. The

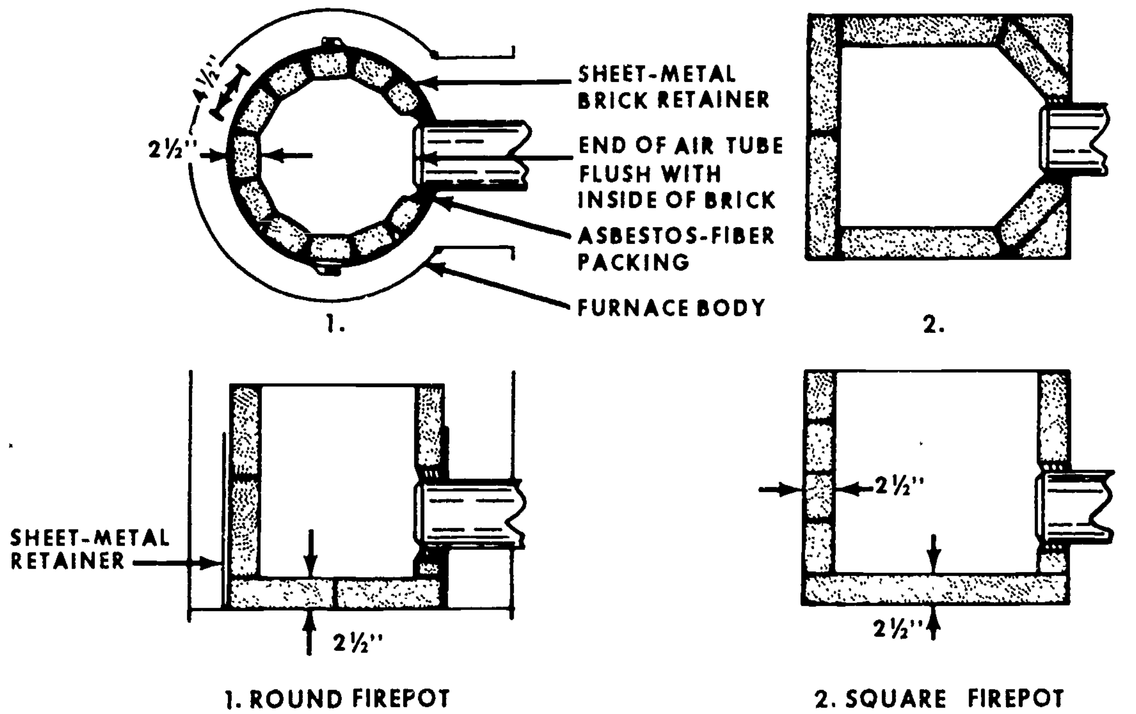



Figure 6. Refractory pot details

condensate is returned to the boiler by gravity. This system is generally found in one-building-type heating systems. The steam is supplied by the boiler and carried through a single system or pipe to radiators as shown in Figure 7. Return of the condensate is dependent on hydrostatic head. Therefore, the end of the steam main, where it attaches to the boiler, must be full of water (termed a wet return) for a distance above the boiler line to create a pressure drop balance between the boiler and the steam main.

Radiators are equipped with an inlet valve and with an air valve (see Figure 8). The air valve permits venting of air from the radiator and its displacement by steam. Condensation is drained from the radiator through the same pipe that supplies steam.

2 Two-pipe Steam Vapor System with Return Trap - The two-pipe vapor system with boiler return trap and air eliminator is an improvement of the one-pipe system. The return connection of the radiator has a thermostatic trap that permits flow of condensate and air only from the radiator and prevents steam from leaving the radiator. Since the return main is at atmospheric pressure or less, a boiler return trap is installed to equalize condensate return pressure with boiler pressure.

B Hot Water Heating Systems - All hot water heating systems are similar in design and operating principle.

1 One-pipe Gravity System - The one-pipe gravity hot water heating system

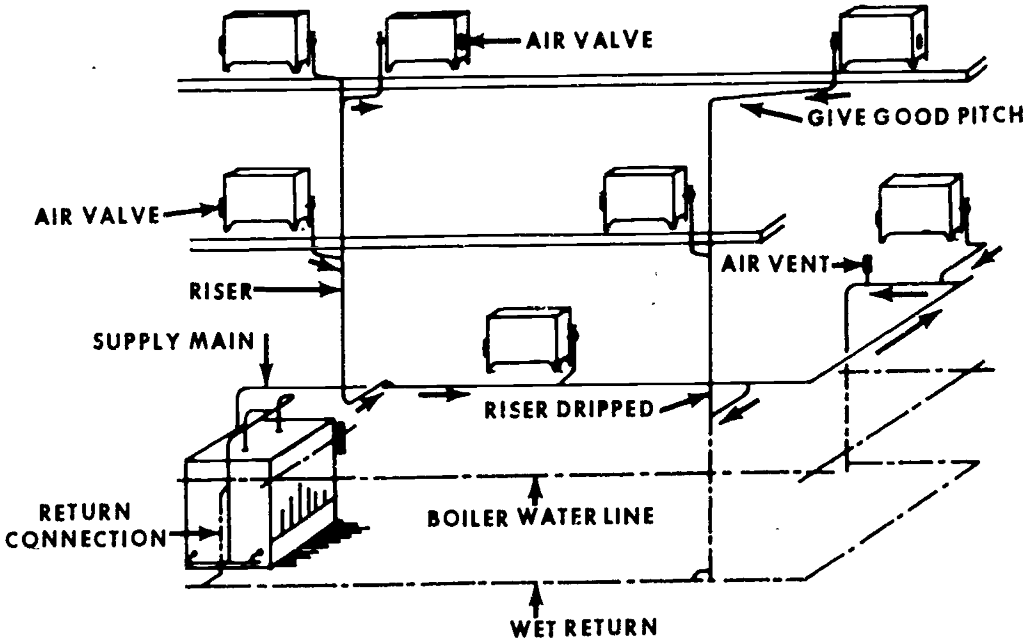



Figure 7. Typical gravity one-pipe steam heating system.

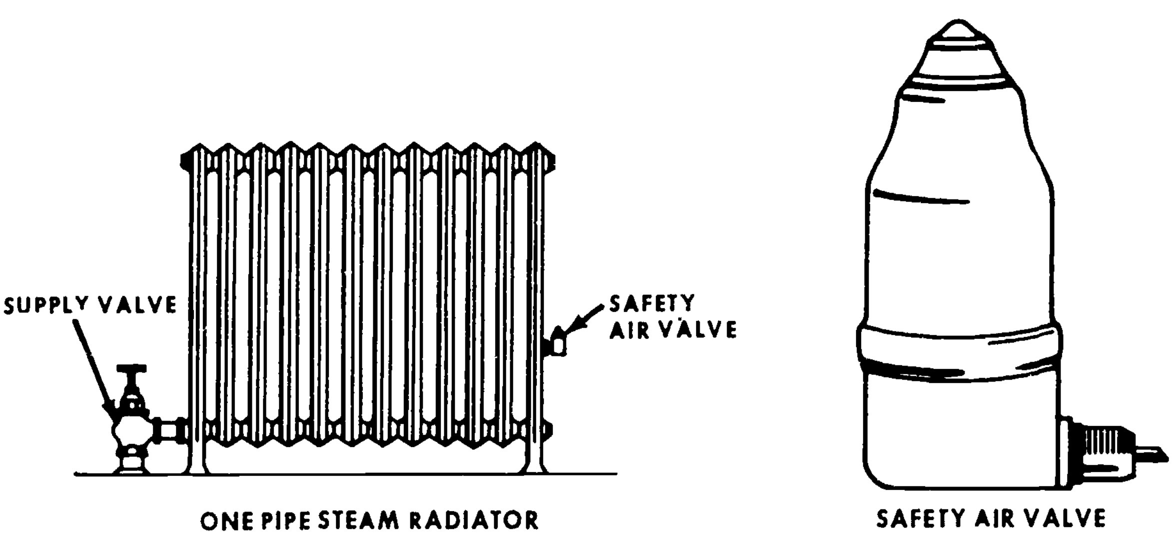



Figure 8. Safety air valve.

is the most elementary of the gravity systems and is shown in Figure 7-9. Water is heated at the lowest point in the system. It rises through a single main because of a difference in density between hot and cold water. The supply rise or radiator branch takes off from the top of the main to supply water to the radiators. After the water gives up heat in the radiator it goes back to the same main through return piping from the radiator. This cooler return water mixes with water in the supply main and causes the water to cool a little. As a result, the next radiator on the system has a lower emission rate and must be larger.

Note in Figure 9 that the high points of the hot water system are vented and the low points are drained. In this case, the radiators are the high points and the heater is the low point.

2 One-pipe Forced-feed System - If a pump or circulator is introduced in the main near the heater of the one-pipe system, we have a forced system that can be used for much larger applications than the gravity type. This system can operate at higher water temperatures than the gravity system. The faster moving higher temperature water makes a more responsive system with a smaller temperature drop through each radiator. Higher operating temperatures and lower temperature drops permit the use of smaller radiators for the same heating load.

3 Two-pipe Gravity Systems - One-pipe gravity systems may become a two-pipe system if the return radiator branch

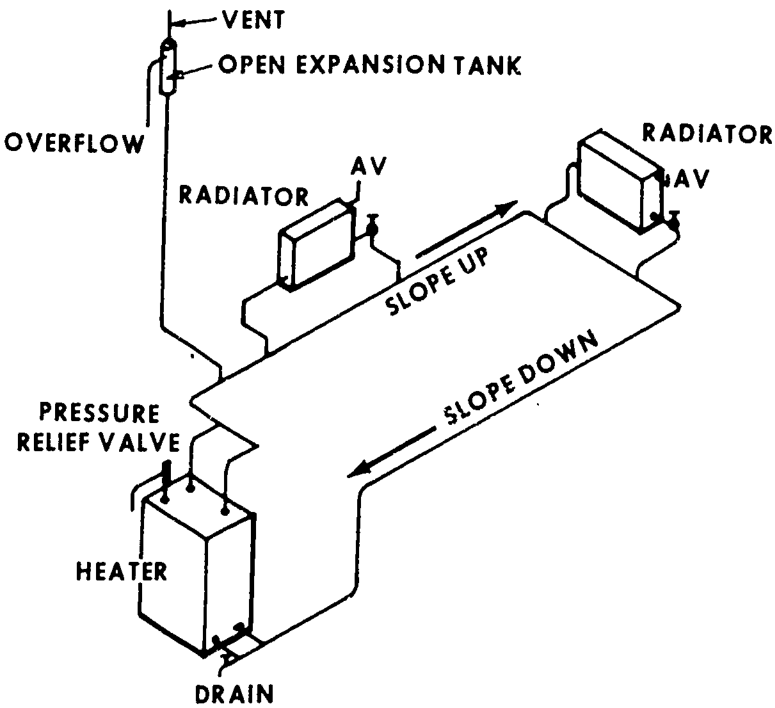



Figure 9. One-pipe gravity hot water heating system.

connects to a second main that returns water to the heater (see Figure 10). Water temperature is practically the same in all the radiators.

4 Two-pipe Forced-circulation System - This system is similar to a one-pipe forced-circulation system except that the same piping arrangement is found in the two-pipe gravity flow system.

5 Expansion Tanks - When water is heated it tends to expand. Therefore, in a hot water system an expansion tank is necessary. The expansion tank, either of open or closed type, must be of sufficient size to permit a change in water volume within the heating system. If the expansion tank is of the open type it must be placed at least 3 feet above the highest point of the system. It will require a vent and an overflow. The open tank is usually in an attic, where it needs protection from freezing.

The enclosed expansion tank is found in modern installations. An air cushion in the tank compresses and expands according to the change of volume and pressure in the system. Closed tanks are usually at the low point in the system and close to the heater. They can, however, be placed at almost any location within the heating system.

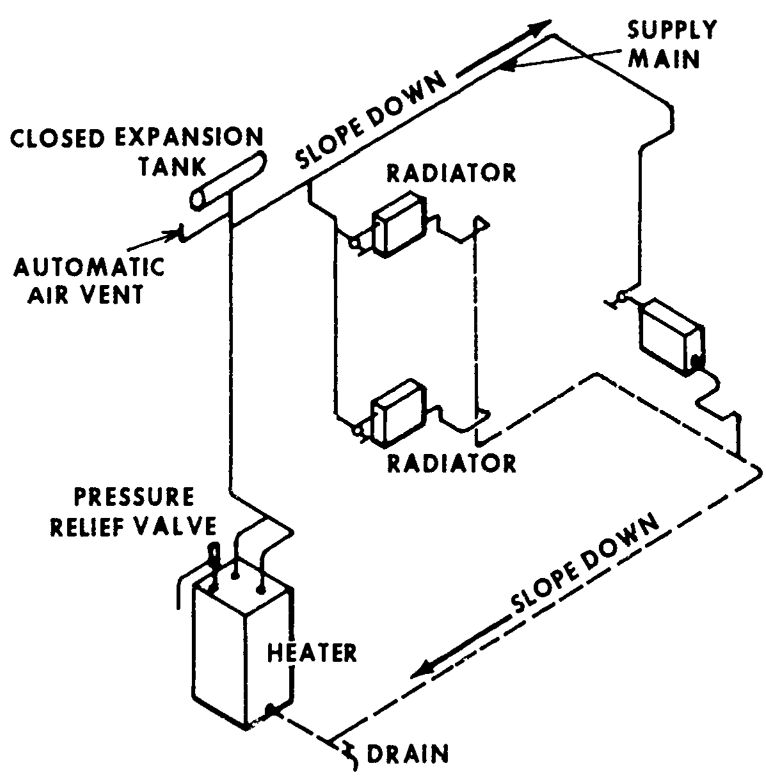



Figure 10. Two-pipe gravity hot-water system.

C Hot Air Heating Systems

1 Gravity-Warm-air Heating Systems - These operate because of the difference in specific gravity of warm air and cold air. Warm air is lighter than cold air and rises if cold air is available to replace it (see Figure 11).

a Operation - Satisfactory operation of a gravity-warm-air heating system depends on three factors. They are: (1) size of warm air and cold ducts, (2) heat loss of the building, (3) heat available from the furnace.

b Heat distribution - The most common source of trouble in these systems is insufficient pipe area usually in the return or cold air duct. The total cross-section area of the cold duct or ducts must be at least equal to the total cross-section area of all warm ducts.

c Pipeless furnaces - The pipeless hot-air furnace is the simplest type of hot-air furnace and is suitable for small homes where all rooms can be grouped about a single large register (see Figure 3). Other pipeless gravity furnaces are often installed at floor level. These are really oversized jacketed space heaters. The most common difficulty experienced with this type of furnace is supplying a return air opening of sufficient size on the floor.

2 Forced-Warm-Air Heating Systems - The mechanical warm-air furnace is the most modern type of warm-air equipment (see Figure 12). It is the safest type because it operates at low temperatures. The principle of a forced-warm-air heating system is very similar to that of the gravity system, except that a fan or blower is added to increase air movement. Because of the assistance of the fan or blower, the pitch of the ducts or leaders can be disregarded and it is therefore practical to deliver heated air in the most convenient places.

a Operation - In a forced-air system, operation of the fan or blower must be controlled by air temperature in a bonnet or by a blower control furnacestat. The blower control starts the fan or blower when the temperature reaches a certain point and turns the fan or blower off when the temperature drops to a predetermined point.

b Heat distribution - Dampers in the various warm-air ducts control distribution of warm air either at the branch takeoff or at the warm-air outlet.

Humidifiers are often mounted in the supply bonnet in order to regulate the humidity within the residence.

D Space Heaters - Space unit heaters are the least desirable from the viewpoint of fire safety and housing inspection. All unit heaters must be flue connected.

1 Coal-Fired Space Heaters

Cannon stove - This is illustrated in Figure 13 and is made entirely of cast iron. In operation, coal on the grates receives primary air for combustion through the grates from the ash-door draft intake. Combustible gases driven from the coal by heat burn in the barrel of the stove, where they received additional or secondary air through the feed door. Side and top of the stove absorb the heat of combustion and radiate it to the surrounding space.

2 Oil-Fired Space Heaters - Oil-fired space heaters have atmospheric vaporizing-type burners. The burners require a light grade of fuel oil that vaporizes easily and is comparatively low in temperature. In addition, the oil must be such that it leaves only a small amount of carbon residue and ash within the heater.

Oil-fired space heaters are basically of two types:

a Perforated-sleeve burner - The perforated-sleeve burner (see Figure 14) consists essentially of a metal base formed of two or more angular fuel-vaporizing bowl burner (see Figure 15) is widely used in space heaters and some water heaters.

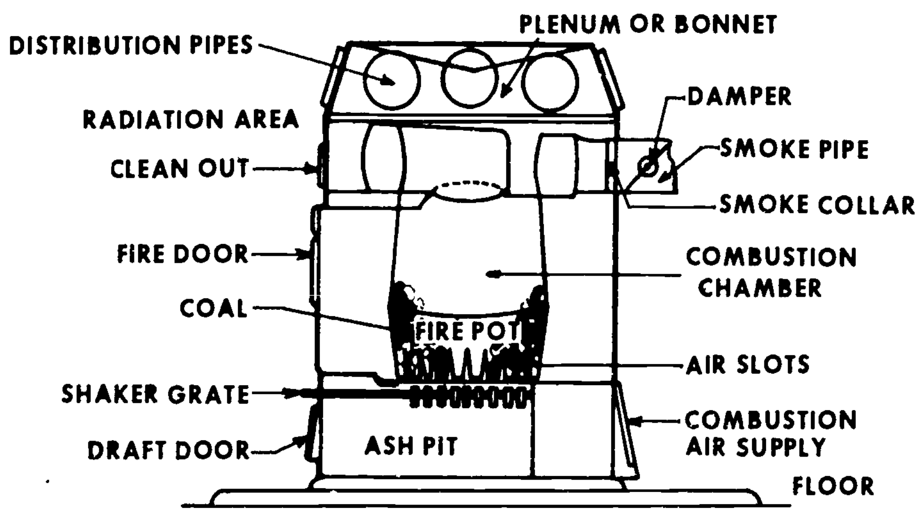
COAL NOTES

1. Approximately 12 pounds of air is required for complete combustion of 1 pound of hard coal.

2. Approximately 5 pounds of hard coal is consumed per hour for each square foot of grate area.

3. Approximately 12 inches of fire bed will heat most efficiently.

4. Anthracite coal burns more slowly than soft coal, is cleaner to handle—hence more widely used.




COAL

5. Large-size coal does not compact—hence the air spaces are too great and allows gases to escape into the flue unburned. Small size coal compacts too much and inhibits airflow through the coal to allow for good combustion. Mixing of coal size is recommended, i.e., stove and chestnut.

6. Fires burn best when the weather is clear and cold, because of reduced atmospheric pressure on the air in the flue—hence greater draft velocity. During periods of heavy atmosphere or rainy weather the temperature of flue gases must exceed normal temperatures to overcome the heavier atmospheric weight.

7. During extreme cold weather, coal should be added to a fire once in approximately 8 hours; moderate weather—12 hours.

Figure 11. Hot air furnace

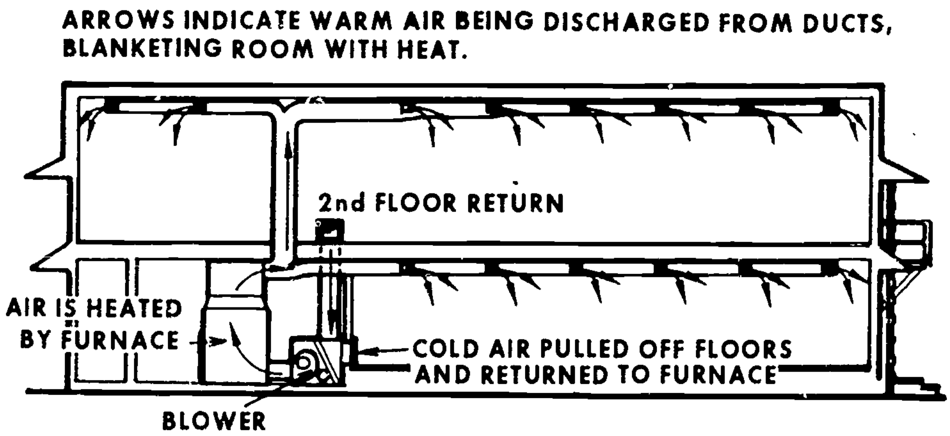



Figure 12. Cross-sectional view of building showing forced-warm-air heating system.

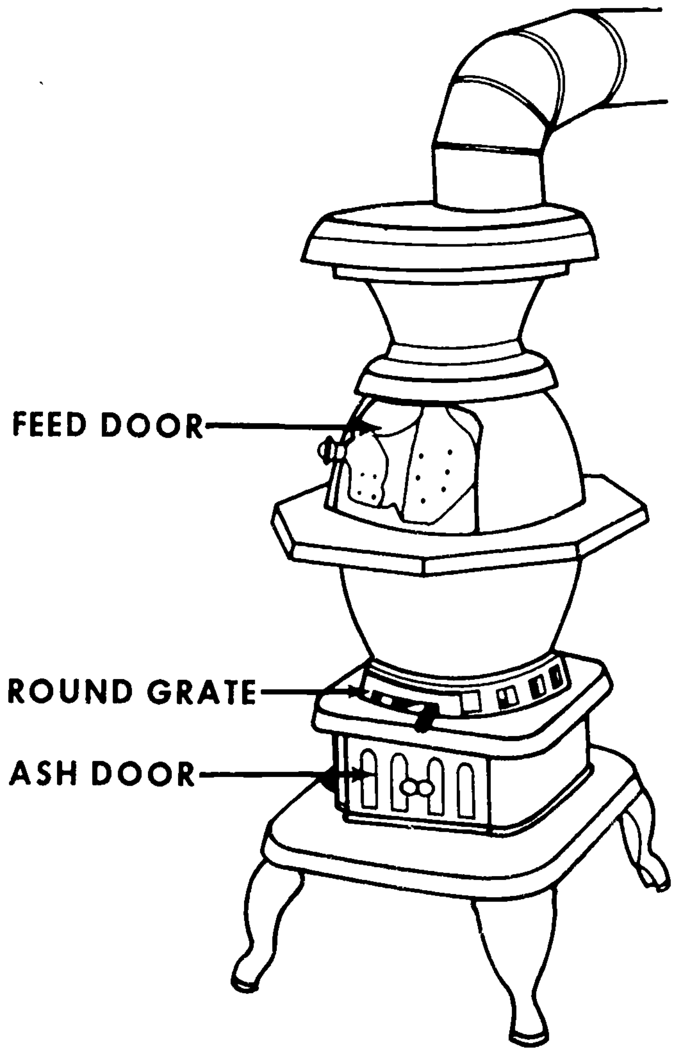



Figure 13. Cannon stove

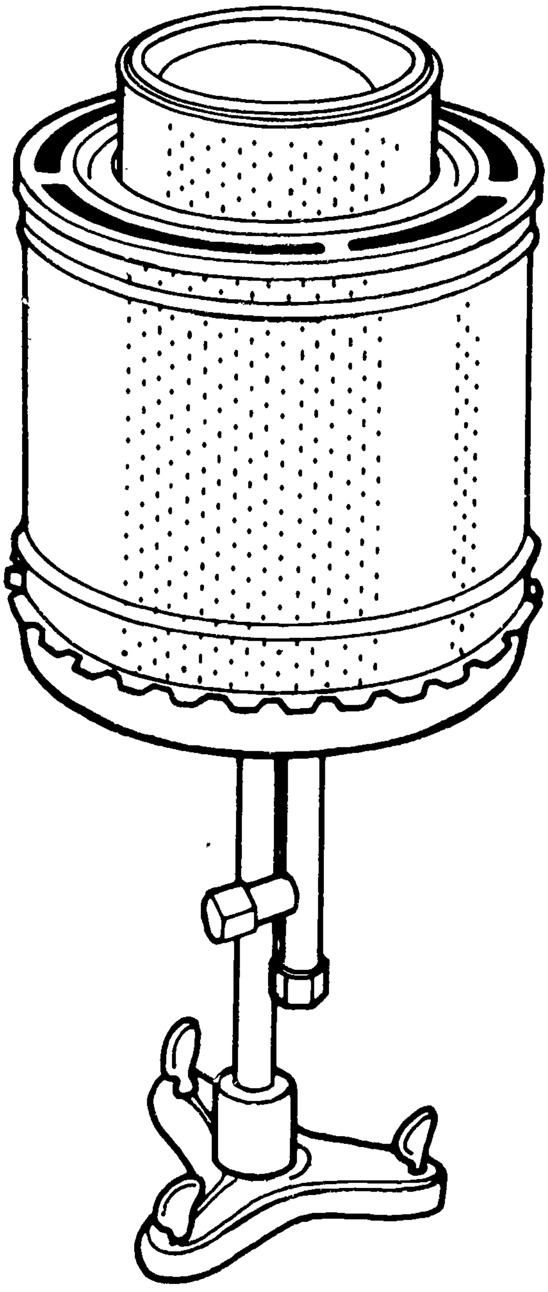
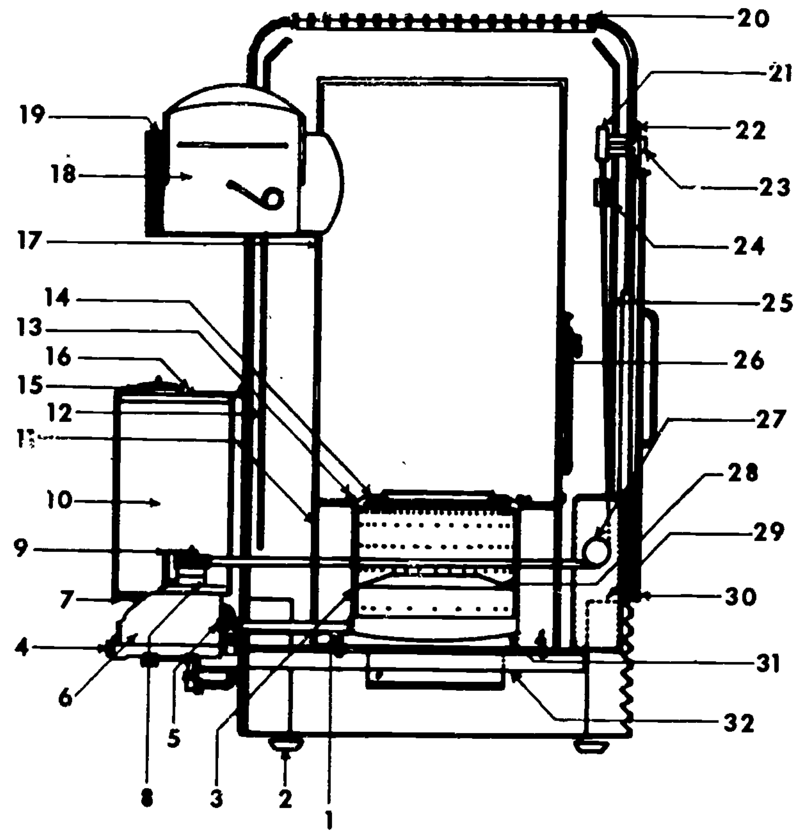


Figure 14. Perforated-sleeve burner




1 Burner-pot pipe.
2 Leg leveler.
3 Pilot-ring clip.
4 Strainer unit.
5 Burner-pot drain plug.
6 Constant-level valve.
7 Tank valve.
8 Control drum (to fit 6).
9 Control pulley bracket
10 Fuel tank.
11 Lower heat unit.
12 Heat shield (rear).
13 Burner-ring clamp.
14 Burner-top ring.
15 Fuel tank cap.
16 Tank fuel gauge.
17 Heat unit.
18 Cold draft regulator.
19 Flue connections, 6-inch diameter.
20 Top grille.
21 Dial control drum
22 Escutcheon plate.
23 Dial control knob.
24 Pulley assembly (short).
25 Heat sheild (front).
26 Heat-unit door.
27 Pulley assembly (long).
28 Pilot ring.
29 Humidifier.
30 Trim bar.
31 Burner pot.
32 Heat-unit support.

Figure 15. Natural-draft pot burner.

The burner consists essentially of a bowl, 8 to 13 inches in diameter with perforations in the side that admit air for combustion. The upper part of the bowl has a flame ring or collar. When several space heaters are installed in a building, an oil supply from an outside tank to all heaters is often desirable. Figure 16 shows the condition of a burner flame with different rates of fuel flow and indicates the ideal flame height.

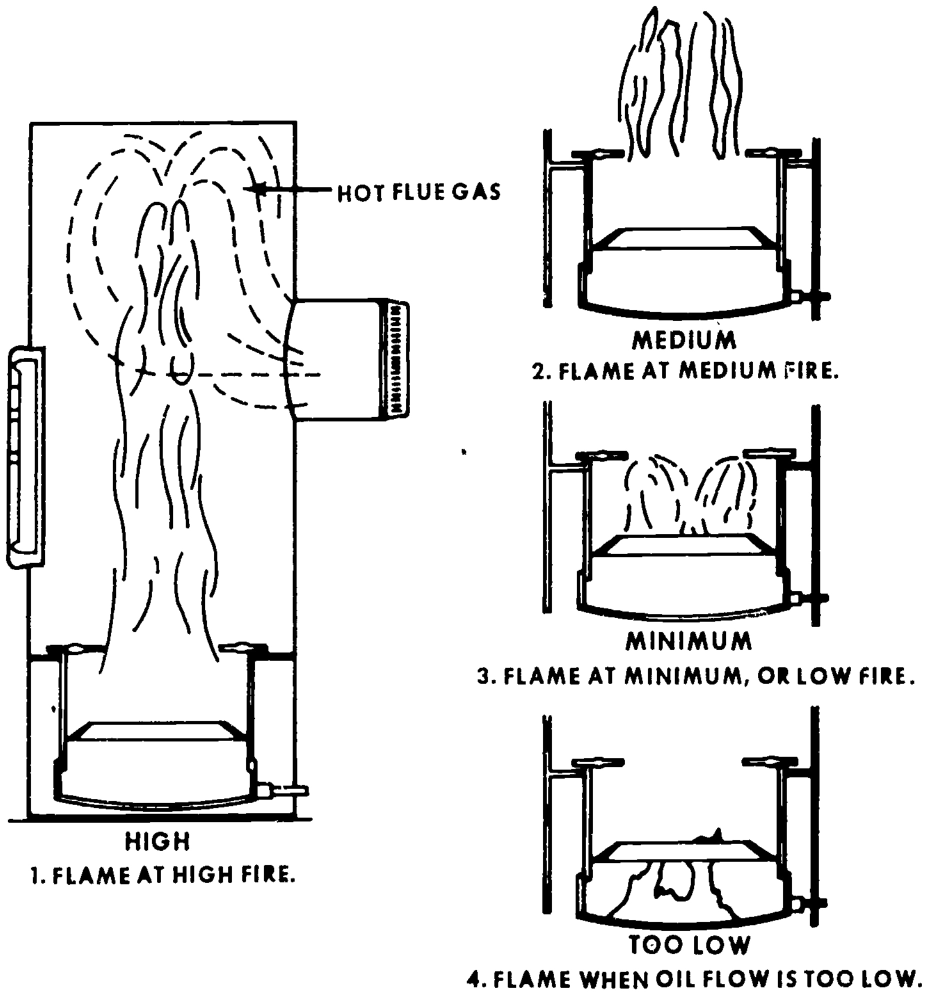



Figure 16. Condition of burner flame with different rates of fuel flow.

3 Gas-Fired Space Heaters - There are three types of gas-fired space heaters: natural, manufactured, and liquified petroleum gas. Space heaters using natural, manufactured, or liquified petroleum gases have a similar construction. All gas-fired space heaters must be vented, except in certain instances such as building construction where there is adequate air leakage to prevent a dangerous buildup of poisonous gases.

Each unit console consists of an enamel steel cabinet with top and bottom circulating grilles or openings, gas burners, heating element, gas pilot, and gas valve (see Figure 17). The heating element or combustion chamber is usually cast iron.

CAUTION: All gas-fired space heaters and their connections must be of the type approved by the American Gas Association (AGA). They must be installed in accordance with the recommendations of that organization or the local code.

a Venting - Use of proper venting materials and correct installation of venting for gas-fired space heaters is necessary to minimize harmful effects of condensation and to ensure that combustion products are carried off. (Approximately 12 gallons of water are produced in the burning of 1,000 cubic feet of natural gas. The inner surface of the vent must therefore be heated above the dewpoint of the combustion products to prevent water from forming in the flue). A horizontal vent must be given an upward pitch of at least 1 inch per foot of horizontal distance.

When the smoke pipe extends through floors or walls the metal pipe must be insulated from the floor or wall system by an air space (see Figure 18). Avoid sharp bends. A 90° vent elbow has a resistance to flow equivalent to a straight section of pipe having a length of 10 times the elbow diameter. Be sure vent is of a rigid construction and resistant to corrosion by flue gas products. Several types of venting material are available such as B-vent and several other ceramic-type materials. A chimney lined with firebrick type of terra cotta must be relined with an acceptable vent material if it is to be used for venting gas-fired appliances.

Use the same size vent pipe throughout its length. Never make a vent smaller than heater outlet except when two or more vents converge from separate heaters. To determine the size of vents beyond the point of convergence, add one-half the area of each vent to the area of the largest heater's vent.

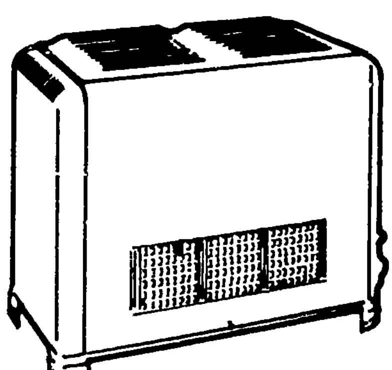
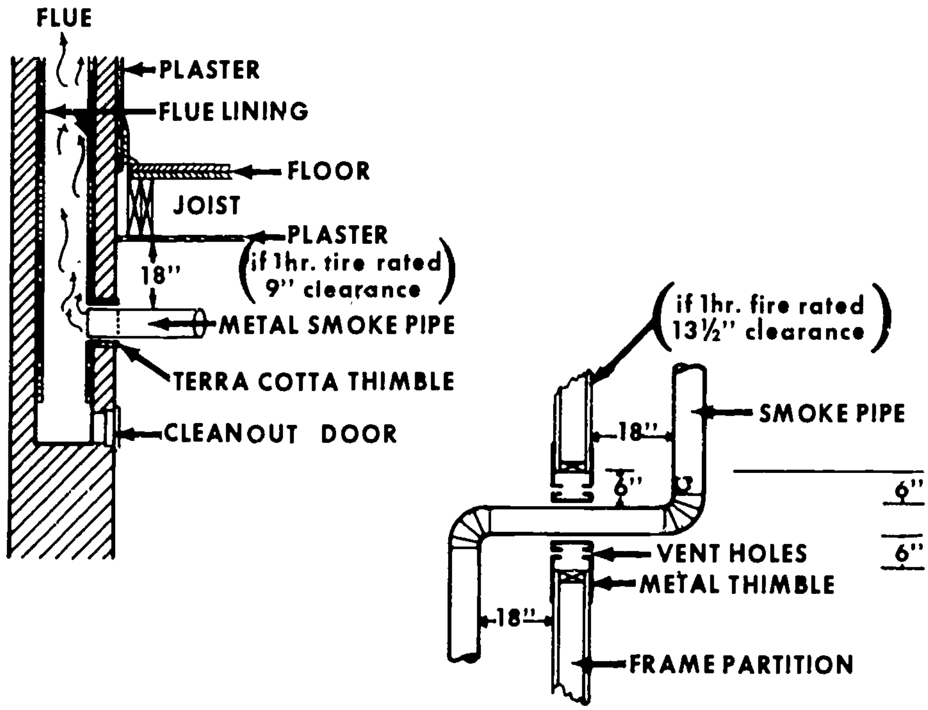


Figure 17. Typical gas-fired space heater.




| PROTECTED CONSTRUCTION MATERIAL (fire rating) | CLEARANCE REDUCTION | |
|---|---|---|
| | TOP | SIDES |
| 20 MINUTES | 7/8 | 5/8 |
| 30 MINUTES | 3/4 | 1/2 |
| 45 MINUTES | 5/8 | 3/8 |
| 60 MINUTES | 1/2 | 1/4 |

## FLUE CONNECTIONS AND CLEARANCES

Figure 18. Wall and ceiling clearance reduction.

Install vents with male ends of inner liner down to ensure condensate is kept within pipes on a cold start. The vertical length of each vent or stack should be at least 2 feet greater than the length between horizontal connection and stack.

Run vent at least 3 feet above any projection of the building within 20 feet to place it above a possible pressure zone due to wind currents. (see Figure 19). End it with a weather cap designed to prevent entrance of rain and snow.

Gas-fired space heaters as well as gas furnaces and hot-water heaters must be equipped with a backdraft diverter (see Figure 20) designed to protect heaters against downdrafts and excessive updrafts. Use only draft diverters of the type approved by the AGA.

The combustion chamber or firebox must be insulated from the floor, usually with an airspace of 15 to 18 inches, or the firebox is sometimes insulated within the unit and thus allows for lesser clearance for combustibles.

Where coal space heaters are located, a floor protection should be provided. This would be a metal-covered asbestos board or a similar durable insulation material. One reason for the floor protection would be to allow cooling off of hot coals and ashes if they drop out while ashes are being removed from the ash chamber. Walls and ceilings of a combustible construction exposed to furnace radiation should be installed, and the following clearances are recommended: Space heaters—A top or ceiling clearance of 36 inches, a wall clearance of 18 inches, and a smoke pipe clearance of 18 inches, (see Figure 18).

## VIII DOMESTIC HOT-WATER JACK STOVES (COAL STOVES)

Domestic hot-water jack stoves (coal stoves) equipped with water jackets to supply hot water for domestic use are to be treated as cold-fire furnaces or boilers previously discussed. Note that flue connections should not exceed two to the same flue unless the draft and size are sufficient to accommodate both exhausting requirements. One flue with one smoke pipe is the rule; however, housing

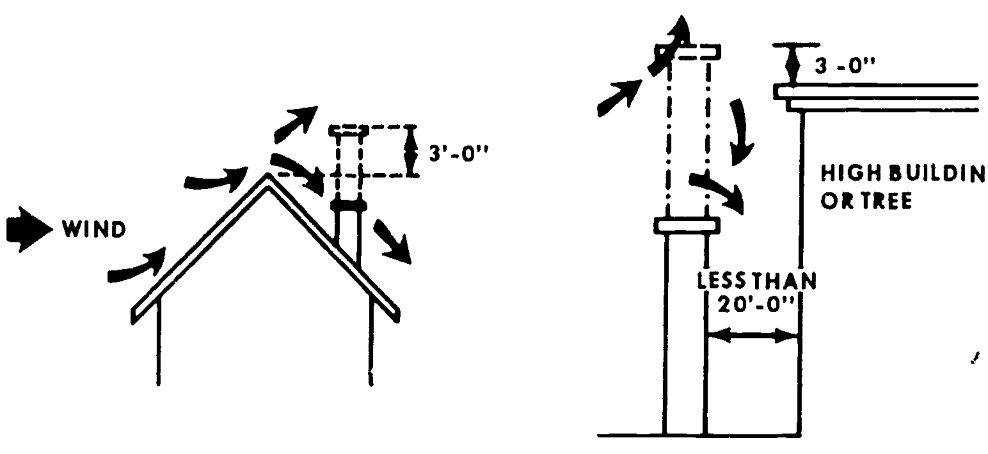



Figure 19. Draft relation to height of chimney.

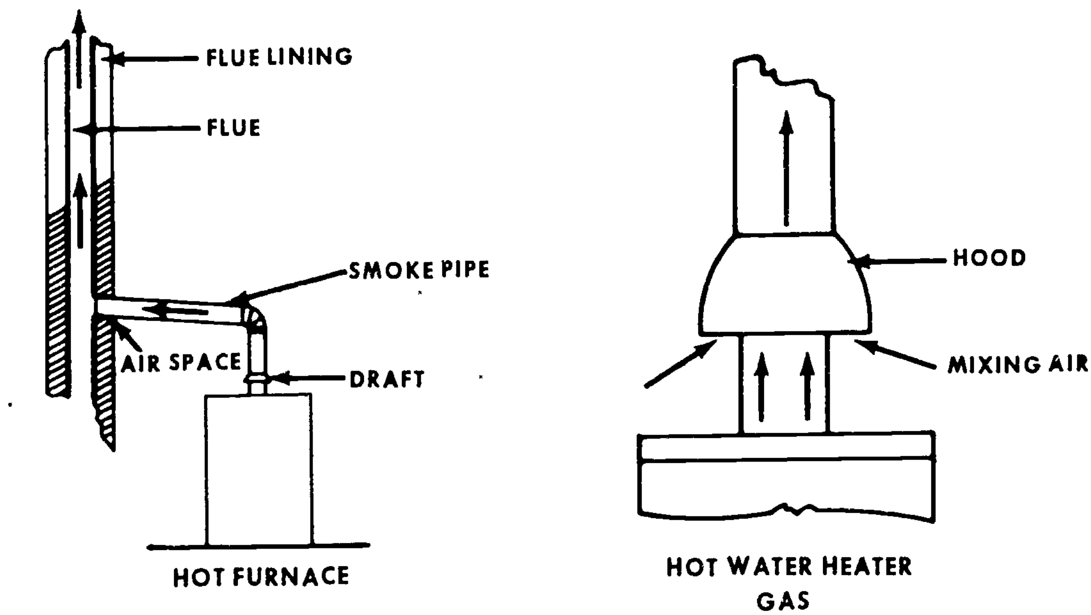



Figure 20. Location and operation of typical backdraft diverter.

inspectors may find a jack stove and main furnace connected to the same flue. Where these conditions are encountered and no complaint about malfunctioning of this system is found, it can be assumed that the system is operating satisfactorily. Where more than two units, other than gas, are attached to a single flue, the building agency should be notified, since this can be considered an improper installation. Gas, oil, and electric hot-water heating units for domestic hot water should be treated the same as previously discussed for central heating units.

## IX HAZARDOUS INSTALLATIONS

A Generalities - The housing inspector should be on the alert for unvented open burning flame heaters, such as manually operated gas logs. Coil-type wall-mounted hot-water heaters that do not have safety relief valves are not permitted. Kerosene (portable) units for cooking or heating should be prohibited. Generally, open-flame portable units are not allowed under fire safety regulations.

In oil heating units, other than integral tank units, the oil filling and vent must be located on the exterior of the building. Filling of oil within buildings is prohibited.

Electric wiring to heating units must be installed as indicated in the electrical section. Cutoff switches should be close to the entry but outside of the boiler room. The inspector should be able to appraise the heating installation and determine its adequacy. Any installation that indicates haphazard location, workmanship, or operation, whether it be building, zoning, plumbing, electrical, or housing, will dictate further inspection.

B Chimneys (see Figure 21 and 22) - Chimneys, as all inspectors know, are an integral part of the building. The chimney is a point of building safety and should be understood by the housing inspector. The chimney, if of masonry, must be tight and sound; flues should be terra cotta lined, and where no linings are installed, the brick should be tight to permit proper draft and elimination of combustion gases.

Chimneys that act as flues for gas-fired equipment must be lined with either B-vent or terra cotta.

To the inspector, on exterior inspection, "banana peel" on the portion of the chimney above the roof will indicate trouble and a need for rebuilding. Exterior deterioration of the chimney will, if let go too long, gradually permit erosion from within the flues and eventually block the flue opening.

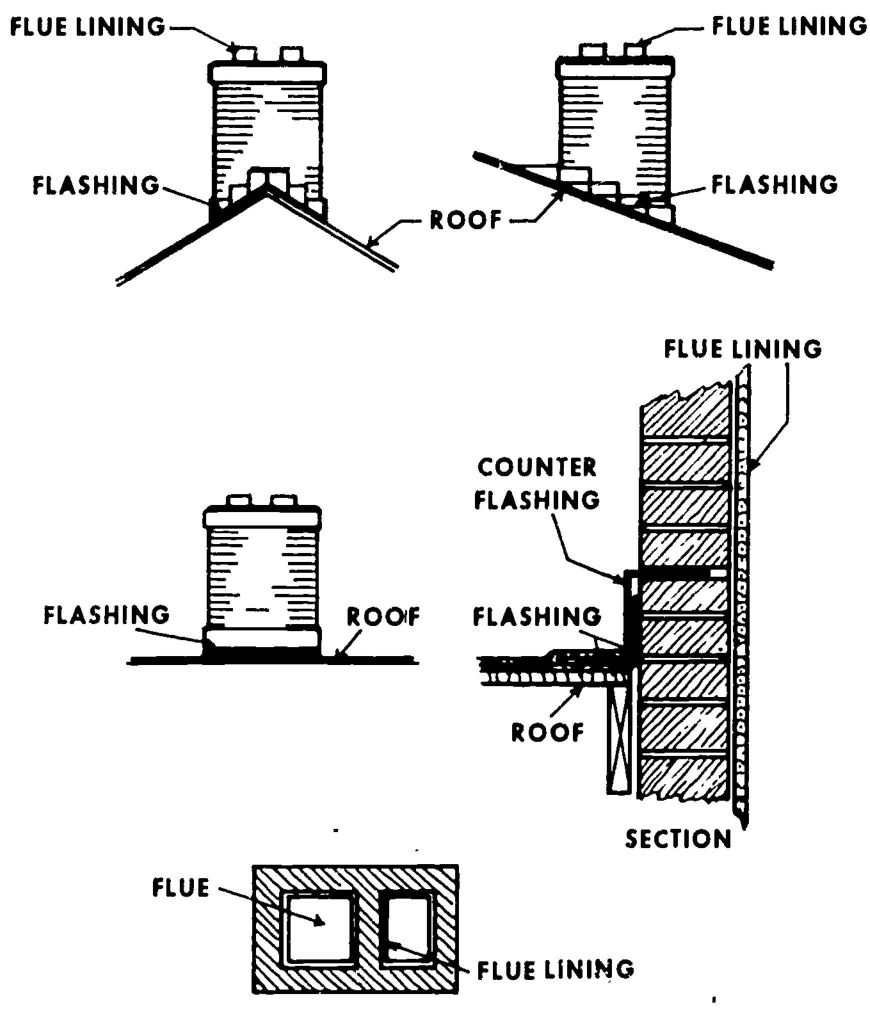



Figure 21. Chimney plan

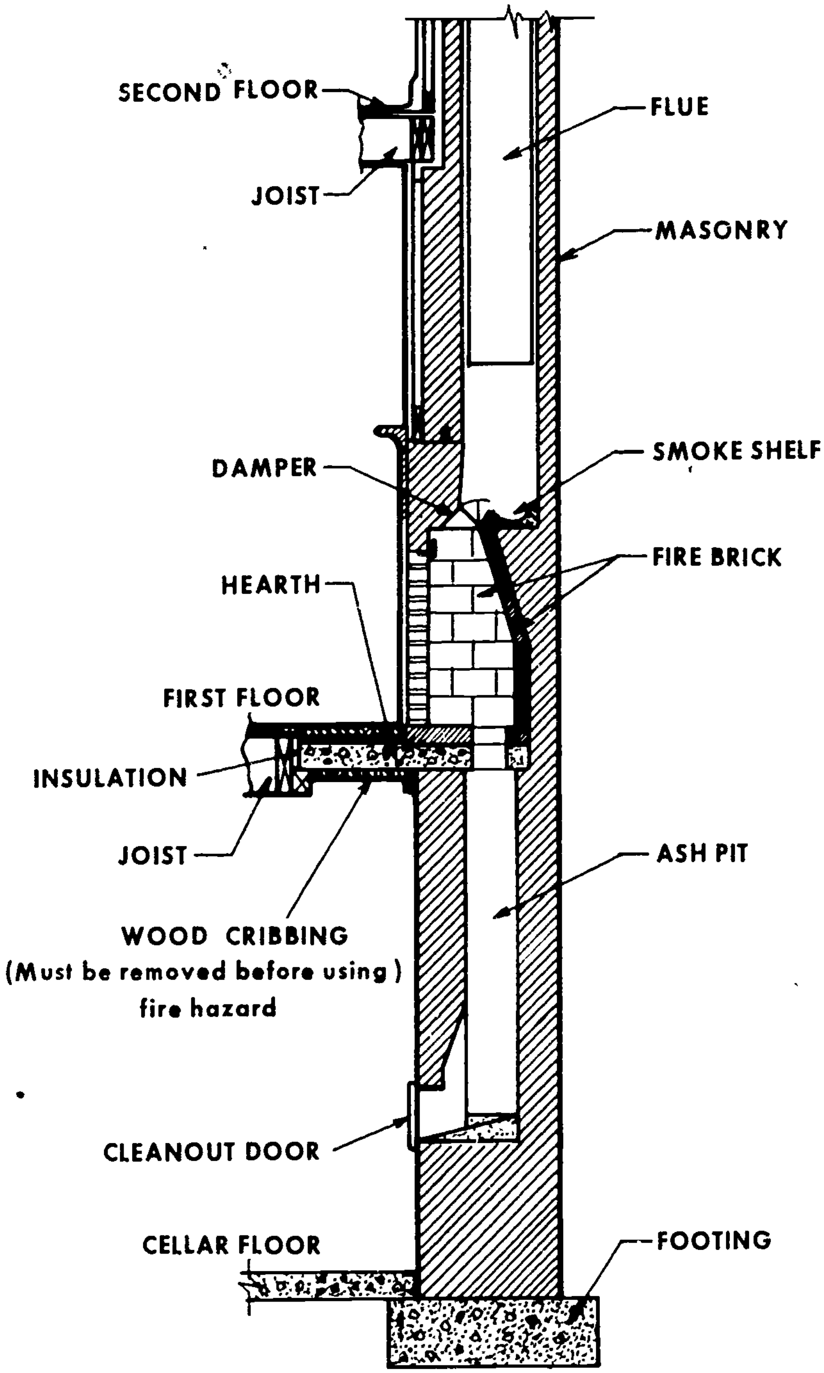



Figure 22. Fireplace construction

Rusted flashing at the roof level will also contribute to the chimney's deterioration. Effervescence on the inside wall of the chimney below the roof and on the outside of the chimney, if exposed, will show salt accumulations a tell-tale sign of water penetration and flue gas escape and is a sign of chimney deterioration. In the spring and fall, during rain seasons, if terra cotta chimneys leak, the joint will be indicated by dark areas permitting actual counting of the number of flues inside the masonry chimney. When this condition occurs, it usually requires 2 or 3 months to dry out. Upon drying out, the mortar joints are discolored (brown), and so after a few years of this type of deterioration the joints can be distinguished wet or dry. The above-listed conditions usually develop during coal operation and become more pronounced usually 2 to 5 years after conversion to oil or gas.

An unlined chimney can be checked for deterioration below the roof line by checking the residue deposited at the base of the chimney, usually accessible through a cleanout (door or plug) or breaching. Red granular or fine powder showing through coal soot or oil soot will generally indicate, if in quantity a (handful), that deterioration is excessive and repairs are needed.

Gas units attached to unlined chimneys will be devoid of soot, but will usually show similar tell-tale brick powder and deterioration as previously mentioned. Manufactured gas has a greater tendency to dehydrate and decompose brick in chimney flues than natural gas. For gas installations in older homes, utility companies usually specify chimney requirements before installation, and so older chimneys may require the installation of terra cotta liners, lead-lined copper liners, or transite pipe. Oil burner operation using a low air ratio and high oil consumption is usually indicated by black carbon deposits around the top of the chimney. Prolonged operation in this burner setting results in long carbon water deposits down the chimney for 4 to 6 feet or more and should indicate to the inspector a possibility of poor burner maintenance. This will accent his need to be more thorough on the ensuing inspection. This type of condition can result from other related causes, such as improper chimney height or exterior obstructions such as trees or buildings that will cause downdrafts or insufficient draft or contribute to a faulty heating operation.

Rust spots and soot-mold usually occur on galvanized smoke pipe deterioration.

C <u>Fireplace</u> - Careful attention should be given to the construction of the fireplace. Improperly built fireplaces are a serious safety and fire hazard (see Figure 7-22). The most common causes of fireplace fires are thin walls, combustible materials such as studding or trim against sides and back of the fireplace, wood mantels, and unsafe hearths.

Fireplace walls should be not less than 8 inches thick, and if built of stone or hollow masonry units, not less than 12 inches thick. The faces of all walls exposed to fire should be lined with firebrick or other suitable fire-resistive material. When the lining consists of 4 inches of firebrick, such lining thickness may be included in the required minimum thickness of the wall.

The fireplace hearth should be constructed of brick, stone, tile, or similar incombustible material and should be supported on a fireproof slab or on a brick arch. The hearth should extend at least 20 inches beyond the chimney breast and not less than 12 inches beyond each side of the fireplace opening along the chimney breast. The combined thickness of the hearth and its supporting construction should be not less than 6 inches at any point.

It is important that all wooden beams, joists, and studs are set off from the fireplace and chimney so that there is not less than 2 inches of clearance between the wood members and the sidewalls of the fireplace or chimney and not less than 4 inches of clearance between wood members and the back wall of the fireplace.

The housing inspector is a very important person in maintaining sound, safe, and healthful community growth. This should be a challenge to every inspector to provide himself with the necessary tools for better and more efficient housing inspection. He must develop the extra senses so necessary in spotting and correcting faults. He must know when to refer and to whom the referral is to be made; he must be continually seeking knowledge, which may be found by consulting with technicians, tradesmen, and professionals. No finer satisfaction can be realized than to know and feel that the security, safety, and comfort of each and every family within your community has a better and more healthful life because of that extra bit of knowledge you have imparted. "An inspector who stops learning today is uneducated tomorrow."

HEATING INSPECTION CHECK LIST

Exterior

Chimney
- Masonry [ ]
- Metal [ ]
- Transite [ ]

Condition of Chimney
- Sound [ ]
- Deteriorated [ ]
- Unsound [ ]

Chimney Flashing
- Sound [ ]
- Unsound [ ]
- Missing [ ]

Chimney Obstruction
- Trees too close [ ]
- Insufficient Height [ ]
- No Obstruction [ ]

Electrical Service
- Two wire and ground [ ]
- One wire and ground [ ]

Interior

Radiators [ ]; Hot Air Register [ ]

Thermostat Yes [ ]; No [ ]

Electric switch at top of cellar stairs (gas & oil only) [ ]

Space Heater [ ]; Coal [ ]; Oil [ ]; Gas [ ]; Electric [ ]

Note: Interior Temperature ____ °F

Exterior Temperature ____ °F

Smoke Pipe
- Sound [ ]
- Deteriorated [ ]
- Unsound [ ]

Breeching Tight [ ]; Open [ ]

Central Heating System
- Hot Air [ ]; Hot Water [ ];
- Steam [ ]; Coal [ ];
- Oil [ ]; Gas [ ];
- Electric [ ]

Condition of Furnace
- Good [ ]
- In need of repair [ ]
- Hazardous [ ]

Safety Relief Valve (hot water or steam)
Yes [ ]; No [ ]

Oil Burner
- Firmly set on floor [ ]
- Leaks & oil spots [ ]
- Air Balance—Operative [ ];
- Inoperative [ ]
- Wiring—Sound [ ];
- Unsound [ ]
- Conversion [ ]

Coal Furnace
- Dampers Operative [ ]
- Inoperative [ ]

Furnace Flues—Clean, Yes [ ]; No [ ]

Ash pit—Full [ ]; Empty [ ]

Size of coal used ________________.

Gas Furnace
- Shutoff Valve Yes [ ]; No [ ]
- Draft Hood Yes [ ]; No [ ]
- Wiring—Sound [ ]; Unsound [ ]

Furnace Room
- Enclosed [ ]
- Open [ ]
- Ceiling Protected [ ]

Combustibles close to furnace—
Yes [ ]; No [ ]

Smoke Pipe Separation from Combustibles

| | Vertical | Horizontal |
| --- | --- | --- |
| Measured distance | ____" | ____" |

Tanks—Set on Solid Bearing Yes [ ]; No [ ]

Gauge—Operating [ ]; Satisfactory [ ] Unsatisfactory [ ]

Filter installed—Yes [ ]; No [ ]

Shutoff valve installed—Yes [ ]; No [ ]

Tanks Vented—Yes [ ]; No [ ]

Oil Line to Burner—Proper [ ]; Improper [ ]

General Appraisal:

- Excellent [ ]
- Good [ ]
- Needs Repair [ ]
- Hazardous [ ]
- Condemned [ ]

Remarks: ____________________

____________________

____________________

____________________

____________________

Signature ____________________ Date ____________________

Chapter 7

# ELECTRICAL ASPECTS OF A HOUSING INSPECTION

There are two basic codes concerned with residential wiring that are of importance to the housing inspector. The first is the local electrical code. The purpose of this code is to safeguard persons and buildings and their contents from hazards arising from the use of electricity for light, heat, and power. The electrical code contains basic minimum provisions considered necessary for safety. Compliance with this code and proper maintenance will result in an installation essentially free from hazard but not necessarily efficient, convenient, or adequate for good service or future expansion.

The majority of local electrical codes are modeled after the National Electrical Code, published by the National Fire Prevention Association. Further reference to the Code in the remainder of this chapter will indicate the National Electrical Code 1968 Edition. (1)

Just because an electrical installation was safe and adequate under the provisions of the electrical code at the time of installation does not indicate that the system is safe and adequate for use today. Hazards often occur because of overloading of wiring systems by methods or usage not in conformity with the code. This occurs because initial wiring did not provide for increases in the use of electricity. For this reason it is recommended that the initial installation be adequate and that reasonable provisions for system changes be made as may be required for future increase in the use of electricity.

The other code that contains electrical provisions is the local housing code. It establishes minimum standards for artificial and natural lighting and ventilation, specifies the minimum number of electric outlets and lighting fixtures per room, and prohibits temporary wiring except under certain circumstances. In addition, the housing code usually requires that all components of the electrical system be installed and maintained in a safe condition so as to prevent fire or electric shock.

This chapter contains electrical terms and major features of a residential wiring system that should be familiar to the housing inspector. It also contains a review of the steps involved in the electrical inspection, as well as commonly found conditions.

## I DEFINITIONS

A Electricity - is energy that can be used to run household appliances: it can produce light and heat, shocks, and numerous other effects.

B Current - the flow of electricity through a circuit.

1 Alternating current is an electrical current that reverses its direction of flow at regular intervals: For example, it would alternate 60 times every second in a 60-cycle system. This type of power is commonly found in homes.

2 Direct current is an electric current flowing in one direction. This type of current is not commonly found in today's homes.

C Ampere - the unit used in measuring intensity of flow of electricity. Symbol for it is "I".

D Volt - the unit for measuring electrical pressure or force, which is known as electromotive force. Symbol for it is "E"

E Watt - is the unit of electric power. Volts X Amperes = Watts.

F Circuit - the flow of electricity through two or more wires from the supply source to one or more outlets and back to the source.

G Circuit Breaker - a safety device used to break the flow of electricity by opening the circuit automatically in the event of overloading or used to open or close it manually.

H Short Circuit - is a break in the flow of electricity through a circuit due to the load caused by improper connection between hot and neutral wires (have the electrical inspector check for its location).

I Conductor - any substance capable of conveying an electric current. In the home, copper wire is usually used.

1 Bare conductor is one with no insulation or covering.

2 Covered conductor is one covered with one or more layers of insulations

J Fuse - a safety device that cuts off the flow of electricity when the current flowing through it exceeds its rating.

K Ground - to connect with the earth—as to ground an electric wire directly to the earth or indirectly through a water pipe or some other conductor. Usually a green-colored wire is used for grounding the whole electrical system to the earth. A white wire is then usually used to ground individual electrical components of the whole system.

L Conductor Gauge - a numerical system used to label electric conductor sizes, given in American Wire Gauge (AWG). The larger the AWG number the smaller the wire size.

M Hot Wires - those that carry the electric current or power to the load: they are usually black or red.

N Service - the conductor and equipment for delivering energy from the electricity supply system to the wiring system of the premises.

O Service Drop - the overhead service connectors from the last pole or other aerial support to and including the splices, if any, connecting to the service entrance conductors at the building or other structure.

P Insulator - a material that will not permit the passage of electricity.

Q Neutral Wire - the third wire in a three-wire distribution circuit; it is usually white or light gray and is connected to the ground.

R Service Panel - main panel or cabinet through which electricity is brough building and distributed. It contains the main disconnect switch and fuses or circuit breakers.

S Voltage Drop - a voltage loss when wires carry current. The longer the cord the greater the voltage drop.

## II FLOW OF ELECTRIC CURRENT

Electricity is usually generated by a generator that converts mechanical energy into electrical energy. The electricity is then run through a transformer where the voltage is increased to several hundred thousand volts and in some instances to a million or more volts. This high voltage is necessary in order to increase the efficiency of power transmission over long distances.

This high-transmission voltage is then stepped down (reduced) to normal 115/230-volt household current by a transformer located near the point of use (residence). The electricity is then transmitted to the house by a series of wires called a "service drop." In areas where the electric wiring is underground. the wires leading to the building are buried in the ground.

In order for electric current to flow it must travel from a higher to a lower potential voltage. In an electrical system the hot wires (black or red) are at a higher potential than the ground or neutral wire (white or green). Therefore. current will flow between the hot wires and the neutral or ground wires.

The voltage is a measure of the force at which electricity is delivered. It is similar to pressure in a water supply system.

Current is measured in amperes and is the quantity of flow of electricity. It is similar to measuring water in gallons per second.

A watt is equal to volts times amperes. It is a measure of how much power if flowing. Electricity is sold in quantities of watthours.

The earth, by virtue of moisture contained within the soil, serves as a very effective conductor. Therefore, in power tranmission. instead of having both the hot and neutral wires carried by the tranmission poles, one lead of the generator is connected to the ground, which serves as a conductor (see Figure 1). Only hot wires are carried by the transmission towers. At the house, or point where the electricity is to be used, the circuit is completed by another connection to ground.

The electric power utility provides a ground somewhere in its local distribution system; therefore, there is a ground wire in addition to the hot wires within the service drop. In Figure 1 this ground can be seen at the power pole that contains the stepdown transformer.

In addition to the ground connection provided by the electric utility. every building is required to have an independent ground, called a "system grounds."

The system ground provides for limiting the voltage upon the circuit, which might otherwise occur through exposure to lighting, or for

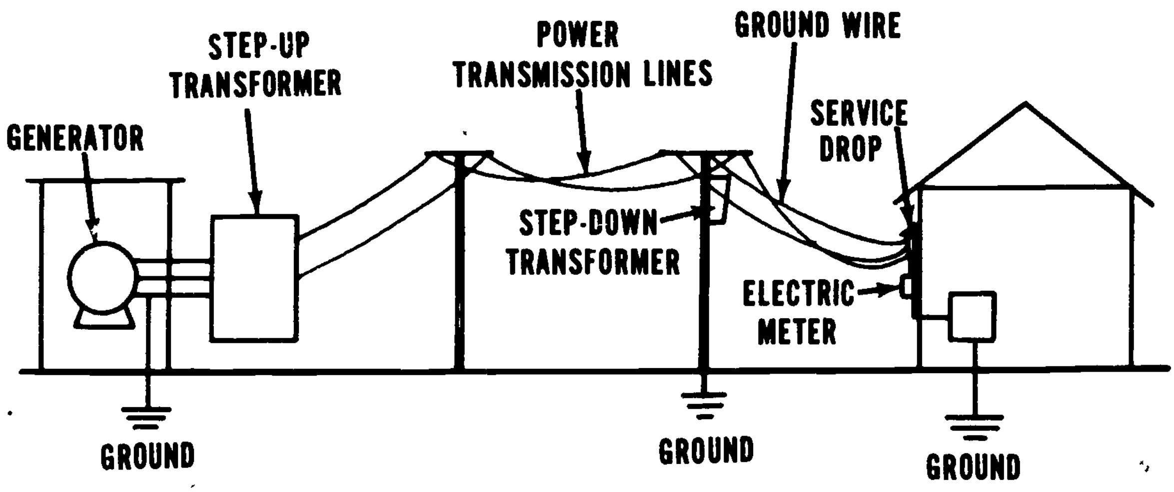



Figure 1

limiting the maximum potential to ground due to normal voltage. Therefore, the system ground's main purpose is to protect the electric system itself and offer limited protection to the user.

The system ground serves the same purpose as the power company's ground, however, being closer to the building, it has a lower resistance.

The "equipment ground," which we will discuss later in this chapter, protects man from potential harm during the use of certain electrical equipment.

The system ground should be a continuous wire of low resistance and of sufficient size to conduct current safely from lightning and overloads.

## III ELECTRIC SERVICE ENTRANCE

### A Service Drop

The "Entrance Head" (see Figure 2) should be attached to the building at least 10 feet above ground, to prevent accidental contact by people. The conductor should clear all roofs by at least 8 feet and driveways and alleys by 18 feet.

The wires or conductor should be of sufficient size to carry the load and not smaller than No. 8 copper or equivalent.

For connecting wire from the entrance head to the service drop wires. the National Electrical Code requires that the service entrance head be installed above the top insulator of service drop wires. Drip loops must be formed on individual conductors. This will prevent water from entering the electric service system.

The wires that form "entrance cable" should extend 36 inches from the entrance head. to provide a sufficient length the connect service drop wires to the building with insulators (see Figure 2).

The entrance cable may be a special type of armored outdoor type of wire or it may be enclosed in a conduit. The electric power meter may be located either within or outside the building. In either instance. the meter must be located before the main power disconnect.

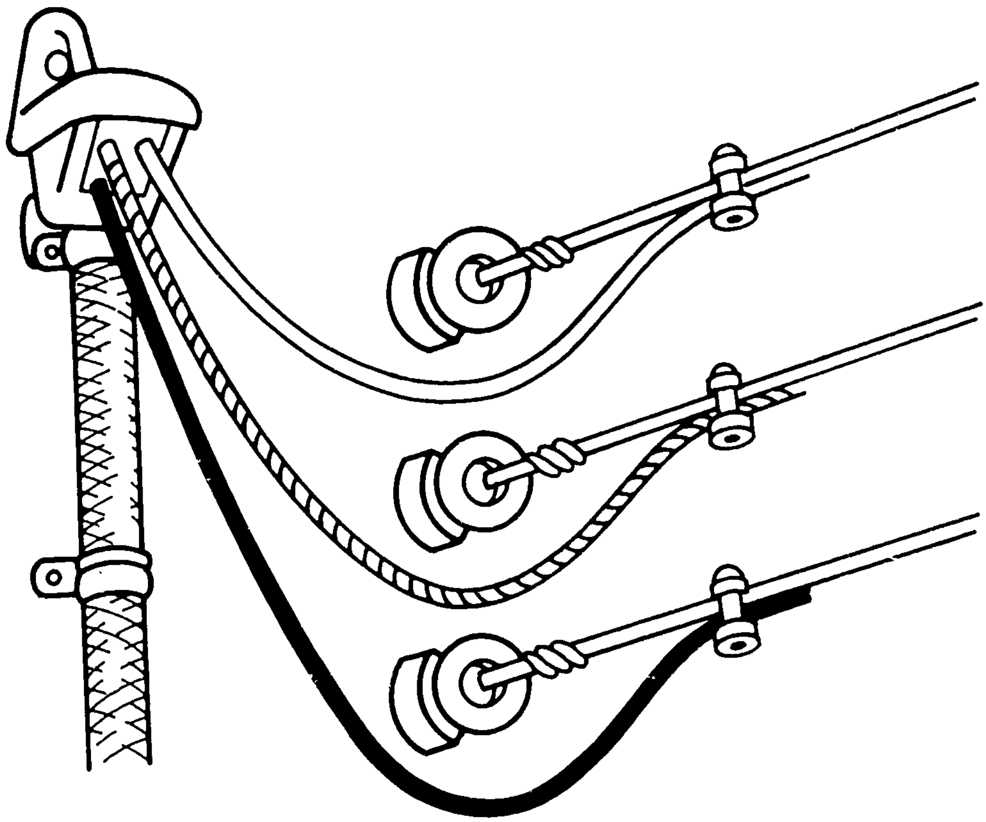


Figure 2. Entrance head

Figure 3 shows an armored duck cable service entrance. The armored cable is anchored to the building with metal straps spaced every 4 feet. The cable is run down the wall and through a hole drilled through the building. The cable is then connected to the service panel, which should be located within 1 foot of where the cable enters the building.

The ground wire need not be insulated. This ground wire may be either solid or stranded copper, or a material with an equivalent resistance.

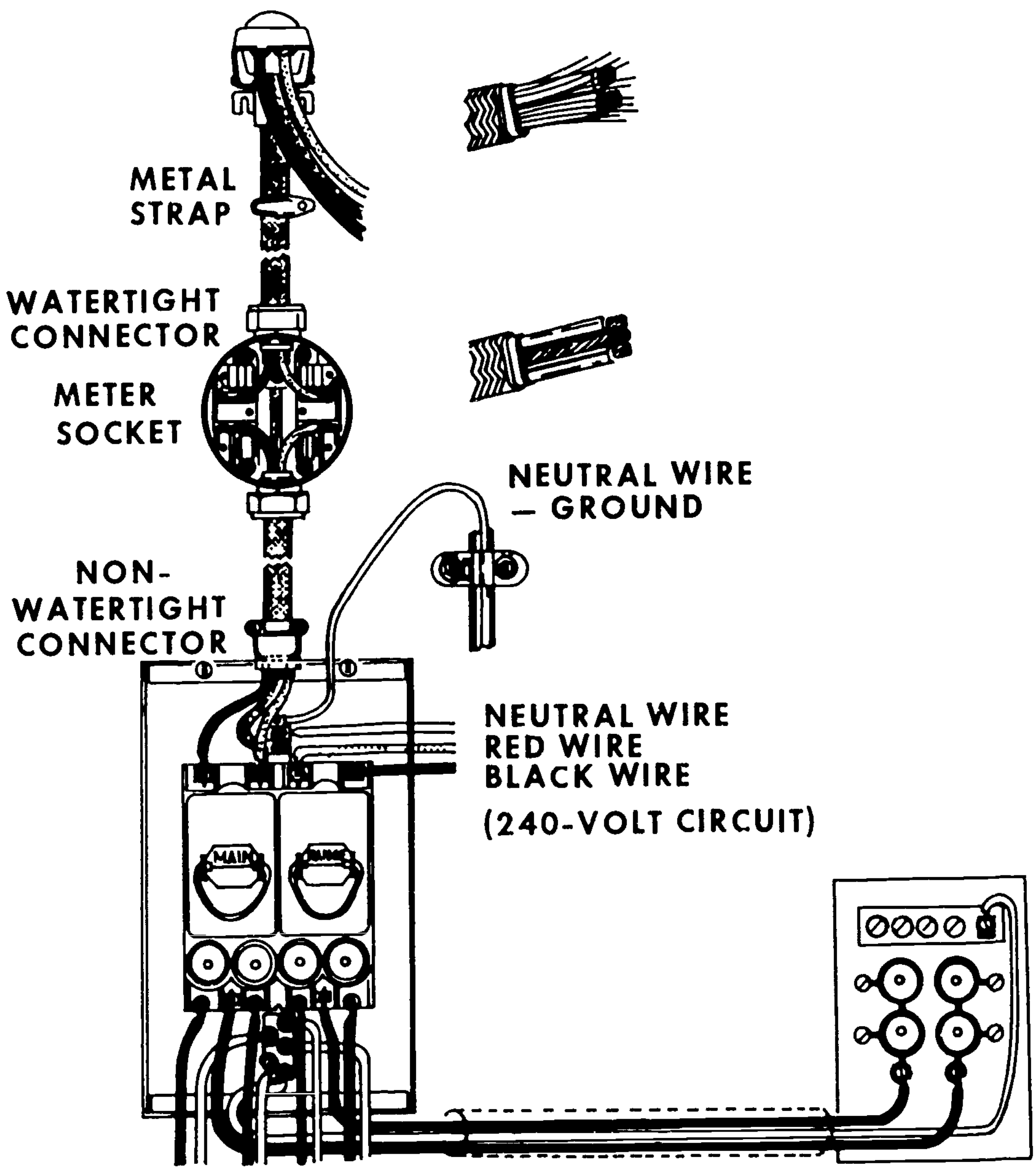



Figure 3. Service entrance, armored cable

Figure 4 shows the use of thin-wall conduit in a service entrance.

B Underground Service

When wires are run underground they must be protected from moisture and physical damage. The opening in the building foundation where the underground service enters the building must be moisture proof. Local codes should be referred to, concerning allowable materials for this type of service entrance.

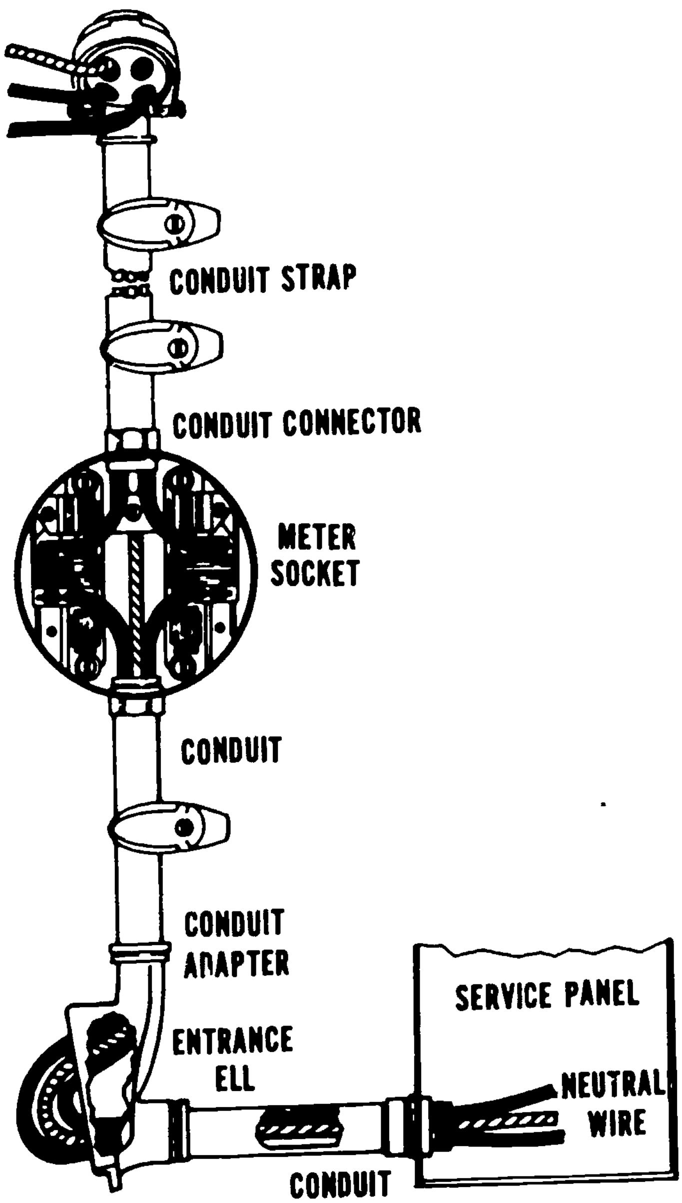


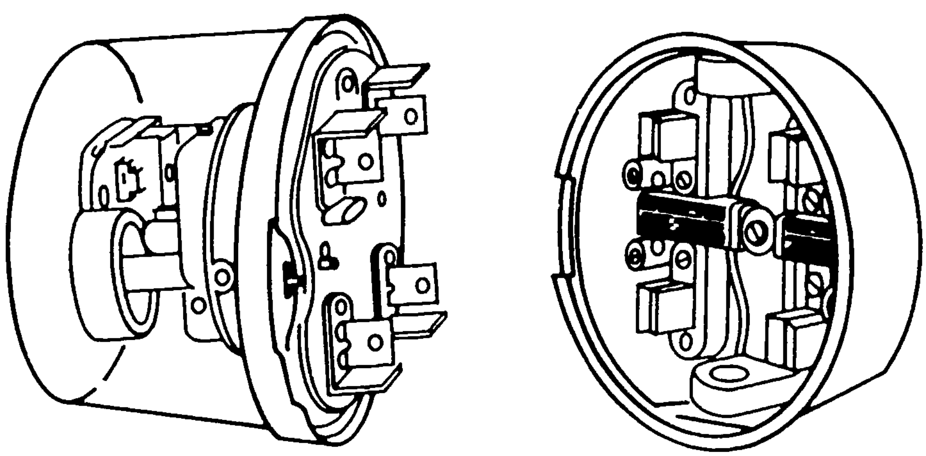

Figure 4. Service Entrance, conduit type

### C Electric Meter

The electric meter may be located inside or outside the building, as shown in Figure 3 or 4. The meter itself is weatherproof and is plugged into a weatherproof socket (see Figure 5). The electric power company furnishes the meter, the socket may or may not be furnished by the power company.

## IV GROUNDING

The system ground consists of grounding the neutral incoming wire as well as the neutral wire of the branch circuits. The equipment ground consists of grounding the metal parts of the service entrance. such as the service switch, as well as the service entrance conduit. armor, or cable.



**A typical weatherproof electric meter and its socket**

Figure 5. Electric meter

The usual ground connection is to a water pipe of the city water system. The connection should be made to the street side of the cold water meter as shown in Figure 6.

If the water meter is located near the street curb, then the ground connection should be made to the cold water pipe as close as possible to where it enters the building.

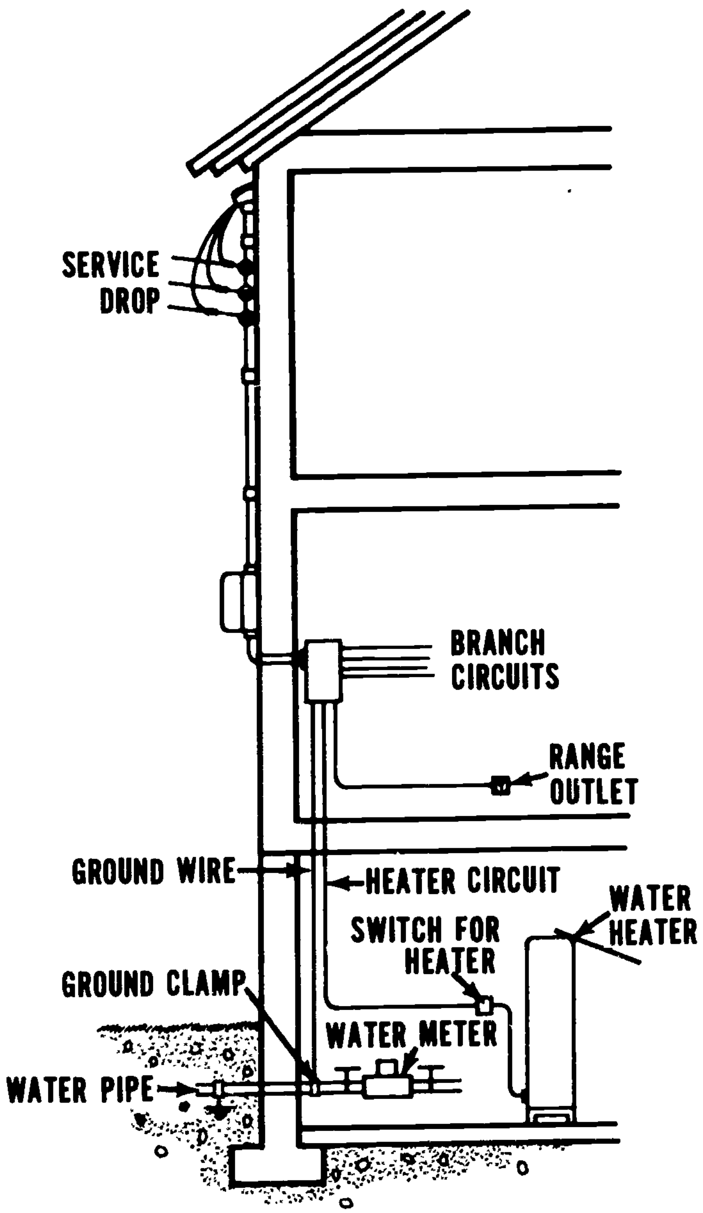



Figure 6. View of a typical service entrance

It is not unusual for a water meter to be removed from a building for service. If the ground connection is made at a point in the water piping system on the building side of the water meter, the ground circuit will be broken upon removal of the meter. This broken ground circuit represents a shock hazard if both sides of the water meter connections should be touched simultaneously.

In some instances the connections between the water meter to pipes are electrically very poor. In this case, if the ground connection is made on the building side of the water meter there may not be an effective ground.

In order to prevent the two aforementioned situations the code, Sec. 25D-112a, requires that when the ground connection is not made on the street side of the water meter, a jumper shall be installed across the meter, as shown in Figure 7. The same jumper arrangement would be required for a water meter that is installed near the curb. In many installations the water meter mounting bracket is designed to serve as an electric jumper.

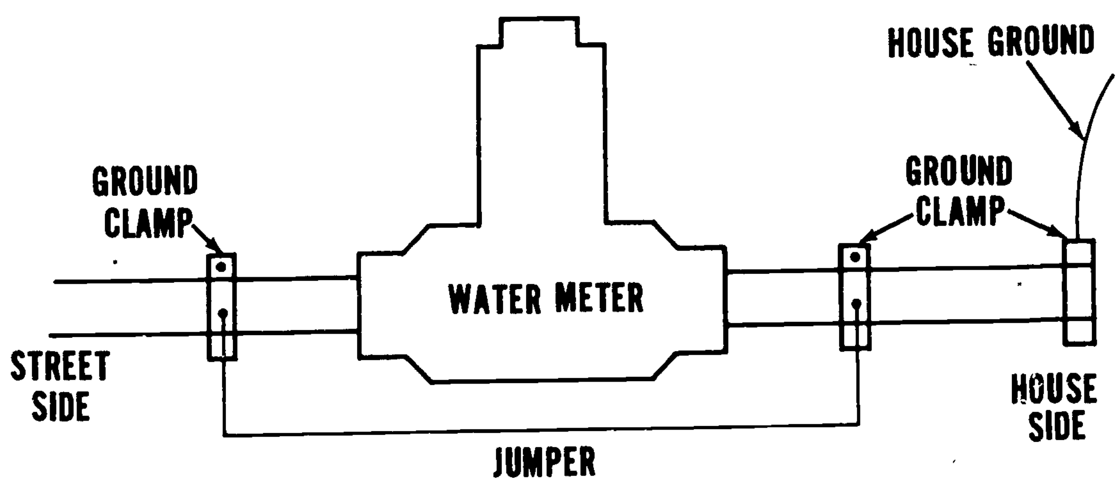



Figure 7. A jumper must be installed around a water meter if the house ground connection is made on the house side of the water meter.

Often an amateur mechanic, in the process of doing a household repair, will disconnect the house ground. Therefore, the housing inspector should always check the house ground to see if it is properly connected.

Figure 8 shows a typical grounding scheme at the service box of a residence. In this figure, only the grounded neutral wires are shown. The neutral strap is an uninsulated metal strip that is riveted directly to the service box. The ground wires from the service entrance, branch circuits, and house ground are joined by this strip.

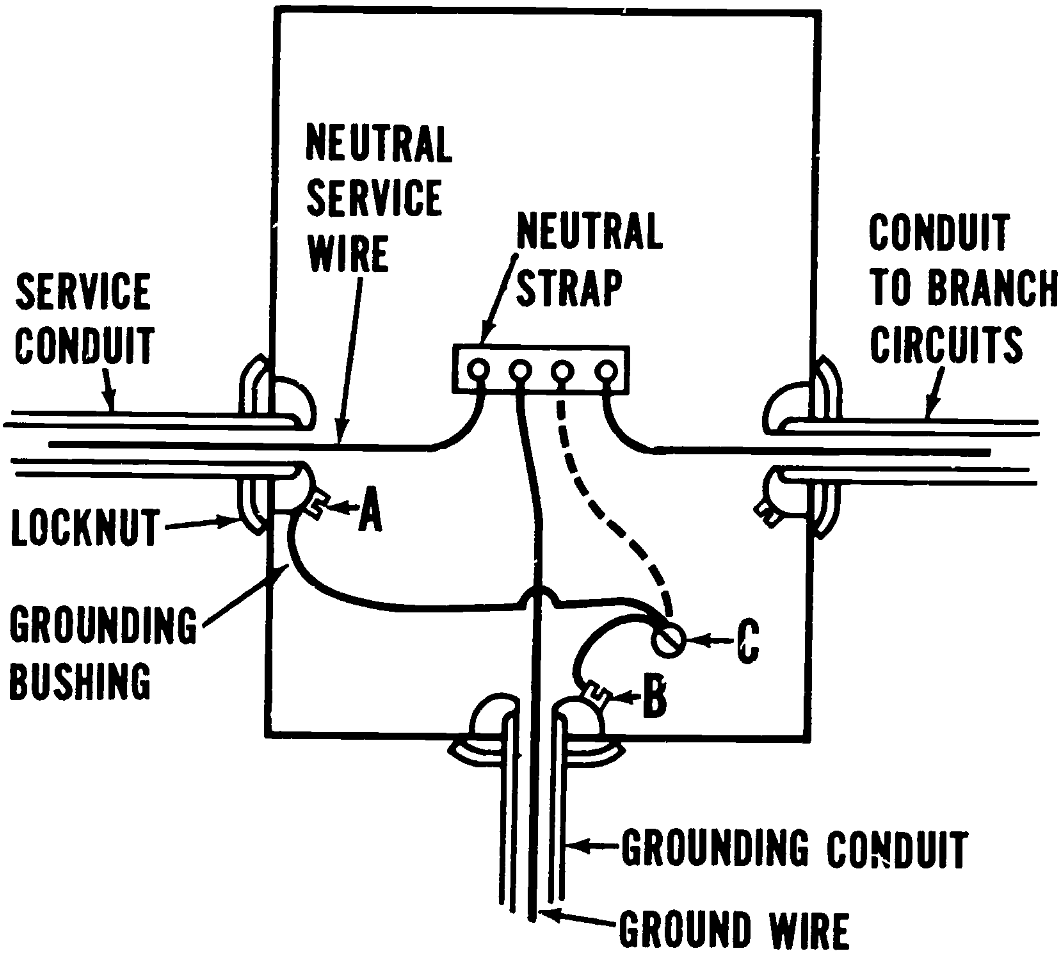



Figure 8. Typical grounding scheme at entrance switch of residential installation. Only the grounded neutral wires are shown. The detail used varies in different localities.

When a city water supply is not available for grounding, a substitute must be made. The most common ground is a pipe or rod that is driven into the ground a distance of at least 8 feet. If the pipe is made of steel or iron, it must be 3/4 inch in diameter and galvanized. A copper ground pipe of $\frac{1}{2}$ inch diameter is sufficient.

The code requires that a ground rod be entirely independent of and kept at least 6 feet from any other ground of the type used for radio, telephone, or lightning rods.

## V TWO- OR THREE-WIRE ELECTRIC SERVICES

One of the wires in every installation is grounded. This neutral wire is always white. The hot wires are usually black or red or some other color, but never white.

The potential difference or voltage between the hot wires and the ground or neutral of a normal residential electrical system is 115 volts. Thus, where we have a two-wire installation (one hot and one neutral) only 115-volt power is available (see Figure 9).

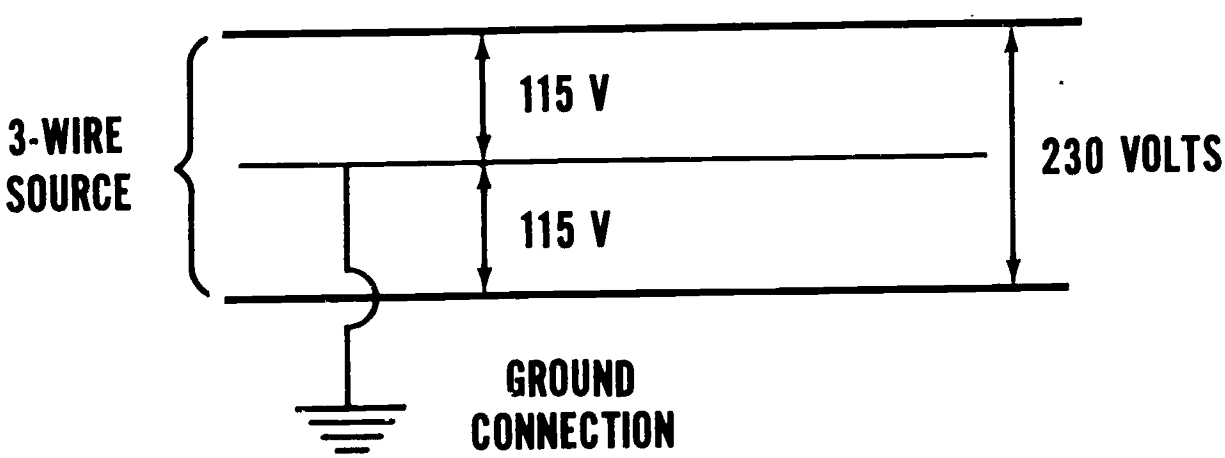



Figure 9

When three wires are installed (two hot and one neutral) either 115- or 230-volt power is available. In a three-wire system the voltage between the neutral and either of the hot wires is 115; between the two hot wires it is 230 volts.

The major advantage of a three-wire system is that it permits the operation of heavy electrical equipment such as laundry driers, cooking ranges, and air conditioners, the majority of which require 230-volt circuits. In addition, the three-wire system is split at the service panel into two 115-volt systems to supply power for small appliances and electric lights. The result is a doubling of the number of circuits, and possibly a corresponding increase in the number of branch circuits, with a reduction of the probability of fire caused by overloading electrical circuits.

## VI RESIDENTIAL WIRING ADEQUACY

The use of electricity in the home has risen sharply since the 1930's. Many home owners have failed to repair or improve their wiring to keep it safe and up to date. The National Electrical Code recommends that individual residences be provided with a minimum of 100-ampere three-wire service. This type service is sufficient in a one-family house or dwelling unit to provide safe and adequate electric supply for the light refrigerator, ironer, and an 8,000-watt cooking range, plus other appliances requiring a total of up to 10,000 watts altogether.

Some homes have a 60-ampere, three-wire service. It is recommended that these homes be rewired for at least the minimum of 100 amperes recommended in the National Code since they are safely capable of supplying current only for lighting and portable appliances such as a cooking range and regular dryer (4,500 watts), or an electric hot-water heater (2,500 watts) and cannot handle additional major appliances.

Other homes today have only a 30-ampere, 115-volt, two-wire service. This system can safely handle only a limited amount of lighting, a few minor appliances, and no major appliances. Therefore, this size service is substandard in terms of modern household needs for electricity. Furthermore, it constitutes a fire hazard and a threat to the safety of the home and the occupants.

## VII WIRE SIZE AND TYPES

### A Wire Size

Electric power flows over wire. It flows with relative ease (little resistance) in some materials such as copper and with a substantial amount of resistance in iron. If iron wire were used it would have to be 10 times as large as copper wire.

Copper wire sizes are indicated by a number. No. 14 is most commonly used in residential branch circuits. No. 14 is the smallest permitted by the Code for use in a branch circuit with a 15-ampere capacity. No. 16, 18, and 20 are progressively smaller than No. 14 and are usually used for extension wires. As the number of the wire becomes smaller the size and current capacity of the wire increases. No. 1 is the heaviest wire usually used in ordinary household wiring.

Wire of correct size must be used for two reasons: current capacity and voltage drop.

1 When current flows through a wire it creates heat. The greater the amount of flow, the greater the amount of heat generated. (Doubling the amperes without changing the wire size increases the amount of heat by four times.) The heat is electric energy that has been converted into heat energy by the resistance of the wire: the heat created by the coils in a toaster is an example. This heat developed in an electrical conductor is wasted, and thus the electric energy used to generate it is wasted. If the amount of heat generated by the flow of current through the wire becomes excessive, a fire may result. Therefore. the code sets the maximum permissible current that may flow through a certain type and size wire.

   The following are examples of current capacities for copper wire of various sizes.

| Size wire (AWG) | #14 | #12 | #10 | #8 |
|---|---|---|---|---|
| Max. capacity, amperes | 15 | 20 | 30 | 40 |

2 In addition to heat generation there will be a reduction in voltage as a result of attempting to force more current through

a wire than it is capable of carrying. Certain appliances, such as induction-type electric motors, may be damaged if operated at too low a voltage.

B Wire Types

1 Weatherproof Wire - This type of wire is intended only for outdoor use. The code prohibits it for indoor use. The insulation is either weatherproof cotton braiding or neoprene. There is no rubber in the insulation.

2 Interior Wiring - If the wire is No. 8 or smaller, it is solid; the copper conductor is a single strand. If it is No. 6 or heavier, the wire is stranded (a number of small wires twisted together). In use the wire is pulled into a pipe (conduit) or made into a cable.

a Type T wire - Consists of a tinned copper conductor over which is a single layer of a thermoplastic compound.

b Type R wire - Consists of a tinned copper conductor over which is a layer of rubber. Over that there is a cotton braid, saturated with a compound that is moisture resistant. The wire is then given a final coating of wax.

C Types of Cable

1 Nonmetallic Sheathed Cable - This type of cable consists of two or three Type T wires wrapped in a paper layer, followed by another spiral layer of paper, and enclosed in a fabric braid, which is treated with moisture-resistant and fire-resistant compounds. Figure 12 shows this type of cable, which often is marketed under the "Romex" name. This type of cable can be used only indoors and in permanently dry locations.

2 Armored Cable - This type of cable is commonly known by the BX or Flexsteel trades names. Either Type T or R wires are wrapped in a tough paper and covered with a strong spiral flexible steel armor. This type of cable is shown in Figure 13 and may be used only in permanently dry indoor locations.

Armored cable must be supported by a strap or staple every $4\frac{1}{2}$ feet and within 12 inches of every switch or junction box, except for concealed runs in old work where it is impossible to mount straps.

D Flexible Cords

Flexible cords are used to connect lamps, appliances, and other devices to outlets. Each wire consists of many strands of fine wire for flexibility. Extension cords in AWG sizes 16 to 18 are usually fine for lamps and smaller applicances, if the cord is not too long. A commonly accepted standard limits their length to 8 feet of unpliced cord. This keeps the cords short enough to prevent the excessive voltage drops, minimizes the possibility of fire caused by overheating of the wire due to overload, and also minimizes the danger of someone's tripping over them.

E Open Wiring

Open wiring is a wiring method using knobs nonmetallic tubes, cleats, and flexible tubing for the protection and support of insulated conductors in or on buildings and not concealed by the structure. The term "open wiring" does not mean exposed, bare wiring. In dry locations when not exposed to severe physical damage, conductors may be separately encased in flexible tubing. Tubing should be in continuous lengths not exceeding 15 feet and secured to the surface by straps not more than $4\frac{1}{2}$ feet apart. They should be separated from other conductors by at least 2 inches and should have a permanently maintained airspace between them and any and all pipes they cross.

F Knob and Tube Wiring

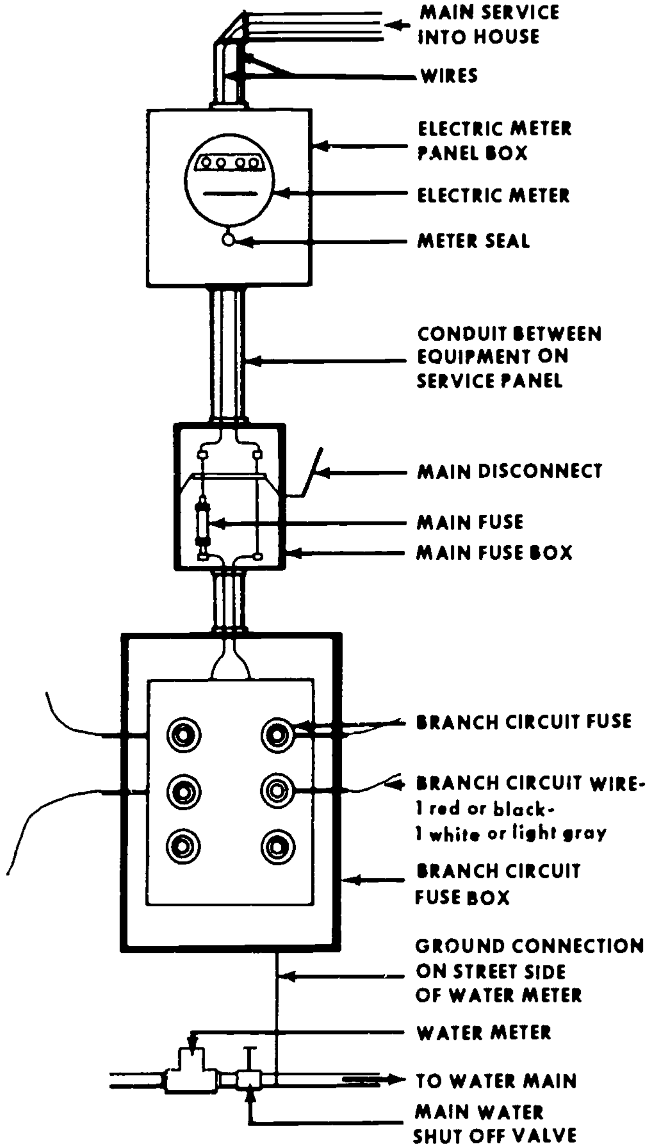
Knob and tube wiring is a wiring method using knobs, tubes and flexible nonmetallic tubing for the protection and support of insulated wires concealed in hollow spaces of walls and ceilings of buildings. This wiring method is similar to open wiring, and like open wiring, is found only in older buildings.

## VIII ELECTRIC SERVICE PANEL

A Service Switch

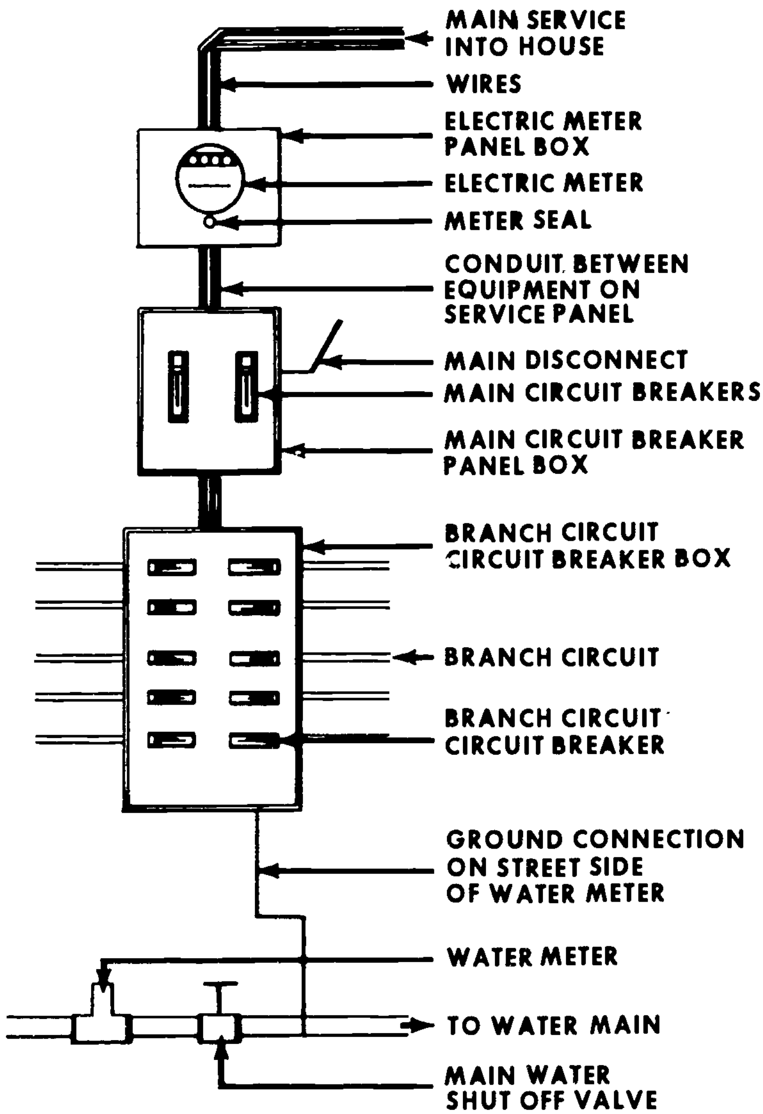
This is a main switch that will disconnect the entire electrical system at one time. The main fuses or circuit breakers are usually located within the "Service Switch" box. The branch circuit fuse or circuit breaker may also be located within this box.

According to the code, the switch must be "externally operable." This condition is fulfilled if the switch can be operated without the operator's being exposed to electrically active parts. Older switches use external handles as shown in Figure 10.




**TWO WIRE SINGLE PHASE GROUNDED SERVICE PANEL (FUSE TYPE)**

Figure 10




THREE WIRE GROUNDED SINGLE PHASE
CIRCUIT BREAKER SERVICE PANEL

Figure 11

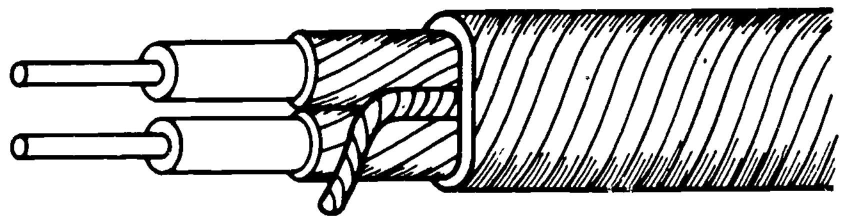


Figure 12. - Nonmetallic sheath cable

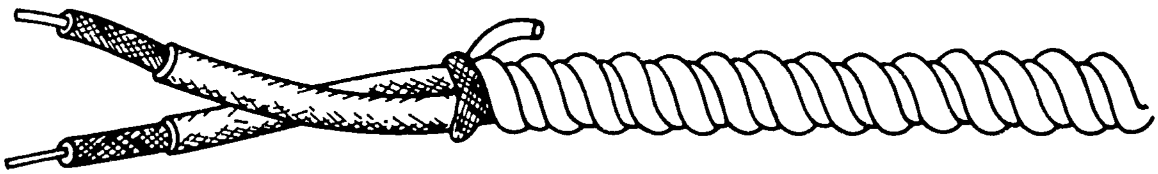


Figure 13. - Armored cable

Most of today's service switches do not have hinged switch blades. Instead, the main fuse is mounted on a small insulated block that can be pulled out of the switch. When this block is removed, the circuit is broken just as if the blades had been operated with a handle.

The neutral terminal or wire of a grounded circuit must never be interrupted by a fuse or circuit breaker. In some installations the service switch is a "solid neutral" switch. This means that the neutral wire in the switch is not broken by the switch or a fuse.

When circuit breakers instead of fuses are used in homes, the use of main circuit breakers may or may not be required. If it takes not more than six movements of the hand to open all the branch-circuits breakers, no main breaker or switch or fuse will be required ahead of the branch-circuit breakers. Thus, a house with seven or more branch circuits requires a separate disconnect means or a main circuit breaker ahead of the branch circuit breakers (see Figure 11).

## IX OVERCURRENT DEVICES

The amperage (current flow) in any wire is limited to the maximum permitted by using an overcurrent device of a specific size as specified by the code. Two types of overcurrent devices are in common use: circuit breakers and fuses; both are rated in amperes. The overcurrent device must be rated at equal or lower capacity than the wire of the circuit it protects.

### A Circuit Breakers (Fuseless) Service Panels

A circuit breaker (see Figure 14) looks something like an ordinary electric light switch. There is a handle that may be used to turn power on or off. Inside is a simple mechanism that, in case of a circuit overload, trips the switch and breaks the circuit. The circuit breaker may be reset by simply flipping the switch. A circuit breaker is capable of taking harmless short-period overloads (such as the heavy initial current required in the starting of a washing machine or air conditioner) without tripping but protects

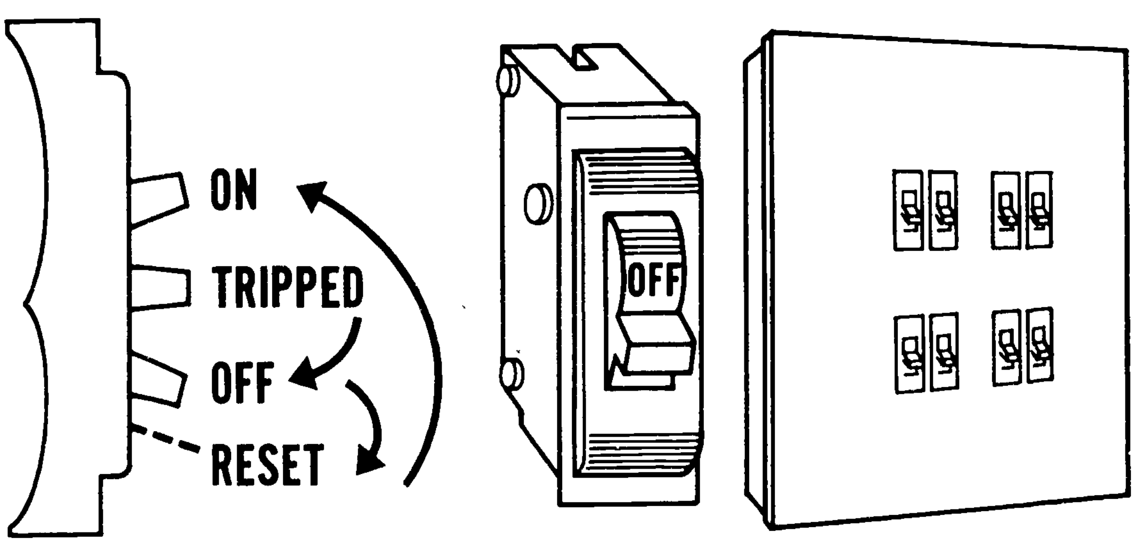



Figure 14. - Circuit breaker

against prolonged overloads. After the cause of trouble has been located and corrected, the power is easily restored by flipping the circuit breaker switch (circuit breakers are modern substitutes for fuses). Fuseless service panels are usually broken up into the following circuits.

1 A 100-ampere or larger main circuit breaker that shuts off all power.

2 A 40-ampere circuit for an appliance such as an electric cooking range.

3 A 30-ampere circuit for clothes dryer, hot waterheater, or central air conditioning.

4 A 20-ampere circuit for kitchen, small appliances, and power tools.

5 A 15-ampere circuit for general purpose lighting, TV, and vacuum cleaner.

6 Space for circuits to be added if needed for future use.

B Fused Ampere Service Panel or Fuse Box

Fuse-type panel boxes are generally found in older homes. They are equally as safe and adequate as a circuit breaker of equivalent capacity, provided fuses of the proper size are used.

A fuse (see Figure 15), like a circuit breaker, is designed to protect a circuit against the dangers of overloading and short circuits and does this in two manners.

a When a fuse is blown by a short circuit the metal strip is instantly heated to an extremely high temperature, and this heat causes it to vaporize. A fuse blown by a short circuit may be easily recognized because the window of the fuse usually becomes discolored.

b In a fuse blown by overload the metal strip is melted at its weakest point, and this breaks the flow of current to the load. In this case the window of the fuse remains clear; therefore, a blown fuse caused by an overload may also be easily recognized.

Sometimes, although a fuse has not been blown, the bottom of the fuse may be severely discolored and pitted. This indicated a loose connection due to the fuse's not being screwed in properly.

Generally, all fused panel boxes are wired similarly for two- and three-wire systems. In a two-wire-circuit panel box the black or red hot wire is connected to a terminal of the main disconnect, and the white or light gray neutral wire is connected to the neutral strip, which is then grounded to the pipe on the street side of the water meter.

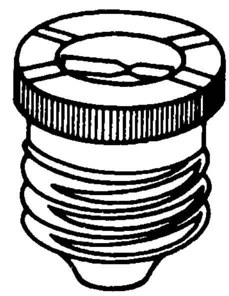
In a three-wire system the black and red hot wires are connected to separate terminals of the main disconnect, and the neutral wire is grounded the same as for a two-wire system (see Figure 10). Below each fuse is a terminal to which a black or red wire is connected. The white or light gray neutral wires are then connected to the neutral strip. Each fuse indicates a separate circuit.

1 Non-tamperable Fuses - All ordinary plug fuses, shown in Figure 15, have the same diamter and physical appearance regardless of their current capacity. Thus. if a circuit designed for a 15-ampere fuse is overloaded so that the 15-ampere fuse blows out, nothing will prevent a person from replacing the 15-ampere fuse with a 20- or 30-ampere fuse, which may not blow out. If a circuit wired with No. 14 wire (current capacity 15 amperes) is fused with a 20- or 30-ampere fuse and an overload develops, more current than the No. 14 wire is safely capable of carrying could pass through the circuit. The result would be a heating of the wire and a potential fire.

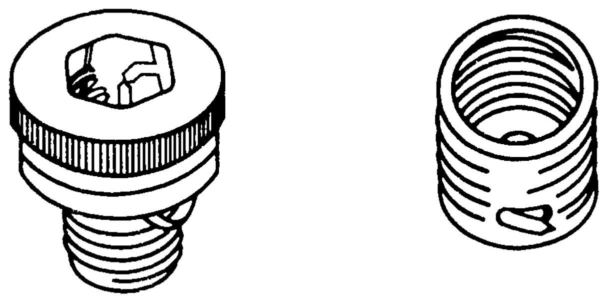
Type S fuses, shown in Figure 15, have different lengths and diameter threads for each different amperage capacity. An adapter is first inserted into the ordinary fuse holder, which adapts the fuse holder for only one capacity fuse. Once the adapter is inserted. it cannot be removed.

2 Cartridge Fuses

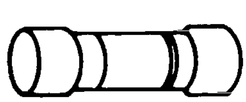
Figure 15 shows two different types of cartridge fuse. A cartridge fuse protects an electric circuit in the same manner as an ordinary plug fuse already described protects it. Cartridge fuses are often used as main fuses.



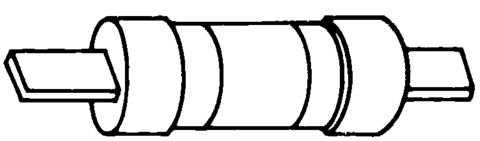
Plug fuses are not made in ratings over 30 amp.



A typical Type-S non-tamperable fuse, and its adapter. Once an adapter has been screwed into a fuse-holder, it cannot be removed. This prevents use of fuses larger than originally intended.



Cartridge fuses rated 60 amps. or less are of the ferrule type shown.



Cartridge fuses rated more than 60 amp. have knife-blade terminals shown.

Figure 15

## X ELECTRIC CIRCUITS

An electric circuit in good repair carries electricity through two or three wires from the source of supply to an outlet and back to the source.

### A Branch Circuit

A branch circuit is an electric circuit that supplies electric current to a limited number of electric outlets and fixtures. A residence generally has many branch circuits each is protected against short circuits and overloads by a 15- or 20-ampere fuse or circuit breaker.

The number of outlets per branch circuit varies from building to building. The code requires enough light circuits so that 3 watts of power will be available for each square foot of floor area in a house. A circuit wired with No. 14 wire and protected by a 15 ampere overcurrent protection device provides $15 \times 115$ or 1,725 watts; each circuit is obviously enough for 1,725/3 or 575 square feet.

Note that 575 is a minimum figure; if future use is considered, 500 or even 400 square feet per branch circuit should be used.

### B Special Appliance Circuits

The branch circuit will provide electric power for lighting, radio, television, and small portable appliances. However, the larger electric appliances usually found in the kitchen consume more power and must have their own special circuit.

Section 220-3b of the code, requires two special circuits to serve only appliance outlets in "kitchen, laundry, pantry, family-room, dining room, and breakfast room." Both circuits must be extended to the kitchen; the other rooms may be served by either one or both of these circuits. No lighting outlets may be connected to these circuits, and they must be wired with No. 12 wire and protected by a 20-ampere overcurrent device. Each circuit will have a capacity of $20 \times 115$ or 2,300 watts, which is not too much when one considers that toasters often require over 1,600 watts.

### C Individual Appliance Circuits

It is customary to provide a circuit for each of the following appliances:

1 Range

2 Water heater

3 Automatic laundry

4 Clothes dryer

5 Garbage disposer

6 Dishwasher

7 Furnace

8 Water pump

Note that these circuits may be either 115 volts or 230 volts, depending on the particular appliance or motor installed.

### D Outlet Switch and Junction Boxes

The code requires that every switch, outlet, and joint in wire or cable be housed in a box. Every fixture must be mounted on a box. Most boxes are made of metal with a galvanized finish. Figure 16 shows a typical outlet box.

When a cable of any style is used for wiring, the code requires that it be securely anchored with a connector to each box it enters.

### E Grounding Outlets

An electrical appliance may appear to be in good repair, and yet it might be a danger to the user. Consider a portable electric drill. It consists of an electric motor inside a metal casing. When the switch is depressed, the current flows to the motor, and the drill notates. As a result of wear, however, the insulation on the wire inside the drill may deteriorate and allow the hot side of the power cord to come in contact with the metal casing. This will not affect the operation of the drill.

A person fully clothed using the drill in the living room, which has a dry floor, will not received a shock, even though he in in contact with the electrified drill case. His body is not grounded, because of the dry floor. If, however, the operator should be standing on a wet basement floor, his body might be grounded, and when he touches the electrified drill case, current will pass through his body.

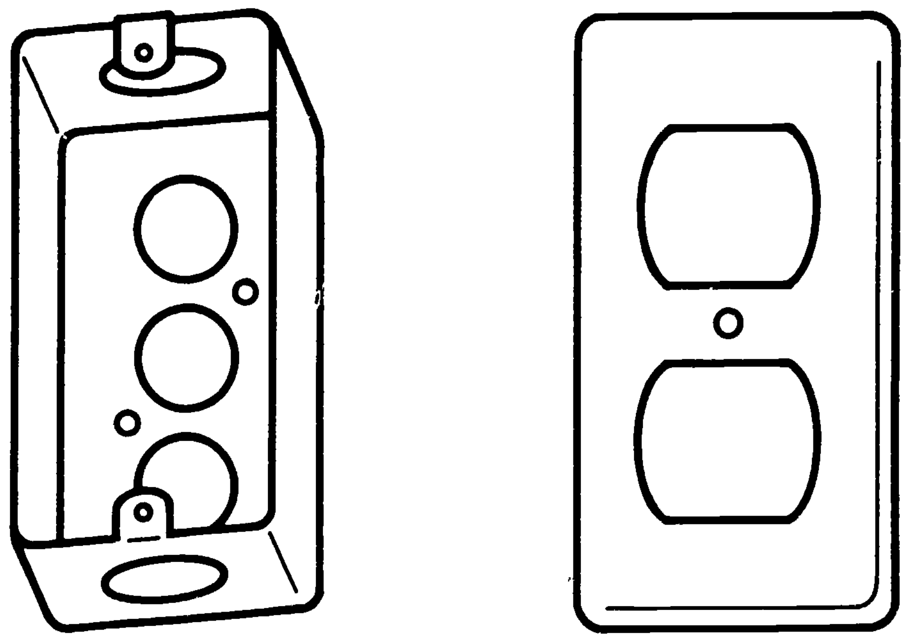


Figure 16. - Outlet Box

In order to protect man, the drill case is usually connected to the system ground by means of a wire called an "appliance ground." In this instance, as the drill is plugged in, current will flow between the shorted hot wire and the drill case and cause the overcurrent device to break the circuit. Thus the appliance ground has protected man.

The appliance ground is the third wire found on many appliances.

The appliance ground on the appliance will be of no use unless the outlet into which the appliance is plugged is grounded. The outlet is grounded by being in physical contact with a ground outlet box. The outlet box is grounded by having a third ground wire, or a grounded conduit, as part of the circuit wiring.

All new buildings are required to have grounded outlets (as shown in Figure 17). The outlet may be tested by using a circuit tester. The circuit tester should light when both of its leads are plugged into the two elongated parallel openings of the outlet. In addition, the tester should light when one lead is plugged into the round third opening and the other is plugged into the hot side of the outlet

If the conventional two-opening outlet is used, it still may be grounded. In this instance the screw that holds the outlet cover plate is the third-wire ground. The tester should light when one lead is in contact with a clean paint-free metal outlet cover plate screw and the hot side of the outlet. If the tester fails to light then the outlet is not grounded. If the outlet is not grounded then the tester will not function.

If a two-opening outlet is grounded, it may be adapted for use by a three-wire

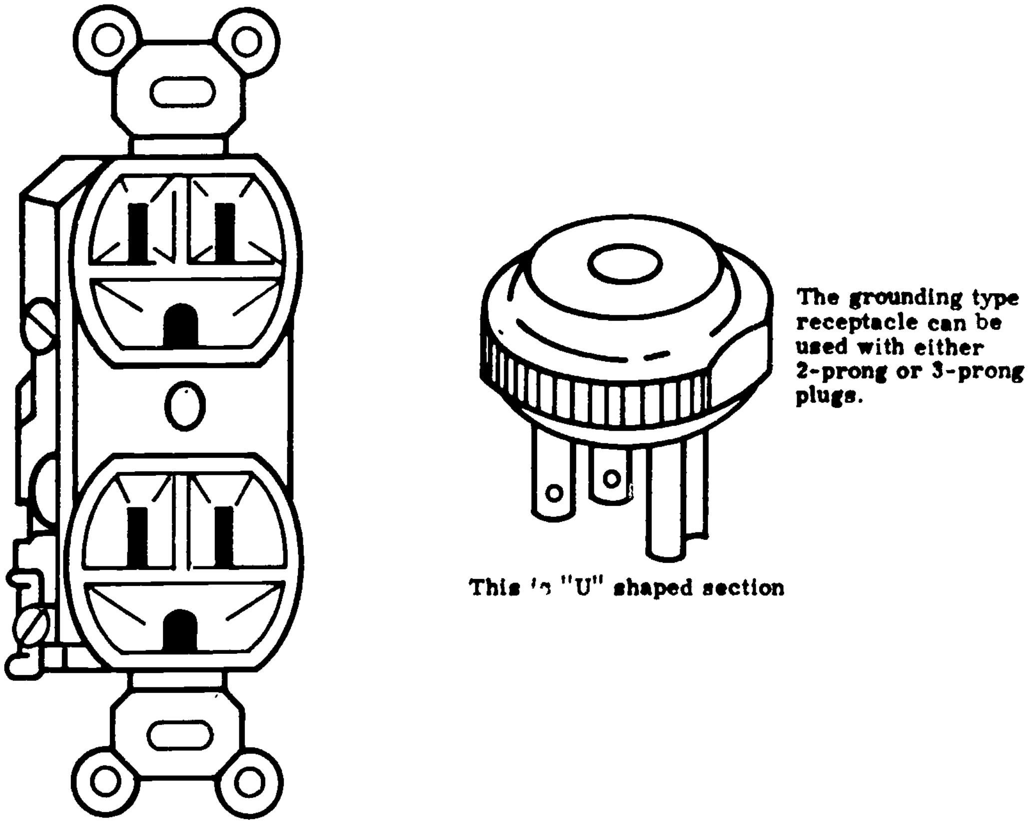



Figure 17. - Grounded type receptacle

appliance by using an adapter. The loose-wire portion of the adapter should be secured behind the metal screw of the outlet plate cover.

Many appliances such as electric shavers and some new hand tools are double insulated and are safe without having a third ground wire.

XI COMMON ELECTRICAL VIOLATIONS

A The most apparent requirements that a housing inspector must check are the existence of the power supply; the types, locations, and conditions of the wiring in use; and the existence of the number of wall outlets or ceiling fixtures required by his local code and their condition. In making his investigations, these considerations will serve as useful guides:

1 Power Supply - Where is it located, is it grounded properly, and is it at least of minimum capacity required to supply current safely for lighting and the major and minor appliances in the dwelling?

2 Panel Box Covers or Doors - These should be accessible only from the front and should be sealed in such a way that they can be operated safely without the danger of contact with live or exposed parts of the wiring system.

3 Switch, Outlets, and Junction Boxes - These also must be covered to protect against danger of electric shock.

4 Frayed or Bare Wires - These are usually the result of long use and a drying out and cracking of the insulation, which leave the wires exposed, or else a result of constant friction and rough handling of the wire, which cause it to fray or become bare. Wiring in this condition constitutes a safety hazard, and correction of such defects should be ordered immediately.

5 Electric Cords Under Rugs or Other Floor Coverings - Putting electric cords in locations such as these is prohibited because of the potential fire hazard caused by continuing contact over a period of time between these heat-bearing cords and the flammable floor coverings. Direct the occupant to shift the cords to a safe location, explain why, and make sure it is done before you leave.

6 Bathroom Lighting - It should include at least one permanently installed ceiling or wall light fixture with a wall switch and plate so located and maintained that there is no danger of short circuiting from use of other bathroom facilities or splashing of water. Fixture or cover plates should be insulated or grounded.

7 Lighting of Public Hallways, Stairways, Landings and Foyers - A common standard here is sufficient lighting to provide illumination of 6 foot-candles on every part of these areas at all times. Sufficient lighting means that a person can clearly see his feet on all parts of the stairways and halls. Every public hall and stairway in a structure containing less than three dwelling units may be supplied with conveniently located light switches controlling an adequate lighting system that may be turned on when needed, instead of full-time lighting.

8 Habitable Room Lighting - The standard here may be two floor convenience outlets—although floor outlets are dangerous unless protected by proper dust and water covers—or one convenience outlet and one wall or ceiling electric light fixture. This number constitutes an absolute and often inadequate minimum given the contemporary widespread use of electricity in the home. The minimum should be that number required to provide adequate lighting and power to accommodate lighting and appliances normally used in each room.

9 Octopus Outlets or Wiring - This term is applied to outlets into which plugs have been inserted and are being used to permit more than two lights or portable appliances, such as a TV, lamp, or radio, to be connected to the electrical system. The condition occurs where the number of outlets is insufficient to accommodate the normal use of the room. This practice overloads the circuit and is a potential source of fire, which may be caused by overloading the circuit.

10 Outlet Covers - Every outlet and receptacle must be covered by a protective plate to prevent contact of its wiring or terminals with the body, combustible object, or splashing water.

The following items are conditions that cause needless dangers and must also be corrected:

a Excessive or faulty fusing - The wire's capacity must not be exceeded by the fuse or circuit breaker capacity or be left unprotected by faulty fusing or circuit breakers. Fuses and circuit breakers are safety devices designed to "blow" as a means of protection against overloadings of the electrical system or one or more of its circuits. Pennies under fuses are put there to bypass the fuse. These are illegal and must be removed. Overfusing is done for the same reason. The latter can be prevented by the installation of modern fusestats, which prevent use of any fuse of a higher amperage than can be handled by the circuit it serves.

b Cords run through walls or doorways and hanging cords or wires - This is a makeshift-type installation and most often is installed by an unqualified handyman or do-it-yourself occupant. The inspector should check with his local electrical section to determine the policy regarding this type of insulation and govern his action in accordance with the electrical section's policies.

c Temporary wiring - This type of installation should not be allowed, with the exception of extension cords that go directly from portable lights and electric fixtures to convenience outlets.

d Excessively long extension cords - This requirement does not apply to specially designed extension cords for operating portable tools, trouble lights, etc. Cities operating under modern code standards limit the length of loose cords or extension lines to a maximum of 8 feet. This is necessary because those that are too long will overheat if overloaded or if a short circuit develops and thus create a fire hazard. Even shorter lengths are feasible in housing with new or updated wiring systems that include one convenience outlet every 12 feet around the perimeter of the room.

e Dead or dummy outlets - These are sometimes installed to deceive the inspection agency. This is why all outlets must be tested or the occupants questioned to see if these are alive and functioning properly. A dead outlet cannot be counted to determine compliance with the code.

## XII STEPS INVOLVED IN ACTUAL INSPECTION

### A Testing Tools

The basic tools required by an inspector of housing for making an electrical inspection are a fuse and circuit tester and a flashlight.

### B Danger of Techniques

The first thing is to remember you are in a strange house and the layout is unfamiliar to you. The second thing to remember is that you are dealing with electricity–take no chances. Go to the water meter and check the ground. It should connect to the water line on the street side of the water meter or else be equipped with a jumper wire. Do not touch any box or wire until you are sure of the ground. Go to the main fuse box and check all fuses in all boxes. Note the condition of the wiring and of the box itself and check whether it is overfused or not. Examine all wiring in the cellar. Make sure you are standing in a dry spot before touching any electrical device. Do not disassemble the fuse box or other devices. Decisions must be made on what you see. If in doubt, consult your supervisor.

Make note whether any fuse boxes or junction boxes are uncovered. Examine all wiring for frayed or bare spots, improper splicing, or rotted, worn, or inadequate insulation. Avoid all careless touching. When in doubt–DON'T! If you see bare wire, have the owner call an electrician. Look for wires or cords in use in the cellar. Many work benches are lighted by an old lamp that was once in the parlor and now has a spliced or badly frayed cord or both. Be certain all switch boxes and outlets are in a tight, sound condition.

Make sure that the emergency switch for the oil burner is at the top of the cellar stairs, not on top of the unit.

If you find an electric clothes washer-clothes dryer combination in a dwelling these should have a 240-volt circuit 30-ampere service connected to a separate fuse or circuit breaker. Washer-dryer combinations and the other portable appliances in the entire house should be served by sufficiently heavy service. If either of these special lines is not available under the above-stated conditions, consult your supervisor.

An electric range needs a 50-ampere circuit. 240 volts. A dishwasher needs a 20-ampere. 120-volt circuit. A separate three-wire circuit must be installed for an electric water heater. Continue your inspection this way through the house. In the bathroom look for the usual items, but also check for dangerous items such as radios or plug-in portable electric heaters. Have them removed immediately. Such items have killed thousands of people either because they touched them after getting out of the bathtub or shower while still wet or because the appliance fell into the water. Look for brass pull chains in bathroom lighting fixtures. If one exists, have owner attach a string to the end of it as a temporary precaution, then order it replaced with a wall switch as required by the electrical code.

To sum up, in broad terms, the housing inspector's investigation of specified electrical elements in a house is made to detect any obvious evidence of an insufficient power supply, to ensure the availability of adequate and safe lighting and electrical facilities, and to discover and correct any obvious hazard. Because electricity is a technical, complicated field, the housing inspector, when in doubt, should consult his supervisor. He cannot, however, close the case as abated until appropriate corrective action has been taken on all such referrals.

## XIII WATTAGE CONSUMPTION OF ELECTRICAL APPLIANCES (100 WATTS = APPROXIMATELY 1 AMPERE)

| Appliance | Watts |
|---|---|
| Air conditioner (central) | 5000 |
| Air conditioner (window) | see nameplate |
| Blanket | 150 |
| Blender | 250 |
| Chaffing dish | 600 |
| Clock | 3 |
| Coffee maker | 600 |
| Deep fryer | 1,320 |
| Dishwasher | 1,800 |
| Egg boiler | 250 |
| Electric shaver | 10 |
| Fan | 75 |
| Food mixer | 200 |
| Furnace (fuel fixed) | 800 |
| Frying pan | 600 |
| Garbage disposer | 900 |
| Griddle | 1,300 |
| Grill | 600 |
| Heater (radiant | 1,600 |
| Heating pad | 50 |
| Hot plate (2 burners) | 1,650 |
| Humidifier | 500 |
| Immersion heater | 300 |
| Iron | 1,000 |
| Ironer | 1,650 |
| Lighting | |
| Bed lamp | 40 |
| Ceiling light | 100 |
| Decorative lights | 80 |
| Dining light | 150 |
| Dresser lamps | 60 |
| Drop light | 60 |
| Floor lamp | 400 |
| Fluorescent | 80 |
| Sun lamp | 275 |
| Table lamp | 100 |
| Radio | 100 |
| Range | 8,000 to 16,000 |
| Refrigerator | 250 |
| Roaster (large) | 1,380 |
| Rotisserie | 1,400 |
| Sewing machine | 75 |
| Soldering iron | 200 |
| Stereo hi-fi | 300 |
| Sump pump | 300 |
| Television | 300 |
| Toaster | 1,100 |
| Vacuum cleaner | 400 |
| Waffle iron | 660 |
| Washing machine | 5,200 |
| Water heater | 2,500-4,500 |
| Water pump | 300 |

## XIV MOTOR CURRENTS

| Horsepower | Full load amperes 120 v | 240 1-phase | 208 3-phase |
|---|---|---|---|
| 1/8 | 3.1 | 1.6 | -- |
| 1/4 | 4.4 | 2.2 | -- |
| 1/2 | 7.1 | 3.6 | 2.1 |
| 3/4 | 9.8 | 4.9 | 3.0 |
| 1 | 12.5 | 6.3 | 3.7 |

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