FUNDAMENTALS OF CARPENTRY

Volume II

PRACTICAL CONSTRUCTION

BEAUTY AND LIVABILITY ARE THE PRODUCTS OF THE CARPENTER'S CRAFTSMANSHIP

Courtesy of American Builder

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Volume II

PRACTICAL CONSTRUCTION

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PREFACE

BUILDING construction is the best vehicle for training in the carpentry trade. This book takes you through each step in carpentry construction, from laying out and excavating the basement to applying the interior finish of the completed structure.

The student or carpenter apprentice, as well as the teacher or skilled tradesman, will find that this book, like a good craftsman, gets down to work with no lost motion. Concise descriptions, simple language, and expertly prepared illustrations make the reader *visualize* the carpentry principles applied to modern building. Thus the reader grasps both theory and practice, with emphasis upon the latter.

Because this volume deals primarily with practical construction, the reader will get the most out of it if he has as background some understanding of carpentry principles, such as he will find in the companion book, *Fundamentals of Carpentry, Volume I—Tools, Materials, Practice.*

In both volumes Walter Durbahn successfully uses teaching devices that increase the efficiency of a book as a learning tool, not only for shops and classrooms but also for home-study purposes as well. The reader can use to excellent advantage the set of "Questions This Chapter Will Answer" at the beginning of each chapter and the review questions "Checking on Your Knowledge" at the end of each chapter.

A number of years ago, at the Deerfield-Shields Township High School in Highland Park, Illinois, Mr. Durbahn tried out the idea that carpentry students and apprentices could learn better by actually erecting houses and other structures along with their class and shop training. It worked! National recognition has been given him for the advancement of this sound method of teaching and training. In learning the carpentry trade, his students have built numerous homes, a bus garage, an elaborate field house, automobile mechanics' building, and a fully equipped vocational shop and classroom building.

Fundamentals of Carpentry, Volume II—Practical Construction prepares the learner to tackle with confidence an actual job of construction, whether the learner is an apprentice in the trade or a layman home mechanic with a repair or construction job in his own home. The teaching method followed in this book employs two clear-cut steps. First, the reader gets an understanding of the principle involved in each job of carpentry construction. This understanding includes knowing the *why* of an operation and the problems encountered. Second, the reader learns exactly *how* to use the principle in building a typical structure. In this way he receives a thorough and well-grounded training both in carpentry principles and in their applications. Within these pages, he actually erects a typical modern building from the footing up. He learns how to construct formwork, frame a structure, join and splice timbers, install beams, lay floors, build stairs, frame roofs, and apply exterior and interior finish.

A closing chapter deals with the special problems in the construction of various types of farm buildings, such as barns, hog houses, poultry houses, granaries, sheepsheds, and rabbit hutches. In this volume, as in the companion book, the reader is aided by valuable tables in the Appendix.

A complete set of eight working drawings, in blueprint form, is included as an integral part of the instructional method of this book. These drawings are contained in a handy envelope attached to the back cover and may be removed for ready reference whenever needed.

The author is indebted to Dan McLellan, who learned his trade in Scotland, and who is remembered for his inspiring interest in training young men for the building trades. He is also indebted to William Aitken, a contractor for whom the author worked for many years and from whom he learned the value of thoroughness in methods of instruction as well as construction.

For their part in preparing this text for publication, acknowledgment is due to the following staff members of the American Technical Society: Miss Pearl Jenison for her careful research and editorial work; Mr. Arthur Burke, head, and Miss Carrie Alden, member, of the art department for their accurate and illustrative art work.

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THE CARPENTER, UTILIZING THE ARCHITECT'S PLANS, PRODUCED THIS COZY, COMFORTABLE SETTING

Courtesy of American Builder

CHAPTER 1

The House of the Book

QUESTIONS THIS CHAPTER WILL ANSWER

1. *What is meant by the term,* The House of the Book? 2. *Why are blueprints and specifications necessary in the construction of a house?* 3. *What relationship exists between building specifications and blueprints? Who prepares the specifications?* 4. *Why should the tradesman on the job be supplied with a set of blueprints, or at least be allowed to study them?* 5. *In what way are well-prepared blueprints and specifications important as timesavers?*

INTRODUCTION TO CHAPTER I

A noted statesman once said, "The secret of success in life is for a man to be ready for his opportunity when it comes." If you as a carpentry student have been waiting for the opportunity to learn how to build a new house, here it is! Roll up your sleeves and go to work.

The author of this textbook assumes that you have learned previously how to use carpentry tools and that you also know how to build simple workshop equipment. With this text at hand, you now have the opportunity to extend your knowledge into a broader field of activity. In *Practical Carpentry Construction* you are given definite and detailed instructions for the actual building of a new house, which for convenience we will call *The House of the Book.*

In addition to the skilful use of his tools and equipment, the carpenter must thoroughly understand how to use architectural drawings or building plans. Construction really begins with the study of the blueprints and building specifications. Since all details cannot be shown on the drawings, a word picture of the work to be done and materials required must be available to the builder by means of written specifications. The information thus provided, together with the blueprints, will help both the builder and owner to understand each other better and to have the same mental picture of the finished house before construction actually begins.

The material in this chapter deals especially with blueprints and building specifications and how to use them. The blueprints which you will find in the back of the book are copies of architectural plans that have been used by various builders in the construction of a number of American homes in different parts of the country. The purpose of this chapter is to teach you how to use the blueprints for *The House of the Book* so you will understand their importance to you as a carpenter, and also to teach you how to use specifications to the best advantage in connection with the directions given on the accompanying blueprints.

In the Appendix at the back of the text you will find the specifications for *The House of the Book.* Specifications may be defined as ***instructions to the builder,*** and as such they must be clear, simple, and complete. They are supplementary to, and an explanation of, the blueprints from which the construction work is carried on. The function of the specifications is to make perfectly clear every item that cannot be made clear on the blueprints.

Read the chapter carefully. After examining the blueprints and reading the specifications, ask yourself the questions at the end of the chapter and see how many you can answer. After a careful and honest effort has been made, check your results with the correct answers given in the Appendix following the specifications. Study all facts given in Chapter I in connection with the information given on the blueprints and in the specifications. This will help you to realize the importance of knowing how to follow the instructions and directions given for the building of *The House of the Book.* Notice particularly the complete and detailed directions given in the specifications. Reading such precise statements as these will help you to see the importance of your obligations and responsibilities as a carpenter.

After studying this chapter, you should have a better understanding than before of how the work of the carpenter must be co-ordinated and harmonized with the work of other skilled craftsmen on the job. You will also have a better appreciation of how essential it is for men, each doing the work assigned to him, to co-operate in bringing together materials, supplies, and equipment with which to fashion and construct a new building. Such co-operation and harmony in working together is necessary if the construction of *The House of the Book,* or any other house which you may construct later, is to be a success.

SHELTERS

Students of social science have called attention to the fact that the principal motivating forces of human life are centered in the home. Here the many responsibilities, joys, sorrows, smiles, tears, hopes, and solicitudes shared by all members of the family make the home the chief school of human virtues. Able statesmen, educators, and other civic leaders stress the importance of the home as a civic unit, which, together with numerous other similar units, comprise a nation. Men have learned, then, from experience that the endurance of a nation, especially a republican nation, depends upon the intelligent and well-ordered homes of its people. Therefore, it behooves every man as an individual citizen to take heed and to provide the best possible home for those dependent upon him for shelter and sustenance.

Shelter, which usually man must provide for himself, is essential to human existence. In the tropics the native erects a grass-roofed hut as a shelter to protect himself from the intense heat of the tropical sun; the Eskimo of the arctic region constructs a snow-covered igloo to protect his family from the rigors of many months of winter weather every year; while between these two extremes are many different kinds of shelters found throughout the temperate zones. These varied types of shelters are proof of man's ability to provide himself with protection against sudden and extreme changes in temperature, thus making it possible for him to live in the same shelter, in comparative comfort the year round, in any kind of weather. A shelter, then, may be either a simple grass hut, an igloo, or an elaborately designed, substantial structure. But whatever the nature of the various shelters built by men, the same purpose is served by all of them; that is, the protection of human life.

Civilized man has attained some of his greatest achievements in the production of architectural masterpieces. Likewise, man's ingenuity is revealed by the widely diversified types and designs of his shelters, which stand today as mute evidence of his skill and painstaking handiwork throughout successive ages of human history. An American writer[1] has truly said, "If cities were built by the sound of music, then some edifices would appear to be constructed by grave, solemn tones, and others to have danced forth to light fantastic airs."

In an industrial age, such as the one in which we are now living, there are, of course, all sorts of structures used as shelters. These include factories, office buildings, department stores, hotels, and many others. However, none of them carry the import of the dwelling house or family residence. When occupied, a house becomes a home; and as a place in which "to make men out of boys, and women out of girls, there is no place like home."

PRACTICAL METHODS OF INSTRUCTION

The process of education becomes simplified when it begins with facts we already know, or deals with some activity we know how to perform, and concerns some tangible objective with which we are most familiar. The best approach to the study of carpentry, then, is through the building of a house, since most of us live in houses and are familiar with them. Those who live in apartments, or even hotels, also find in their place of abode the same component parts which are found in a house.

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[1] Nathaniel Hawthorne.

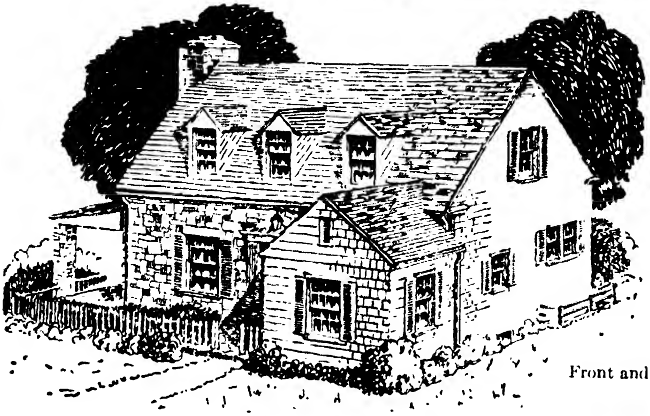
Fig. 1. The House of the Book—Front View

One of the most practical methods of instruction is by the use of a specific example to illustrate the material as it is presented to the student. A means of applying the principles of carpentry to the different phases of construction is provided in this text by *The House of the Book,* a typical American home built according to the methods presented here. The front or south view of this house is shown in Fig. 1. By the use of architectural drawings, building specifications, and numerous illustrations, workable methods of procedure in the building of this house are introduced. Three different views are shown in Fig. 2. The design, materials, and arrangement of rooms are typical of a well-constructed American home of today. The many and varied features of *The House of the Book* incorporate a great diversity of construction problems commonly encountered by the carpenter during the process of erecting a new building. For brevity and convenience, when referring to *The House of the Book* throughout this and following chapters, the term is shortened to *The House.*

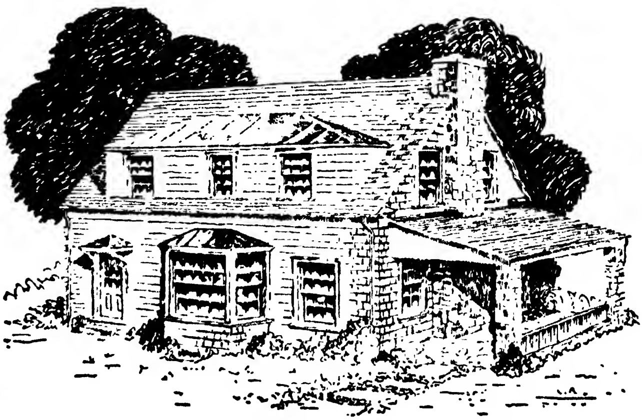
No One Best Method. Since methods of construction vary in different parts of the country and with different individuals, depending upon conditions and past experience, it is always well to bear in mind that there is *no one best method.* However, the methods described in the following instructions have been tested and tried, and have proved satisfactory. For many, a mastery of the methods presented in this text may be the beginning of a procedure followed through life; for others this method will be just another way of doing a particular job. The most capable and progressive mechanic will try to find as many methods as possible for doing any job, then he will take from each method anything which will fit best into his own particular situation, and will develop his own individual technique.

Methods Proved Workable. As commonly used, the term *carpentry* refers to the art or science of cutting, fitting, and assembling wood or related materials in the construction of buildings, boats, bridges, and piers or any other structure made from such materials. Throughout many successive periods of human history, wood construction, or carpentry, has maintained a prominent position in the building industry. In spite of many new buiding materials developed in recent years, wood construction still remains one of the most important phases of the building trade, especially in the building of a house. The knowledge and skill

Front and West-Side View



Front and East-Side View



Rear View

Fig. 2. The House of the Book

required for the construction of a house are basic in the carpentry trade, since the same knowledge and craftsmanship required for the erection of a house are likewise essential in all types of wood construction.

The general interest in the house as a home, together with the knowledge of building materials required and the varied problems encompassed in the erection of a house, prompted the use of *The House* as a means of approach to the study of *Practical Carpentry Construction.* In building a house, the carpenter is confronted with many different kinds of construction problems. He must also be able to use many different kinds of building materials, including cabinet woods, builders' hardware, and building insulation products. He must know how to frame walls, floors, and roofs, as well as be able to carry through to completion the exterior and interior finishing work. He must provide for the work done later by other tradesmen involved in the construction process, and be able to work with them harmoniously.

In order to be a thoroughly trained mechanic in the building trade, a carpenter must be informed concerning available materials and tools. He must also know how to use both materials and tools effectively in the construction of a new building. The study of carpentry construction may be divided into two distinct parts:

1. Preliminary stage or preparation, including a study of the history, development, and use of carpentry tools; learning how to select and apply the common building materials; acquiring a knowledge of the growth, chief characteristics, and use of the various woods used in the building trade. As an assistant to the architect in advising the house owner, the carpenter should be familiar with the preliminary steps necessary in selecting a home site, looking up city building codes and other building restrictions. One of the most important features of this preliminary preparation is learning how to read architectural drawings, or blueprints, and how to follow directions given there in connection with the building specifications. If you have not previously acquired this preliminary information, it is presented concisely in *Fundamentals of Carpentry,* Vol. I—*Tools, Materials, Practice.*[2]

2. The second stage deals with the study of the actual construction

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[2] Walter E. Durbahn, *Fundamentals of Carpentry, Vol. I—Tools, Materials, Practice* (Chicago: American Technical Society, 1947).

work in a building project as presented in this text. Here instructions and methods of procedure are given in detail, step by step, in the process of erecting *The House.*

VISUALIZING *THE HOUSE OF THE BOOK*

In this text only the work of the carpenter is dealt with in detail. The activities of other tradesmen on the job are considered only when their work may affect the work of the carpenter.

In this chapter you will learn how to interpret plans used in the actual construction of a new house. In any building project floor plans are especially important. Such plans must be prepared carefully and be exact in every detail. The floor plans presented in the blueprints found at the back of this text will help you as a student to understand how to go about the actual construction work of a new house. When you look at the floor plans for *The House* you should be able to form a mental picture of the work to be done, also the appearance and arrangement of the rooms after the building is finished. This visualizing process requires a knowledge of several important principles, as well as familiarity with the special language and symbols used in the building trade.

Because floor plans are proportionately so small, it is not possible to show all details exactly as they will appear in full size. For example, walls contain many parts and it would be impossible to show all of the parts on such a small scale. Hence, symbols are used, each symbol having a definite meaning either as to structure or material, or both.

The drawings of course have to be made much smaller than the portion of the house they represent. However, this does not affect their usefulness since they are drawn accurately to scale and contain all the necessary measurements. Therefore, by means of the blueprints which show both floor plans and elevation views, you are able to visualize *The House* shown in Fig. 1 as it will appear in actual full size when completed.

WORKING DRAWINGS

When a carpenter speaks of *drawings* or *plans* for a house, he refers to a specific group of architectural drawings which show every detail of the particular job to be undertaken. These plans show the exterior appearance of the completed building, including front view, rear view, and each side view. The drawings also show the location of windows, doors, and the division of the interior space into rooms, together with other details. Such details must be shown in a standard manner on the drawings so that everyone who reads them will form the same mental picture of the finished structure and will understand what work is to be done before the project is completed. In visualizing floor plans, you must remember that the plans are drawn as though you were looking directly down into the rooms. Then, once you understand the symbols used, you can easily form a mental picture of each room.

The success of any construction job depends to a great extent upon the builder's foreknowledge of the various problems involved in the project to be undertaken and in his ability to solve these problems as they arise. In order to achieve the results desired, a carpenter must have in mind a clear picture of the completed building before he begins any part of the construction work. In addition to being able to visualize the finished house himself the architect or builder must also be able to convey his mental picture to others, including the various mechanics and tradesmen, as well as the prospective homeowner. This transfer of the mental image of the new house can be accomplished only by means of *drawings* or *building plans*, together with *specifications*. Such plans must be prepared by a competent architect, and copies, or *blueprints,* given to those individuals who are responsible for any part of the construction work. It is only by the use of such drawings that all possibility of misunderstanding regarding construction details can be eliminated.

To the trade, building plans are known by various names. The term *working drawings* is sometimes used because the drawings show the work that is to be done. Many people engaged in the building industry refer to architectural drawings as *plans,* since to most of us a plan is the outline of something we expect to do. In this text the term *architectural drawings* is applied to a set of building plans showing the front, rear, and side views of a typical American home which is called *The House of the Book*. See Fig. 2, also the blueprints at the back of the book. The floor plans show the arrangements into rooms and the numerous details of the interior of the building. Also shown are the locations of doors, windows, and stairs. Various other details given include dimensions, material symbols, design of the fireplace, layout of the kitchen and bathroom, also the sizes and kinds of materials to be used throughout the building. Every detail must be noted carefully by the carpenter and other mechanics. All such details are a part of the actual planning for a new house.

A complete set of working drawings for *The House,* such as are prepared by any competent architect, are found at the back of this text. These include the south elevation or front of *The House;* the east elevation, or right side; also with this view are shown details of the fireplace, together with the kitchen cabinets; the north elevation, or rear, together with the details of the stairs and doors *C* and *D;* the west elevation, or left side, together with the details of the bay-window construction of the dining room, interior trim, and the beam construction of the porch.

The working drawings for *The House* also show the different floor plans, together with the various detail drawings. These plans include the basement-floor plan with its room arrangement and foundation requirements; main, or first-floor plan, together with the window and door schedules, the key to the various materials, and symbols used for electric and other outlet requirements, and second-floor plan. Since entrance features are important and demand more careful detailing than can be shown on the front-elevation drawing, the details for the entrance are shown with the second-floor plan.

Details shown on the working drawings bring out certain important construction information which would be difficult to show in either the elevation or floor-plan drawings. Because of the importance of the details in wall construction, sectional wall views of *The House* are shown on a separate working drawing; a section of the south wall in the living room is shown at *A–A,* and a corresponding section of the north wall is shown at *B–B.*

CARPENTRY SPECIFICATIONS

The architect or builder who is responsible for drawing the architectural plans should also write the *carpentry specifications.* He should check all details to see that everything called for in the plans is explained either on the blueprints or in the written specifications.

It is impossible to show every minute detail on the working drawings; therefore, additional explanations should be given in written specifications which supplement the drawings. These specifications should tell in words what cannot be shown graphically on the architectural drawings. The information furnished by the specifications should include directions regarding concrete mixtures, grades of lumber, bricks and other materials; quality and catalogue number of mechanical appliances; and detail instructions as to how the work is to be performed.

If carefully written, specifications, together with the drawings, can be used by the estimators to figure the exact cost of labor and building materials. However, with inadequate, poorly prepared, and confusing specifications, the estimator is unable to determine exact cost, hence he is apt to add some to the estimated cost in order to protect himself. The term *estimator* includes the general contractor, sub-contractor, manufacturers, and dealers in building materials. In the case of the various tradesmen on the job, the specifications become directions and explain each step of the work. Hence, well-prepared specifications save time, reduce waste, and assure better workmanship. If all necessary items are amply covered by the building specifications, there can be no grounds whatever for disagreements or disputes. Since contracts are made in accordance with the building specifications and working drawings, it is especially important for the specifications to be carefully prepared and well written.

You can readily see then that specifications are necessary in the construction of a new house because they are used: (1) by estimators in calculating the cost of materials and labor; (2) as a guide to all tradesmen in carrying out their specific part of a construction job; (3) as a means of preventing disputes between the contractors and homeowner; (4) as instructions for the purchase of all types of fixtures, special millwork, and built-in furnishings.

SPECIFICATIONS FOR *THE HOUSE OF THE BOOK*

Complete specifications deal with every phase of the building under construction, including carpentry, masonry, tile work, concrete work, electric wiring and fixtures, heating and ventilating, plumbing, lathing and plastering, painting, papering, roofing, insulation, weather stripping, and varous miscellaneous items peculiar to every specific construction job. In addition, building specifications usually give general information regarding building permits for various trades, contract payments, insurance, liabilities, provisions for any changes which are not provided for in the original plans, drawings, or specifications and supervision of construction work. However, in this text we are interested only in the carpentry phase of the work. The reference in this chapter to any other type of construction is merely for the purpose of presenting facts which will help you as a student to understand and appreciate more fully the value and importance of written specifications in the building industry. This additional information will also help you to understand better how to use specifications to the best advantage on any new building you may construct later. For specifications for *The House of the Book* and for the answers to the following questions see the Appendix at the back of this text.

QUESTIONS ON *THE HOUSE OF THE BOOK*

General

1. Before beginning construction work on any building project, such as *The House of the Book,* what picture must the architect or builder have in mind?
2. How does the builder transfer this mental image to the minds of the carpenter and other tradesmen on the job?
3. (*a*) In the set of architectural drawings provided for *The House,* how many elevation views are shown? (*b*) Name them.
4. What particular drawings for *The House* help you to visualize the various floors as arranged into rooms?

Basement and Foundation

5. (*a*) Where is the recreation room located? (*b*) Give the width and length of this room without the recess for the bay window. (*c*) How many ceiling lights are provided for in the recreation room? (See Symbols.)
6. What type of material is indicated for partition walls in the basement? (See Key to Materials.)
7. (*a*) What kind of material is indicated for the basement floor? (*b*) How thick is this floor?
8. (*a*) How many windows are there in the basement? (*b*) What kind of material is to be used for the sashes of the basement windows? (See Specifications.)
9. How thick are the outside foundation walls?
10. What is the thickness and width of the footings for the outside foundation walls?

Superstructure

11. What part of *The House* is shown in the sectional views *A–A* and *B–B*?

12. (*a*) What material is indicated for the exterior covering of the south wall of the main section? For the addition? (*b*) For the north wall? (*c*) For north dormer?
13. (*a*) How many chimneys are there in *The House?* (*b*) How many flues? (*c*) What kind of material is used for lining in the flues? (*d*) Is the chimney constructed of brick?
14. What type of roofing is used on the main section of *The House?*
15. (*a*) What type of roofing is indicated for the north dormer? (*b*) For the porch? (*c*) For the bay window?
16. (*a*) What size door is indicated for the front, or south, exterior door? (*b*) For the west exterior door? (*c*) For the rear, or north, exterior door? (*d*) For the closet doors (*G*)? (*e*) For the closet doors (*H*)?
17. (*a*) How many bathrooms are there in *The House?* (*b*) How long are the bathtubs?
18. What material is used for all weatherstrips on outside doors? (See Specifications.)
19. What kind of material is specified for outside door and window frames?
20. What kind of wood is used for facing of kitchen cabinets?
21. (*a*) What are the dimensions of the addition? (*b*) How many ceiling lights are indicated for this room? (*c*) How many duplex receptacles are indicated?
22. How many windows are there in the superstructure, that is, the first and second stories?
23. (*a*) How many windows have 16 lights? (*b*) What is the size of the three dormer windows shown on the south elevation? (*c*) How many lights are indicated for these three windows?
24. What is the height of the ceiling of the first-floor rooms?
25. (*a*) How many inside stairways are indicated? (*b*) How many outside stairways?

CHECKING ON YOUR KNOWLEDGE

The following questions give you the opportunity to check up on yourself. If you have read the chapter carefully, you should be able to answer the questions. If you have any difficulty, read the chapter over until you have the information well in mind before you go on with your reading.

DO YOU KNOW

1. What information is given on architectural drawings?
2. Why written specifications, in addition to the working drawings, should be prepared for every construction job such as a house?
3. The relationship between working drawings and written specifications?
4. In what way well-prepared specifications save time and reduce costs?
5. What the estimator is apt to do if specifications are not well written and instructions given are not clear?
6. How the carpenter and other tradesmen on a construction job obtain a mental picture of the new building?

7. What information the carpenter finds on the drawings regarding windows and doors?

8. Where the carpenter will find instructions regarding materials to be used?

9. Why all tradesmen on a construction job should have a set of architectural drawings and a copy of the building specifications?

10. Where you can find the building specifications for *The House of the Book?*

TO LENGTHEN THE LIFE OF A STRUCTURE, THE CARPENTER APPLIES NEW SHINGLES OVER OLD SIDING

Courtesy of American Builder

CHAPTER II

Foundation Formwork

QUESTIONS THIS CHAPTER WILL ANSWER

1. *Why should a carpenter avoid wearing tennis shoes while working on a construction job?* 2. *In early days before concrete came into use, where did the carpenter's work begin on a new building?* 3. *Are forms for a concrete foundation always constructed on the job?* 4. *Are the forms for porches and outside stairs built before or after the forms for the main section are built?* 5. *What are footings? How wide are the footings for the foundation walls for* The House of the Book?

INTRODUCTION TO CHAPTER II

That "there is no royal road to anything," is a proverb so well established in fact that we may accept it as a general rule which regulates the activities of men. Wise men know that the successful achievement of any enduring and constructive enterprise requires much patience, perseverance, and hard work on the part of the enterpriser and his co-workers. The construction of a new house is no exception to the rule. There is no king's highway over which the building tradesmen may travel at high speed in luxurious ease. It is well for you to keep this fact in mind as you study this chapter which deals with the beginning of construction work on a new home.

Any building is composed of three distinct parts—foundation, main section of the superstructure, and the roof. Each of these parts should be constructed as if it were the most important part of the building. If the roof leaks, moisture from rain or snow may cause damage to the walls of the main section of the superstructure, which in turn may become permanently impaired. Poorly constructed walls or faulty framing of window and door openings may likewise cause serious damage to the building which even a perfect roof cannot save from destruction. However, if repaired in time, a leaky roof or even minor faults of construction of walls, windows, and doors may be remedied without great inconvenience or loss to the owner; but of all building failures, a defective foundation is the most serious. Unless the foundation walls and footings under the entire superstructure are all properly constructed, the foundation will not support the load put upon it and the building project may end in failure.

Even a slight settling of the foundation walls will cause plastering to crack, pull away trim, and in general seriously mar the appearance of the home. Extensive settling may also cause the structural failure of the whole house which ultimately becomes an architectural wreck, and consequently a loss as an investment to the owner. Practically all soil contains moisture from rain or snow which will freeze during the cold weather months. Frozen ground expands and tends to rise above its normal elevation and settles back when the frost is out of the ground. Buildings affected by frost action will develop foundation and plaster cracks, damage interior decoration, cause openings in walls and floors, as well as other structural troubles. Therefore, it is wise to extend all foundation walls below the freezing point in cold regions. When it becomes impractical to extend foundations below the frost line, concrete foundations must be carefully designed and reinforced.

In order to protect himself against unjust criticism, the carpenter must make sure all foundation walls extend below the freezing point before he starts construction work. If he is a newcomer in the community he can find out from other builders, or old residents, what the freezing point is for that particular region.

Faulty construction of foundation walls is another cause of building failures. Since the carpenter builds the forms for the concrete walls, he should take all necessary precautions to insure a firm and substantial foundation which will safely carry the weight of the load which it is to support. If the carpenter fails to build the foundation walls correctly, the superstructure which he builds later may "tumble about his ears" as tragic evidence of his inefficiency in construction.

As you begin the study of this chapter, follow carefully the instructions given for building forms for foundation walls. Compare the illustrations with the text frequently. This procedure will help you to understand the purpose of the illustrations and will also help to make the content of the text more clear. Observe every detail of the construction process and learn from the beginning to build well whatever you undertake.

BEGINNING CONSTRUCTION WORK

Safety Measures. Before beginning actual work on the foundation of *The House,* let us consider some necessary safety measures. Every building mechanic should learn to beware of the particular dangers of his own trade, as well as those of associated trades. When the young carpenter becomes conscious of these ever-present dangers, he should begin to practice all safety measures necessary to protect himself and his fellow workmen against preventable accidents.

The accident rate is comparatively high in the building industry. Accidents often result in partial or total disability and even in deaths. In addition to these serious accidents there are innumerable minor cuts and bruises which are not only painful but are handicaps to the workman, temporarily at least. To reduce this accident rate to a minimum, the workman must become safety conscious; that is, he must learn to think of safety for his fellow workers as well as for himself. The majority of accidents in the building industry are due to falls or falling objects. In most cases these accidents indicate carelessness on the part of the workmen in handling either materials or tools, or in building unsafe scaffolds. The higher the building rises, the greater the hazards become. However, certain hazards are found even on the ground during the construction of foundations, and workmen should not be indifferent to them. Some hazards are common in every phase of building construction.

Clothing. A workman's clothing should suit his individual needs, as well as weather conditions. In the building industry, a workman should avoid wearing overalls which are too long for him. Cuffs made by turning up the legs of overalls are apt to catch heels and cause tripping and falls. Overalls without cuffs should be worn if possible. When shirt or jacket sleeves are left unbuttoned, they are liable to become hazards by catching on nails, scaffolds, and projecting boards. Therefore, all sleeves should be kept buttoned or rolled up. If a jacket is worn, it should be kept buttoned or tucked into overalls. As a protection against nails, the builder should wear shoes with thick sturdy soles. Thin-soled shoes or tennis shoes should never be worn while on a construction job. When carrying materials, a workman should avoid jumping over puddles of water. As a safety precaution, after a rain it is advisable to wear rubbers or boots, since wading through puddles of water is less dangerous than jumping over them.

Falls. Boards used temporarily for framing purposes are only lightly nailed and frequently give way under a man's weight; hence, it is a dangerous practice for a workman to climb in and out of a basement over forms or framework. Neither should he attempt to jump from the top of a form which is liable to give way, causing him to fall. Since there is no great need for scaffolding in foundation work, frequently the little that is needed is too hastily or carelessly built. This carelessness oftentimes results in unnecessary falls.

Other Hazards. Protruding wires, bolts, and reinforcing rods on forms are the cause of many scratches and other injuries; such projecting parts either should be bent down or protection otherwise provided for workmen. After the forms for concrete have been pulled, wires protruding from the concrete walls should be cut off immediately. When left in walls and floors for later construction connections, reinforcement bars should be bent down out of the way of workmen, as a precaution against accidents.

Loose heads on nail hammers, axes, and sledge hammers are dangerous. A loose head on an ax or hammer should be tightened before using the implement. A split or cracked handle should be replaced with a new one.

Nails are an ever-present hazard on any building-construction job, especially when removing forms. If nails are not pulled immediately when forms are taken down, the boards should be stacked in a pile away from the traffic lanes. Later the nails can be withdrawn and the lumber properly piled. A young carpenter should form the habit of pulling all nails from loose boards whenever he sees them. This habit should be practiced until it becomes a rule with every workman in the building industry. If for any reason it is impractical to pull a nail in a board when it is first seen, the nail should at least be bent down as protection to all workmen.

STAKING OUT *THE HOUSE*

Whenever we speak of *The House*, we are referring to the house shown in Fig. 1, Chapter 1. In this text instructions and requirements for the carpentry work are presented in such a way that the reader can follow through, step by step, the process of building a new house, exactly as an experienced carpenter would proceed with his construction work. This method makes it possible for a beginner to visualize types of jobs which a builder must perform, and helps him to understand how these different jobs fit into the whole scheme of building a new home.

Let us assume that this particular house is to be built on a lot measuring 75 by 150 feet, with the south side facing the street. Then the front of the house becomes the *South Elevation;* the rear, the *North Elevation;* the right side, the *East Elevation;* and the left side, the *West Elevation.* We will assume also that the lot is a flat piece of ground practically on a level with the sidewalk. The corners of the lot are established when the lot is surveyed, shown as (*a*), (*b*), and (*c*), Fig. 1.

Note: If possible, it is always advisable to have the surveyor also stake out the house on the lot. However, if his services cannot be obtained for this additional work, the builder must stake out the house.

In order to simplify the layout of *The House,* the basement plan is blocked out into areas (*A*), (*B*), (*C*), (*D*), and (*E*), Fig. 1. First,

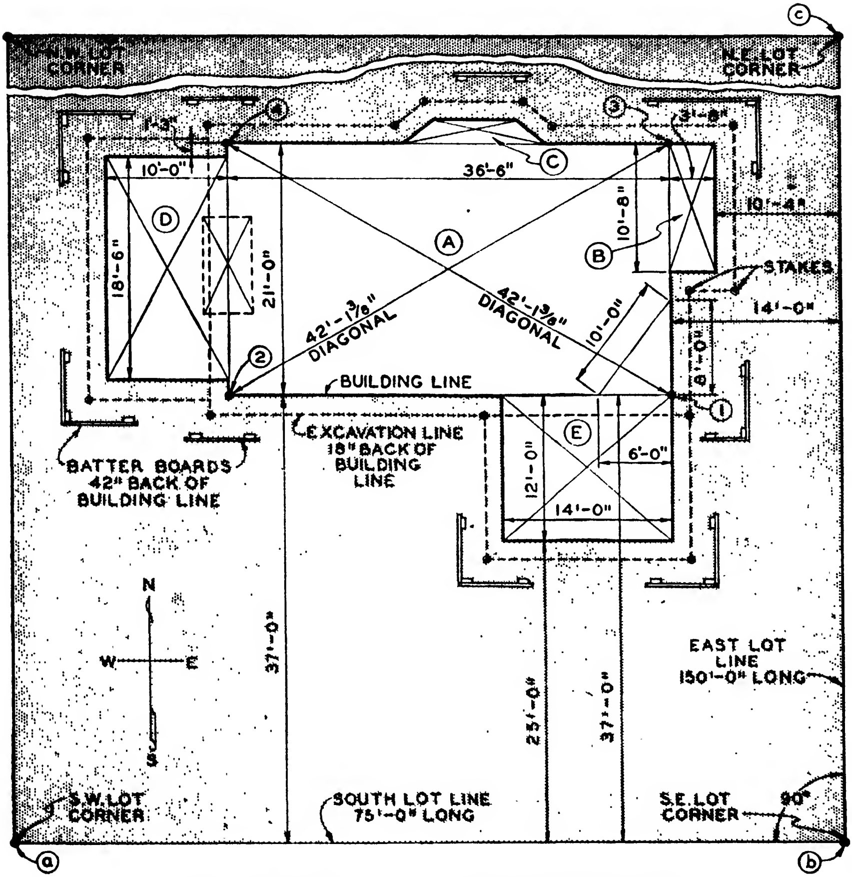


Fig. 1. Excavation Layout for *The House of the Book*

the outside of the building, or the building lines, is staked out completely. These building lines show the exact size and shape of the building so that it may be checked carefully on level ground before any excavating is begun. The main portion of the building should be the first considered, since it constitutes the largest area, rectangle (*A*), Fig. 1.

PROCEDURE

1. Fasten lines between the lot stakes (*a*), (*b*), and (*c*), Fig. 1.

2. Locate a point 37 feet from the south lot line and 14 feet from the east lot line and drive stake *(1)* at this point. Ideal stakes for this purpose can be made by cutting a 2x2 stick into pieces 2 feet in length. An 8-penny (8d) common nail should be driven into the top of the stake to indicate the exact location of the point after it is found.

3. Set stake *(2)* 36 feet 6 inches to the west of stake *(1)* and 37 feet from the south line of the lot.

4. Stake *(3)* should be set 21 feet north of stake *(1)* and 14 feet from the east line of the lot.

5. Stake *(4)* should be set 36 feet 6 inches west of stake *(3)* and 21 feet north of stake *(2)*.

Note: The basement plan shows the outside measurement of the north wall to be 36 feet 1 inch. This means that while the length of the front, or south, wall of the building is 36 feet 6 inches in length, the north, or rear, wall is exactly 36 feet 1 inch in length. This difference of 5 inches is due to the fact that while the exterior finish of the west wall north of the chimney is of shingles, the exterior finish south of the chimney is of stone veneer, which adds to the wall thickness. However, in excavating, this difference in the length of the north and south walls is ignored, and although the northwest corner of the building is only 36 feet 1 inch west of stake *(3)*, stake *(4)* is set at a distance of 36 feet 6 inches from stake *(3)*, and area *(A)* as staked out is a rectangle.

6. Check all distances again. If the sides of the rectangle *(A)* have been laid out parallel with the lot lines, the angles of the rectangle should be square and the diagonals, that is, the distance from stake *(1)* to stake *(4)*, and from stake *(2)* to stake *(3)*, should measure the same—42 feet and approximately 1⅜ inches. Check trueness of the southeast corner of area *(A)* with a right triangle of dimensions shown in Fig. 1. This is known as the ***6–8–10 method*** of checking for squareness at corners.

7. For the outside basement stairs, stake out area *(B)* 3 feet 8 inches by 10 feet 8 inches. Locate a point 3 feet 8 inches directly east of stake *(3)* and establish this point by driving a stake which should be 10 feet 4 inches from the east line of the lot. Directly south of this stake, 10 feet 8 inches, drive another stake which should also be 10 feet 4 inches from the east lot line. Then locate a point 3 feet 8 inches directly west of this stake and 10 feet 8 inches directly south of stake *(3)*, and drive another stake. Lines connecting these four stakes should form a perfect rectangle, with the longest sides parallel to the east lot line. You can test the correctness of the position of the stakes by finding the length of the diagonals shown in Fig. 1 with a steel tape measure. If the rectangle is true, the two diagonals will be exactly the same length.

8. Stake out the bay window according to plan, area *(C)*. As shown on the basement-floor plan, the width or depth of the bay window is 2 feet. Connect stakes *(3)* and *(4)* with strong cord to locate the outside building line. With this line as a guide, locate a point 10 feet directly west of stake *(3)*; drive a stake to mark the point. Locate a second point 21 feet 10 inches west of stake *(3)* and drive a stake to mark the point. These two stakes mark the points where the bay window connects with the wall of the house. Locate a third point 12 feet 6 inches west and 2 feet north of stake *(3)*; drive a stake to mark the point. Locate a fourth point 6 feet 10 inches directly west of the third stake, and drive a stake. These two stakes mark the outside points of the bay-window recess. Find the diagonal distance between the stakes shown in Fig. 1 with a steel-tape measure. If your dimensions are correct, the two diagonals will be exactly the same length.

The foundation for areas *(D)* and *(B)* are to be in trenches which usually are dug after the main areas *(A)*, *(C)*, and *(E)* have been excavated, but it is advisable to establish building lines for these areas at the same time building lines for the other areas are established.

9. Stake out the porch, as shown in Fig. 1. Connect stakes *(2)* and *(4)* with strong cord to locate the west building line. With this line as a guide, locate two points, one of them 1 foot 3 inches north of stake *(2)*, the other 1 foot 3 inches south of stake *(4)*, and drive stakes to mark these two points. Measure off a distance of 10 feet directly west of these two stakes and drive two more stakes, 18 feet 6 inches apart. Connect these stakes with strong cord. If your measurements are correct, this line will be parallel to the west building line and the west lot line. With a steel-tape measure, find the distance between the stakes diagonally, as shown in Fig. 1. If your dimensions are correct, the two diagonals will be exactly the same length.

In addition, stakes should be set at this time for the excavation lines of the chimney foundation and footings. The excavations for the chimney extend into area *(D)*, as shown on the plan view for the basement floor. Even though it extends into area *(D)*, the chimney is actually a part of area *(A)*. The plan gives the dimensions of the chimney footing as 4 feet by 8 feet. After stakes have been set for the footing of the chimney, check your dimensions with diagonals as you did for the other rectangles staked out previously. If your measurements are true, the diagonals will be exactly the same length.

10. Stake out area *(E)*. Connect stakes *(1)* and *(2)* with a strong cord to locate the south building line. With this line as a guide, measure off a distance of 14 feet directly west of stake *(1)* and drive a stake to mark the point. Locate a point 12 feet directly south of this stake and another point 12 feet directly south of stake *(1)*. Mark these points with two stakes which should be 14 feet apart. Measure the diagonal distance between the stakes shown in Fig. 1. If your dimensions are true, the diagonals will be exactly the same length.

11. *(a)* Stake out the areaways for the basement windows at this time. The three rectangular areaways as shown on the basement-floor plan have the same dimensions—3 feet 9¾ inches by 2 feet 6 inches. The central point of the areaway for the east laundry window is 17 feet 3 inches from the south building line of area *(E)*. The radius or depth of the semicircular areaway for the window under the bay window is given as 2 feet 2 inches. *(b)* Also stake out, at this time, the foundations for the front and rear entrances. Dimensions for these entrances are also given on the basement-floor plan. After you have driven stakes to mark all important points, check your measurements with diagonals as you did when testing dimensions for correctness in areas *(D)* and *(E)*.

12. At each corner of areas *(A)*, *(B)*, and *(C)* set excavation stakes 18 inches back from the building lines, as shown in Fig. 1. In firm soil, shallow excavations up to 5 feet in depth require a clearance of 18 inches outside of the building line for erecting and removing forms. For deeper excavations 2 feet or more must be allowed for working space between the building lines and the excavation lines.

13. When excavating begins, the stakes marking the location of the various corners of the building are necessarily dislodged and no permanent mark remains to indicate the proposed position of the exact corners, or the lines indicating the sides of the building. In order to avoid confusion in relocating the exact corners of the proposed building, it is customary to use *batter boards* located at some distance away from the points where the corners are to be located. These batter boards are placed well outside the line of excavation so they will not be dislodged by digging of the foundation trenches or basement excavation.

The batter boards should be erected at all corners, as indicated in Fig. 1. In firm ground, the batter boards should be at least 18 inches back of the line of excavation, so they will not be disturbed by the excavating. The batter boards for areas *(D)* and *(E)* are also set back 18 inches from trench excavating lines. Batter boards may be made of 2x4 stakes about 30 inches long and square-edged 1x6 boards. The height of the batter boards is not important, except that all the boards should be approximately on a level in relation to each other. The purpose of the batter boards is to hold lines for re-establishing the building lines at the bottom of the excavation. Wall heights are determined later.

14. Fasten lines to the batter boards and draw the lines tight directly over the nails in the corner stakes indicated in Fig. 1. Check all measurements again and mark the position of the lines on the boards with a pencil; then remove the lines and make a slight saw cut on the mark for easy identification.

EXCAVATION FOR BASEMENT

The work of excavating should not begin until all stakes have been set and all dimensions have been rechecked, including excavation stakes for the chimney footing which extends into area (*A*), Fig. 1. Likewise stakes and dimensions for all building lines, excavating lines, and the placing of batter boards should be checked again. After this preliminary work is completed, the work of excavating may be started. Areas (*A*), (*B*), (*C*), and the chimney footing which extends into area (*A*), should be excavated to the full basement depth of 5 feet. Dimensions for the chimney footing (4′0″x8′0″x12″) are given on the basement-floor plan. When excavating, remember to allow an extra 18 inches for working room outside of the building lines.

Note: The depth of the footing for the chimney is 12 inches, which is 4 inches more than the depth of the footings for the foundation walls.

This means that the excavation for the chimney footing must be dug 4 inches deeper than the excavation for the basement. See the west-elevation plan.

The excavations for areas (*D*) and (*E*) are in trenches which are not dug until after the main areas have been excavated. When these trenches are excavated, they should be dug to the depth shown by dimensions given on the elevation drawings, and to a width of the footing (18″), as the ground at the side of the trenches serves as a form for the footing in firm soil. However, in soil that is not firm, this procedure cannot be followed and forms for footings must be built in the trenches. In such a case, working space must be allowed outside of the building lines when excavating, to assure room for the workmen to place and remove the forms.

The depth of excavation for the foundations or basement of any house depends upon the ground level of the lot in relation to the street or sidewalk, and the ground slope desired from the house to the sidewalk. To insure adequate drainage of surface water away from a house, it is always advisable to have the ground around the building slope away from the foundation. In the case of *The House,* it is assumed that when construction begins, the surface of the lot will be level with the street sidewalk. Therefore, if the total excavation of the basement is 5 feet, then, according to the elevation drawings, the backfill of dirt around the finished foundation will bring the level of the ground to within 8 inches of the top of the basement walls. The grade level of *The House* will then be about 30 inches above the level of the sidewalk. This provides a gradual and desirable slope for the 37-foot distance from *The House* to the sidewalk.

After excavations for the main areas have been made to the correct depth, that is, 5 feet for areas (*A*), (*B*), (*C*), and the chimney footing which extends into area (*A*), trenches should be dug for areas (*D*) and (*E*), Fig. 1. Trenches for the foundations for the front and rear entrances may also be dug at this time, as well as the excavations for areaways for all basement windows. However, these are small excavating jobs which may be left until later if desired. The depths of trenches for entrance foundations are shown on the north and south elevation views. For depths of areaways for basement windows, see sectional view of south wall, *B–B*. (See blueprints at back of book.)

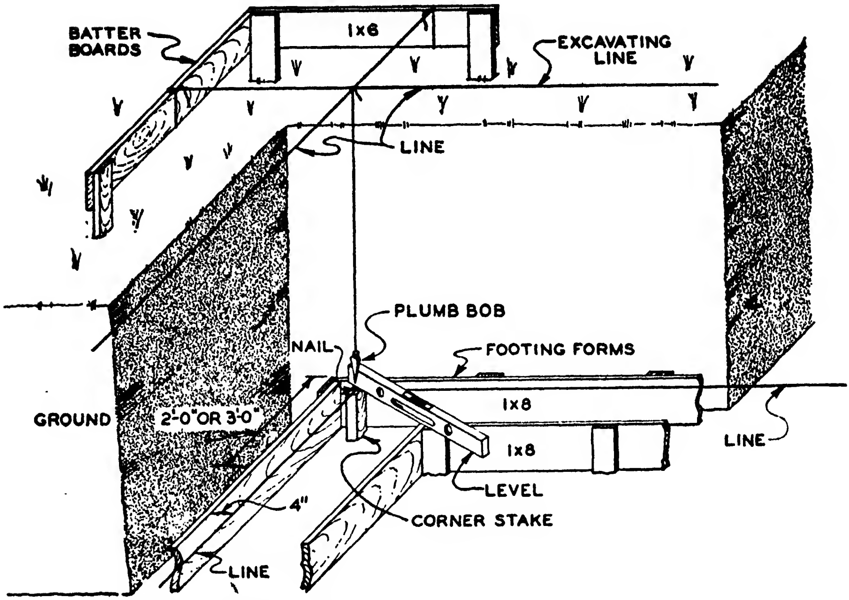


Fig. 2. Method of Starting Construction of Footing Forms

FORMS FOR FOOTINGS

After all excavations have been made to the correct depths, forms for footings must be laid out and erected. These footings must be not only in the right places but they must also be straight and level. The importance of straightening and leveling the footings must not be minimized. After each portion of the building has been excavated to the correct depth, it must be laid out again at the bottom of the excavation. In this layout the lines must indicate the exact dimensions of the building. In addition, when laying out the building the second time, the tops of all corner stakes at the bottom of the excavation must be on a level with each other, and at the exact height of the footings which, in the case of *The House,* is 8 inches above the ground level at the bottom of the excavation. Included in this layout is the footings for the chimney and for the columns, which are shown on the basement-floor plan.

PROCEDURE

1. Fasten lines to the batter boards in the saw cuts previously made, as shown in Fig. 2.

2. From each intersection of these lines, drop a *plumb bob* to locate the position of the corner stakes, Fig. 2. Cut 2x2 stakes to a length of about 16 inches. Drive a stake at the point indicated by the plumb bob, so the top of the stake will be 8 inches above the ground level of the bottom of the excavation. Establish the exact location of each corner, according to the plan, by driving a nail in the corner stake directly under the point of the plumb bob.

Note: In order to make the footings for area *(A)* a perfect rectangle, a stake is driven at the northwest corner at the same point as the one established for the building line, that is, 36 feet 6 inches directly west of stake *(3)*. Drive a second stake 5 inches east of this point to establish the exact location of this corner when footing forms for the foundation are built. For layout of the northwest corner, see the basement-floor plan.

3. Drive stakes to mark all outside corners for areas *(A)*, *(B)*, *(C)*, and the chimney footing which extends into both areas *(A)* and *(D)*. In case the batter boards may have been disturbed, check all dimensions again with diagonals, as you did when laying out the building lines the first time.

4. Connect the corner stakes with lines tied to the nails which you previously have driven in the top of the stakes. The lines connecting the corners of areas *(A)*, *(B)*, and the footing for the chimney foundation form rectangles, while the lines connecting the corners of area *(C)* form a polygon with two parallel sides, as shown in Fig. 1. These lines locate the building lines.

Erect outside footing forms so the inside of the boards are 4 inches back of the building line for 10-inch walls and 6 inches back of the building line for 12-inch walls. The top of the forms must be level with the top of each corner stake and the stakes which support the form boards. If 1-inch boards are used for the forms, the stakes should be set 2 or 3 feet apart. Greater distances can be allowed between the stakes when 2-inch boards are used for the forms. For method of construction see Fig. 2.

5. The footing form for the chimney must be built at this time. This is to be 12 inches in thickness, equal to the height of the wall footings (8″), plus the additional 4 inches which the chimney footing extends below the level of the bottom of the basement excavation.

Note: The footing for the chimney extends 2 feet into area *(D)* and 2 feet into area *(A)*. For layout of this form see the basement-floor plan. The dotted lines indicate the footings for the walls, also for the footing for the chimney. When building footing forms for the north wall, note particularly the irregularities of the bay-window area shown on the basement plan. (See blueprints at back of this book.)

6. Erect inside footing forms just the reverse of the outside forms. The inside of the forms should be 18 inches from the outside forms for 10-inch walls, and 24 inches from the outside forms for 12-inch walls. Before concrete is poured into the footing forms, dimensions should be checked carefully, and the tops of all stakes must be exactly the same height, that is, 8 inches for the footings for any part of *The House*. The form for the chimney will extend 4 inches deeper than the level of the bottom of the basement excavation, but the top of the footing for the chimney will be level with the top of other footings, such as for areas *(A)* and *(C)*. The level of the tops of the stakes can be set with a transit or a line level. A spirit level, used to test the correctness of the footing heights, is shown in Fig. 2.

When the concrete is placed in the forms for footings, care must be exercised not to disturb the corner stakes or the nails in them, as the stakes and nails will serve later to establish the exact corners of the forms for the foundation walls.

Note: The width and thickness of footings depend upon soil conditions and the load the footings must support. Some city codes require that footings for small buildings be no less than 12 inches wider than the foundation walls.

7. Forms for foundation walls of area *(E)* are to be built at the same time forms for area *(A)* are built. Therefore, the concrete for the footings for area *(E)* must be poured when the footings are poured for area *(A)*. If the concrete is to be poured directly into the trenches for area *(E)* without building footing forms, then stakes must be driven at corners and other points where necessary to indicate the depth (8") to which the concrete is to be poured. Where the soil is firm, trenches can be excavated with reasonably smooth and straight walls which will require no forms for footings. In other words, if the soil is firm, footings for area *(E)* can be poured directly into the trench to the required thickness shown by the stakes previously driven at the corners and other places necessary to show thickness and produce a level footing. Where soil is not firm, footing forms must be built for area *(E)*.

Since the trenches for the foundation walls of area *(E)* are not dug down to the full basement depth, the footings for area *(E)* will be on a higher level than the footings for area *(A)*. This will produce a step which requires a form board at each of the open ends of the trenches for area *(E)*.

The excavated space allowed for working room, when building and removing forms for area *(A)*, makes it necessary to extend the footing of the east wall of this area up to the excavation line of the south wall, and directly below the trench for area *(E)*. Another short footing form must also be built directly below the end of the trench of the west wall of area *(E)*, to support the foundation where this wall connects with the south wall of area *(A)*.

8. After the concrete has been poured for the footings of areas *(A)*, *(C)*, *(E)*, and for the chimney, a groove, or key, is made in the center of the footings, to insure a tie between the footings and the foundation walls. This *key,* shown in Fig. 3, is made by driving a wedge-shaped piece of 2x2 or 2x4 in the surface of the footing after the concrete has been struck off flush and while it is still in its plastic state. The key serves as a tie between the footing and the concrete wall which is poured later.

9. After the concrete of the footings has set, the boards used for footing forms should be removed. *Drain tile* should then be laid around the outside of the footings and connected with the sanitary sewer or with a *sump pump* in the building. After the tile is laid, it should be covered with gravel. When the filling is completed, the gravel should be flush with the top of the footings. Drain tile 4 inches in diameter is used in *The House,* as shown in Fig. 3.

FORMS FOR FOUNDATION

There are several different types of forms in use for foundation work. These include a variety of sectional forms made either of wood or metal, large panels of ¾-inch plywood, and built-up forms made of materials which later can be used in framing and sheathing the building. Large construction firms use principally the sectional and plywood forms because these can be used over and over many times. Small contractors usually find the built-up method more economical. Unless they are constantly repaired, sectional forms soon show wear and produce poor walls. Regardless of what type of form is used, the

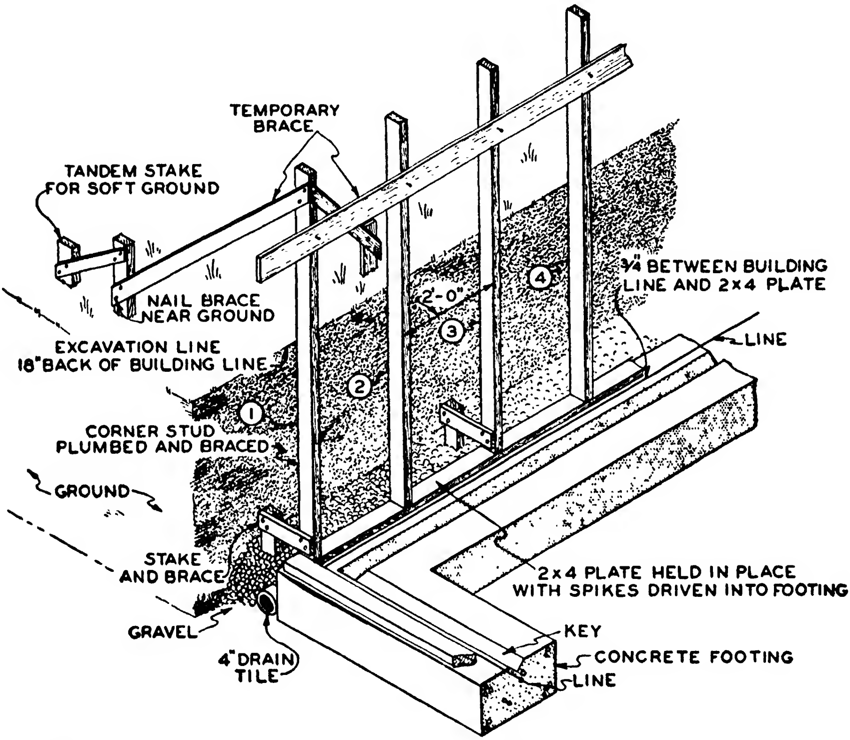


Fig. 3. Method of Beginning Construction of Outside Forms for Foundation Walls

outside forms of the foundation usually are erected first, Fig. 3. After the outside forms have been plumbed, straightened, and braced, forms for the inside of the walls are erected.

Built-Up Forms. Since the built-up form is used to some extent by both large and small builders, this is the type described in this text. The foundations of all the areas (*A*), (*B*), (*C*), (*D*), and (*E*) of *The House* could be built and the concrete poured at the same time. However, this method complicates the work and results in excessive and wasteful cutting of materials. Therefore, it is advisable to build first the forms for those areas which make up the main part of *The House;* that is, areas (*A*), (*C*), and (*E*). The forms for areas (*D*) and (*B*), porch and outside basement stairs, can be built and the concrete poured at a later time. If the forms for areas (*A*), (*C*), and (*E*) are to be built and the concrete poured at the same time, then the trenches for area (*E*) should be dug as soon as the excavating for area (*A*) has been finished. If this procedure is followed, the forms for area (*E*) can be built as a part of the forms for area (*A*).

A form built for holding concrete is similar to a jacket placed around an object. The form is the reverse of the object which may be a concrete wall, a pier, or a statue base. Any irregularities appearing on the face of the form will also appear on the surface of the finished object. Therefore, if a smooth, attractive surface is desired, the form must.be carefully built and greased with form oil. Furthermore, when poured into the forms, plastic concrete has a tremendous force. Unless the forms are strongly built, thoroughly tied, and braced, they will give way under the pressure of the wet concrete. Although there are many patented form-holding devices on the market, annealed form wire No. 9, 10, or 11 is still commonly used to hold the forms together. The chief advantage of the patented devices is the saving of labor. Also, some of them are so designed, they do not extend through the finished concrete wall; hence, they do not leave a hole when they rust out, nor any unsightly rust markings. The forms also must be approximately watertight; otherwise the cement and water will leak out, leaving the sand and stones bare. If carefully nailed, a No. 2 grade of tongue-and-groove or shiplap sheathing make good, tight forms.

ERECTION OF OUTSIDE FORM WALLS

PROCEDURE

1. **Locate the nails in the corner stakes which were left in the concrete, and check again for accuracy of dimensions.**

2. **Spike a 2x4 plate to the green concrete footings ¾ of an inch (the thickness of the sheathing) outside of the building line, as shown in Fig. 3. This plate is a great help when erecting the outside forms. If the concrete footing is so hard nails cannot be driven into it, the plates can be held in place with stakes driven outside the footing.**

3. **Lay out and mark the stud spaces 2 feet on center (O.C.), on the plate.**

4. Begin erecting the studs on the longest straight wall, in the case of *The House,* the east wall of area *(A).* Toenail each stud to the plate with one 6-penny (6d) coated nail on each side. Beginning at the northeast corner of area *(A),* nail, plumb, and brace one corner stud, as shown at *(1),* Fig. 3. Then erect and brace another stud a board length to the right of stud *(1).* Tack a sheathing board near the top of the studs to hold them in position, as shown in Fig. 3. Next erect studs *(2), (3), (4),* and others necessary to complete the section. On the next corner, the southeast corner of area *(A),* nail, plumb, and brace another stud as you did at the northeast corner. Work to the left of this stud, proceeding as you did at the northeast corner, to meet the first section. Continue the process until all the studs have been erected and braced, and the sheathing boards at the top are connected with the first section erected at the northeast corner.

5. After the studs have all been placed in position for the east wall, begin at the bottom and sheath up the wall. Nail the first sheathing board to each stud with two 6-penny nails. All other boards should have only one nail to each stud.

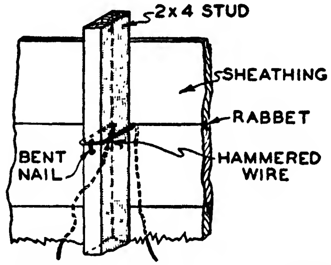


Fig. 4. Form Wires Held in Place with Bent Nails

6. Before continuing with the sheathing, wires should be cut to use in holding the forms in place. To get the correct length of the wires, add twice the thickness of the wall, plus twice the width of the studs (4″), plus twice the thickness of two sheathing boards (each ¾″ thick), plus 12 inches—the length of wire allowed for twisting. For a 10-inch concrete wall the wires should be about 3 feet 6 inches in length.

7. On the top edge of the bottom sheathing board, close to each stud, make shallow double saw cuts to hold the wires. After placing a piece of wire around a stud, bring the wire into the saw cuts, then pull the wire tight and hammer it until it fits snugly around the stud. Drive a nail close to the wire and bend it around the outside of the wire to hold it in place, as shown in Fig. 4. Since wires sometimes become a source of annoyance to the workmen, some carpenters prefer to wait until the inside forms are being built before putting the wires in place.

8. Using the same procedure, continue sheathing up the wall, breaking joints after every third board. Wires are placed about two feet apart vertically, and where 8-inch shiplap is used as sheathing, a set of wires should be inserted after every third board. Omit the top set of wires. Where the ends of boards meet at joints, all boards should be cut off square and fitted together tightly. Where possible, allow the boards to extend past the corners as shown in Fig. 5, in order to avoid excessive cutting. The lower boards of this first wall must extend against the excavation of the south wall below the trench of area *(E).*

When the forms for area *(A)* have been brought up to the place where the trench for area *(E)* begins, the form boards for area *(A)* should extend into the trench for area *(E).* From that point the forms for the east foundation wall of area *(E)* should be built in connection with the forms for area *(A)*, with the forms for area *(E)* continuing through to the end of the east-wall trench. Forms over trenches are built in the same way as forms over footings; that is, with a 2x4 plate on the bottom of the trench to serve as a nailing piece to which the studs are fastened.

9. When the outside forms for the east wall are completed, the north wall should be started. First, check the northeast corner for plumbness, then

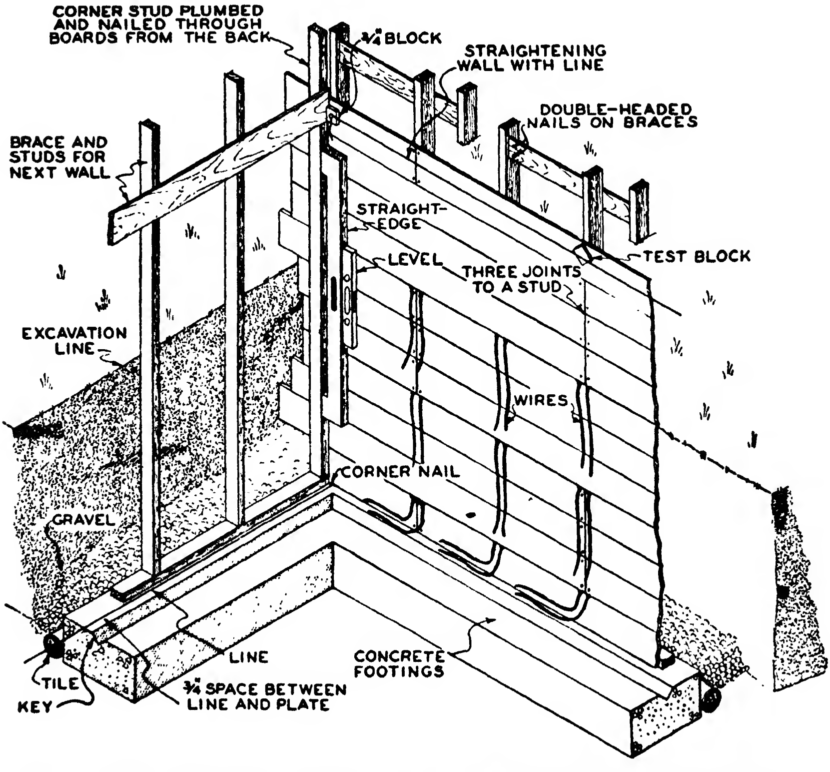


Fig. 5. Beginning Erection of Second Wall Forms after Forms for First Wall Are Completed

fasten a 2x4 to the face of the sheathing, as shown in Fig. 5. This is accomplished by nailing through the boards from the outside with double-headed nails. The double-headed nail saves time and material in removing forms. The 2x4 used for this purpose should be straight and plumb. Erect the studs for the north wall as was done for the east wall, then continue placing in position the sheathing boards and wires, building this wall around the irregularities of the bay window, area *(C)*, as shown on the basement-floor plan.

10. After completing the north wall, the third, or west, wall is started by setting the corner stud in the same way as the first stud at the northeast corner was set. Never rely alone on plumbing of the stud; it is always advisable to check the wall length on top of the forms with a steel tape measure. The length of the top of the form should be exactly the same as the length of the form at the bottom, and should always check with the dimensions on the plan.

Note particularly the irregularities in this wall. The northwest corner is set in 5 inches, making the north wall 36 feet 1 inch in length. The west wall at this corner has a short section with a wall thickness of 10 inches, and length of 1 foot 3 inches, the wall then moves out 5 inches to line up with the south-wall length of 36 feet 6 inches. The form wall for this corner must be carefully built in accordance with the dimensions shown on the basement-floor plan. This 5-inch offset at the northwest corner will allow the wood frame of the west wall to come flush with the foundation and to extend through in back of the stone veneer south of the chimney. The remainder of the west foundation wall must be wide enough to carry the concrete floor of the porch and the stone veneer on the south side of the chimney. Since the porch posts and floor are of stone and concrete construction, the responsibility for this part of the building is left to the masons.

11. The chimney is in the west wall. This necessitates a break in the outside wall form. Therefore, it is necessary to build the short wall section which when completed will be 7 feet 3 inches in length, measuring from the northwest corner to the chimney. According to the plan the chimney jogs out 12 inches to the west, then extends to a width of 6 feet to the south, with another 12-inch jog back into line with the main wall, and from here the west wall extends to the southwest corner of the building.

When the west-wall forms are completed, begin the outside forms for the south wall, starting at the southwest corner. Erect, plumb, and brace a stud at the corner, then continue building the outside forms for this wall as you did for the east wall. The outside form for the south wall may be built through until it meets the east wall, then openings should be cut in the wall where the forms for the foundation walls for area *(E)* will join. Additional studs should be used to reinforce the form wall where these openings are cut.

When the outside forms for the walls of area *(A)* are completed, the outside forms for the south and west walls of area (*E*) should be built. These forms are built in the same way as previously described for building the east-wall forms for areas *(A)* and *(E)*. Two short forms must be built over the footings below the ends of the east and west wall trenches of area *(E)*, to connect these walls with the south wall of area *(A)*. All outside forms for area *(A)*, also the west and south walls of area *(E)*, must be completed before beginning work on the inside forms.

12. Before work on erecting the inside forms is begun, all outside forms should be straightened and thoroughly braced, since this work is more difficult to perform satisfactorily after the inside forms have been built and the two wall forms have been tied together with wires. In order to get the outside forms straight and true, a line with a ¾-inch block placed under it is fastened to the face of the top board at each corner, as shown in Fig. 5. The form wall is then moved into correct position and tested with a third

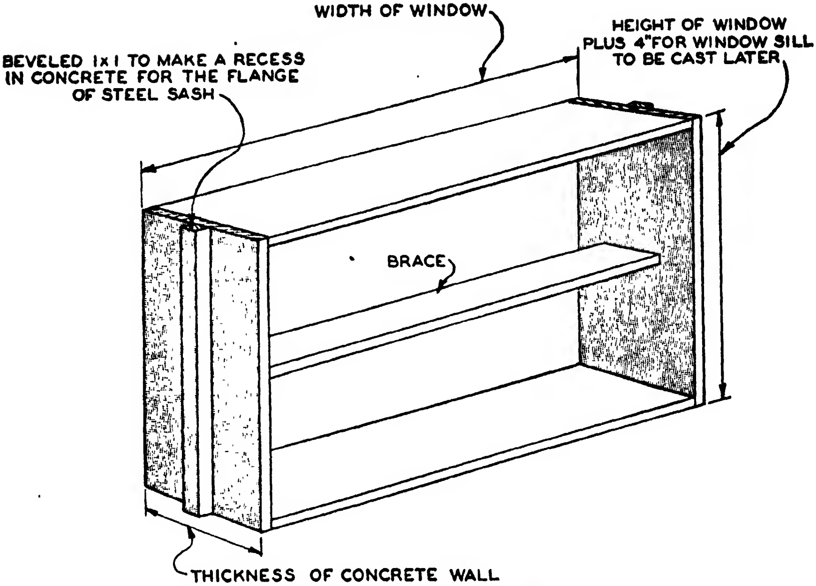


Fig. 6. Rough Form for Steel Sash of Basement Window

¾-inch block held between the wall and the line. The wall should then be secured in the correct position with adequate braces.

13. Certain other provisions must be made and various items installed before the inside forms are built, such as rough frames for the steel sashes for the basement windows, Fig. 6; outside door frames for the basement,

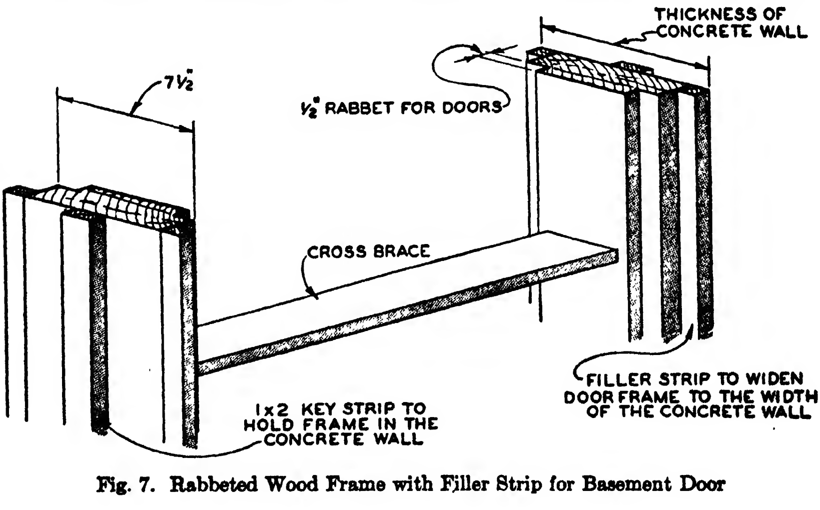


Fig. 7. Rabbeted Wood Frame with Filler Strip for Basement Door

Fig. 7; keys and reinforcing rods for future wall extensions for the outside stairway, porch foundations, front and rear entrances, and window areaways. (See Fig. 10.) Also provisions must be made at this time for any pipes which must be run through the walls later.

Reinforcing tie rods and keys are placed in walls to make concrete wall connections more secure. The number and size of rods will vary with different construction, but for the ordinary window areaway it is advisable to have at least three ½-inch reinforcing rods 2 feet long for each connection.

It is also necessary at this time to insert the flue lining in the chimney. The flue lining extends from the footing up the full height of the foundation

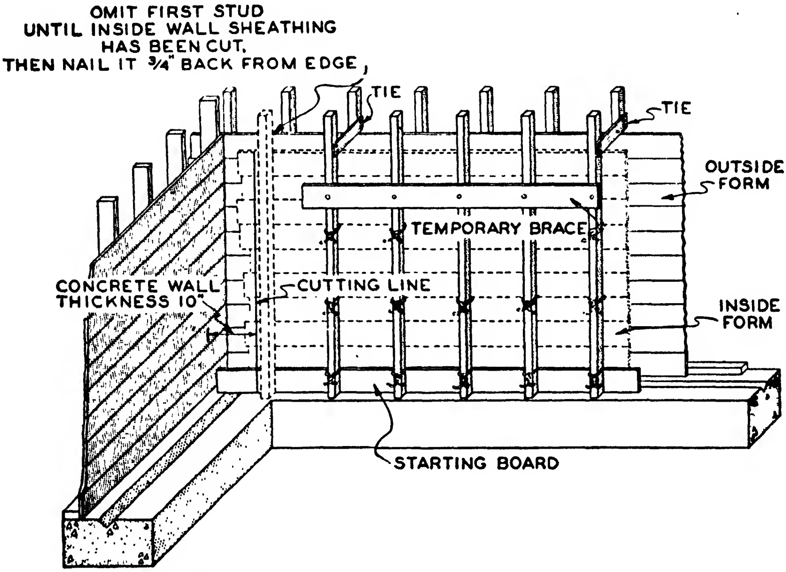


Fig. 8. Starting Inside Forms for Foundation Walls

wall. It is held in position with spreaders and wires which are put in place when the outside and inside forms are tied together. The holes in the flue lining for the chimney thimble and the cleanout door must be cut in the flue lining before it is erected. The thimble and the cleanout door and their connections to the flue lining are set when erecting the inside forms.

ERECTION OF INSIDE FORMS

PROCEDURE

The east wall is also a desirable place to start the inside forms because it has no breaks. Studs for inside form walls must be exactly opposite outside form studs; no plates are required at the bottom. Note that this wall is 10 inches thick.

1. Place a sheathing board in position, with one end within the limits of the wall thickness of the adjacent outside form; that is, the north-wall form. The other end of the board should be directly opposite an outside wall stud. Erect and tie two studs onto the outside form wall, as shown in Fig. 8. Beginning at the bottom, nail the first board to these two studs. Place the first stud one stud space back from the corner, as shown in Fig. 8. The other stud should be nailed at the end of the board directly opposite a corresponding stud in the outside form wall. Allow for a wall thickness of 10 inches.

2. In the same manner set up another section of one board length and continue this procedure until the next corner is reached. As the first stud was omitted at the beginning of the inside form, likewise the last stud at the next corner is temporarily omitted until the wall has been sheathed up and the boards cut to the correct distance from the adjacent outside form for the south wall.

3. Tack a piece of sheathing near the top of the studs as a temporary brace to hold the other studs, as shown in Fig. 8. Next, place the other studs in position, each stud being directly opposite to a corresponding stud of the outside form. Nail the bottom board to each of these studs, then tack them to the board used for a temporary brace near the top.

4. For the spreaders, prepare a 1x1 or 1x2 by cutting it to a length equal to the thickness of the concrete wall, 10 inches for this wall. Frequently carpenters select a straight-grain piece of softwood (1x8), cut it to correct length for spreaders, then split the piece with a hatchet into the widths desired.

5. On the top edge of the bottom board on each side of every stud, close to each stud, make double shallow saw cuts to hold the wires.

6. Place the spreaders between the outside and inside form boards near the saw cuts for the wires. Place the wires in the saw cuts and bring them into position by crossing them within the form. Pull the wires taut and twist them tightly on the outside of the stud, as shown in Fig. 8. Both wires must be twisted around each other four or five times and the ends bent down against the forms, as they are apt to be a source of danger to workmen. With a wire twister, twist the wires within the forms until the wires *sing* when struck with the twister. Usually wires are twisted with a screw driver or a steel rod; however, this method leaves a loop in the wire which will collapse when the concrete is poured, thus tending to allow the forms to spread. The homemade twister brings the two wires tightly together without a loop, Fig. 9.

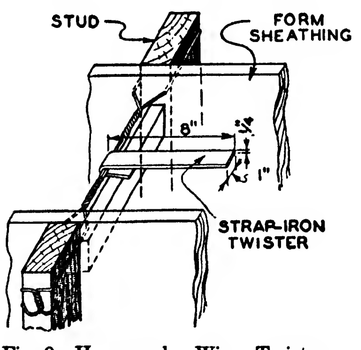
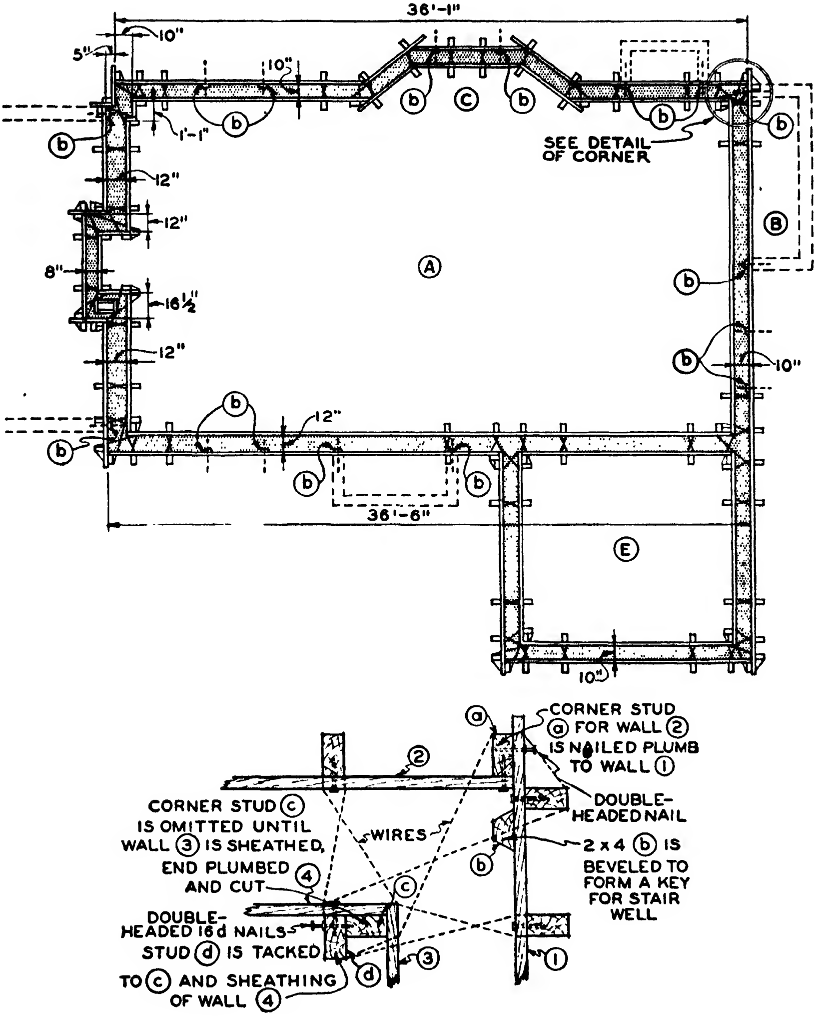


Fig. 9. Homemade Wire Twister—Leaves No Loop in Wire

7. Following the foregoing instructions, continue to sheathe up the inside form walls, breaking joints after every third board, placing spreaders, putting wires in place, and twisting them taut as before. Omit temporarily the top set of wires and the corner wires.

8. After plumbing the forms, cut off the ends of the boards straight and true at the corners, the correct distance from the adjacent outside forms.



DETAIL OF CORNER

Fig. 10. Plan of Forms for Foundation Walls, with Stud Arrangement for Corners

Note the cutting line shown in Fig. 8. Set the corner stud ¾ of an inch back from the trimmed edges of the boards, thus allowing space for the sheathing boards for the next wall to be built.

9. Begin building the inside form for the north wall, following the same method as that used for building the inside form for the east wall, except that one end of the boards of the north wall will fit against the boards of the east wall at the northeast corner. Corner wires must be installed as the inside form walls are built up. Break joints after every third board. Remember also that wires are installed after every third board, as shown in Fig. 8. The plan of the forms for areas *(A)* and *(C)* of the basement walls and for the foundation of area *(E)* are shown in Fig. 10. Also, note the plan for the chimney foundation shown in Fig. 10. Note particularly the detailed layout for the corner studs and the method of wiring them. The detail also shows the stud arrangement in the corners to insure easy removal of the forms.

10. Continue with the building of all other inside form walls in the same way. Careful attention should be given to the different wall thickness shown in Fig. 10. For *The House of the Book* the east and north walls for area *(A)*, the walls of area *(C)*, and the east, south, and west walls of the addition, area *(E)*, are all 10 inches thick. Also, the short section (1′3″) at the northwest corner, where there is a 5-inch offset, is 10 inches thick. The remainder of the west wall and the south wall of area *(A)* are 12 inches thick. This extra thickness is necessary to carry the concrete floor of the porch and the stone veneer. Remember, when building the inside form for the west wall, that the chimney form must be built according to plan. A 4-inch brick wall and a cleanout door close up the ash pit in the chimney. The form for the concrete must be built as shown, with the chimney wall in the basement being 12 inches thick, the same as the rest of the west wall, except where the flue extends into the foundation; here the chimney wall is widened to about 16 inches, as shown on the basement-floor plan. Before erecting the inside form walls, it is important for you to make a careful study of the thickness of the various walls. Also, study carefully the various details of the forms for all foundation walls, as well as the form and stud details for the corners, Fig. 10.

11. To insure a rigid and straight wall, as well as a support for the runway for the wheelbarrow used in filling the forms with concrete, a *whaler,* or *ranger,* is placed on the outside and inside of the form about 6 inches below the top of the finished concrete wall, Fig. 11. The whaler should be a straight 2x4 or 2x6. On the outside of the form the whaler is placed on edge and spiked to the studs. On the inside form the whaler is spiked flat against the studs. Tie wires should be run around these whalers and through the forms. After spreaders have been placed in the correct position between the outside and inside form walls, the wires should be twisted tight.

12. On the inside of the basement wall, build plank runways around the form wall as shown in Fig. 11. One end of the cross ledgers which support the boards for the runway rests on the inside whalers. The other end of the ledgers rests on the 1x6 cross bracing of the outer frame of the runway, Fig. 11. The ledgers which support the runway planks should be spaced at a distance to correspond with the length of the planks, with sufficient ledger support between to insure a safe and strong runway.

13. Before the concrete is poured for the foundation walls you should again make a thorough check of all details. Note especially the wiring of the forms, as shown in the *detail of the corner,* Fig. 10. Correct wiring of form walls for concrete cannot be overemphasized. If outside and inside forms are not properly held together on all sides, as well as at the corners and around irregularities in wall construction, the forms will spread when the concrete is poured. This spreading of the forms will cause irregularities in the finished concrete wall.

Study and check carefully all details of the northeast corner, Fig. 10. In addition to the method of wiring for holding the forms together at the corners, this detail also shows how the corner stud *(a)* for the north wall *(2)* is nailed plumb to the east wall *(1)*. Note also the beveled 2x4's used as keys shown as *(b)* for tying the concrete walls together at the corners, and as ties for concrete connections to the walls of area *(A)*. Such ties are shown for connection of the outside stair well and for the front entrance foundation, Fig. 10. Note, also, the studs *(c)* and *(d)* used for bracing the inside form walls indicated as *(3)* and *(4)*, detail drawing, Fig. 10. Check again provisions made for all openings for basement windows and the doorway. Tie rods, for walls that adjoin the main wall but are built later, are shown on the basement-floor plan. All such tie rods must be placed in position before pouring the concrete.

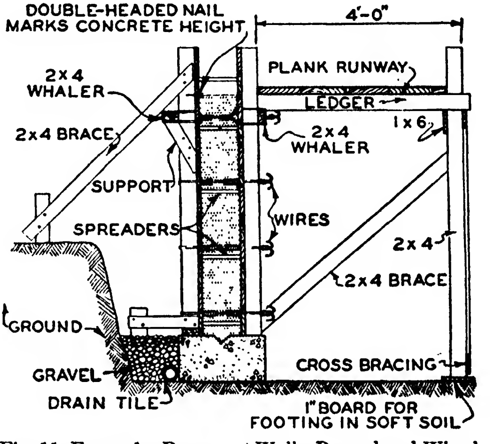


Fig. 11. Forms for Basement Walls, Braced and Wired with Runway Ready for Pouring Concrete into Forms

14. The proper height for the top of the concrete wall should be marked with double-headed nails before any concrete is poured. The nails should be driven into the sheathing of the outside wall form at a uniform height and spaced at a distance of every 4 or 5 feet. Nail heights should be set with a transit to insure a level-wall top. If a transit is not available, nails should be set in each corner and leveled with a line level. A taut chalk line fastened to these nails and snapped will make a guide line for setting the remainder of the nails.

Green lumber should never be used for building forms, as exposure to air and sun often will cause such lumber to shrink. The shrinking of the lumber will open the joints and allow a part of the wet concrete to leak out, leaving only the larger stones or gravel. The porous condition of the concrete thus created weakens the foundation walls. On the other hand, if the lumber is too well seasoned it may absorb moisture and swell when the wet concrete is poured into the forms. If the form walls become distorted by swelling of the boards, the walls of the finished foundation will not be straight and true. Obviously boards containing knot holes are not desirable for use in wall forms. Frequently, in building wall forms, lumber which has given satisfactory results include hemlock, spruce, fir, and yellow pine. White pine is too soft for this purpose.

REMOVAL OF FORMS

Several days should elapse after the concrete has been poured before the forms are removed. Jarring or excessive pressure on the fresh concrete will cause it to crack. Such breaks are extemely difficult to repair. When the concrete has become set firmly enough to permit removal of the forms, this work should begin by first cutting the wires. Then the studs should be removed by prying them away from the sheathing boards with a pinch bar or a 2x4. Never attempt to remove the studs by pounding or driving them loose. Immediately after the form boards are removed, all nails should be pulled out and the lumber stacked in an out-of-the-way place where it can remain until needed again.

BUILDING OF ADDITIONAL FORMS

After the foundations for the main parts of the building have been completed, the trenches should be dug for the porch and entrance foundations. Forms for these foundations, as well as for the outside stairway of the basement, should be built in the same manner as those for the foundation walls of the main sections of *The House.*

For the basement-window areaways, excavations should be dug down to good solid ground. The dirt taken from these excavations should be used as filling around the basement walls. As the dirt is put in place it should be packed firmly. Small forms, such as those for the window wells, usually are built in panel sections which are fastened together on the location. The forms for the semicircular window areaway for the north side of *The House,* can be made of $\frac{1}{4}$-inch plywood or similar material which can be bent to the desired shape, Fig. 12.

For details of this window construction see Fig. 12. Note particularly the 2x4 stake and brace, the reinforcing rods where the wall of the window well joins the main wall, and the construction of footing forms showing the cinder and gravel fill over the drain tile.

Before beginning construction of outside stairs, relocate the outside corners of area (*B*) with lines and a plumb bob. After the concrete wall has been built for the outside stair well, forms are set up for building the concrete stairway. Forms for concrete stairs can be built by first laying out the stairs on a piece of 1x10, indicating the risers and treads,

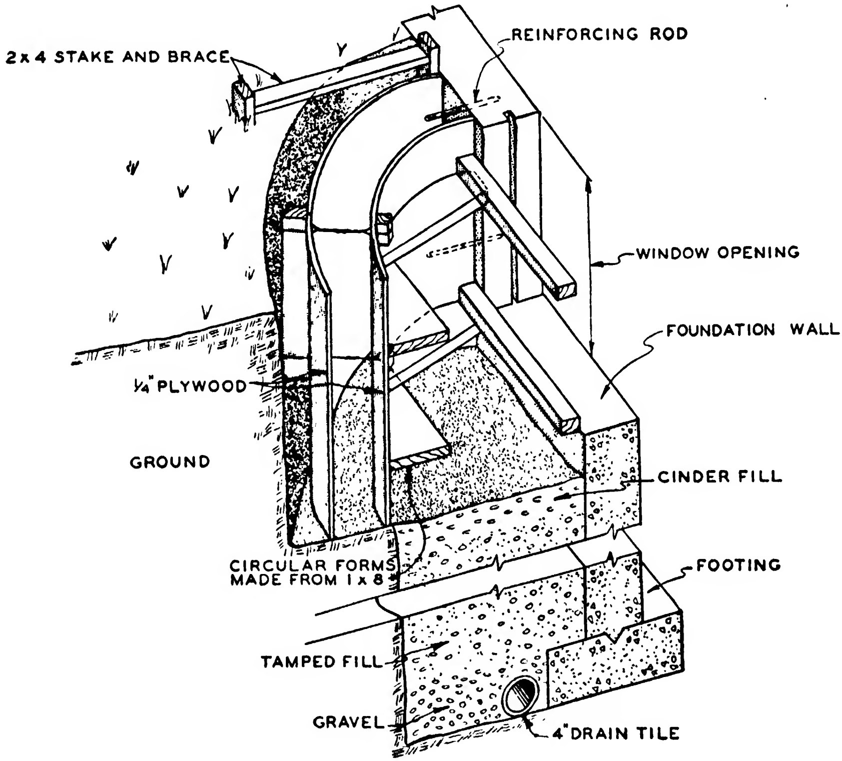


Fig. 12. Plan and Sectional View of Semicircular Window in Basement

also the location of the riser-form board, as illustrated in Fig. 13. (Stair layout is described in detail in the chapter on Interior Finish.) To support the risers of the form there are two 2x6's which are held against the 1x10 while the braces are nailed in the exact position with double-headed nails. After placing and fastening the 2x6's in position in the stair well, the risers are nailed to them. The risers are held in place in this manner so they can be removed easily after the concrete has set sufficiently to be troweled.

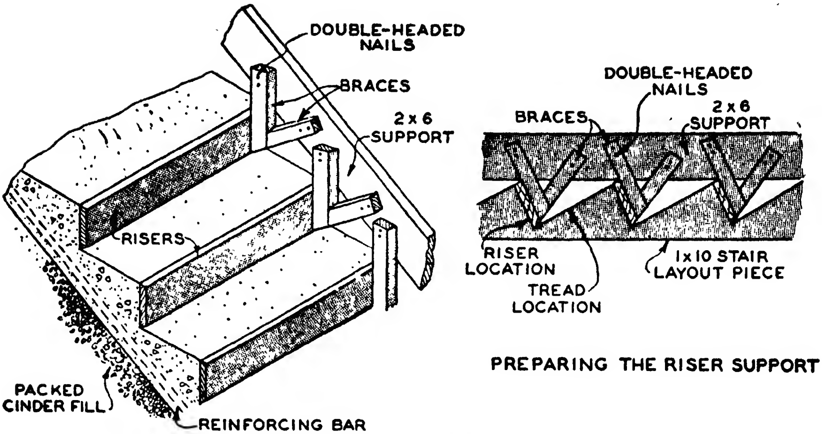


Fig. 13. Layout for Erection of Supports for Concrete Stairway

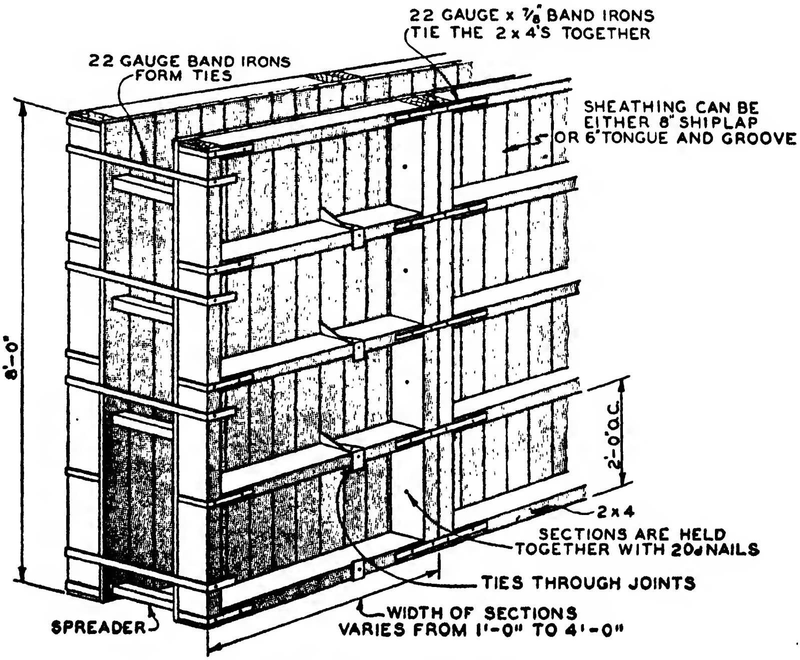


Fig. 14. Unit of Sectional Form

OTHER METHODS USED IN BUILDING FORMS

Unit or sectional forms illustrated in Fig. 14 have the advantage of repeated use. They can also be built and repaired in the shop during dull seasons. The height of all sections should be the same; that is, 8 feet. This height is suitable for all ordinary residential purposes. Several different widths ranging from 12 inches to 4 feet are necessary; wider sections become too heavy for convenient handling.

The frame for each unit is made by nailing 2x4's together. The joints should be secured with band iron. The sheathing should be either 1x8 shiplap or 1x6 tongue-and-groove lumber thoroughly nailed with etched or coated nails. Narrow boards are the most suitable for the purpose. Good woods to use are the white or Norway pines, which are light, yet dense enough to withstand rough usage. The exact width of the different units should be governed by the width of the boards used. For the last board it is better to use a full-width board than to use a narrow strip. Before the panels are put into use they should be given two coats of paraffin-base form oil, with an additional coat after each job to keep the forms in good condition.

Sectional Forms. When sectional forms are used, the outside forms of the walls are erected first, just as in the built-up form work. The Illustration, Fig. 15, shows the usual procedure in the erection of sectional forms.

ERECTION OF SECTIONAL FORMS

PROCEDURE

1. Beginning at one corner of the building, the first section *(1)* with its *band iron* fastened to the bottom is put into position on the footings. This section should be carefully plumbed, aligned, braced, and anchored at both the bottom and the top.

2. The second section *(2)* is then brought into position and fastened to the first section with 20-penny (20d) common nails driven through the 2x4 frame of the sections. Other sections are then added according to the needs of the building.

3. It is not likely that a builder will find form sections available to meet all different wall dimensions; therefore, small spaces can be filled in with plank filler strips where needed, as shown in illustration, Fig. 15. Such filler strips are usually fitted into place after such sections as *(3)* have been erected and braced.

4. Builders have found that the best method for holding two wall forms (outside and inside) together is by the use of band iron. For this purpose a 22-gauge ¾- or ⅞-inch wide band iron is used. The iron is tightened with a band-iron tightener shown in Fig. 16, and held in place with 8-penny (8d) double-headed nails. For the lower four feet of the wall, the band iron

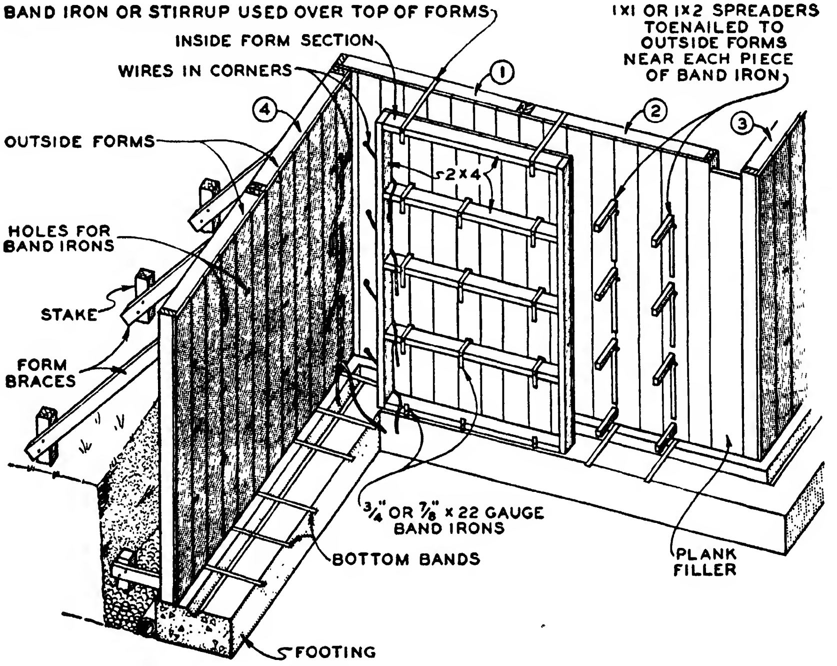


Fig. 15. Erection of Sectional Forms

should be spaced about 2 feet apart because of the greater pressure near the bottom of the forms while they are being filled with concrete. On the upper three feet of a seven-foot wall, iron bands can be spaced as much as 3 feet apart.

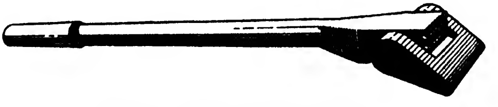


Fig. 16. Band-Iron Tightener

5. The holes for the band irons are usually cut at the time the forms are made. Three holes, one in the middle and the other two about 10 inches from each edge of the section, should be spaced along the three center (2x4) cross pieces. These holes will serve in most cases for tying forms together with band iron. Before starting to erect the inside forms, the carpenter will find it to his advantage to place the band iron in the outside forms after they have been erected.

6. After the band iron is in place on the outside forms, spreaders are toenailed to these forms. The spreaders should be made from 1x1 or 1x2 stock. They must be of the same length exactly, and exactly equal to the thickness of the concrete wall which is to be constructed. The spreaders should be nailed to the outside form either over or under the band iron. The closer the spreaders are to the band iron the less danger there is of distortion of the form when the bands are tightened.

7. Outside corners, such as are formed by section *(1)* and section *(4),* Fig. 15, can be more easily and more securely held in place by using a No. 9 or No. 10 wire. The two outside wall sections are tied together with the inside forms by use of the wire, which is inserted at the time the outside forms are erected.

Plywood Forms. Large plywood panels are coming rapidly into use for form building. Fir plywood panels, measuring 4 feet in width by 7 or 8 feet in length, are available on the market. Such panels are easily handled and easily stored. They also can be erected quickly when needed. However, since the edges become damaged easily, special care should be taken when handling the panels. Such plywood panels are tied together with band iron or with one of several kinds of patented concrete wall ties.

PATENTED CONCRETE WALL TIES

A special type of patented wall tie is the *Richmond Snap Ty* shown in Fig. 17. The Snap Ty consists of a steel rod with spreader washers which hold the wall forms apart. These ties are available on the market in different sizes, making it convenient to use this type of tie with various wall thicknesses. Note the break points indicated in the illustration. A special wrench will break the ties at a break point one inch within the concrete, leaving only a small hole to be plugged. A *tyholder* slipped over the rod on the outside of the whalers will draw the forms together tightly.

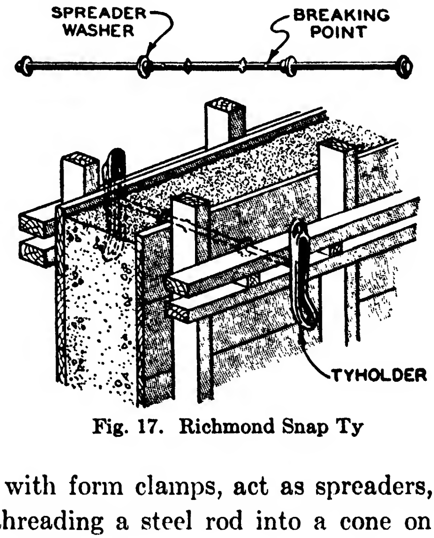


Fig. 17. Richmond Snap Ty

Cone nuts, used in connection with form clamps, act as spreaders, Fig. 18. These ties are made by threading a steel rod into a cone on the end. Together with a clamp, which has a set screw, another rod, threaded into the other end of the cone nut and passing through the whalers, holds the form in position. When removing the forms the outside clamp is removed first, then the rod and cone are screwed out, leaving a cone-shaped hole to be plugged.

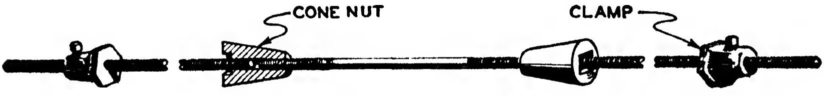


Fig. 18. Cone Nuts with Form Clamps

A type of tie requiring only an occasional stud is the *economy wedge-spacer tie* shown in Fig. 19. The spreader and wedge hold the boards in place.

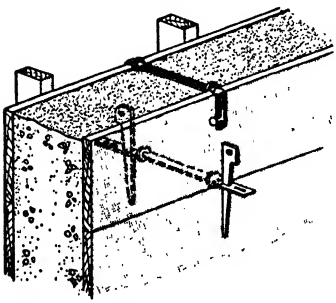


Fig. 19. Economy Wedge-Spacer Tie

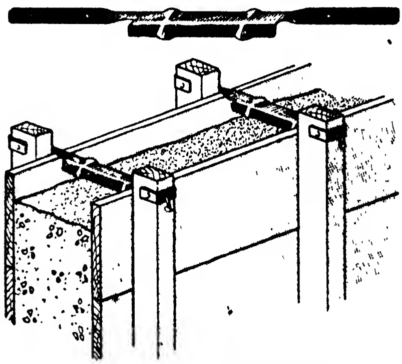


Fig. 20. Nelson Spreader Tie

Another type of tie is shown in Fig. 20. This is the *Nelson spreader tie,* which is made of 15-gauge metal 1¼ inch wide formed into a special corrugated angle shape with the ends punched and twisted.

CONCRETE FLOORS AND COLUMN FORMS

Concrete-Floor Construction. Concrete floors reduce the fire hazard. Therefore, in buildings intended exclusively for residential purposes, concrete floors are gaining favor for the first floor. To carry the 2½-inch concrete slabs, such floors usually have precast joists, as shown at (*A*), Fig. 21, or what is known as junior steel beams, shown at (*B*), Fig. 21. Between these joists or beams, the form work is carried on 2x4 spreaders held in place with bent-wire saddles, as shown at (*A*), Fig.

21, or by spreaders made of 1-inch material to fit the joist depth, and resting on the lower flange, as at (*B*), Fig. 21. If a smooth ceiling is required, the sheathing can be square edge (1x6) covered with waterproof building paper. When putting the sheathing in place, an allowance of ¼- or ½-inch opening should be made for each joist space to provide for wood expansion when the boards absorb moisture from the wet concrete. If the boards are wet when put in place they may be laid tight because there will be no danger of additional expansion.

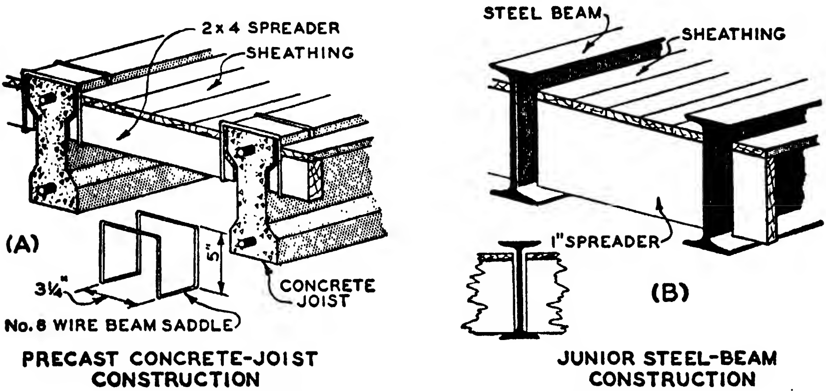


Fig. 21. Forms for Precast Concrete Joist and Junior Steel Beam

Where the joist and slab are poured at the same time as in the case of large construction jobs, Fig. 22, the forms may be entirely of wood. Note the various details shown in the illustration. Usually, however, metal pans are used. The pans rest on 2x10 planks, which are supported by shores, either solid or adjustable.

Columns. For constructing columns, 6-inch tongue-and-groove boards are used. The columns are built up in vertical panels, each side being constructed on the carpenter's work bench, then assembled later on the location. Plywood panels produce a smooth concrete finish free from the marks which are left when boards are used. Plywood panels are usually preferred for better-grade work. Column forms are held together with *yokes* made of 4x4's held in place with ⅝-inch bolts and wedges; see (*A*), Fig. 23. Yokes with wedges, but without bolts, as in view (*B*), also are satisfactory. Patented steel adjustable clamps, shown at (*C*), Fig. 23, are much more easily adjusted

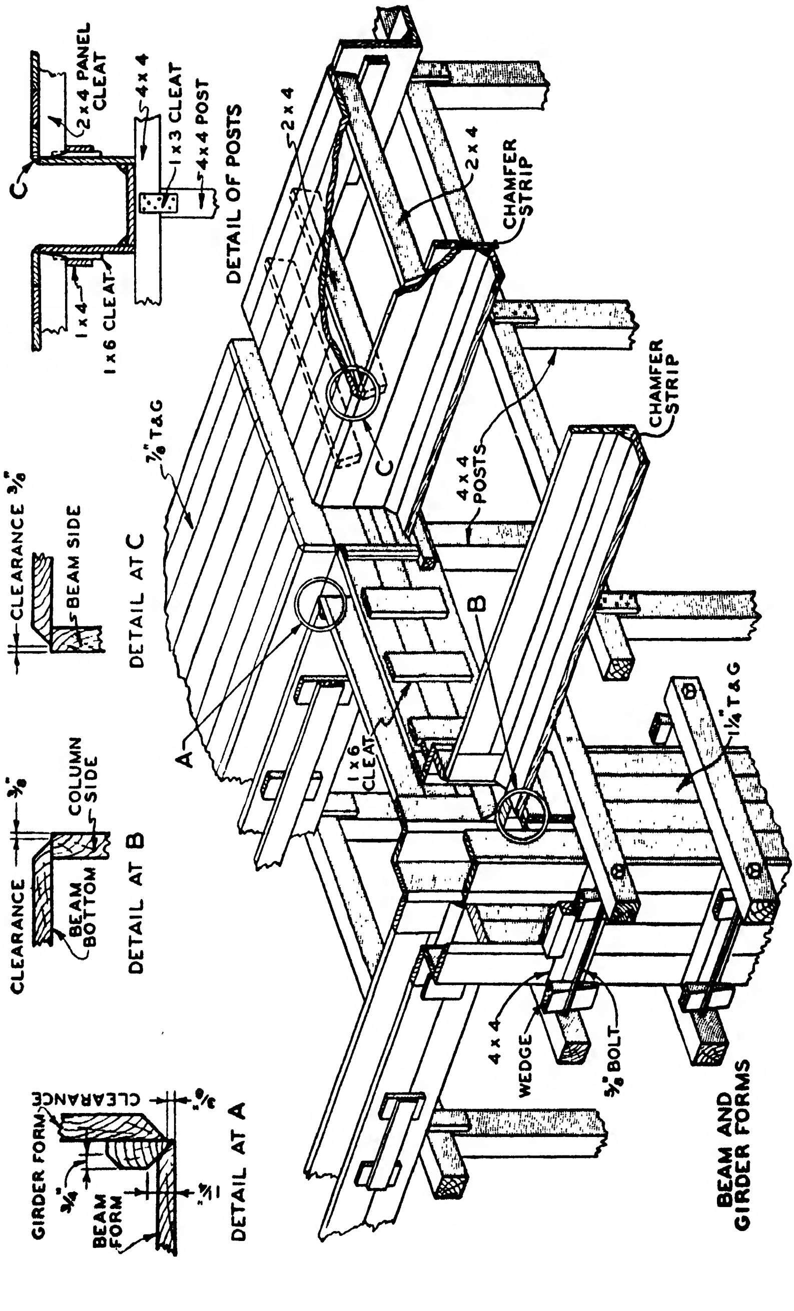
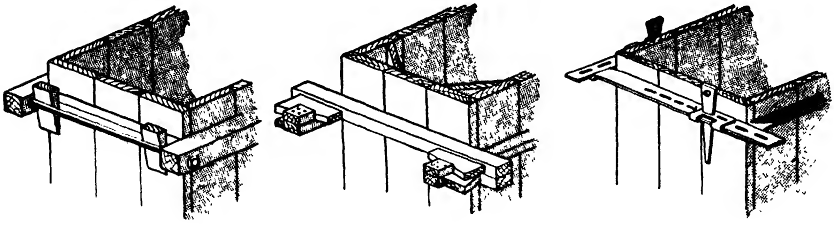


Fig. 22. Forms for Beam and Girder Floor System
Courtesy of Universal-Atlas Cement Company

and are time saving. In order to make the form strong enough to withstand the pressure of the concrete, the yokes must be spaced closer together near the bottom. The distance between yokes may be gradually increased near the top of the forms. Spacing should vary according to the size and height of the column.



(A) (B) (C)

Fig. 23. Yokes for Concrete Column Forms

The extent to which form building is used on large structures today is illustrated in Fig. 24. Competent and skilled carpenters are required for doing this type of work. Mechanics for this type of construction must be able to read and understand blueprints, and then build forms

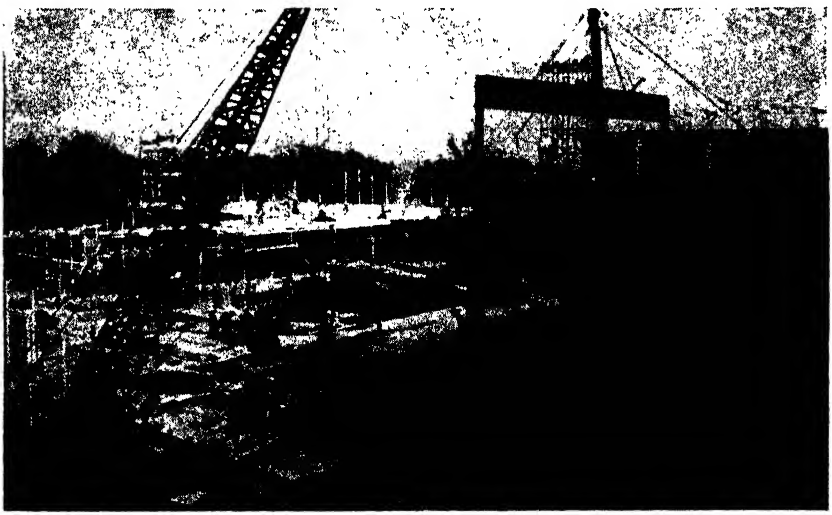


Fig. 24. Forms for Concrete Walls for a Large-Scale Building Project—Northwestern University

which will withstand any stress or strain likely to be put upon the forms.

CHECKING ON YOUR KNOWLEDGE

The following questions give you the opportunity to check up on yourself. If you have read the chapter carefully, you should be able to answer the questions. If you have any difficulty, read the chapter over once more so that you have the information well in mind before you go on with your reading.

DO YOU KNOW

1. Why the accident rate in the building industry is comparatively high?
2. In what way the individual carpenter can help in reducing this high accident rate?
3. Who should stake out the house on the building lot? Is this the carpenter's responsibility?
4. How deep the excavations are to be made for the basement and the trenches for the addition of *The House of the Book?*
5. The length of the outside south and north walls of *The House?*
6. What construction feature causes this difference in the length of these two walls?
7. When excavations are to be made for the basement window areaways, the outside stairway, and the trenches for the porch; at the same time, before, or after, excavating for the main sections?
8. How outside and inside forms for concrete walls are held together? Why is this strengthening of the form walls especially important for the success of a building project?
9. When building form walls, what provision is made for basement window and door openings?
10. Of what material the form for the semicircular basement window is made? Why is this material better, in this case, than boards?
11. When building forms for basement foundations, what provision is made to prevent foundations for window and door areaways pulling away from the main wall?

CHAPTER III

Wall and Floor Framing

QUESTIONS THIS CHAPTER WILL ANSWER

1. *When constructing frame buildings, how can the carpenter provide protection against termites?* 2. *When framing walls, what precautions should be taken to reduce the fire hazards?* 3. *What two types of wall framing are commonly used in the United States?* 4. *What name is usually given to the story-by-story method of framing?* 5. *When did the first rigid fiber insulation board appear on the market in America? Where was it manufactured?*

INTRODUCTION TO CHAPTER III

You are now going to learn how to frame a new house. This is one of the most important chapters in your textbook. The importance of foundations has been emphasized previously, but in addition to a solid foundation, a house must have a well-built superstructure, also. This is the portion of the building in which "we live, move, and have our being." Therefore, the constructing of walls so as to insure a substantial superstructure must be stressed. As you study this chapter you will understand why the information you acquired in your preliminary study of carpentry was necessary before beginning the actual building of a new house.

In this text the author has given you exact and practical instructions on how to proceed step by step in the framing of walls, floors, and subfloors. Directions are given for the handling of details connected with the placing and fastening in position of joists, girders, and beams. Instructions are given also for dealing with many other important features pertaining to the framing of walls and floors. You are told how to frame a building to prevent damage by termites and reduce fire hazards. Considerable attention is given to the framing of walls so as to equalize the shrinkage of the lumber used in different parts of the building. Explanations are given regarding methods to use when framing around door and window openings. Special problems involved in framing walls so as to provide for the installing of water pipes and heat ducts are discussed and instructions given regarding the solution of such problems.

Information given in Tables I and II will help you in determining the size and type of joists and girders required to carry the load, or weight, of the superstructure of a new building. In addition to the blueprints, sixty drawings are provided to show you the details of the various parts of a frame wall during the process of construction. These illustrations will help you to visualize each portion of the frame of a house as you advance in your study of carpentry construction. In the progress of your work, note particularly the many dimensions and the elevation drawings shown on the blueprints. The drawings, together with the plans or blueprints, make it possible for you to form a mental picture of the relative size and appearance of the different portions of the walls and floors of the building.

At the close of this chapter the author discusses the general instructions which he has given on wall and floor framing and shows how this information can be applied to a particular building such as *The House of the Book,* a typical American home.

As pointed out previously, the author does not claim that the methods he presents are the only ones that may be used for successfully constructing a new home. However, he does maintain that the methods he recommends have been tried and proved satisfactory in the construction of many homes throughout the country.

FRAMEWORK OF THE SUPERSTRUCTURE

The wall and floor framing, together with the roof, form the skeleton of that part of a building known as the *superstructure;* that is, the portion which rises above the foundation. The sheathing, outside finish, inside wall finish, trim, and finish-floor work are fastened to the framework of the superstructure. Since the strength and rigidity of a building depend upon the design and workmanship involved, it is advisable to give these two factors special consideration. When erecting the framework of a building, any one of several different methods may be employed depending upon design, conditions peculiar to a certain locality, and the experience of the builder. Before taking up the discussion of the framing of *The House of the Book* we will consider some of these various methods.

TYPES OF WALL FRAMING

During the early history of our country timber was abundant, but the means of working it up into lumber were primitive, requiring much work by hand. Because of this necessary handwork, it was cheaper to use large-sized pieces when framing a building than it was to cut the lumber into smaller sizes. Nails were comparatively scarce and expensive, but labor was cheap and it was the custom to use mortise-and-tenon joints where various pieces of the framework came together. The pieces were then held in place by wooden pins. This custom persisted until about the middle of the nineteenth century. However, during the passing of years materials have become more expensive and the means of producing lumber in smaller sizes have been more highly developed; meanwhile, the sizes of pieces used for framework have become steadily smaller.

Because of these changing conditions, gradually the methods of framing buildings began to change also. Among the new methods developed are those known as *balloon framing* and *platform* or *story-by-story framing,* in which only small-sized lumber, or *scantlings,* are used. Where necessary for greater strength these pieces are doubled or trebled and nailed together to make a single piece. Since nails and spikes have become more plentiful and wages higher, joints are fastened by spiking the pieces together instead of making mortise-and-tenon joints.

When framing a building by the old method, the joints are made more easily on the ground. Therefore, it is customary to frame each side separately and to raise one whole side into position as a single unit. This procedure requires strong braces at all corners where the frame must be held square and true while it is being raised. Since the balloon and platform frames are nailed together in place, instead of on the ground, braces are not so essential and are sometimes omitted. However, in the better class of work some form of bracing is employed at the corners even in balloon framing. Such bracing tends to prevent cracks in the plaster by making the frame more rigid and more resistant to wind pressure. Progress in the use of the newer types of framing has been slow, especially in the older sections of the country. Even at the present time, the old braced-frame method, or some modifications of it, is employed to some extent, particularly in the East. The braced frame has the advantage of being more rigid than the balloon or platform frame, and it also provides greater resistance to fire.

1. Balloon Frame. A modern type of framing, acceptable for the building of substantial houses in all parts of the country, is shown in Fig. 1. Distinguishing features of this type of framing are the outside studs and, where possible, the load-bearing partition studs which are made to extend the full two stories from the foundation to the rafter plate. On the second-floor level the joists rest on a *ribbon board,* shown at *4,* Fig. 1, and are nailed against the studs. The attic-floor or ceiling joists rest on the doubled top plate shown at *6* Fig. 1. The ribbon board used in the balloon type of framing is cut into the supporting studs as shown at *4,* Fig. 1. The use of a ribbon makes it necessary to put in fire stops between studs to prevent the circulation of air throughout

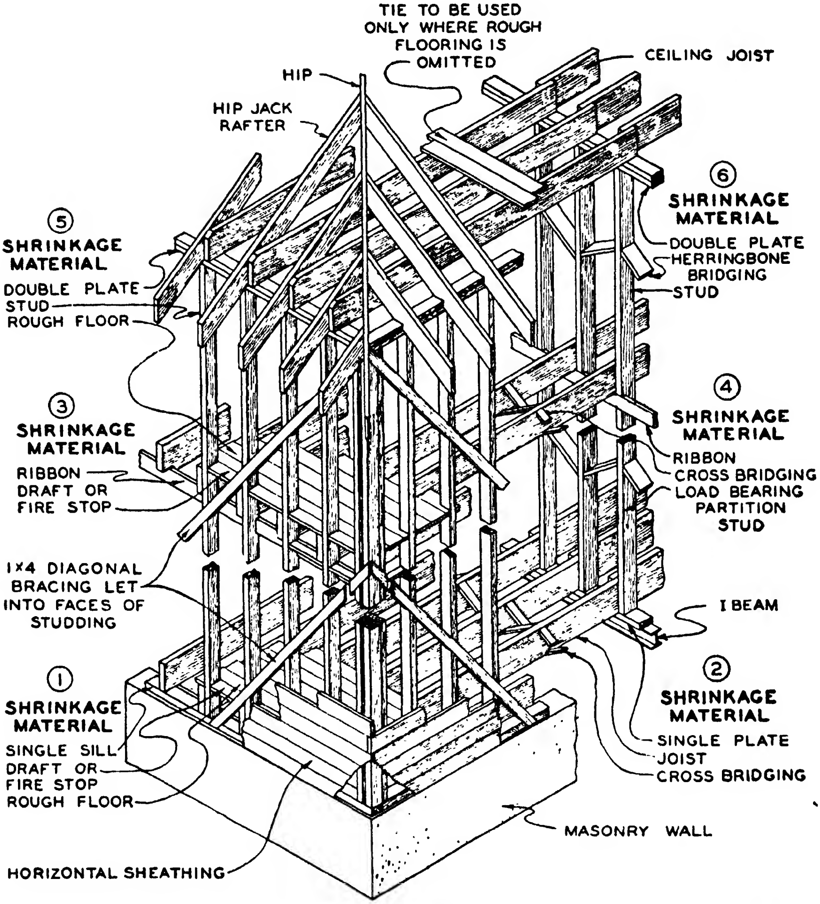


Fig. 1. Balloon Frame Construction Showing Location of Shrinkage Materials

the walls; see *1* and *3*, Fig. 1. Where the sheathing is nailed on diagonally, the (1x4) diagonal brace which is shown at *3*, Fig. 1, may be eliminated if so desired.

The balloon frame offers the advantages of speed and economy of construction. The outside wall and load-bearing partition studs extend from the foundation sill to the rafter plate. These continuous studs make possible easy installation of service pipes without the cutting of plates and consequent weakening of the structure. The balloon frame also possesses rigidity and reduces shrinkage by reducing the

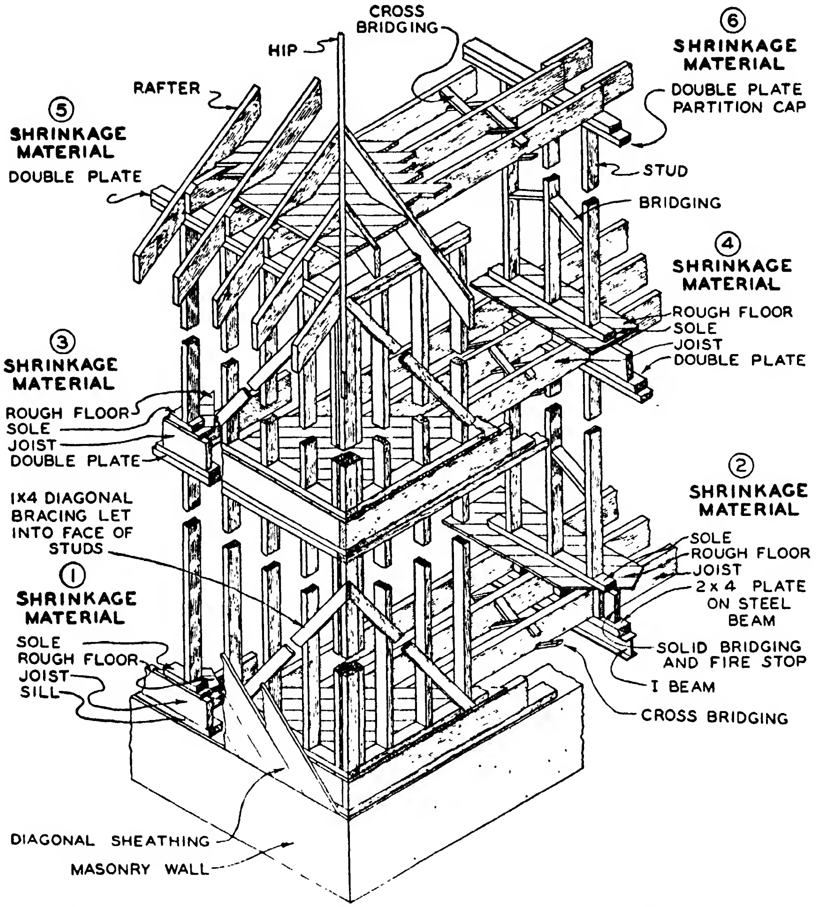


Fig. 2. Western Frame Construction Showing Balance of Shrinkage Materials

amount of cross-section lumber to a minimum. Note the balance of shrinkage materials on the outside walls and load-bearing partitions shown at point *1* and *2*, *3* and *4*, *5* and *6*, Fig. 1.

2. Platform or Western Framing. With the advent of kiln-dried framing lumber the more recently developed platform frame has been gaining in favor rapidly, Fig. 2. This type of framing is unquestionably the fastest and safest form of good construction and also allows for greater use of short materials for studding. Interior and exterior walls are framed exactly the same, thereby insuring proper balance in case any shrinkage or settling occurs. Where steel beams are used instead of wood girders, wood of the same cross-section size as the sills on the foundation should be used to insure an equal amount of shrinkage. Each floor is framed separately, story-by-story, and the subfloor is laid before the wall and partition studs are raised. Note the balance of shrinkage materials on the outside walls and load-bearing partitions at points *1* and *2*, *3* and *4*, *5* and *6*, Fig. 2.

Platform framing automatically provides fire stops for the walls and partitions at each floor level. Diagonal subflooring may be laid easily for each story before any studs are raised for the story above, thereby speeding up the operation of subflooring and securing a safe and sound floor on which the workmen may stand.

FRAME-CONSTRUCTION PROBLEMS

Shrinkage. Frequently, shrinkage causes unequal settling which results in cracked plaster, damage to decoration, and infiltration and escape of air. A good and careful builder can control shrinkage to a great extent by:

1) Securing properly seasoned and dried lumber.

2) Equalizing shrinkage of material in outside walls and load-bearing partitions through the method of framing the building.

3) Providing artificial heat in the building after it is inclosed and before lath and plaster are applied, with another drying-out period after plastering and before trimming the building.

Most builders give too little attention to the second point—*equalizing shrinkage*—yet this is an extremely important factor in preventing damage to the building after it is finished. Wood will change size and shape according to its moisture content, and this fact must be taken into consideration when framing a building.

A greater amount of shrinkage will result from the platform type of framing, Fig. 2. However, the shrinkage can be equalized more easily, not only between the outside walls and load-bearing partitions but, also, for all other partitions. Although balloon framing has less shrinkage than the platform type, the shrinkage is more difficult to equalize in the balloon type, Fig. 1. Despite this fact it is better to use the balloon type of framing when buildings are to be veneered with brick or stone, or when a building is to be stuccoed. The veneer masonry in such buildings is rigid, while the window and door frames which extend into the masonry are fastened to the wood frame; thus, if any great amount of settling should occur, the frame may be torn loose, causing interior wall damage.

Sill Construction. The sill is the first part of the frame to be set in place. It rests directly on the foundation wall and extends all around the building wherever wood framing members are to be erected. The 4x6 or 6x6 timber sills of former days have been replaced by 2x4, 2x6, or 2x8 sills embedded in mortar and held in place with ½-inch anchor

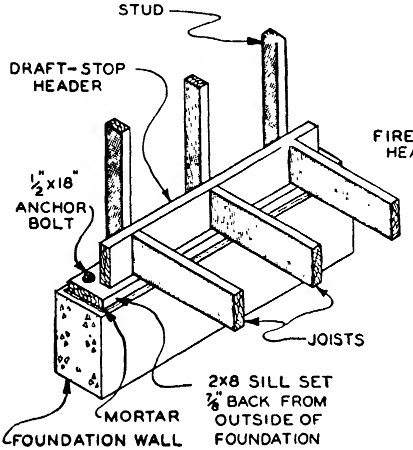


Fig. 3. **T**-Sill Construction

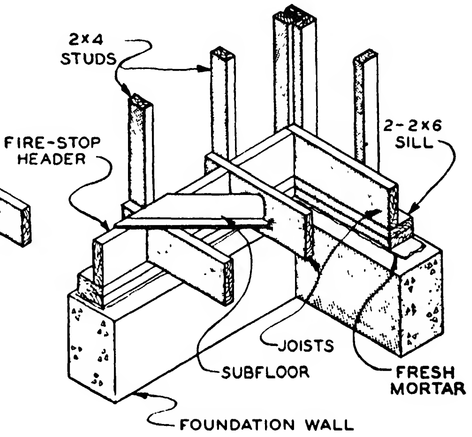


Fig. 4. Eastern-Sill Construction

bolts. These bolts are spaced 4 feet on center (O.C.) and set in the masonry.

The **T**-sill assembly is the best construction to use for balloon framing, Fig. 3. The minimum shrinkage in the single sill and a header joist which acts as a draft and fire stop make this a desirable type of sill. Another feature which is an advantage is the ease with which it can be assembled.

When joists are nailed against the studs, as in the eastern-sill construction, a 2x6 sill is wide enough, but it necessitates the cutting and fitting of headers between the joists for fire stops, as shown in Fig. 4. In cheap balloon construction the header is omitted, as in Fig. 5.

The box-sill assembly is the best construction to use with the platform frame, Fig. 6. This type is sometimes cheapened by omitting the header joist.

The double sill, which can be used in any kind of sill assembly, has the advantage of sills lapping at the corners and other joints. However, the need of this is not so essential if the sill is well anchored every 4 or 6 feet. A double sill needlessly increases the shrinkage area of lumber, and adds to the cost of construction.

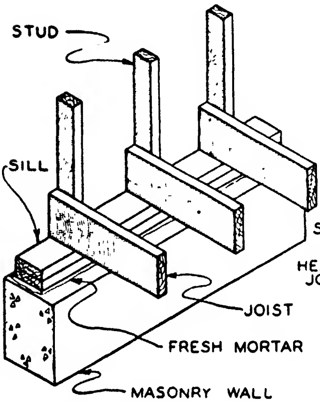


Fig. 5. Sill without a Header

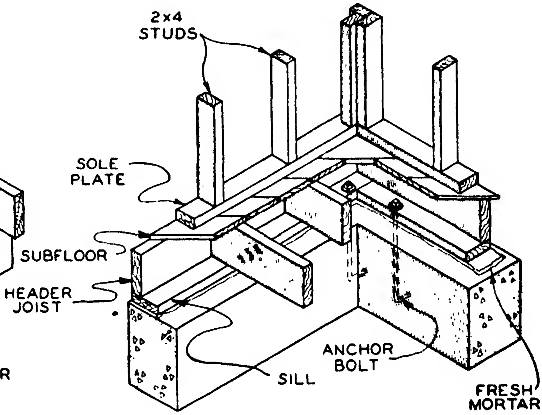


Fig. 6. Box-Sill Construction

Protection against Termites. The wood-devouring termite or *white ant* is one of the enemies of wood construction. Of the many different species of termites the two most common in the United States are the subterranean and the nonsubterranean, or dry-wood, types. The subterranean termite is most active and can be found in almost every state in the Union. However, it is more prevalent in the southern part of the country. These destructive insects live underground, coming out to feed on wood. After feeding, they return to the ground for moisture. If shut off from moisture they die. These termites will burrow through poor mortar in order to reach the wooden superstructure of a building. Sometimes they build earthlike shelter tubes over materials through which they cannot burrow. Then they travel back and forth through these tunnels between the ground and the wood on which they feed. See Fig. 7.

In localities where the attack of the subterranean termite is inevitable, preventative measures must be taken at the time of construction.

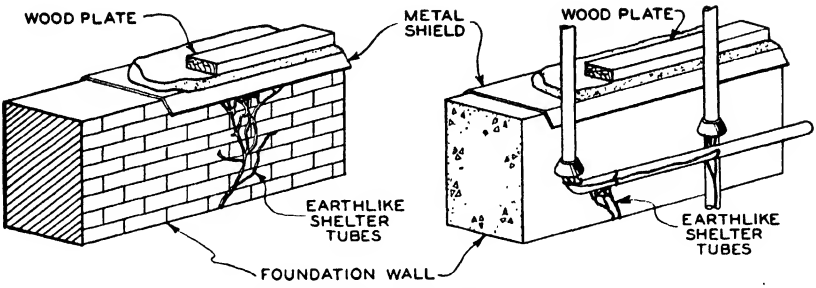


Fig. 7. Metal Termite Shields under Wood Sills and around Pipes

Sills and other framing members should be at least 18 inches above the ground and should be treated with coal-tar creosote, or protected by metal termite shields, as shown in Fig. 7. The shields, of 24-gauge galvanized iron or copper, should project on both sides of the wall and all around piers to prevent access from any side. Masonry units should be laid in mortar rich in cement; porous concrete foundations should be avoided as they permit penetration by termites.

Columns, Girders, and Beams. The joists rest on sills placed on top of the foundation walls around the outside of the building. However, the distance between the foundation walls (the span) may be so great that additional support must be provided between the walls. When such support is necessary it may be in the form of a *cross-bearing wall,* a *wood girder,* or a *steel beam.* Not only are the girders or beams supported at the ends which rest on the walls, but usually additional support is provided by the use of one or more posts placed in between the two walls. Necessary footings must be constructed for the posts. When wood posts are used it is advisable to construct a

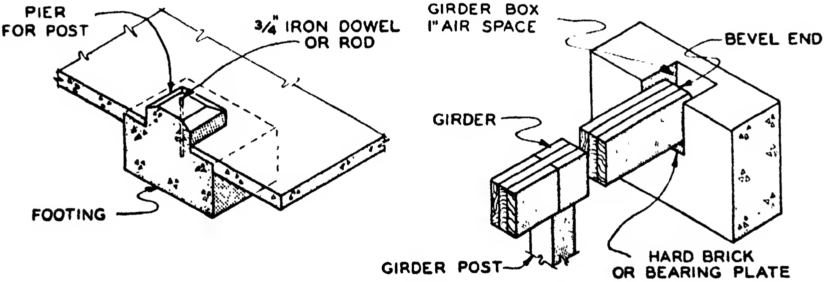
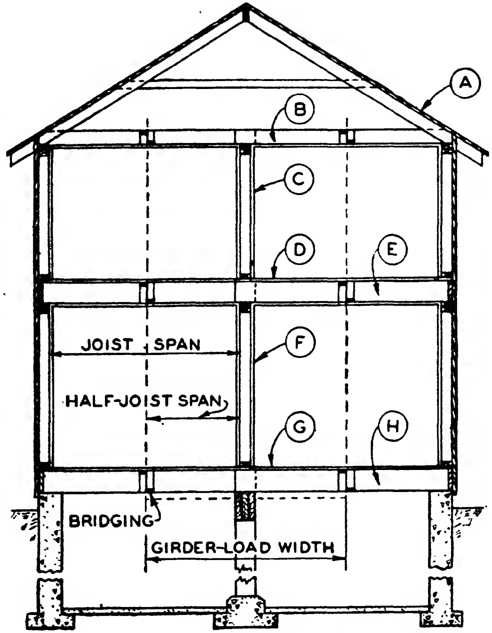
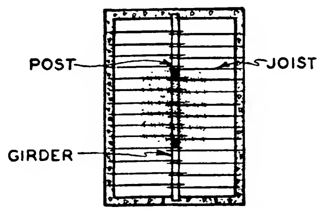


Fig. 8. Pier under Wood Post and Air Space around End of Girder in Concrete Wall



(A) Live load on roof = local requirements for wind and snow (usually 30 lbs. per sq. ft.). Dead load of roof of wood-shingle construction = 10 lbs. per sq. ft.
(B) Live load on attic floor = local requirements (usually 20 lbs. per sq. ft., when used for storage only). Dead load of attic floor not floored = 10 lbs. per sq. ft. Dead load of attic floor when floored = 20 lbs. per sq. ft. (storage space).
(C) Dead load of partitions = 20 lbs. per sq. ft. of floor area.
(D) Live load on second floor = local requirements (usually 40 lbs. per sq. ft.).
(E) Dead load on second floor = 20 lbs. per sq. ft.
(F) Dead load of partitions = 20 lbs. per sq. ft. of floor area.
(G) Live load on first floor = local requirements (usually 40 lbs. per sq. ft.).
(H) Dead load of first floor, ceiling not plastered = 10 lbs. per sq. ft. Dead load of first floor, ceiling plastered = 20 lbs. per sq. ft.



PLAN OF FLOOR FRAMING SHOWING THE GIRDER-LOAD AREA

Fig. 9. Diagram Showing Method of Calculating Girder Load for Small House

concrete base with a 6-inch pier which will bring the bottom of the post safely above the moisture of the basement floor, as shown in Fig. 8. A concrete pier under the wooden post and an air space around the end of the girder in the concrete wall will help to prevent decay. A 3/4-inch iron dowel pin in the concrete pier will hold the post in place.

In order to insure proper support for a girder or beam, it is necessary to calculate the size of post required to carry the girder load. For ordinary wood posts not longer than 9 feet nor smaller than a 6x6, it is safe to assume that a post is sufficiently strong if the longest dimension of the cross section equals the width of the girder; that is, for a girder 8 inches wide a 6x8 or 8x8 post should be used.

Steel beams—either I or **H**—usually are supported by *Lally columns;* that is, iron pipes filled with concrete, set on plates on footings and bolted to the beams at the top.

Calculation of Loads. The size and strength of the girders or beams should be calculated carefully to make sure they will be strong enough to carry the necessary load. The method for calculating loads for small homes is illustrated in Fig. 9. The girder load is determined by adding together the weight of all materials resting on the *span of the girder* plus the live load required for the type of building according to the city or state building codes. Roof loads usually are carried by the rafters resting on the outside walls. Where partitions in the attic carry part of the roof load, these loads must be taken into consideration if such weights are carried by the girders. Not only must the load directly above the girder be considered but also half of the floor load on each side; that is, half of the joist weight which rests on the girder and the load which the joists carry. This is called the *girder-load area.* See Fig. 9.

Therefore, in determining the size of the girder, it is necessary to find: (1) the greatest distance between the girder supports (span); (2) the girder-load widths; (3) the total floor loads (dead and live loads) per square foot carried by the joist and bearing partition to the girder. When calculating loads for small-house framing, you will find the information given in Fig. 9 of great value.[1]

After figuring the weights or loads the various girders will be

[1] Information given in Fig. 9 and in Tables I and II was taken from the *High Cost of Cheap Construction,* Weyerhaeuser Timber Co., Chicago, Illinois.

required to carry, consult Table I for the size of wood girders needed and the space permissible. This information is intended to assist you in the selection of proper sizes of wood structural members for the average house. This method of procedure is not recommended when designing large buildings because there are so many factors involved in the designing of any large-sized building. The calculations given here are based on the working-unit stresses of No. 1 dimension Douglas fir which is the grade of lumber recommended for girders,

TABLE I. RECOMMENDED SIZES OF NO. 1 DOUGLAS FIR LUMBER FOR GIRDERS

GIRDERS	SAFE LOAD IN POUNDS FOR SPANS FROM SIX TO TEN FEET				
Size	Six Feet	Seven Feet	Eight Feet	Nine Feet	Ten Feet
6x8 solid	6,875	5,893	5,156	4,583	4,125
6x8 built-up	6,100	5,220	4,575	4,065	3,663
6x10 solid	8,575	8,667	8,273	7,354	6,618
6x10 built-up	9,795	8,385	7,345	6,525	5,865
8x8 solid	9,285	8,036	7,031	6,250	5,625
8x8 built-up	8,145	6,960	6,125	5,425	4,880
8x10 solid	11,690	11,820	11,281	10,028	9,025
8x10 built-up	13,050	11,180	9,775	8,700	7,825

joists, and rafters, by the West Coast Lumbermen's Association. These recommendations are: extreme fiber stress in bending, 1,200 pounds per square inch; maximum horizontal shear, 120 pounds per square inch; modulous of elasticity, 1,600,000 pounds per square inch; compression across grain, 325 pounds per square inch. Compensation for structural differences must be made when other species or grades are used. When solid girders are used they should be of old-growth material and free of heart centers.

Steel beams are used frequently in place of wood girders. Such beams can be obtained in various weights, as well as in different sizes. The selection of the most suitable beam to use for any particular job depends upon the load the beam must carry. Loads for steel beams are calculated in the same way as loads for wood girders. The required sizes for steel beams can be determined from information supplied by steel manufacturers.

Joists. The size of joist commonly used in dwellings is 2x10 for the first floor, and usually the same size joist is used on the second floor also. In some cases the size of the second-floor joists can be decreased without danger if the spans are short. However, a change in joist size on the same floor will cause a step up or down. Joist sizes for different lengths of spans and for various loads are given in Table II. This information is based upon material of the same size and strength as that of the girders.

Framing Joists on Girders or Beams. Methods of framing joists on foundation walls was explained in connection with the directions given for sill construction, and illustrated in Figs. 3 to 6. Several different methods may be used when framing joists on girders, but the simplest method is to rest the joist on top of the girder as shown

TABLE II. SIZES OF NO. 1 DOUGLAS FIR LUMBER RECOMMENDED FOR JOISTS ON DIFFERENT LENGTH SPANS FOR VARIOUS LIVE LOADS

Joists		Spans for Carrying Live Loads Shown with Additional Weight of Joists and Double Flooring													
		Live Loads													
		20 lbs.		30 lbs.				40 lbs.				50 lbs.			
Size	Spacing	Plastered Ceiling		Plastered Ceiling		No Plaster		Plastered Ceiling		No Plaster		Plastered Ceiling		No Plaster	
		Span		Span		Span		Span		Span		Span		Span	
	Inches	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
2x4	12	7	8	—	—	—	—	—	—	—	—	—	—	—	—
	16	7	0	—	—	—	—	—	—	—	—	—	—	—	—
	24	6	1	—	—	—	—	—	—	—	—	—	—	—	—
2x6	12	11	9	11	6	13	4	10	8	12	0	10	0	10	11
	16	10	9	10	6	11	11	9	8	10	6	9	1	9	6
	24	9	6	9	3	9	6	8	6	8	7	7	10	7	10
2x8	12	15	7	15	3	17	9	14	1	15	10	13	3	14	5
	16	14	3	13	11	15	5	12	11	13	10	12	1	12	7
	24	12	7	12	3	12	5	11	4	11	5	10	4	10	4
2x10	12	19	7	19	2	22	2	17	9	19	11	16	8	18	2
	16	17	11	17	6	19	5	16	3	17	5	15	3	15	10
	24	15	10	15	6	16	0	14	3	14	5	13	1	13	1
2x12	12	23	6	23	0	26	7	21	4	23	11	20	1	21	10
	16	21	7	21	1	23	7	19	7	21	0	18	5	19	1
	24	19	1	18	8	19	3	17	3	17	4	15	9	15	9
3x8	12	17	10	17	7	22	0	16	4	19	9	15	4	18	9
	16	16	3	16	1	19	4	14	11	17	4	14	1	15	10
	24	14	5	14	3	16	4	13	2	14	4	12	4	13	1
3x10	12	22	4	22	0	27	2	20	6	24	8	19	3	22	7
	16	20	6	20	3	24	0	18	10	21	9	17	8	19	1
	24	18	2	17	11	20	3	16	7	18	1	15	7	16	5

in Fig. 10. Another method which may be used successfully is to cut away a portion of the joist and frame it around the girder, as shown in Fig. 11. When flush ceilings are required underneath the joists, the ends of the joists may be supported by *joist hangers* or *iron stirrups,* as shown in Fig. 12. The method used for framing joists on girders depends upon the requirements for the ceiling below and the procedure necessary to equalize the shrinkage of the structural lumber used in the building.

Girders may be of solid wood as shown in Figs. 10 and 12, or be built up as illustrated in Fig. 11. Girders are built up by placing two

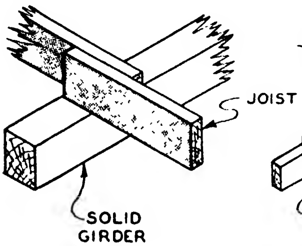


Fig. 10. Simple Method of Framing Joist on Girder

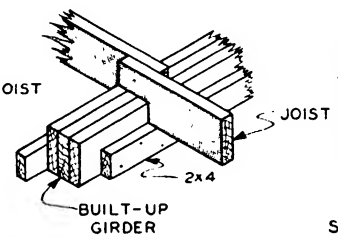


Fig. 11. Framing Joist around a Girder

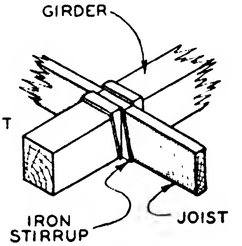


Fig. 12. Joist Supported by Iron Stirrup

or more joists side by side and fastening them together with nails or bolts. When consisting of several planks held together with ⅝-inch bolts, which are staggered and spaced 20 inches apart, built-up girders are as strong as solid-wood girders. Built-up girders also have the advantage of not warping as easily as solid-wood girders, and are less likely to contain decayed wood.

Since nails cannot be driven into steel, framing joists on steel beams presents problems slightly different from those involved in framing joists on wood girders. However, joists may be attached to steel beams with hangers or iron stirrups the same as to wood girders. The iron stirrups, either double or single, can be bolted to the steel beams, thus providing a bearing for the end of the joist. When this method is used, the joists should always be set with a clearance of not less than ⅜ of an inch above the top flange of the steel girder to allow for shrinkage of the lumber. If hangers or stirrups are not used and nailing is necessary, wood members must be bolted to the steel beam, either at the side as shown at (*A*), Fig. 13, or on top of the steel beam as shown at (*B*), Fig. 13. Resting the joist directly on the lower flange of the steel beam is not recommended, because the narrow, sloping surface of the frame of the beam does not provide sufficient bearing for the end of the joist.

When using the method illustrated at (*A*), Fig. 13, it is necessary to cut out the end of the joist so it will fit around the top of the **I** beam, as shown in the illustration. Care must be taken to allow at least 3/8-inch clearance over the top of the beam to prevent splitting of the joist when the lumber shrinks. After the joists are placed in

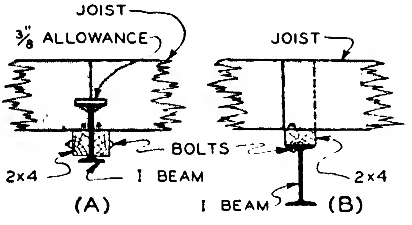


Fig. 13. (*A*) Wood Member Bolted to the Side of an **I** Beam; (*B*) Wood Member Bolted to Top of **I** Beam. Provision Must Be Made for a 3/8-Inch Clearance Over the Top of the Beam in the Case of (*A*)

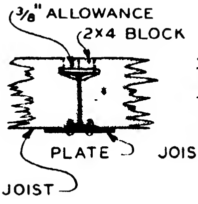


Fig. 14. Metal Plate Bolted or Welded to Bottom of **I** Beam

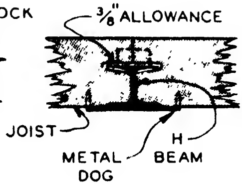


Fig. 15. Method of Framing Joists into **H** Beam with Joists Held in Position by Metal Dog

position, they should be toenailed to the wood member which is bolted to the steel beam. When joists are framed on steel beams, as illustrated at (*B*), Fig. 13, a wood member is bolted to the top of the beam, as shown in the illustration. The ends of the joists are lapped, thus providing each joist with a bearing equal to the width of the wood member.

When flush ceilings are required underneath the joists, metal plates can be bolted or welded to the bottom of the steel beam as shown in Fig. 14. Such a plate provides a wider resting place for the ends of the joists. Another method of framing joists on steel beams is illustrated in Fig. 15. In this case an **H** beam with a wide flange is used. The joists are framed into the **H** beam and the ends of the joists held together with a metal dog, or strap, as shown in the illustration.

Whenever a part of a joist extends over the top of a steel beam, an allowance, or clear space, of at least 3/8 of an inch for a 2x10 joist must be provided above the top flange of the beam for shrinkage.

This precaution will prevent splitting of the joint when the wood dries out and consequently shrinks.

Doubling Joists. In the framing of floor joists, it sometimes becomes necessary to cut away part of the joist; for example, in the construction of stairways, or when framing around chimneys and

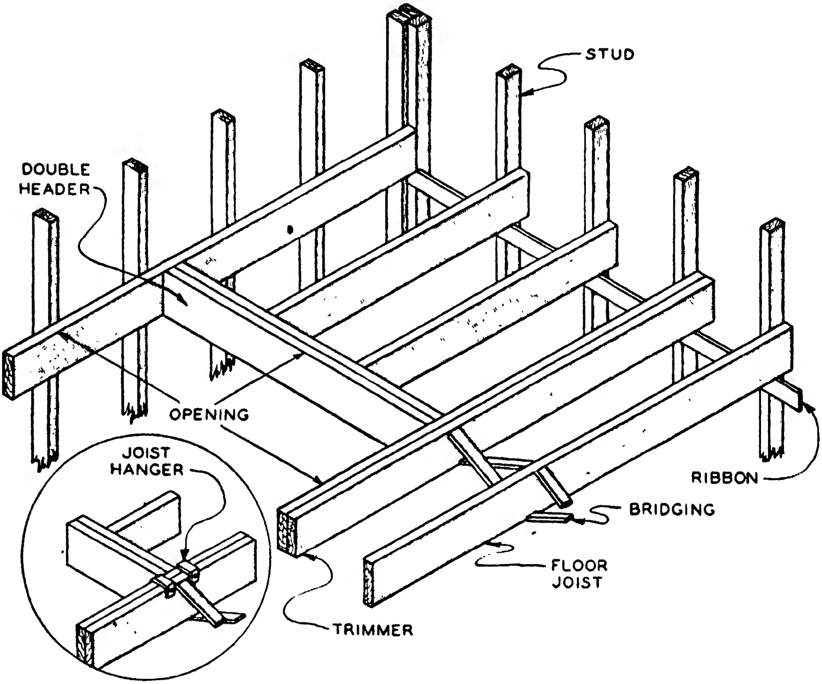


Fig. 16. Method of Framing around Openings by Use of Double Headers and Trimmers

fireplaces. When cutting a joist is necessary, the strength thus lost must be replaced or compensated for in some way. Whenever floor joists are cut and consequently weakened, they must be framed against headers, and the headers must be doubled, as shown in Fig. 16. These headers, in turn, are supported by double or triple joists called *trimmers.* The framework around openings is tied together again in this way, thus compensating for the strength which was lost through cutting of the joists. When it becomes necessary to use headers more than 6 feet in length, they should be fastened to their supporting joists by means of iron stirrups or joist hangers shown in detail in Fig. 16. It is not necessary to double the joists which are nailed to the wall studs.

Sometimes we see a building so constructed that the second story *overhangs* the first story; that is, the second story projects over the wall of the first story. If the projection is perpendicular to the second-

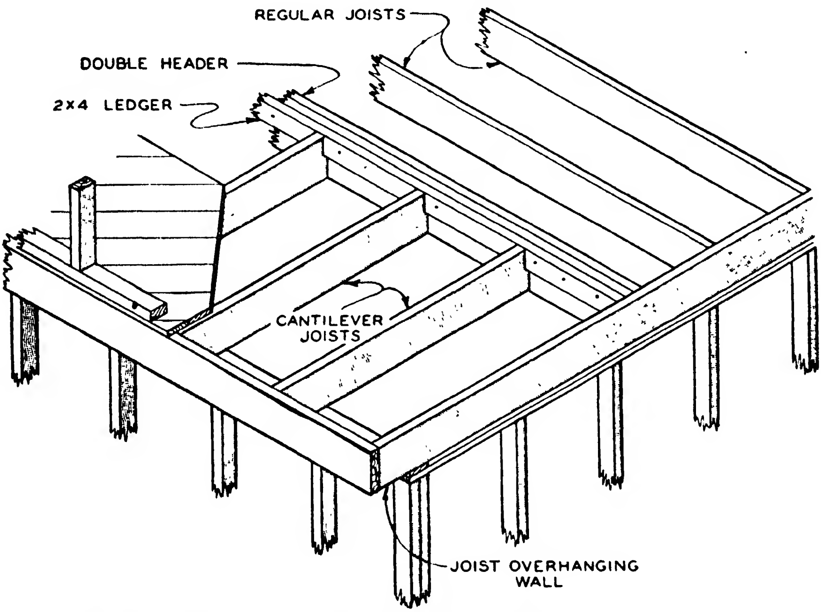


Fig. 17. Framing Second-Floor Overhang with Cantilever Short Joists

story joists, the framing for this type of structure is comparatively easy and is accomplished by merely using longer joists for the second story than those used in the first story. However, if the *overhang* is parallel with the second-story joists, then it becomes necessary to cantilever short joists as shown in Fig. 17. A similar situation is found in a bay window which has no supporting foundation underneath.

The rooms of an upper story are not always planned so that every partition will come directly above a partition of the story below. In such a case, if any partition of an upper story runs parallel with the floor joists, the joists supporting the partition must be doubled to carry the additional load placed upon them. Frequently, pipes or heating ducts must be run into such partitions. This makes it necessary to double the joists on each side of the partition to provide for the installing of pipes and heating ducts. The method of procedure for this type of framing is shown in Fig. 18. (See also Fig. 20.) When a partition runs crosswise on floor joists, alternate joists must be doubled. In some cases, it is necessary to double every joist in order to provide sufficient support for carrying the load, or weight, of the partition. This method of procedure is illustrated in Fig. 19.

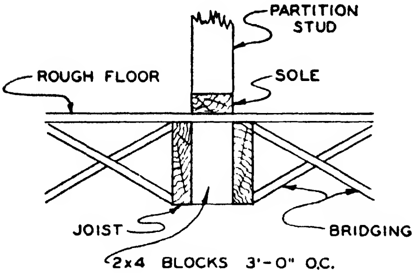


Fig. 18. Joists Framed for Supporting Partition, Cut for Pipes and Ducts

Rough Flooring. Lumber intended for rough flooring usually is square edged. The size of the boards commonly used, for this purpose, is 1x6, although sometimes 1x8 shiplap or 1x6 dressed-and-matched lumber is used. However, since dressed-and-matched material increases the cost of construction, the advantage of its use for rough flooring is questionable. Rough flooring may be laid either straight or diagonally. Laying the rough flooring diagonally permits laying of the finish flooring either parallel or crosswise on the floor joists. This is an advantage when furring strips are omitted between the rough and finish flooring. Laying the rough flooring diagonally is also an advantage when the floor joists are not all framed in the same direction; that is, the floor joists of one section of a building are laid at right angles to the floor joists of an adjoining section. Laying the rough flooring diagonally also stiffens the floor structure of a building. However, this is not so important in the case of the first floor where the joists are framed on sills bolted to the foundation walls. Unless the lumber used is end matched, the ends of the rough-flooring boards should be joined and nailed to a joist. It requires more time to lay rough flooring diagonally than to lay it straight. There is also more waste in cutting the boards for a diagonal floor than for a straight one. Diagonal flooring also tends to throw the floor joists out of alignment, and this makes the installing of cross bridging far more difficult.

Since straight flooring runs at right angles to the floor joists, it can be laid more quickly and with less waste of materials than diagonal flooring. Hence, when the work of other tradesmen, such as electricians and plumbers, makes it necessary to remove the rough flooring, straight flooring can be taken up and replaced more easily than diagonal flooring.

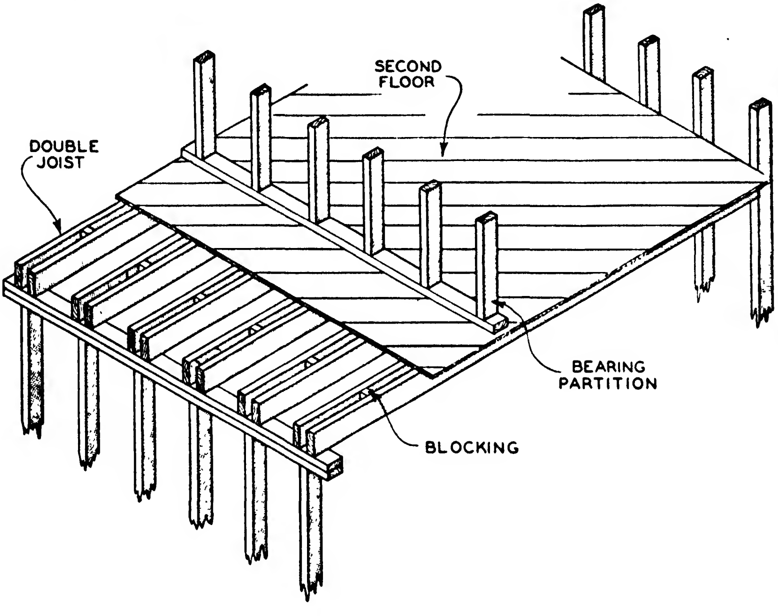


Fig. 19. Method of Supporting a Partition Running across Joists

Therefore, the question as to whether or not the laying of rough flooring diagonally has more advantages than disadvantages is a debatable one.

Caution. Regardless of whether or not the rough flooring is laid diagonally or straight, it should never be laid so that the ends of the boards will fit tightly against walls of either wood or masonry or steel beams. At least from ½- to ¾-inch space should be left between the flooring and the walls, to allow for expansion of the boards when they become wet. Expansion joints, with ½-inch space between boards, should also be provided at a distance of about every 6 feet. This precaution is necessary because all wood expands when wet; and during the process of construction the rough flooring will probably be wet, by rain or snow, several times before the building is completely inclosed. If the necessary provisions for expansion are not made, and the rough flooring expands, it will push the walls and beams out of alignment or cause them to buckle. The danger of expansion, as well as the problems of repair, is far greater in a diagonal floor than in a straight one. This is due to the fact that the diagonal distance between

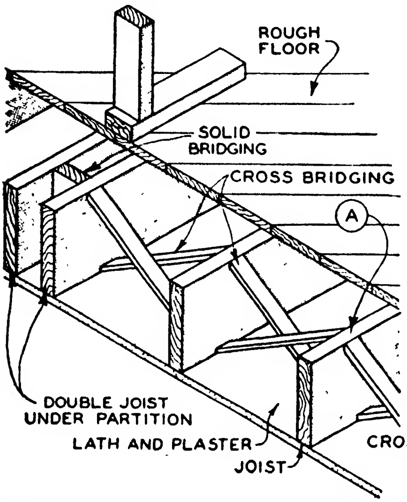


Fig. 20. Bridging Which Distributes Load at (*A*) to Other Joists

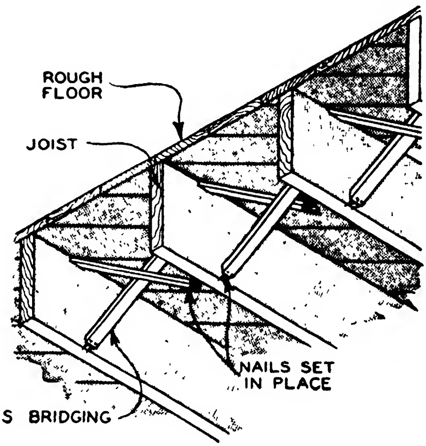


Fig. 21. Bridging Left Free at Bottom until Rough Floor Is Laid

the walls of a building is greater than the width of the span, consequently when repairing diagonal flooring it is necessary to remove more boards than when repairing straight flooring.

Bridging. The term *bridging* is used when referring to a system of bracing for floor joists. *Cross bridging* and *solid bridging*, two types of bridging commonly used, are illustrated in Fig. 20. The advantage of bridging lies in its effectiveness in helping to sustain and distribute a concentrated floor load, for example, a *piano*, over a larger area of floor space. Bridging also stiffens the joists and helps not only to hold them in alignment, but also helps to prevent warping. *Cross bridging* consists of transverse rows of small diagonal braces, or struts, set in pairs and crossing each other between joists, as shown in Fig. 20. *Solid bridging* consists of single pieces of boards, or blocks, set at right angles to the joists and fitted between them as shown in the illustration, Fig. 20. It is customary to insert rows of cross bridging from 5 to 8 feet apart. To be most effective, the rows of bridging should be in straight lines extending continuously the entire length of the floor. Exceptionally long joist spans should be bridged at distances of every 6 feet. Cross bridging, shown in Fig. 20, is superior to solid bridging, because when nailing the braces in place they are wedged tightly against the joists. Each bridging strut should be set in such a position that it will be directly opposite the corresponding strut of an adjacent pair, as shown in the illustration, Fig. 20. Cross bridging can be made of material size 1x3, 1x4, or 2x2. Some contractors prefer to use 2x4's for bridging.

When bridging struts are placed in position, they are first nailed to the joists only at the top, with the lower end of each piece left free until after the rough flooring has been nailed to the joists, as shown in Fig. 21. When the floor joists have adjusted themselves to the rough flooring, the lower end of each bridging strut is nailed in place. In order to speed up the bridging operation, after the material has been cut for the bridging but before nailing begins, two nails are set on each end of each piece.

The angle of cut and the length of the bridging braces may be obtained by making a full-size layout on a piece of joist or plank. The length of the piece used for the layout must be greater than the distance between the floor joists. For example, if the floor joists are to be spaced 16 inches on center, a piece of plank 3 or 4 feet long provides a suitable length for the layout. The width of the plank must be the same as the width of the joists to be used. First lay out the position of two adjacent floor joists and draw two diagonal lines representing the bridging brace, as shown in Fig. 22. Then lay a framing square in position along the line representing the inner edge of the floor joist, as shown in the illustration. Select a figure on the tongue of the square somewhere near the middle point, for example *6*, and place this figure directly over the line representing the upper edge of the bridging brace. On the body of the square, take the figure at the point where the square crosses the same diagonal line. Transfer these two figures to the top edge of a simple miter box made by nailing together a 2x6 and a 2x4, as shown in Fig. 23. Hold the square firmly in position at the correct figures and draw a line along the outer edge of the tongue. This gives you the correct angle of cut for the bridging braces. Make a saw cut on this line through the side of the miter box as a guide for cutting the braces. At a distance equal to the length of the diagonal, place a stop, as shown in the illustration, for cutting the bridging braces to the correct length.

Note: The cutting lines for the top and bottom of the bridging braces must be parallel. After the first brace is cut, it should be fitted into position to make sure you have the dimensions correct and

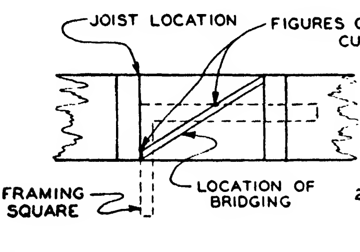


Fig. 22. Method of Finding Angle Cut and Length of Bridging by Layout on Piece of Joist

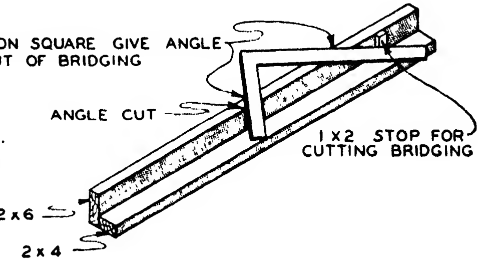


Fig. 23. Transferring Figures from Framing Square to Miter Box to Find Angle Cut for Bridging

the angle of cut the exact size. It is advisable to fit all braces into position soon after they are cut, as the distance between the joists may vary slightly and material may be wasted if too many braces are cut at one time. When finding the angle of cut for bridging braces, you must use the dimensions which fit your particular job. The foregoing example is given merely to explain one workable method of finding the angle of cut and the length of bridging braces.

Some carpenters prefer finding the required length of bridging braces by holding a strip of wood in place between the joists and cutting the braces while in this position. This procedure is not recommended when the spacing between the joists is to be uniform, since the joists can be brought into alignment and held in place more easily when all the bridging braces are of the same length. However, when the spacing between the joists is not uniform, cutting the bridging braces while holding them in position is a simple and practical method to use.

Regardless of the method used, it requires a considerable amount of time to cut bridging braces, in addition to the time required for fitting and nailing them in place. Therefore, with a view to reducing this labor cost, a new type of bridging made of steel has been placed on the market. This bridging can be installed in a fraction of the time required for installing wood braces. Steel bridging comes in various sizes designed to meet the needs of the average builder.

Corner Construction. The corners of the wall construction may be of either a solid or built-up type. In present-day construction, wall

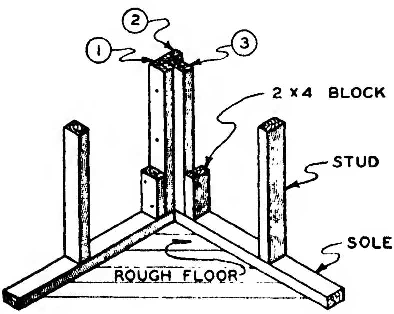


Fig. 24. Assembly of Three Studs for Outside Corner

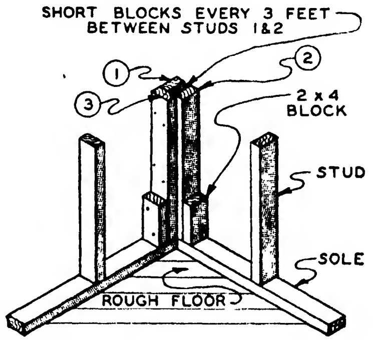


Fig. 25. Assembly of Three Studs for Outside Corner, Using Blocks

corners are usually of the built-up type. The studs for this kind of construction can be assembled in several different ways. The method used depends upon the requirements for the application of wall sheathing and outside finish, as well as for the application of lath and plaster or other interior finish. All built-up corners should be constructed so as to allow for a maximum of air circulation. The solid type of corner construction is more liable to deteriorate from decay than the built-up corner.

The stud for all corners should be of the best straight stock available, carefully selected and nailed together firmly. The type of corner requiring the least amount of material and also taking the least amount of time to construct is shown in Fig. 24. After the material has been cut to the correct length for three studs, stud (*1*) is nailed to stud (*2*). Then stud (*3*) is nailed in place. If the corner construction is for a two-story building of a balloon type of frame with a ribbon, the housing for the ribbon should be laid out and cut on stud (*1*) before the corner studs are assembled.

Another type of built-up corner assembly shown in Fig. 25 requires the nailing of 2x4 blocks to stud (*1*). These blocks should be spaced at regular intervals of about 3 or 4 feet apart. In this type of assembly, stud (*2*) is nailed to the blocks. Special attention must be given to

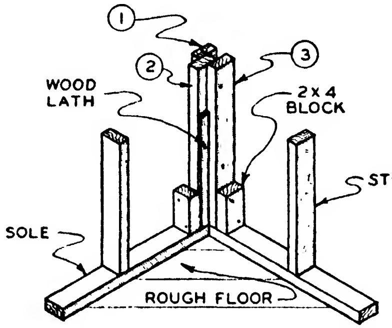


Fig. 26. Assembly of Three Studs for Outside Corner, Allowing for Material of Full-Wall Thickness

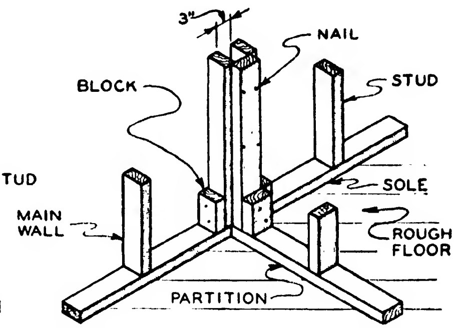


Fig. 27. Assembly of Three Studs at Corner Where Partition Meets Main Wall

nailing of the blocks and studs so the corner will remain square. Stud (*3*) must be nailed to both stud (*1*) and stud (*2*).

Still another method of assembly for built-up corners is shown in Fig. 26. This method requires the nailing of a piece of ⅜-inch stock such as wood lath on stud (*2*), to build the stud out to full-wall thickness. In this kind of construction the studs are assembled in the order indicated by the numbers. The 2x4 blocks at the bottom of each side of every corner assembly provide solid nailing anchorage for the baseboards of the interior trim.

Partition Corners. When constructing partition corners, provision must be made for nailing base for the interior trim. The carpenter must also provide for the tying of the walls together firmly. Solid anchorage is essential where two walls meet. This is a construction detail that cannot be stressed too strongly, as careless treatment at these corners may cause unsightly plaster cracks. Also, improper or careless framing of partition corners may allow infiltration of cold air or permit the loss of heat by the escape of warm air. One method of framing partition corners is by the use of three studs tied together with spikes, as shown in Fig. 27. Another method illustrated in Fig. 28 allows the studs in the main wall to follow their regular spacing of 16 inches on center (O.C.) with the corner stud of an adjoining partition wall placed between two main-wall studs. As shown in the illustration, the corner stud of the partition is backed with a 1x6 or 1x8 to provide a nailing base for lath. The partition stud is tied to the main wall with 2x4 cross blocks, spaced at intervals of every 2 feet and spiked to all three studs. A crosspiece of 2x10 material at the bottom insures solid nailing anchorage for the baseboards of the interior trim.

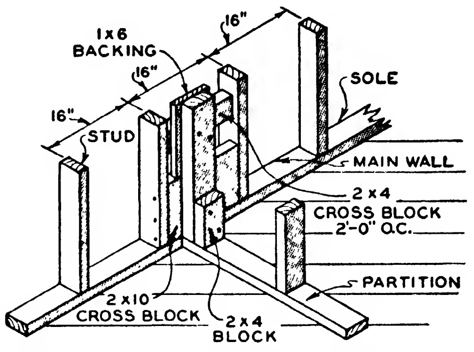


Fig. 28. Partition Corner Assembly with Studs of Main Wall Uniformly Spaced

Wall Plates. Continuous pieces of timber placed on top of a wall as supports for posts, joists, and other similar structural members are called *wall plates.* The primary purpose of wall plates is threefold; (1) They tie the studding together at the top and insure stud alignment; (2) they provide support for the structural members above the plates, for example, attic joists; and (3) they provide a base for the roof rafters which tie the roof and walls of a building together. To meet satisfactorily all requirements of the purpose for which they are intended, wall plates should be doubled at the top of walls and partitions. For walls which have the same plate height, the outside corners and partitions should be tied together by lapping the plates as illustrated in Fig. 29. In the balloon frame the partitions on the second-floor level are tied to the outside walls with 2x6 cross blocks fitted between the studs, then nailed to both the studs and the partition plate, as shown in Fig. 30.

Framing Top of Partition Walls. Proper framing of the top of partitions and tying them firmly to the ceiling with suitable backing is just as important as providing solid anchorage for wall corners. Where partitions run across the joists, at right angles to them, each joist is toenailed to the wall plates, as shown in Fig. 31. When parti-

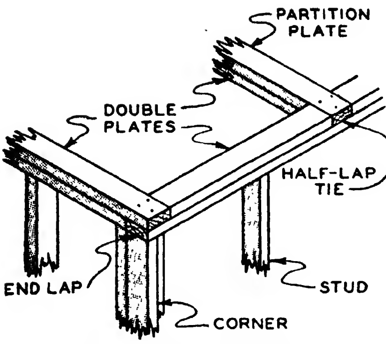


Fig. 29. Corner Plates Lapped to Tie Corners and Partition Plates Together

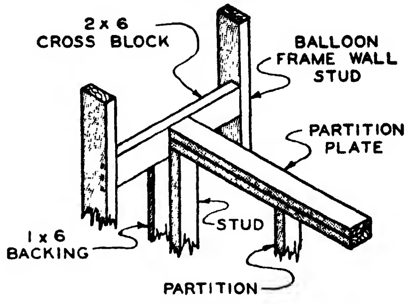


Fig. 30. Partition Plate Tied to Balloon-Frame Wall with Studs

tions run parallel with the joist and come between two adjacent joists, as shown in Fig. 32, the top wall plates are backed with 1-inch material to provide a nailing base for interior-ceiling finish. The walls are anchored to the joists with 2x4 cross blocks at intervals of every 3 feet, Fig. 32. When the partitions are parallel with the joist and the partition studs are continuous, or the second-floor studs extend down to the wall plates of the first-floor partition, a joist is nailed to both sides of the studs, as shown in Fig. 33.

Framing Rough Openings for Windows and Doors. Any one of several methods may be used for framing openings into stud walls. One method is to erect, first, all the studs, spacing them at regular intervals, usually 16 inches on center (O.C.), before laying out and cutting any openings. Another method is to lay out the openings on

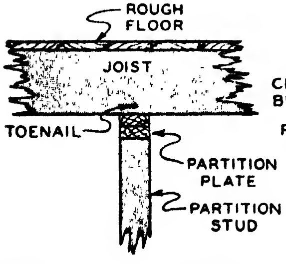


Fig. 31. Top of Partition Fastened to Joist by Toenailing

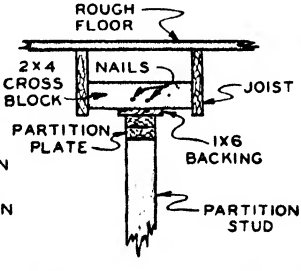


Fig. 32. Top of Partition Fastened to Joist Parallel to Partition

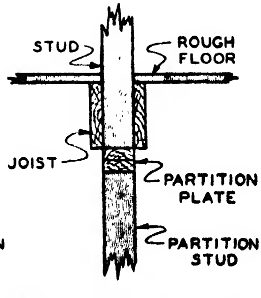


Fig. 33. Partition Parallel to Joists Spread for Pipes and Ducts

the sole of the wall in addition to the regular stud spacing, then erect only those full-length studs which come outside of the openings. Framing of the openings can be completed later. A third method is to frame the wall completely, including all openings, on the floor or ground. When the framing is completed, then the entire wall, or one section of it, is raised into position. This method is commonly used for nonbearing partitions and frequently for outside walls for platform framing. Any one of these methods will be found satisfactory. However, errors are less likely to occur when using the first method given here, since it is easier to visualize the location and the size of openings on a framed wall when it is up and in position.

Size of Rough Openings for Doors. The size of the rough opening for a door can be found approximately by adding together the various thicknesses of materials and the allowances for wedges which must be taken into account besides the actual size of the door itself, Fig. 34. The jambs, or door frames, for inside doors in a partition usually are made of stock ¾ of an inch in thickness. The head jamb is housed, or gained, into the side jamb, leaving a short lug at the top (see chapter on interior trim, Fig. 41). Jambs, or frames, for outside doors are made of 1¾-inch stock which is rabbeted to receive the door. Such frames usually have a sloping wood sill. Since lumber sizes may vary slightly, there may be a slight variation when determining the sizes for rough openings for doors, because of the various structural materials which must be considered.

Size of Rough Openings for Double-Hung Windows. To find the sizes of rough openings for double-hung windows, use the same method as for finding size of rough openings for doors; that is, by adding together the sizes of all materials used and the allowances, Fig. 35. The size of sash is not given for windows. Only the glass size is shown, as $\frac{20}{24}$, which means that each pane of glass is 20 inches wide and 24 inches high. If the sash is divided by muntin bars ¼ inch must be added for each bar. Casement sash (sometimes referred to as *French windows*) has no pulley pockets. The jambs, or frames, are made like the frames for outside doors with the jamb rabbeted. Therefore, the width of these window openings is less.

Before laying out the size of any opening, it is always advisable, first, to consult the drawings, details, and specifications to determine

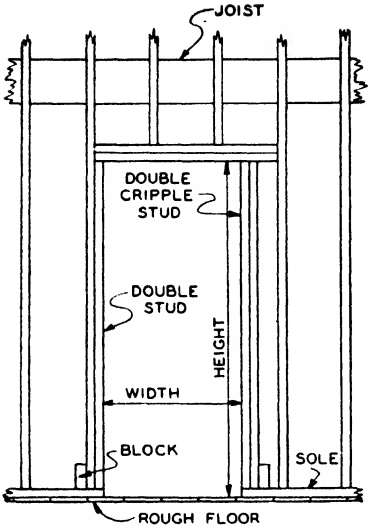


Fig. 34. Method of Figuring Rough-Opening Size for Partition Door

HEIGHT FOR ROUGH OPENING FOR DOORS

1" Side jamb lugs at the top
¾" Thickness of head jamb
Height of finished door
⅝" At bottom for door clearance or threshold
¾" Finish floor
1⅛" Furring strip if electric conduit is used on top of rough floor

WIDTH OF ROUGH OPENING FOR DOORS

½" Allowance for wedges on right side
¾" Thickness of jambs on right side
Width of finished door
¾" Thickness of jamb on left side
½" Allowance for wedges on left side

HEIGHT FOR ROUGH OPENING FOR WINDOWS

1" Side jamb lugs
¾" Head jamb
2" Top sash rail
Glass height top sash
1" Check rail
Glass height bottom sash
3" Bottom sash rail
2" Window sill
¾" Allowance for sill bevel

WIDTH OF ROUGH OPENING FOR WINDOWS

2¼" Pulley pocket
¾" Side jamb
2" Sash stile
Width of glass
2" Sash stile
¾" Side jamb
2¼" Pulley pocket

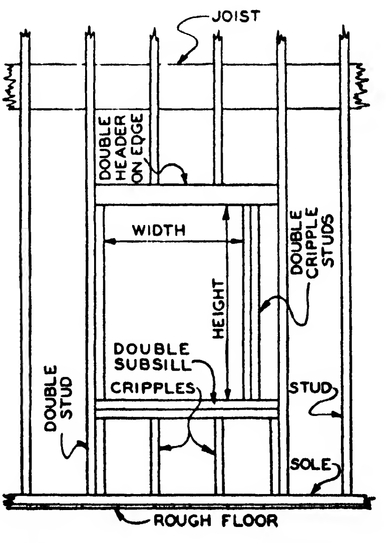


Fig. 35. Figuring Rough-Opening Size for Double-Hung Window with Sash Weight

the type, as well as the size of the frame for each opening. Openings should be framed so that the cripple studs on the sides will carry the header load. The doubling of these cripples also provides a nailing base for the interior trim. Where the side cripples come near the middle of stud spacings, a double stool for windows is required.

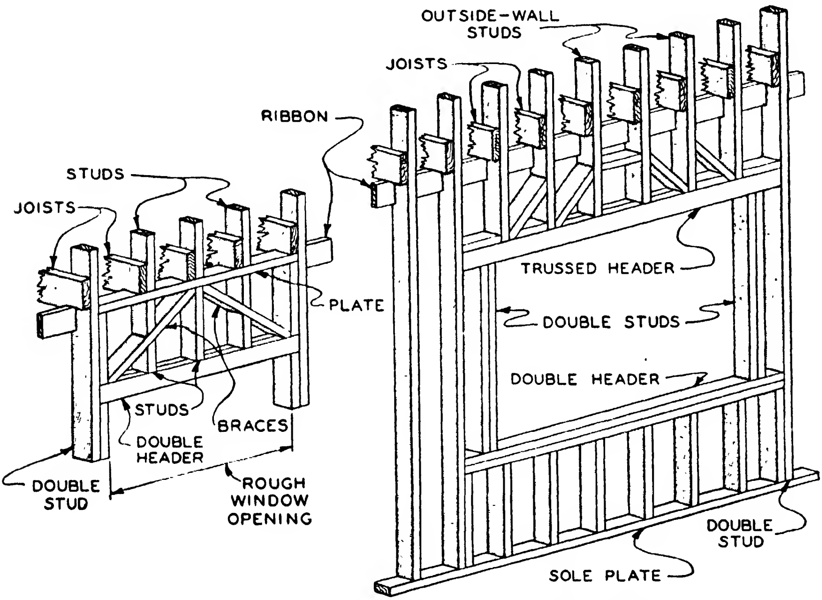


Fig. 36. Trussed Wall Opening Where Concentrated Load Must Be Carried

Header sizes and construction depend upon the load to be supported. On nonbearing partition walls, a double header laid flat is strong enough to carry the load. Where an ordinary joist load rests on the header, the header should be placed on edge. The Federal Housing Administration recommends the following header sizes for openings:

Spans up to 4 feet in length, two 2x4's.
Spans 4 feet to 5½ feet in length, two 2x6's.
Spans from 5½ to 7 feet, two 2x8's.
Spans more than 7 feet in length, two 2x10's.

Wide openings, or openings with a concentrated load above, such as a bath tub full of water, should be trussed (see Fig. 36). The *rule of thumb* (any crude process) should never be the guide for headers which have special loads to carry. All such loads should be carefully figured by a competent architect or engineer, and the proper header designed for the loads to be supported.

Wall Sheathing. After completing the framework of a new building, a covering known as *sheathing* is fastened to the frame, usually with nails. In addition to serving the purpose of covering for the frame, sheathing also furnishes a base for exterior trim, such as siding and veneer—stone or brick. The sheathing also helps to stiffen a building, making the walls more resistant to wind pressure, as well as providing insulation against extreme weather conditions, either hot or cold.

Before the beginning of the present century, the material commonly used for sheathing was wide, rough, square-edged boards one-inch thick. However, this type of sheathing was not satisfactory because the use of undressed lumber left open joints and wide cracks between the boards. In an attempt to overcome these defects, builders began to use dressed-and-matched boards, with rabbeted edges, called *shiplap*. Tongue-and-groove material was also sometimes used for sheathing. But neither of these methods proved to be entirely satisfactory, since the use of any kind of dressed lumber for sheathing increases the cost of construction considerably. Hence, there was a constantly growing demand for a less expensive type of sheathing material. This demand was met when a process of manufacturing insulation boards was discovered.

About 1914 a manufactured, rigid-fiber insulation board appeared on the market. This product, known as *Universal Insulite*, was developed at International Falls, Minnesota. These boards were made of wood pulp. The regulation size of this new structural material was 4 feet in width, from 8 to 12 feet in length, and about $7/16$ of an inch in thickness. The first use made of these large-sized boards was for insulation, but today this type of manufactured board is playing a prominent role in the construction industry. Not only are insulation boards used for structural sheathing but they are extensively used for a plaster base, interior decorative wall finish, and for many other structural purposes. A comparatively recent use of these boards is for lining of concrete forms. Contractors and builders have learned that the slightly absorbent surface of the rigid building board will remove the excess air in the concrete at the surface of the form and insure a good smooth finish.

Since 1914 many methods of manufacturing insulation board have been developed. It is now made not only from wood pulp but also from numerous other products, such as sugar cane (bagasse), corn stalks, and licorice roots. Structural insulation board is also made today by many different manufacturers. It is sold on the market under more than 50 different trade names, including *Celotex, Fir-Tex, Flintkote, Masonite, Maizewood, Nu-Wood, Weatherwood,* and many others.[2]

The process of manufacturing structural insulation board varies somewhat with the different manufacturers. However, the first step, that of reducing the raw material to pulp, is much the same regardless of the differences in the processes used by different producers in following steps. This first step is accomplished either by steaming, with or without chemicals, and grinding, or merely by grinding. The pulp mass then is washed, waterproofed or otherwise treated, and afterward formed into large cohesive sheets of various thicknesses by a process known as *felting.* The process of felting may be accomplished either by the use of large wire screens or by means of suction on huge drums. After the water is removed and the board dried and pressed, it is cut and trimmed to finished sizes.

About 20 per cent of the manufactured fiber insulation board is used today as structural board, mainly as sheathing for walls and roofs, Fig. 37. For sheathing, the board is made in a convenient size 2 feet wide by 8 feet long and $^{25}/_{32}$ of an inch in thickness. It is waterproofed either by surface or integral treatment with asphalt, or by means of paper covering. It can also be obtained in 4-foot widths and in different lengths. The long edges of this sheathing are fabricated (tongue-and-groove or otherwise matched) to insure a tight joint, while the ends which are nailed to studs are square edge.

The large units in which insulation board is made and its tensile strength provide a structure with exceptional rigidity. According to tests made at the United States Forest Products Laboratory, Madison, Wisconsin, walls sheathed with units of insulating board 4 feet wide

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[2]For a more complete list, see Paul D. Close, *Building Insulation* (Chicago: American Technical Society, 1946).

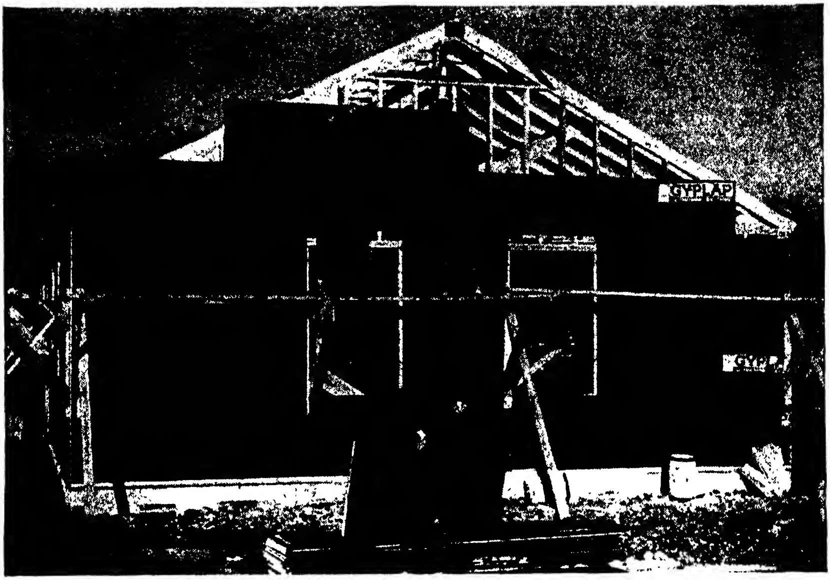


Fig. 37. Application of Structural Fiber-Board Sheathing
Courtesy of Rob Manning Photos, Louisville, Ky.

and $^{25}/_{32}$ of an inch thick have a rigidity factor of 3.0 compared to a factor of 1.0 for a wall sheathed with lumber applied horizontally. However, the fiber board does not provide solid anchorage for nails. Any exterior finish placed over such sheathing must be nailed to the studs of the frame or be nailed to furring strips provided for the purpose.

The use of another type of wall sheathing called *plywood* is steadily gaining in favor with contractors and builders, especially in prefabrication units; that is, wall sections built in a factory and assembled on the job. Plywood has greater rigidity than horizontal sheathing or structural fiber board. Plywood also provides solid anchorage for nails.

Wood sheathing is still used extensively for covering the framework of buildings. The method of applying wood sheathing and the number of nails used in each board will greatly affect the rigidity and strength of the structure. Careful consideration must be given to diagonal corner braces as well as to the condition of the lumber,

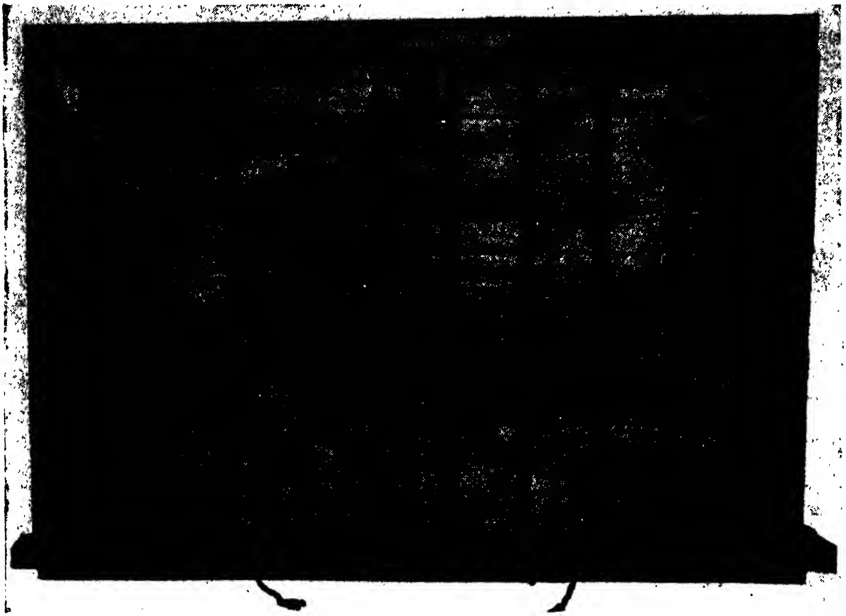


Fig. 38. Wall Panel Sheathed Horizontally with Diagonal Strips Let in the Studs

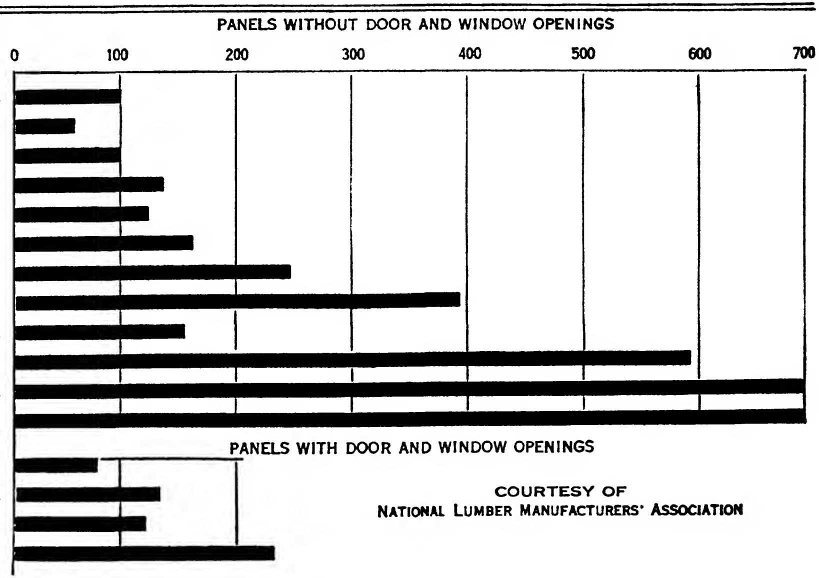
whether seasoned or green, when construction begins. Other important factors which must also be considered when determining the amount and kind of bracing required to insure the desired rigidity of a building are: (1) the design of the building; (2) its height; (3) the number and size of the wall openings (windows and doors); (4) the kind of roof; and (5) the number of cross walls. Emphasizing the importance of the foregoing factors, the following statement appears in Bulletin R1151, published by the United States Forest Products Laboratory, Madison, Wisconsin:

A two-story house 16 feet wide and 24 feet long with a gable roof and no cross walls would require the equivalent of well-nailed diagonal sheathing or the very best type of let-in bracing to give satisfactory rigidity and strength. On the other hand, a one-story house 24 feet square, with a hip roof, one cross wall, two doors and two windows, horizontal sheathing, and no bracing would be fully as storm resistant as the above mentioned two-story house with the best type of bracing.

A series of tests were made at the Forest Products Laboratory in conjunction with the National Lumber Manufacturers' Association to

Table III. Rigidity of Lumber Construction

Panel Construction			
Nails	**Sheathing**	**Lumber**	**Bracing**
2	Horizontal	Seasoned	None
2	Horizontal	Green*	None
3	Horizontal	Seasoned	None
4	Horizontal	Seasoned	None
2	Horizontal	Seasoned	Herringbone bridging
2	Horizontal	Seasoned	2x4 cut in braces
2	Horizontal	Seasoned	1x4 let in braces
2	Diagonal	Seasoned	None
2	Diagonal	Green*	None
3	Diagonal	Seasoned	None
4	Diagonal	Seasoned	None
	No sheathing—wood, lath, and plaster		
2	Horizontal	Seasoned	None
2	Horizontal	Seasoned	1x4 let in braces
2	Diagonal	Seasoned	None
	No sheathing—wood, lath, and plaster		



*Panel allowed to stand 30 days

*The information given in this table is based on a two-nail panel horizontally sheathed with one-inch seasoned lumber taken as 100 per cent. The tests were made on framed panels 9x14 feet, at the Forest Products Laboratory, Madison, Wisconsin.

determine the strength and rigidity values of these different methods. Table III gives the results of these tests. The table shows that one-inch thick, seasoned, horizontal sheathing fastened to each stud, with two nails to a board, was taken as 100 per cent. However, three nails to a board does not increase the rigidity for horizontal sheathing. Four nails will increase the strength to 135 per cent. If a 1x4 brace is let into the studs, as shown in Fig. 38, the rigidity is

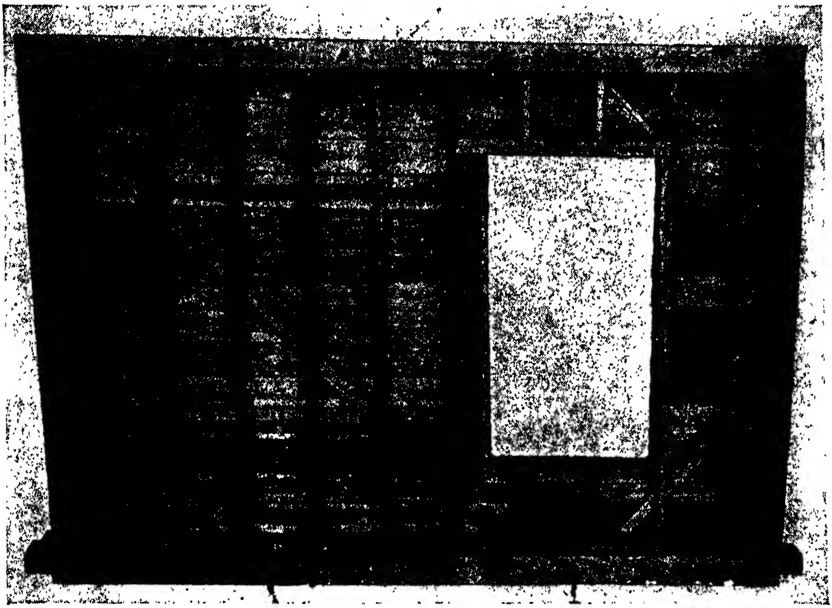


Fig. 39. Panel Sheathed Horizontally around Window Opening, Strengthened by Knee Braces and Diagonal Let-in Brace

increased to 350 per cent. The practice of using a 1x4 brace is acceptable for meeting the usual strength requirements in most communities. A modification of diagonal let-in braces, shown in Fig. 39, may be necessary to accommodate openings in the wall and still retain adequate rigidity.

The 2x4 set-in brace shown in Fig. 40, even though heavier materials are used, is not as rigid as the 1x4 let-in brace, probably because of the shrinkage of cross-section materials. When sheathing is nailed diagonally, as shown in Fig. 41, the strength of the wall is increased to 700 per cent. This added strength may be required under exceptional conditions such as those found in areas where storms of unusual severity occur frequently.

Plaster Grounds. Before lath is applied, strips of wood called *grounds* are nailed to the inside walls of buildings to serve as guides for the plasterer. Grounds insure a straight and true plaster surface against which the finished woodwork is nailed. In most cases the

Fig. 40. Panel Sheathed Horizontally, Strengthened by Diagonal Braces Cut into Studs

grounds should be placed so they will come near the edge of trim members where such members meet the plaster.

The need for grounds varies greatly. Likewise, the size and methods of application of grounds also vary. Such variations depend upon the kind of interior trim used, including door jambs, baseboards, chair rails, wood cornice against the ceiling, special picture moldings, wainscoting, and the plaster thickness.

The thickness required for the grounds is determined by the combined thickness of the lath and plaster, which in common practice is $^{25}/_{32}$ of an inch. However, this thickness has been increased to $7/8$ of an inch in certain areas. The width of the grounds usually is 1 inch or 2 inches. Roughly speaking, grounds are made of 1x1 or 1x2 lumber. Around inside door openings a 1x1 may be used. The strength of a 1x1 is sufficient here, because it has a solid backing. Where grounds are run across studs, as for base and wainscoting, 1x2's are commonly used. Occasionally even wider materials may be required to meet the needs of a particular situation. Window frames and outside

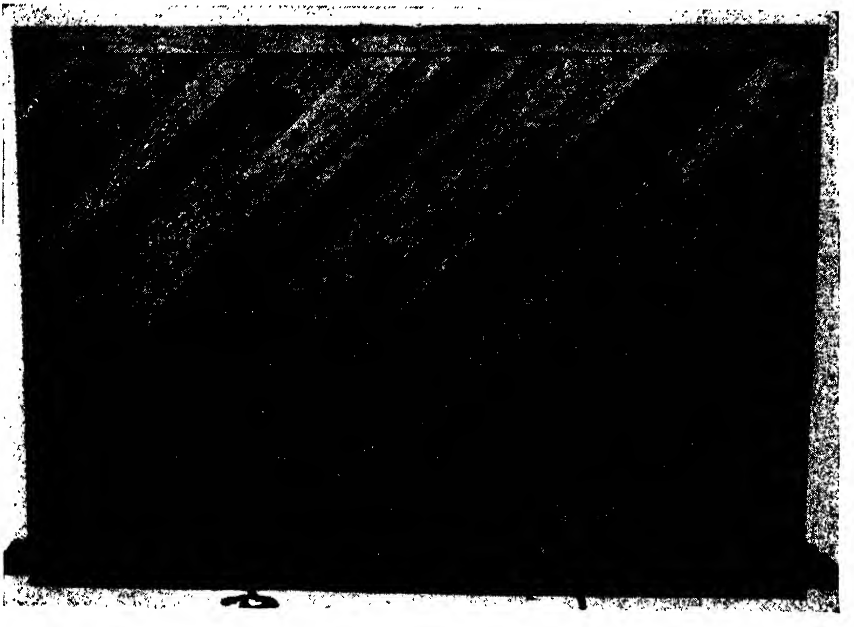


Fig. 41. Panel Sheathed Diagonally on Ordinary Stud and Plate Wall

rabbeted door frames are usually made wide enough to meet the lath and plaster requirements. Therefore, no grounds are necessary for such openings.

The last of the rough interior work to be done is the placing of the grounds which usually are nailed on after the roof is finished, and all other tradesmen have completed their work. The location for the grounds must be determined carefully so they will be covered by the wood trim. This is especially important because of the work which must be done later, such as adding dadoes, wainscoting, chair rails, and baseboards. For the inside doors, the grounds are nailed against the studs next to the opening side, as shown in Fig. 42. For the base the best practice is to use a 1x2, nailed so that the bottom of the ground is on a level with the top of the finished floor. Some carpenters prefer nailing the ground near the top of the base or setting a double ground, but since plasterers rarely will fill in below or between such grounds, there would be no solid setting for the base; therefore this procedure is not recommended.

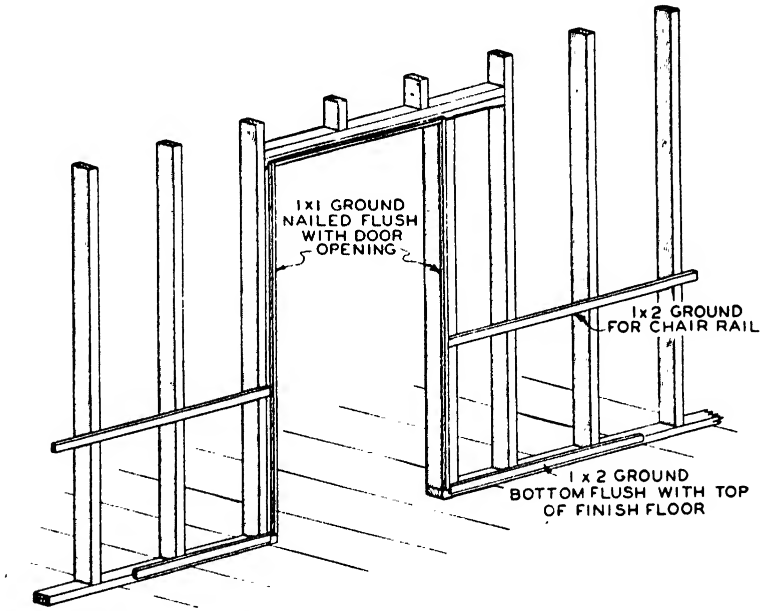


Fig. 42. Method of Framing Plaster Grounds to Give Them Value

Since the purpose of plaster grounds is to provide a straightedge as a guide for the plasterer to follow, it is essential that the carpenter exercise special care in placing the grounds, using a straightedge and sometimes even a level, so the position of the grounds will be absolutely correct and true. Any extra time consumed in setting the grounds accurately will be compensated for later when nailing on the trim. It will take much less time and patience to fit the trim to the plaster if the grounds are in the right place.

Grounds play an important role in masonry construction. Here they not only serve as a straightedge and guide for the plasterer to follow, but also provide a firm base on which trim members are nailed or otherwise fastened. Grounds are not required on wood-frame construction when walls are finished with materials other than plaster, such as plywood or decorative fiber board, or where Sheetrock forms the finished wall surface.

SPECIAL FRAMING PROBLEMS

The building of a modern frame house involves the labor of many tradesmen besides carpenters. These tradesmen include plumbers, steam fitters, sheet-metal workers, electricians, tile setters, brick and stone masons, and others. The contractor for each trade is responsible only for his own work, but all tradesmen must co-operate in every respect, since all of them share in the responsibility of giving the owner the best house possible. With the proper co-operation on the part of all tradesmen, the completed house will conform to the specifications and agreements signed by the owner and contractors for the various trades represented.

The carpenter is looked upon as the key man in the construction of buildings with wooden frames, since he provides the framework of the building into which other tradesmen must fit their work. The carpenter, then, must have a fair working knowledge of the requirements of all other trades concerned with the erection of a modern frame house. He must also have a fair working knowledge of the materials used by other trades, so he can properly frame the building to accommodate the work of all tradesmen involved in the construction process. The building must retain its structural strength and be free from hazards common to frame buildings after the tradesmen who install the pipes, heat ducts, electric fixtures, and other special features have completed their work.

Fire Hazards. Many a fire has started in the basement of a family residence and spread to the attic and roof before the occupants were aware of their danger. Such a predicament may be due to the neglect of the carpenter who failed to cut off drafts with fire stops at joist levels in the walls, as shown in Figs. 1 and 2 of this chapter. A fire may also result from the failure of the builder who neglected to pack incombustible materials around pipes or heat ducts in walls which connect with the basement. If left open at top and bottom, the stud spaces in a frame wall are similar to the flues of so many chimneys. Such open spaces tend to create drafts in the walls, and may become definite fire hazards.

The carpenter must know the size to which any brickwork will lay-up, in order to frame around chimneys and fireplaces so that a 2-inch free space will be left between the framework and the masonry, as shown in Fig. 43. This 2-inch space must be packed with incombustible material as cracks are apt to develop in such masonry work,

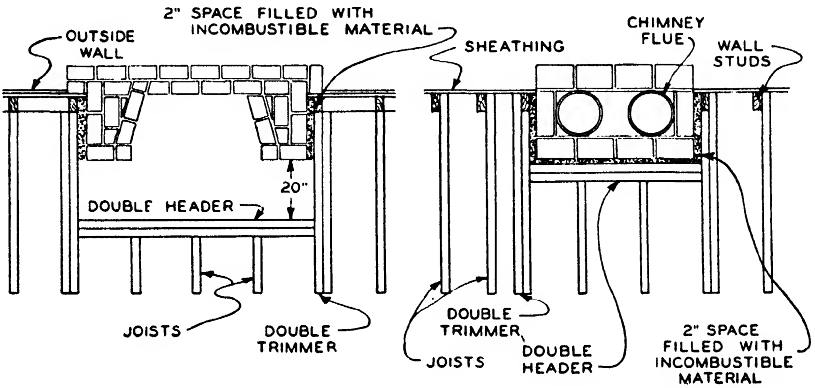


Fig. 43. Wood Framing around Masonry of Chimney with Two-Inch Space Filled with Incombustible Material

due to settling or because of faulty construction. Any combustible materials left near such cracks also constitute potential fire hazards.

Plumbing Pipes. The proper framing of walls for installing plumbing pipes and making provision for heating ducts installed by sheet-metal workers present the carpenter with two of his most difficult framing problems. The installing of pipes and heating ducts often require an unobstructed wall space extending from the basement to the second floor, and frequently even to the attic.

The soil stack, with a hub that measures about 6¼ inches, requires a wall with studs larger than 2x4 and free of plates or girts, as shown in Fig. 44. In making provision for soil stacks, the wall must be designed so that any necessary cutting of the studs will not weaken the structure. Here 2x6 studs with a 1x2 added, or a 2x8 stud, will be necessary. Then, too, in bathrooms or lavatories, the walls against which plumbing fixtures are set or fastened should have studs of no less than 2x6 in order to leave sufficient strength in the studs after the plumber has installed the 2-inch pipes for reventing the traps on the fixtures. If the toilet is placed against the stack wall, the minimum joist clearance from the stack wall must be 16 inches.

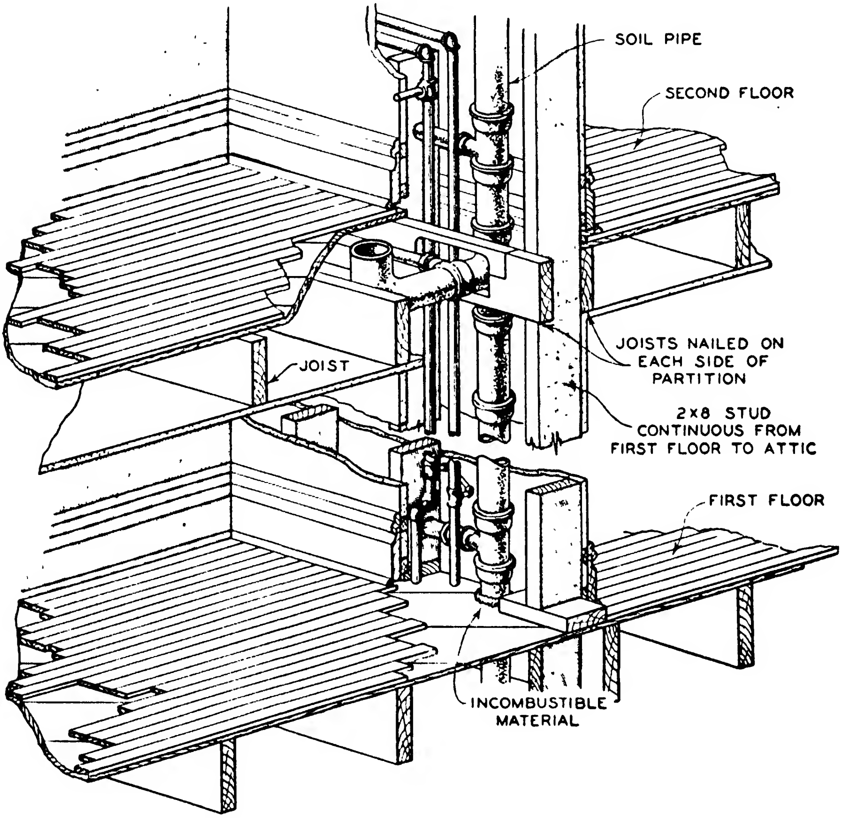


Fig. 44. Walls and Floors Framed to Accommodate Plumbing Pipes by Means of a Continuous 2x8 Stud from First Floor to Attic

If the toilet is away from the stack wall the joist must be fitted with headers, or trimmers, which will not require cutting when installing the soil pipes.

The rough flooring in both the toilet and bathrooms should also be cut at the wall line and nailed lightly so that it can easily be taken up and relaid by the plumber.

Heating Ducts. In most instances the carpenter will be called upon to provide openings in the floors and walls for heating ducts. Therefore, he should demand a heating-duct layout showing the size and location of registers, ducts, and other equipment before he begins the framework. The layout will enable him to provide for such work as he proceeds with the framing of the house. Here again a little foresight is better than hindsight.

Where heat stacks run continuously from one floor to the next, it becomes necessary to line up the studs of the walls for the two floors so as to accommodate the pipes. In the basement ample space must be left between the floor under partition walls and the beams or

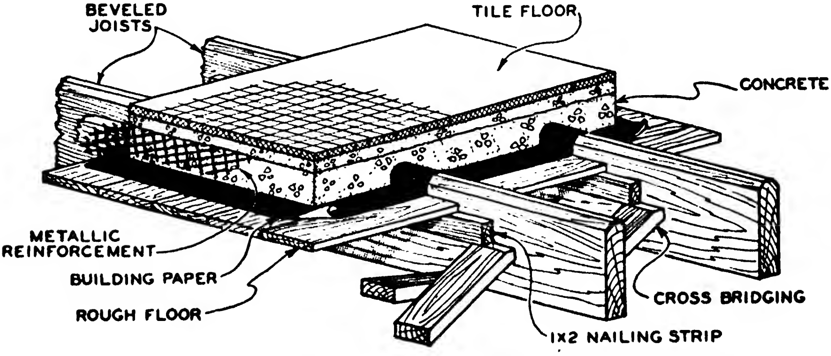


Fig. 45. Rough Floor Dropped to Provide Concrete Base for Tile Floors

girders. This is especially important, since there must be room enough so pipe connections can be made with wall stacks. When registers in the walls fail to come within stud spaces, the studs must be cut and headers and cripple studs nailed in position. In many cases heat stacks in walls are brought up to the next floor level, where they are run horizontally to a new position in a second-story partition wall; in such cases the floor joist must line up with the wall studs. The foregoing instances are just a few examples showing how the carpenter can save himself a great deal of work and time later by planning the framework of a house so as to accommodate the heating ducts.

Tile Floors. Bathrooms, lavatories, and frequently even hallways have tile floors which require a concrete base. To provide room for this base the rough floor must be dropped between the floor joists and nailed to 1x2 strips secured to the joists, as shown in Fig. 45.

Elliptical and Circular Arches. Plastered arches must have a rough frame, of the exact shape of the finished opening, to which the lath and corner bead can be fastened by the lathers. Since it is not economical to cut the top of this rough frame out of one wide piece of lumber, it is usually made of four pieces of lumber either one inch or two inches thick. These four pieces are then nailed flush with the side of the header and the studs of the opening, as shown in Fig. 46. The

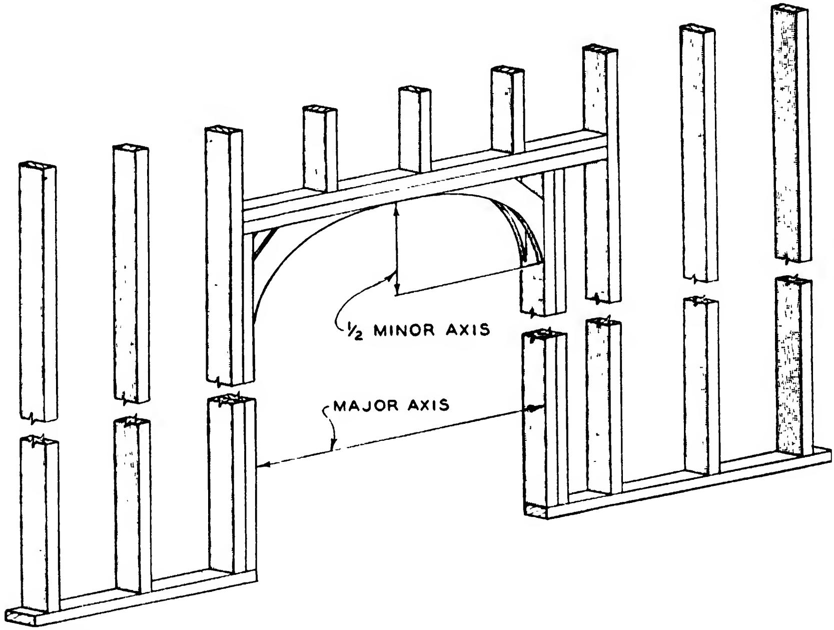


Fig. 46. Circular or Elliptical Arch Framed with Pieces Cut to Desired Shape

semicircular arch can be laid out rather simply by the use of a set of trammel points, or with a stick having a lead pencil attached to one end, and a nail in the other end to serve as a center. Another simple method of laying out an ellipse or semicircular arch is by use of a piece of inelastic string and a pencil. However, although the foregoing methods may appear simple to an experienced carpenter, to the carpentry student the laying out of an elliptical arch may appear as a difficult problem.

Of the various methods which may be used for laying out an

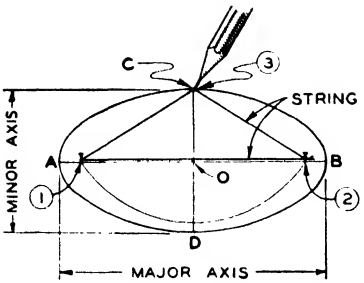


Fig. 47. Drawing Ellipse by String Method

ellipse, the so-called *string method* has the advantage of being both simple and practical.

Drawing Ellipse by String Method. Laying out an ellipse by the string method is illustrated in Fig. 47. A reasonably accurate ellipse can be obtained if it is drawn according to the following instructions.

PROCEDURE

1. On any relatively large, smooth surface, such as the face of a wide board, draw a straight line through a central point, as *(O)*, Fig. 47. On this line lay off *(AB)*, the major or long axis of the ellipse desired, Fig. 47.

2. Through the point *(O)* draw another straight line at right angles to the line *(AB)*. On this line lay off *(CD)*, the minor or short axis of the ellipse, Fig. 47.

3. Tie a pencil to the end of a piece of inelastic string. With the point *(C)* as a center and with a radius *(OA)*, equal to one-half of *(AB)*, describe an arc cutting the line *(AB)* at the points *(1)* and *(2)*, Fig. 47.

4. Drive a nail at each of the points *(1)*, *(2)*, and *(3)*, shown in Fig. 47. Tie an inelastic string tightly around these nails.

5. Remove the nail at the point *(3)*. Then hold a pencil in its place and proceed to draw the ellipse. Keep the string taut by holding the pencil tightly against the string shown in Fig. 47. This will give you the ellipse desired if you take care to use the correct dimensions.

Drawing Ellipse with Stick and Pencil. Another relatively simple method for laying out the rough frame for elliptical or semicircular arches is the use of a straight stick with a pencil in one end and a nail to serve as a center in the other end. This method is especially convenient when the rough frame is to be made on the job, in sections of narrow boards, from material on hand.

PROCEDURE

1. Select 2 straight, smooth pieces of 1x2 or 1x4. Square up one end of each board and cut both boards to a length which is 2 inches less than one-half the length of the major axis of the ellipse which is to be drawn. Tack the two pieces to the rough floor, or any level surface, at right angles to each other, as shown at *(1)* and *(2)*, Fig. 48. (Check the right angle with the framing square for trueness.)

2. On a 1x1 stick, 6 inches longer than the major axis of the ellipse to be drawn, Fig. 47, lay out the three points *(3)*, *(4)*, and *(5)*. The distance between *(3)* and *(5)* is equal to one-half of the major axis of the ellipse to be drawn. The distance between *(3)* and *(4)* is equal to one-half the minor axis of the ellipse.

3. Bore a hole the size of a pencil at *(3)* and set 2 four-penny (4d) finish nails at points *(4)* and *(5)* so that the heads of the nails will be about one-half inch above the surface of the board. Insert a pencil in the hole at *(3)* with the point of the pencil on the same side of the board as the nail heads.

4. Place the board, out of which the elliptical arch section is to be cut, in the position shown in Fig. 48. Check the position of the board by placing the marking stick in position *(A)*, Fig. 48, with *(3)*, coinciding with the lower edge of the board; nail *(5)* at the corner of the right angle formed by pieces *(1)* and *(2)* and nail *(4)* against the edge of piece *(1)*. Then move the marking stick to position *(B)* with nail *(4)* at the corner of the right angle formed by pieces *(1)* and *(2)*, and nail *(5)* against the side of piece *(2)*, as shown in Fig. 48.

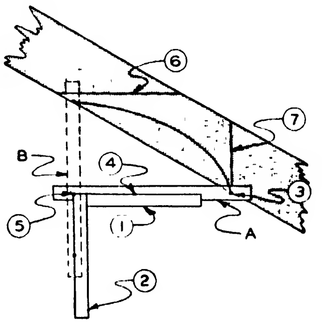


Fig. 48. Method of Laying Out Elliptical Arch Member

5. Proceed to draw one-quarter of an ellipse for the arch by holding nails *(4)* and *(5)* against the respective edges of pieces *(1)* and *(2)*; that is, with the marking stick slipped under the corner angle made by pieces *(1)* and *(2)*, move the pencil to scribe the curve and at the same time move nail *(4)* to the right along the edge of piece *(1)* and nail *(5)* upward, holding it against the edge of piece *(2)*. Continue this procedure until the curve for one-quarter of the section arch has been completed.

6. Hold the board for the rough frame in the position shown in Fig. 48, and draw line *(6)* parallel to piece *(1)*, then draw line *(7)* parallel to piece *(2)*. Allow as much thickness, or width, at the ends of the elliptical section as desired for nailing purposes.

If you follow the foregoing directions carefully, this will give you the layout for one-quarter of the rough frame for an elliptical arch, when four pieces of narrow boards are to be used for the frame.

FRAMING OF *THE HOUSE OF THE BOOK*

In this text, previous instructions given on carpentry construction have been sufficient to provide you with all the information necessary for framing a new house. Therefore, you should now be prepared to proceed with the actual framing process of *The House of the Book*.

However, before beginning this work it is necessary for you to turn to the Appendix and read the specifications given there in connection with the blueprints which you will find inside the back cover of this book. These blueprints, together with the specifications, must be studied carefully so you will be able to determine the size of studs and joists which are to be used in *The House*. You will also find the spacing called for on the drawings for both studs and joists.

The author of this text has assumed that either through previous study of the *Fundamentals of Carpentry*,[3] or by experience in the trade, you are familiar with the best established practices of simple frame construction. However, definite directions are given in this chapter to help you solve any framing problems which may need explanations in connection with the framing of *The House*. In addition to the instructions given in the text there are numerous illustrations which also supply information on details of construction which may appear difficult to an inexperienced carpentry student.

The wall construction shows that the frame used for *The House* is of the balloon type. A method of framing the walls of this type so as to equalize the shrinkage of materials is shown in Fig. 1 of this chapter. The wall construction also shows that a **T** sill is used similar to the one illustrated in the detail drawing, Fig. 3. In order to further provide for equalizing of shrinkage of materials on the outside walls and the bearing partitions, it will be necessary to have a single plate on the steel beam and on the basement cross walls. The steel beam rests on small concrete piers on top of the basement wall and masonry partition, with the bottom of the beam level with the top of the mud sill.

FLOORS

When all concrete foundations, including the masonry unit of the basement cross walls, have been completed, and the outside wall foundations backfilled with dirt to rough-grade level, then you may begin framing the floors and walls of *The House*.

Sill Framing. Let us begin by setting the sills on the outside walls at the northeast corner, shown at (*1*), Fig. 49. Proceed with the work by fitting and placing the sills on the east wall first, then following around the south and west sides, including the addition, leaving the

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[3] Walter E. Durbahn, *Fundamentals of Carpentry, Vol. I—Tools, Materials, Practice* (Chicago: American Technical Society, 1947).

placing of the sills on the north side until the last. Construction of the **T** sill requires a 2x8 for the walls where the joist ends rest; in this case the east and west walls. For all other walls and the steel beam, a 2x6 sill will be large enough.

PROCEDURE

Since the east wall is 33 feet long, therefore, an 18-foot and a 16-foot 2x8 should be selected for the sills and fitted into place as follows:

1. Square both ends of the 2x8. Remove the nuts from the anchor bolts in the concrete foundation wall. Lay the 2x8 on the wall against the bolts, as shown in Fig. 50. The end of the 2x8 should be set back 7/8 of an inch from the outside of the north wall to allow room for the sheathing boards.

2. Square lines across the 2x8 from the center of each anchor bolt.

3. Measure the distance from the center of the bolt to the face of the concrete wall. Then subtract 7/8 of an inch to allow for the sheathing boards. This will give you the distance the holes for the bolts should be bored from the outside edge of the 2x8.

Note: Separate measurements must be taken for each bolt, since the bolts seldom are set in the concrete the same distance from the outside of the wall.

4. Locate all bolt holes, then remove the sill to a pair of sawhorses and bore the holes with an auger bit 1/8 of an inch larger than the bolt, to allow for slight adjustment in setting the sill.

5. Place the 2x8 in its proper position over the bolts. Take the next section of the sill to complete the east wall, saw one end square and lay it against the bolts with one end against the first sill section. Lay out bolt holes as before and mark the length by measuring in 7/8 of an inch from the outside of the south foundation wall.

6. Remove the sill. Place it on two sawhorses and cut it to the exact length required. Bore the holes and place the sill in position on the wall.

7. Continue the same procedure around the entire building.

Note: Part of the south and west walls is to have stone veneer for exterior finish. In order to provide for the veneer it will be necessary to set the plate back 6 inches instead of 7/8 of an inch. The concrete slab for the porch must rest on the foundation wall. Hence, the sill can be only a 2x4 along the porch wall. The sill must be set flush with the outside of the header joist. The sill for the studs along the porch wall will later rest on top of the concrete slab.

8. After all sill sections have been carefully fitted, each section should be removed and a good cement mortar placed on the wall. The sills are then replaced, leveled with a transit, straightened with a line, and fastened down into place with washers and nuts over the ends of the bolts. Wedges driven under the sill where needed will hold it up in place and keep it level until the mortar sets.

The sills on top of the basement partition walls do not need to be anchored with bolts, but can be held in place with a few spikes.

However, it is necessary to set the sills in mortar, level with the outside-wall sills. These sills must also be straightened to insure squareness of the partition walls.

The joist framing on the steel **I** beam presents a special problem since the beam is not to show on the ceiling of the recreation room

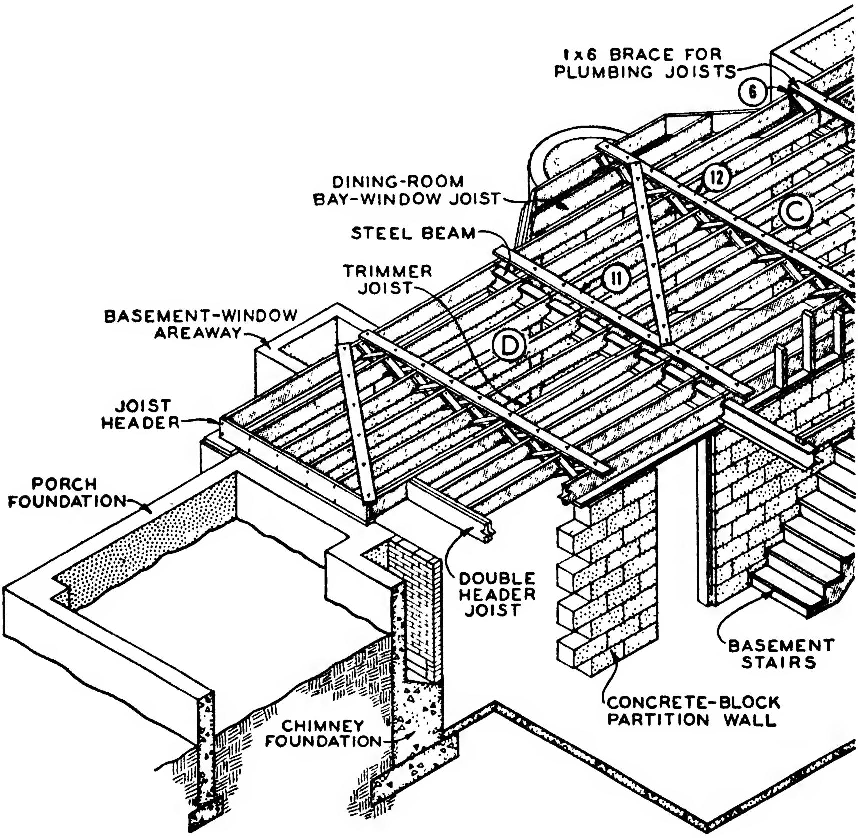
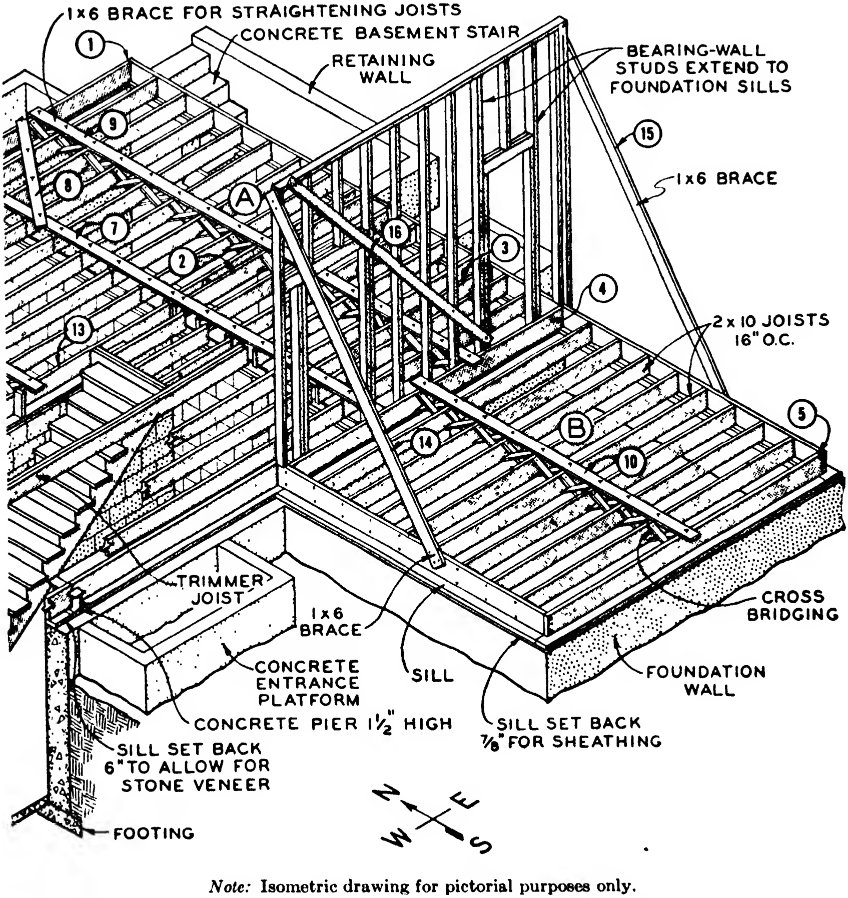


Fig. 49. First Stage in Framing a House—Sills and Joists

in the basement. The bearing wall resting on the steel beam must also carry the heating ducts. To equalize the shrinkage between the outside wall and the bearing partition of the first floor, 2x4 blocks must be nailed between joists on top of the beam, as shown in Fig. 14. This 2x4 sill on which the partition studs will rest can be cut out later in those stud spaces which are to carry heating ducts. However, it will be necessary to have the joist rest on the plate of the beam as shown in Fig. 14. Therefore, the shrinkage on the floor will not be the same



Note: Isometric drawing for pictorial purposes only.
For dimensions and details see blueprints and detail illustrations.

as the outside walls with its 2x6 sill but, since this will affect only the floor joist, the shrinkage is not likely to be great enough to cause serious damage to the floor.

Floor Joist Locations. The spacing for the joists can be laid out on the sills, but if laid out on the header joist the line will serve as a guide for nailing the joist plumb. Select two straight joists, 18 and

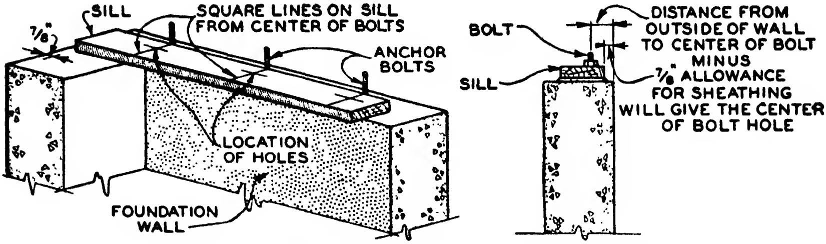


Fig. 50. Laying Out Holes for Anchor Bolts on Sills

16 feet long, for the header joists on the east wall. Beginning at the square end of one of the joists lay out joist spacing with the framing square; the first space should be 15 inches, as shown in Fig. 51. All others should be 16 inches. The 15-inch space is necessary to accommodate lath on walls and ceilings. The need for this spacing will become more apparent as the building progresses. Draw a single line with a cross mark (X) to indicate on which side of the line the joist is to be nailed. Draw another line ¾ of an inch from the last joist space. This is the cutting line for joining up the next header section. Toenail the header in place on the sill so that the end and sides will be 3⅝ inches (the width of the 2x4 stud) back from the edge of the sill. It will be advisable to set the header so the joist markings will be outside. Continue with the next header section in the same way until the other end of the wall is reached.

After spacing the joist, lay out the location of the cross walls for the kitchen and bathroom shown at (*2*) and (*3*), Fig. 49. Here added

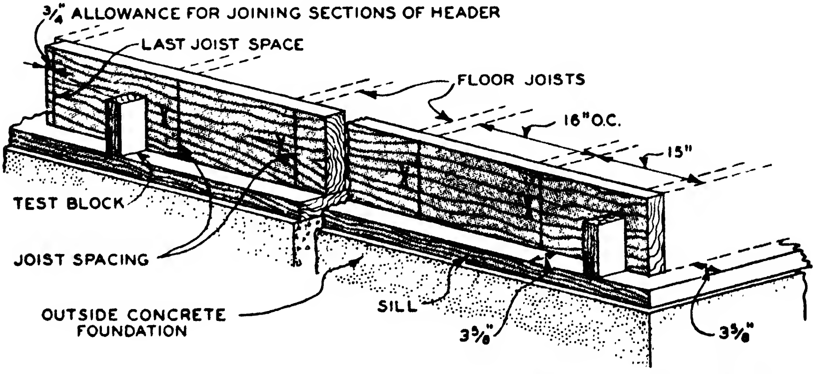


Fig. 51. Layout of Joist Spacing and Location of Header Joist on East Wall

strength must be provided with an additional joist placed so it will help to carry the wall load; also, to allow space for the heating ducts or plumbing stack, as shown in Fig. 18. If necessary, a joist can sometimes be moved an inch or two to accommodate such installations, especially in the first floor.

Lay out the joist spacing on the basement cross wall and on the steel beam. These spacings must be the same as on the east wall. A simple and accurate method for doing this is to take a 1x2 stick, tack it to the top of the header joist flush at (*1*), Fig. 49, and transfer the markings; then move the stick to the other locations and reproduce the spacings on the other sills. The header joist for the west side of the first-floor bedroom, area (*B*), Fig. 49, and the header joist for the west side of the living room should be cut to the correct lengths and the spacings laid out; but they should not be nailed in place until the joists are in position and nailed on the other end.

Framing of the Joists. The parallel pieces of small timber commonly known as *joists* make up the body of the floor frames. Special care must be taken in framing floor joists since the boards of the flooring are nailed to them. Floors must be strong enough to carry any load placed upon them. They must also be stiff enough so they will not vibrate when a person walks across them, as is the case in cheap, poorly constructed buildings.

PROCEDURE

1. Lay out the joist pattern for area *(A)*, Fig. 49. To find the length for the joist, measure from the inside of the header joist to the middle of the basement cross-wall sill. Cut as many joists as are needed for area *(A)*, Fig. 49, and lay them down flat on the wall in the approximate location. For the outside joist select a sound, straight piece of lumber.

2. Next, lay out the pattern for area *(B)*, Fig. 49. The joist in *(B)*, the addition, will have a header on both east and west sides when finished. To find the length for the joists, measure the distance between the header joist on the east wall and the header location on the west wall. Cut the joists for the entire addition floor, then lay them on the foundation wall in the approximate location.

3. Nail the joists in position, through the header, with 20-penny (20d) nails, and toenail the joists with 8-penny or 16-penny nails to the sill on the basement cross wall, area *(A)*, Fig. 49. The outside joists at *(1)* and *(5)* are nailed to the sill 3⅝ inches back from the outer edge of the sill to allow room for the 2x4 studs. Two men can work to advantage in framing joists—one man at each end.

4. Plumb the end of the outside joist at *(6)*, Fig. 49. Secure this joist with a short brace. Then lay a 1x6 across the joists as shown at *(7)*, tacking the board at *(6)*. Continue to plumb each joist into position, holding it in place with a nail through the 1x6.

5. Straighten the outside joist *(1)* of area *(A)*, Fig. 49. Place a diagonal brace in position *(8)*, and tack it at each end to hold it in place. Lay a 1x6 piece *(9)* through the center of the joist span in *(A)*, tacking it to the outside joists, as shown in the illustration, Fig. 49. Lay another 1x6 piece *(10)* through the center of the joist span in *(B)*. With one man sighting the joists and another man tacking the 1x6 pieces to the joists, straighten all joists in both area *(A)* and area *(B)*, Fig. 49.

6. Lay out and cut a pattern for the joists for area *(C)*, Fig. 49. Cut the joists to the correct length with the west end cut to fit around the steel beam, as shown in Fig. 14, with the ends of the joists resting on a metal plate. Care must be taken to allow at least ⅜ of an inch at this end for clearance over the steel beam, a situation similar to that shown in Fig. 14. This precaution will prevent splitting of the joist when the wood dries out and consequently shrinks. Nail the joists for area *(C)*, Fig. 49, in place, butting them against the joists of area *(A)*, plumbing and tacking them in place with a 1x6 brace *(11)* at the west end. Straighten the joists and hold them in place with a 1x6 piece *(12)* through the center of *(C)* in the same way as you did for area *(A)* and area *(B)*, Fig. 49.

7. When framing joists around the stair well, joist *(13)* should be kept back 4½ inches, the width of a 2x4 stud plus lath and plaster. This will allow the plaster to come flush with the basement masonry wall. However, if the basement wall is to be plastered also, the joist should then be set back only 4 inches. The joist on the south side of the stair well should be kept back about 2 inches to allow part of the studs from the wall above to come down over the side of the joists. The studs must be cut out at the bottom to fit around the joists. Allowing the partition studs to extend through the wall hole will tend to prevent plaster cracks at this point as a result of joist shrinkage.

8. The size of the stair well, especially the length, must be carefully worked out to allow ample headroom. The joists on the south side and the ends of the well hole must be doubled to carry the extra floor and partition load.

9. Finally, lay out and cut the joist pattern for the last portion, area *(D)*, of the first floor, Fig. 49. Cut all the joists for *(D)* and lay them in the approximate location. The joists for *(D)* are fitted into the steel beam at the east end and against a header joist on the west end. To prevent the joists for *(C)* and *(D)* from spreading apart, they should be held together on top with metal straps or metal dogs, as shown in Fig. 15. Trimmers and double headers must be added, as indicated, to carry the floor load as previously explained. A 2-inch space must be allowed for packing fire-resistant material between the framing members and the masonry of the fireplace. This precaution is especially important as a provision for reducing the fire hazard.

10. Bearing-partition walls, which run parallel with joist and extend to the sills, should be set before the rough floor is laid. Fitting flooring around the studs is much easier than cutting out openings for the partition studs later. Such a partition wall must be raised at joist *(4)*, Fig. 49, between areas *(A)* and *(B)*. Therefore, it will be necessary to lay out, cut, and erect studs for this wall before any rough flooring is laid. A workable method for laying out, cutting, and setting bearing-partition studs is discussed in the paragraph on Wall Layout.

Subflooring and Bridging. Before starting to lay the subflooring, or rough flooring, check all joists carefully to make sure each joist is plumb, straight, and the end joists diagonally braced. Also make sure every joist is nailed securely in position. This final check will help to insure straight outside walls and full joist strength. In each joist span, the diagonal braces which hold the end joists straight must be placed so as not to interfere with the laying of the rough flooring. When laying the subfloor, begin on the east side and proceed toward the west.

The specifications (see Appendix) call for 1x8 shiplap, or sheathing, for the rough flooring. Therefore, select a straight 1x8 piece of sheathing and nail it to the joist along the east wall, holding the edge of the board back ¾ of an inch from the outside edge of the header joist. This board is kept back ¾ of an inch to allow for expansion of the floor, in case it should become wet from rain or snow. Otherwise, the expanding of the wet boards might push the wall studs out of place. The ends of the rough-floor boards should be nailed flush, or a little back from the edge of the outside joists, so as not to interfere later with the erection of the wall studs.

The rough floor for the bathroom should be cut on joists (*2*) and (*3*). These boards should not be nailed on the ends and only lightly tacked between these two joists, so the plumber can remove them easily for the installation of his work. Continue fitting and nailing the rough flooring with two 8-penny (8d) nails to every joist crossing until the middle of area (*A*) has been reached, where bridging is to be placed.

Lay out and cut bridging according to instructions given previously. Set two nails on each end of the bridging pieces, and nail the bridging in place, as shown in Figs. 20 and 21. Remove the diagonal braces which hold the end joists, then proceed with the laying of the rough flooring, placing the bridging at the middle of each span until the entire first floor has been covered. Where partition walls are to

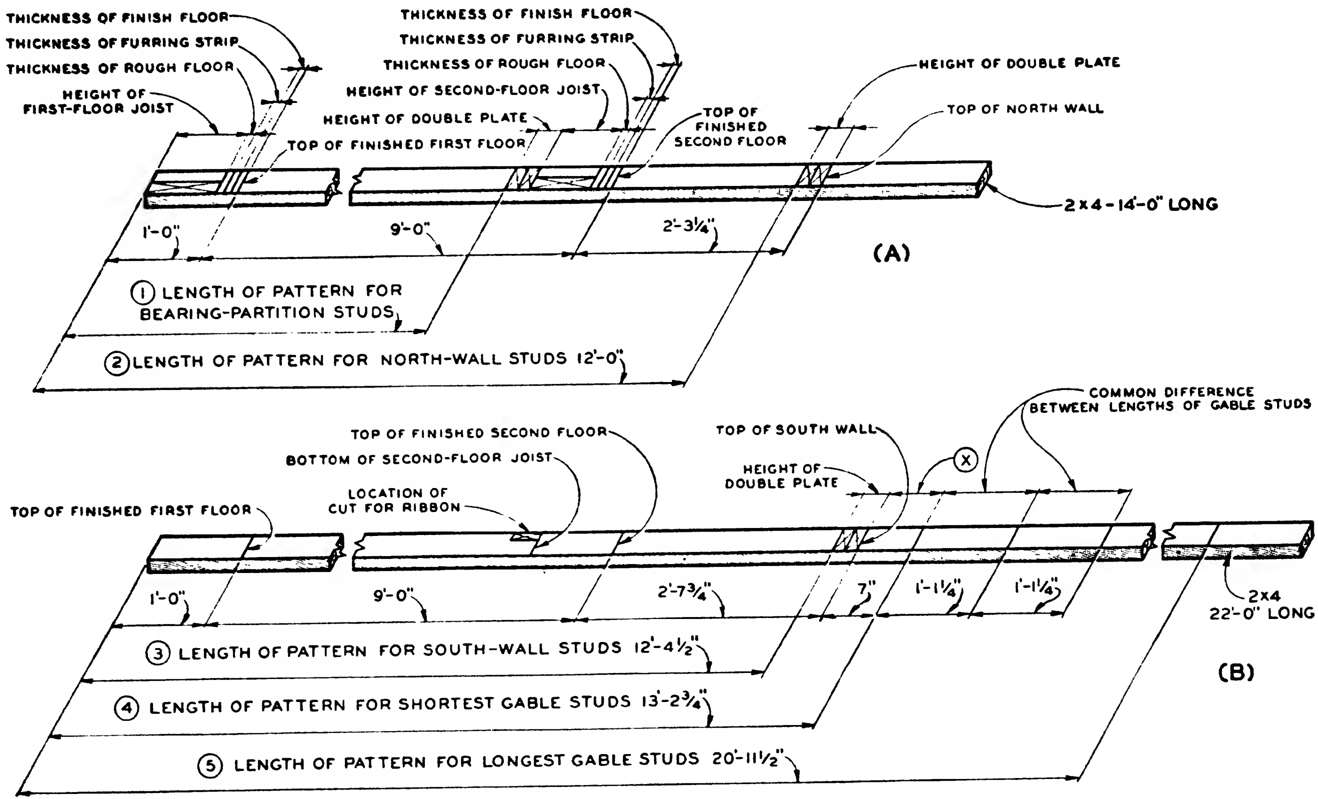


Fig. 52. Layout for Master-Stud Patterns Giving Lengths for Important Studs of the Building

extend down to the sills as at (*6*) and (*11*), Fig. 49, the boards should be fitted but only lightly tacked, so they can be removed easily when the studs are set. Such walls may be raised, also, when the rough flooring has been brought up to these points and the rough-floor boards can then be fitted and nailed permanently in place.

WALLS

In the framing of walls it is advisable first to lay out a pattern for each different kind and length of stud which is to be used in the various walls, then mark each stud so it can be readily identified when needed. Let us begin by laying out a master-stud pattern. This will be the pattern for the longest stud, which is in the east wall extending from the sill to the tip of the gable. See *East Elevation* of the blueprint drawings.

Master-Stud Pattern. With a rule, scale the height of the building on the east-elevation drawing (blueprints), measuring from the foundation to the highest point on the roof. Select a straight 2x4 of this length, or longer, and proceed to lay out a master pattern. The lengths of the various studs can be laid out on one master-stud pattern, but since there are several different stud lengths for *The House,* this procedure might become confusing. Therefore, it is advisable to make two stud patterns, as shown at (*A*) and (*B*), Fig. 52. One (*A*) shows the lengths for the bearing partitions and the north wall; the other (*B*) shows the gable-end studs and the south wall.

Select a smooth, straight piece of 2x4 fourteen feet long. Lay this 2x4 on a pair of sawhorses. Beginning at the squared end, lay off the height of the first-floor 2x10 (9½″) joist, as shown at (*A*), Fig. 52. Next lay off the thicknesses of the rough floor, the furring strip, and the finish floor. The wall section (*B–B*) (blueprints), gives the dimension from the top of the finished first floor to the top of the finished second floor, as 9 feet. Lay out this dimension and work back from the point of the finished second floor to lay out the thickness of the finish floor, furring strip, rough floor, and second-floor joists. Since the first-floor partitions are to have a double plate on top, just below the joists, it will be necessary to show this double 2x4 plate on the pattern below the joist. The north wall, which carries the roof rafters, will extend 2 feet 3¼ inches above the finished second floor. Lay out this stud, indicating the double 2x4 plate.

For the second stud pattern, (*B*), Fig. 52, select another straight and smooth piece of 2x4. This piece should be twenty-two feet in length, a little more than the length of the longest gable stud. Lay out on this piece the lengths for the studs for the south wall and for the gable ends. Lay this second 2x4 piece alongside the first master-stud pattern, with the squared ends flush. Transfer the finished first-floor line and the finished second-floor line to the second pattern; also the bottom of the second-floor joist. The gable studs in the east and west walls are to have a 1x4 ribbon; this must be indicated on one edge of the second pattern under the second-floor joist. From the top of the finished floor on the second pattern, measure 2 feet 7¾ inches which will be the top of the south wall. Draw the double plate below this point.

Due to the slope of the roof, the studs of gables are of different lengths, since each stud must be cut to fit against the rafters of the gable. If necessary, the exact length can be calculated and laid out on the master-stud pattern, but this procedure is not advisable. The time spent in doing this, plus the possibility of error, offsets any gain in advantage of such procedure. However, it is advisable to calculate the rough length of the gable studs, to insure the selection of stud material which will be long enough and yet will not produce excessive waste when the studs are cut. After the end rafters of each gable are in place, then the studs can be cut to the exact length required and fitted into place against the rafters.

To find the approximate lengths of the gable studs it is advisable to lay out the different stud lengths beginning with the shortest and working to the longest. The south wall of the house is about 4½ inches higher than the north wall. Therefore, it is advisable to use the south-wall height for the shortest stud to insure ample length. Then the shortest stud will be 12 feet 7¾ inches, the height of the south wall plus 7 feet, as shown at (*X*), Fig. 52, on pattern (*B*). This is the distance the stud will extend alongside the rafter, a total of about 13 feet 3 inches. Lay out this length on the second stud pattern (*B*), Fig. 52. If the unit rise for the roof is 10 inches for every foot of run, then the unit rise for every 16 inches of run is 13¼ inches, the common difference in gable-stud lengths. There will be 8 studs in each half of the gable. Therefore, it is necessary to lay out seven units of 13¼ inches each, beginning at the 13 feet 3 inches length, or shortest stud, to find the approximate gable-stud lengths. In selecting studs for the gable it will be necessary to select two studs for each length, one for each half of the gable. Since lumber comes in even feet only, some of the studs will naturally be longer than necessary, but they should not be cut off until the end rafters are in place. Then all studs can be plumbed and cut to correct length.

Cut out the housing on the gable-stud pattern, 7/8 of an inch deep, for the 1x4 ribbon. Mark each pattern carefully so it can be readily

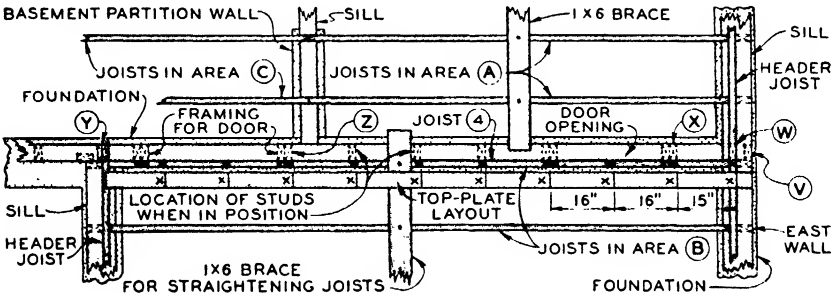


Fig. 53. Stud and Plate Layout for Partition Wall between Addition and Main Part of *The House*

identified when needed. Then lay the stud patterns aside for future use. Other partition stud patterns can be laid out when the partitions are sėt in place. This usually is done after the main-wall framing has been completed.

Wall Layout. The first wall of this building which you will lay out is the partition shown at (*4*) between area (*A*) and area (*B*), Fig. 49. The layout for the studs of this wall is somewhat out of the ordinary, inasmuch as the wall is a partition wall as well as part of the main wall. The studs must be set so they will take the lath and also accommodate the rafter plate.

You should begin by laying out the stud spaces on the joist (*4*) as shown in the detail drawing, Fig. 53. Note that stud (*V*) is set flush with the outside of the sill on the east side to carry the rafter plate. Stud (*W*) is set inside the wall line to carry the lath. This stud must later be backed to carry the lath for the adjoining wall which is at right angles to the partition. The stud space between (*W*) and (*X*) is 15 inches on center (O.C.); this will allow lath to fit tightly into the corner. All other stud spacings will be 16 inches on center, regardless of door openings. This will give the correct stud spacing for the top plate. After the 16-inch spacing has been laid out for the entire wall length, then the rough-door openings should be laid out. The size of these openings can be determined by the door sizes shown on the drawings of the first-floor plan, together with the door schedule. The doors for the first-floor bedroom are indicated as (*C*) and (*G*). See first-floor plan (blueprints) and door schedule at right. According to the door schedule, (*C*) is 2 feet 6 inches in width and 6 feet 8 inches in height; (*G*) is 2 feet in width and 6 feet 8 inches in height. A method for finding rough openings for doors has been explained previously and illustrated in Fig. 34.

Select a straight 2x4 for the top plate, lay it near the wall position and transfer the stud locations to this piece. If the top plate layout for the studs is taken from the bottom layout, then all studs in that particular wall will be parallel. Likewise, if the end stud is plumbed and braced, all studs of that wall will be plumb. This precaution is extremely important in wall layout and should be observed carefully. If this procedure is followed, all studs will be plumbed automatically, also the top and bottom of the wall will be the same length. The top plate should be cut so that it will be half on stud (*Y*), Fig. 53, allowing a tie-in of the next top-plate section.

The stud patterns are indicated in the illustration, Fig. 52, as (*1*), (*2*), (*3*), (*4*), and (*5*). Using the pattern marked (*3*), Fig. 52, for the south wall, cut as many full-length studs as are required for this partition wall. To speed up the operation, lay all of the 2x4's on the sawhorses. Nail a small block on one end of the pattern to serve as a stop. Mark all the 2x4's, then cut them to the correct length. Studs (*W*) and (*Y*), Fig. 53, are to rest on top of the header joist. Therefore, they must be shortened 9½ inches.

Raising the Wall. Since the partition wall between area (*A*) and area (*B*) is to be raised before the subfloor is laid, it will be necessary to lay a few boards across the joists to walk on while working. Lay all the studs for the wall across the joists, with one end of each stud in its respective position along the wall location. Lay the top plate on the other end of the studs, with the plate-stud markings on the outer side. Spike the plate to the studs with two 16-penny (16d) nails to each stud, omitting, of course, the studs on each side of the door openings. Between studs (*Y*) and (*Z*), measure the length of the door header at the top plate. Then cut two 2x6's to this length and nail them together. The header height for this opening is governed by the size of the door (*C*) shown on the first-floor plan and the door schedule at the right; see blueprints. Make the necessary allowances for jambs and lugs as illustrated in Fig. 34. Spike the header in its proper position, omitting the cripple studs on the side of the door until the wall has been raised. Fit and nail the short cripples in place above the header. Frame the second door, the closet door marked (G), on the first-floor plan. (See blueprint and door schedule.)

Raise the wall into position, hold it plumb and fasten each stud in its proper location at the bottom with one spike through the top of the joist on which the location marks have been indicated. Then fasten two 1x6 braces (*14*) and (*15*) near the top of each of the outside studs, Fig. 49. Plumb the outside studs with a level and straightedge, then nail the lower end of each brace to the outside of the sill. Plumb the other partition studs and add a third brace (*16*), Fig. 49. Nail each stud securely in position. The braces are only temporary; they hold the partition wall in place until the subflooring has been laid and the adjoining walls have been raised. After the temporary braces are nailed in position, fit and nail the cripple studs in place for the doors (*C*) and (*G*) of the partition.

According to methods previously explained in this chapter, the rough flooring can now be laid for area (*A*) and area (*B*). When the location for the bearing-partition wall between (*A*) and (*C*) is reached, then this wall may be raised. The studs for this partition should be placed on the north side of each floor joist with the first stud resting on top of the header joist. Since it rests on a header joist, the first stud should be shortened 9½ inches. Lay out the stud spacings on the rough floor near to the partition location. Door openings should be located where indicated on the first-floor plans shown on the blueprints. The position of the cripple studs for these openings should also be marked on the rough floor.

The top plate for this wall should extend from the outside of the north joist to the partition wall previously raised between area (*A*) and area (*B*), Fig. 49. Two pieces of 2x4 will be required for the length of this top plate. These pieces must be joined on top of a stud to tie the wall together. Transfer the stud spacings to the top plate.

Cut the required number of studs for this partition, using pattern (*1*), Fig. 52. Lay the studs in the proper position on the floor and spike the top plate in place. Then raise each portion of this wall into position. Proceed the same as you did when raising the partition wall between area (*A*) and area (*B*). When all portions of this wall have been raised into position, plumb and brace each portion as you did the first partition wall. Then nail each stud securely in place.

When the subfloor has been brought up to the location of the bearing-partition wall between area (*C*) and area (*D*)—the dining room and living room—lay out and raise this wall. Proceed as you did when raising the other partition walls. Double the top plates of these two bearing-partition walls. Use good straight 2x4's, breaking the joints; that is, no two joints should come in the same place. There should be a distance of 4 or 5 feet between joints.

The rigidity of the building during construction, or until the sheathing has been applied to the outside walls, will depend upon the bracing of these two bearing-partition walls. Therefore, each of these partitions should have at least two 1x6 diagonal braces 16 feet long, extending from the top plate to the bottom of a stud and tacked to each stud; also, at least four 2x4 diagonal braces 14 or 16 feet long, extending from the top of the studs to blocks nailed on the rough floor over a joist. The position for placing one such 1x6 partition brace is shown at (*16*), Fig. 49; a 2x4 partition brace is shown at (*17*), Fig. 54. Before nailing the braces in place, recheck the end studs for plumbness and sight along the top for straightness.

Outside Walls. The studs for the east and west walls must be laid out directly opposite each other so that the joists can be nailed to the same side of the studs and extended in a straight line across the bearing partitions directly over the studs of the partitions. This is not only good construction but also permits pipes and ducts to pass from the walls to second-floor joist spaces. The spacing of the studs of these two outside walls is started at the north wall and stepped off toward the south. The first spacing is to be 15 inches, the same as the partition wall shown in the detail in Fig. 53; all other spacings 16 inches on center (O.C.). When the stud layout reaches the fireplace on the west wall, a 1x6 should be tacked across the opening of the fireplace so the spacing can be carried on across and continued on the south side of the fireplace.

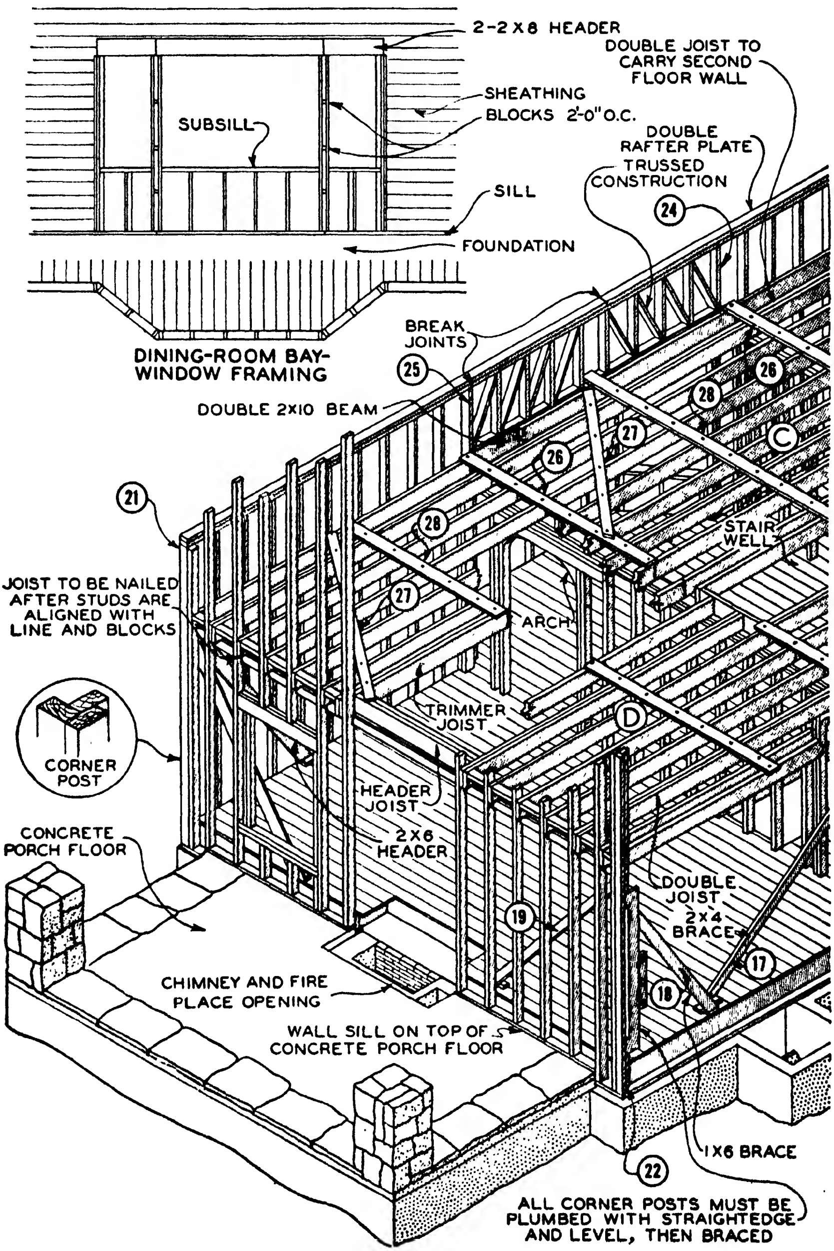
The studs on the north and south walls should also be spaced directly across from each other so that the rafters will later come to rest on the top plate over the studs. Begin laying out these stud spaces from the east side with 15 inches as a starting space followed by 16-inch spaces and working toward the west. On the north side, the spacing should continue directly across the floor of the dining-room bay window instead of around the window. The studs of the bay will be laid out later, independently of the rest of the building.

The concrete floor for the porch is laid directly against the first-floor header joist on the west side. Therefore, a sill on which the west wall studs can rest must be laid on the floor at this place. This sill should be laid level in a good cement mortar and be toenailed against the header joist.

Each one of the outside corners (*20*), (*21*), and (*22*), Fig. 54, require a 3-stud corner, constructed as shown in Fig. 24. One of each of these three studs must have a housing for the ribbon. Take the stud pattern (*2*), Fig. 52, and cut six studs for the two north-side corners. Then take stud pattern (*3*), Fig. 52, and cut three straight studs for the southwest corner. House three of the studs for a ribbon, and nail the studs together for each corner, so the housing will come on the correct side to receive the ribbon. Nail these three corner posts in place, then plumb and brace them from two sides.

The corner post of a building is of considerable importance. First, it must be straight and plumb. After it is nailed in the correct position, it must be properly braced to hold it there. These braces should not be removed until enough sheathing has been nailed on the studs to hold the corner post in place. Since braces are to remain in place until the sheathing has been applied, therefore, they must be placed so they will not interfere with the setting of other studs or with nailing of sheathing.

An ordinary level placed against framing lumber is not absolutely accurate, due to the irregularities of such lumber. To insure accuracy, a straightedge with two lugs should be used.


2-2 X 8 HEADER
DOUBLE JOIST TO CARRY SECOND FLOOR WALL
SHEATHING
BLOCKS 2'-0" O.C.
SUBSILL
DOUBLE RAFTER PLATE
TRUSSED CONSTRUCTION
SILL
FOUNDATION
DINING-ROOM BAY-WINDOW FRAMING
BREAK JOINTS
DOUBLE 2X10 BEAM
JOIST TO BE NAILED AFTER STUDS ARE ALIGNED WITH LINE AND BLOCKS
CORNER POST
STAIR WELL
ARCH
TRIMMER JOIST
HEADER JOIST
2X6 HEADER
CONCRETE PORCH FLOOR
DOUBLE JOIST
2X4 BRACE
CHIMNEY AND FIRE PLACE OPENING
WALL SILL ON TOP OF CONCRETE PORCH FLOOR
1X6 BRACE
ALL CORNER POSTS MUST BE PLUMBED WITH STRAIGHTEDGE AND LEVEL, THEN BRACED

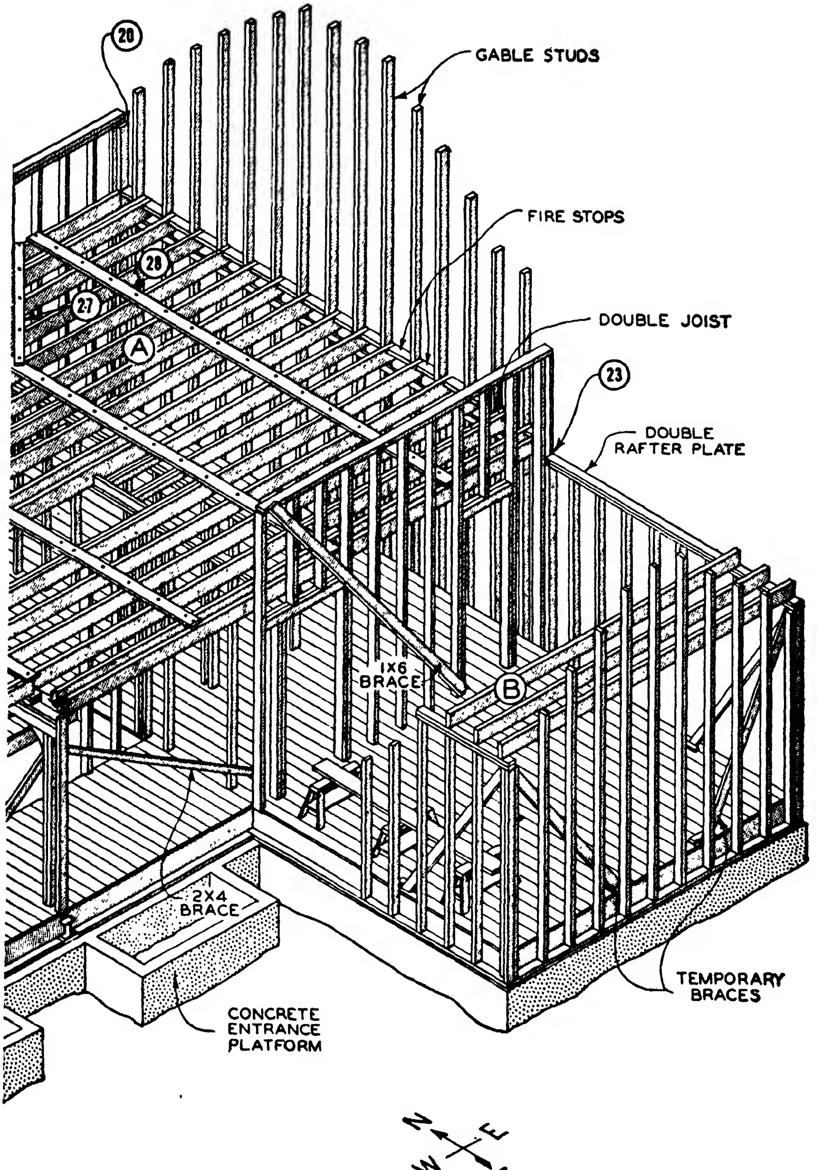


Fig. 54. Second Stage in Framing of a House—Studs Up and Rough Flooring Laid for First Floor

Note: Isometric drawings for pictorial purposes only.
For dimensions and details see blueprints and detail illustrations.

How to Plumb and Brace a Corner Post. To plumb a corner post, follow the instructions given here; also see position of braces as shown at corner (*22*), Fig. 54.

PROCEDURE

1. Nail the corner post securely to the sill in the exact position.

2. Fasten two braces on the inside near the top, at the ribbon or just below, leaving the bottom end free for adjustment later. Place the braces in the positions shown at *(18)* and *(19)*, Fig. 54.

3. Place the straightedge against the corner post midway between the bottom and the point where the braces are fastened at the top.

4. Place the level on the straightedge, stand back about two feet from the post and look directly at the glass.

Caution: Inaccuracy will result from reading the level at an angle.

5. Nail a block to the floor where the lower end of the brace is to be fastened. In the free end of the brace, set a nail ready to drive home when the correct position for the brace is found. While one man takes the reading on the level, a second man should be ready to nail the brace as soon as the correct position is found. He should move the brace until the man taking the reading informs him that the bubble of the level is exactly in the center marking of the glass. The lower end of the brace is then nailed securely to the block previously nailed to the floor for that purpose.

6. After the brace has been fastened at the lower end, check the reading a second time. It is advisable to check the level, also the straightedge, occasionally, by first reversing the level and taking the reading, then reversing the straightedge and reading the level. All readings should be the same. If the readings fail to check, find the cause. Then repair or replace the faulty tool.

After setting the corner posts, take the stud pattern (*5*), Fig. 52, and cut enough studs for both gable ends, beginning with the longest stud. The top ends of the studs should not be cut until after the studs are in place and the end rafters, which help to locate the exact position of the studs, are also in place. Shorter materials can be used for the shorter studs, but you must make sure each piece is long enough for its respective position.

The housing for the ribbon should be made with reasonable accuracy. The depth should be marked with a marking gauge and the two outside saw cuts made exactly on the lines with a third saw cut in the middle. With a 1½-inch, or wider, framing chisel score the depth line, then reverse the stud and cut from the other side.

Erecting Gable-End Studs. As previously stated in this chapter, the framing for *The House* is of the balloon type illustrated in Fig. 1.

In this type of framing, the ends of the second-floor joist rest on a ribbon which is housed in the gable-end studs. The layout for these studs is illustrated in Fig. 52, which also shows the layout for the ribbon to be housed in the stud.

For this ribbon, select two straight pieces of 1x4 long enough for the east wall, Fig. 49. Tack this 1x4 to the floor along the east edge where the stud spaces are laid out. One end of the first ribbon board should be flush with the outside (north side) of the joist at the northeast corner. The other end of the ribbon should be cut so it will be half on a stud. The second piece of 1x4 ribbon should be butted against the first board and be cut off to fit against the partition stud at (*4*), Fig. 49. Then transfer the stud spacings to the ribbon board. Erect the first stud at the joint of the ribbon and hold the stud in place with a brace. Take up the first portion of the ribbon strip and nail it in place to the corner post shown at (*20*), Fig. 54, with two 8-penny nails. Then nail the other end of the ribbon to the stud just erected. While doing this work, you may stand on a sawhorse. Remember to keep the markings on the ribbon strip toward the inside of the building. Fill in the studs between the corner and the first stud erected by placing each stud in position separately. Toenail each stud at the bottom with five 8-penny nails. Next, nail the second section of the ribbon strip in place and proceed to fill in the balance of the studs for the east gable. Following the same procedure used in laying out the ribbon for the east gable, lay out the ribbon strip for the west gable.

Note: The studs which are to rest on the porch sill must be shortened at the bottom. The ribbon strip should extend across the fireplace or chimney opening and should be left there until the second-floor subflooring has been laid and nailed in place. The ribbon strip can then be cut out. The ribbon strip should be cut to fit the layout at the floor level, and the stud spacings transferred to the ribbon. When nailed into the correct position, the ribbon, like the top plate of a wall, will automatically make all studs of that particular wall parallel. Also, the wall will be as long at the ribbon level as at the lower-floor level.

The north wall can be framed entirely on the ground and raised into position if enough workmen are available to do the work. However, this method of procedure is not recommended. It is advisable to delay raising this wall until the second-floor joists are in place. The joists will provide a working platform for the carpenters. This wall can be framed one stud at a time by two workmen. Framing of the outside walls for the bedroom, area (*B*), Fig. 54, can also wait until the walls and second-floor joists of the main part of the building have been framed, properly braced, and partly sheathed. The sheathing gives strength to the building.

Second-Floor Joists. For the second-floor joists, 2x8's are to be used. The length of these joists should be measured at the first-floor level. These joists should butt against each other on top of the bearing walls, and should extend to within one inch of the outside of the gable-end studs. The pattern for the joists for each portion of the main section of the building can be laid out with a steel tape, or be laid out on the first floor, working from east to west. After the joists have been laid out, they can then be marked, cut, and fitted into place. Using this method for laying out second-floor joists tends to prevent errors. As each joist pattern is cut it should be marked carefully for identification when needed later. Proceed to cut as many joists as required for the second floor.

Before placing the second-floor joists in position, check the bearing partition and corner posts again, to make sure they are plumb. Also check the walls again to make sure they are straight and thoroughly braced.

Begin placing the second-floor joists in area (*A*), Fig. 54. Select good straight joists for the outside and place them in their respective positions. To raise the joists to the second-floor position, first push one end up over the bearing partition, then raise the other end, and step up onto a sawhorse. Lift the joist over the ribbon, leaving it in a flat position until all joists of area (*A*), Fig. 54, are on the wall.

Nail the joists to the bearing-partition plate, with each joist resting directly over the stud of the wall. The ends of these joists should extend to the middle of the plate. When placing the joists in position, sight each one and make sure the crowned side is up. *Do not nail* the joist to the outside-wall studs until all joists have been nailed to the bearing wall and the outside wall has been straightened. When toenailing a joist to a plate, never drive nails in such a position they will interfere later with the cutting of the plate for pipes or heating ducts.

Note: When joists are cut at the mill some of them are *crowned.*

The process known as *crowning* consists of shaping the top of a joist to a slight curve, so it is one inch or more higher in the middle than at the ends. As the joist sags or deflects, due to the load put upon it, the top becomes level, while the convexity will appear at the lower edge, or bottom, of the joist. Joists are crowned for use in particularly long spans, where the loads are heavy enough to cause a deflection of an inch or more at the center of the joist.

Lining Up Gable Studs. Check all of the end and corner studs to make sure they are plumb. Select three small blocks of wood of equal

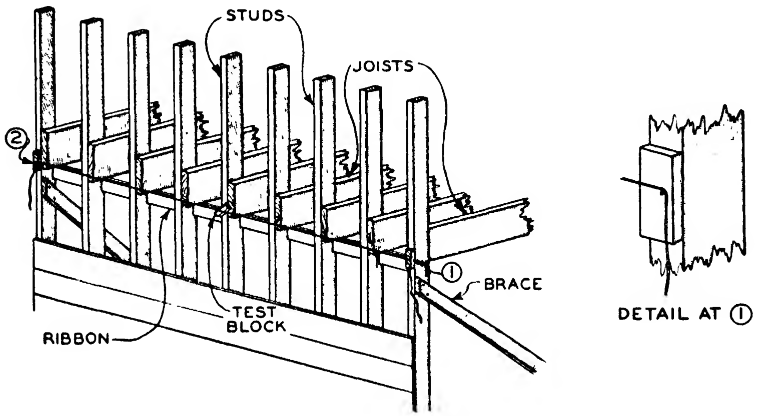


Fig. 55. Method of Lining Up Gable Studs with Three Blocks and Line

thickness about 1x2x6 and tack one block to the outside of each of the corner studs at the second-floor joist level. Fasten a line to the nails of the blocks and stretch the line taut, as shown in Fig. 55. Push the wall studs clear of the line so the line is free. Beginning at one end move a stud to the correct position in relation to the line by testing the position of the stud with the third block, then nail the joist securely to the stud with 16-penny (16d) nails. Continue nailing the rest of the joists to the studs.

Place and nail all the joists in area (*C*) and area (*D*), Fig. 54, then cut and fit headers and trimmers around openings for the chimney and stair well. The joist in the stair well must be kept back to ½ the thickness of the stair-well studs. Line up the studs and nail the joists to the studs in the west-end gable. Double the joists where second-floor partitions are to be located. Additional strength, to carry the load of the partition, is provided by the double joists, as shown in Fig. 18.

Framing North Wall. Because of the bay window in the dining room, the north wall of *The House* requires a 2x10 beam. Therefore, it is advisable to use a top plate of three sections. The middle portion of this plate should be joined to each of the end sections on the studs which carry the beam, because these studs are near the bearing partition which will help to strengthen the outside wall. To prepare the top plate, fit it to the stud layout at the sill level and transfer the markings. This plate must extend to the outside of the sills on the east and west ends.

Lay a number of boards across the second-floor joist to serve as a scaffold and move the plate to the second-floor level to be ready for erection. Cut as many full-length studs as required for the north wall, using stud pattern number (*2*), Fig. 52. Erect studs (*24*) and (*25*), Fig. 54, first, then nail the top plate of the two end sections in place, with the markings up. Fill in all other full-length studs.

The bay-window beam extends between studs (*24*) and (*25*), resting on at least one shortened stud on each side. For details of bay-window construction, see west-elevation plan (blueprints), at left. Cut two 2x10's to the correct length for the beam, spike the two pieces together, then spike the beam into position on the wall flush with the outside of the studs. Be sure to have the crowned side of the beam up. Nail the center portion of the top plate in place, then cut and fit the cripple studs over the beam; also cut and fit the diagonal braces for the truss. For truss construction see Fig. 36. Unless these braces are fitted tightly and are thoroughly blocked and nailed, their value as a truss is lost. In fitting the cripple studs and braces, care must be taken to keep the top plate straight and level. Double the top plate, breaking joints to give strength to the wall.

Spike the outside joist to each stud of the north wall. Sight each stud and straighten it before nailing it in position. Then proceed to erect the outside south wall of the main part of the building, nailing the outside joist to these wall studs. Tack a 1x6 (*26*), Fig. 54, across the second-floor joist at the first-floor partition line, plumbing each joist. Straighten the end joist of each of the three parts of the top plate, and hold each part in place with a 1x6 diagonal brace (*27*), Fig.

54. Straighten the joists in each part through the middle and hold the part in place with a 1x6 brace (*28*), Fig. 54, tacked to each joist.

Subflooring for Second Story. The rough floor for the second story is to be laid diagonally to give added strength to the building. Before this floor can be laid, 2x4 blocks must be nailed between the studs on the end gables. These blocks must be nailed flush with the outside of the studs. The blocks not only provide a place on which the ends of the rough-flooring boards can be nailed but will also provide a fire stop at the second-floor level. On the north and south side of the building the rough flooring is nailed to the inside-stud line only. Later, 2x4 fire stops can be nailed in between the studs at the second-floor level on these two sides.

Begin laying the rough flooring in one corner of the building. The first board laid will be a small piece coming to a point with a 45-degree angle cut on each end. Each succeeding board will be longer but will always be cut at a 45-degree angle to the joist. All end joints of the rough floor should be half on the joist and securely nailed in place. To allow for the expansion of the flooring boards in case of rain before the building has been roofed, it is advisable to tack every eighth or tenth board only lightly in place. This precaution will allow the boards to buckle or jump out if the floor should expand. If this precaution is not taken, the swelling of the rough-floor boards may push the outside walls out of position, causing considerable damage.

Before proceeding farther with the framing of the second floor, it is advisable to frame the openings for the windows and doors of the first floor, the 1x4 let-in corner braces fitted and nailed, and part of the sheathing applied. The braces and sheathing will keep the building from twisting out of shape, or possibly even from collapsing in case of a high wind.

Framing Window and Door Openings. As previously stated, some contractors prefer to omit the studs in the outside walls where openings are to come, framing only those studs which will not have to be cut for openings. Others prefer to frame walls complete on the ground, just as the bearing walls of this building were framed. However, the outside walls of this building should be framed solid; that is, full-length studs should be put in each stud space, then these studs will have to be cut out when framing the window and door openings.

The width for the windows and doors will be found on the working drawings (blueprints). To find the rough-opening size, you must work out the widths of the doors and windows as illustrated in Figs. 34 and 35. First, lay out the rough opening on the floor at the location of each opening, and indicate the position of the cripple studs on each side of the opening.

Then lay out a *story rod* or *pole* to show the vertical rough sizes of the various openings for the outside walls. This story pole may be a 1x2 or 1x4 and should be laid out so that when resting on the rough floor, it will show the position of the subsill and header of the windows on one side and headers for the doors on the other side. The finished height of the doors and windows, as indicated on the working drawings, is to be 6 feet 8 inches. Other dimensions must be taken from the elevation drawings (blueprints) when working out the rough-opening sizes.

To find the window opening, hold the story pole against one of the studs which is to be cut. Transfer the marks for the bottom of the subsill and the top of the header to one of the studs, then level across to the other studs which are to be cut for the opening, using a spirit level for this purpose. In order to hold the remaining portion of the stud in place after the center has been cut out, tack a piece of 1x6 across the studs above the top cut and below the bottom cut.

Cut and fit the double sill into place, nailing the pieces in place one at a time. Cut two pieces of 2x6 for the header and spike these pieces together. Nail the header in place, nailing it flush with the outside of the studs and toenailing up from the bottom to drive the header tight against the studs above. Then spike the header securely in place by nailing through the side studs.

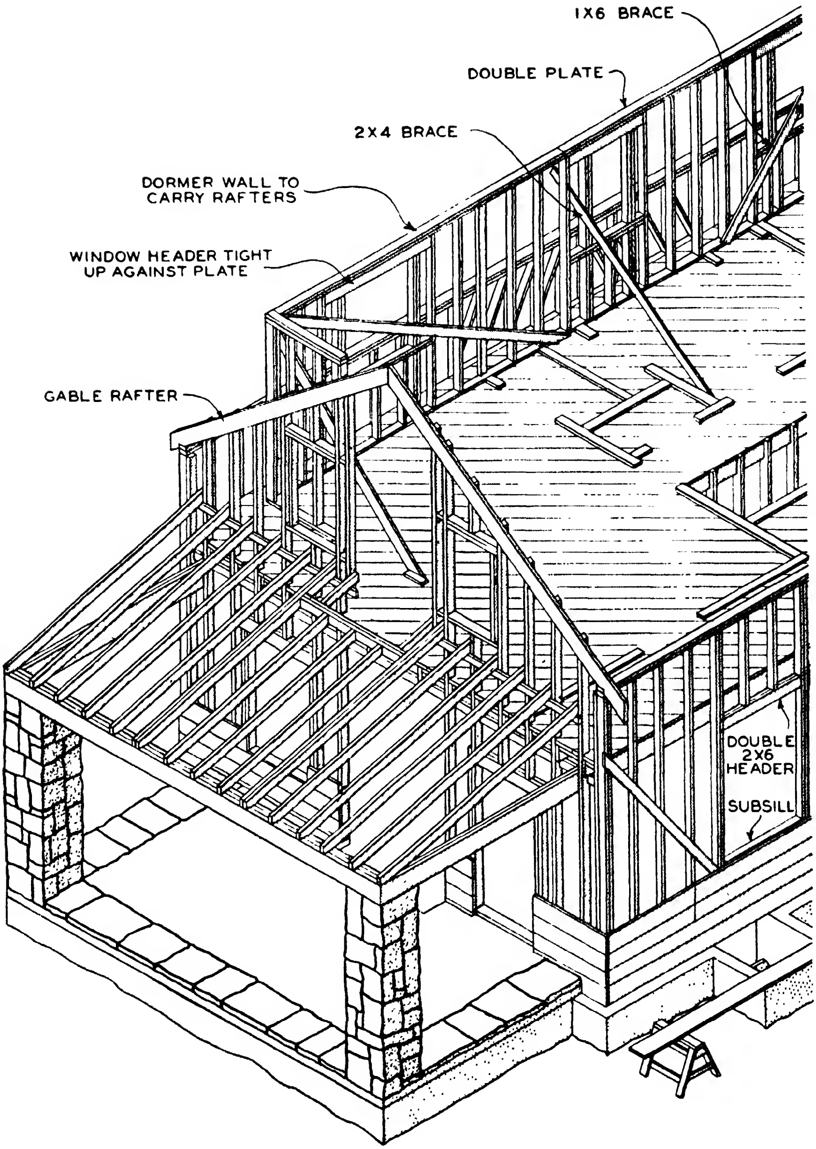
Lay out the position of the cripple studs for the side of the opening on the subsill. Plumb up these studs from the marks on the floor. Measure the length of the cripple studs for the side of the opening. These cripples must fit tightly between the subsill and the header to carry the load above. If a double cripple stud is required, cut two pieces and nail them together. Nail them to the subsill to hold them in place, then plumb them and nail them to the header; also toenail to the header the studs above it.

After the openings have been framed, the let-in 1x4 diagonal corner brace should be housed and nailed into place, as shown in Fig. 56. Since these diagonal braces might interfere with the framing of the openings, or might even have to be cut off, which would lessen their value, it is advisable to delay the fitting and nailing of the braces until the openings have been framed. These let-in braces should be framed on the outside from the ribbon or second-floor level to the sill at an angle as near 45 degrees as possible. Where this method of procedure is impossible, knee braces should be used, as shown in Fig. 39.

These let-in braces should be made of good solid 1x4's laid out to correct length, with angle cuts on the bottom end. Tack each brace in place and mark the studs where the brace is to be housed. Then remove the brace and gauge the depth for the housing notch with a marking gauge. Make the side cuts with the saw and remove the wood between the cuts with a framing chisel. Nail the brace in place and cut it flush with the stud on the top end.

Nailing Sheathing. The sheathing should now be nailed on all walls where the openings have been framed. Nail the sheathing in place up to the height which can be reached by a workman when standing on a sawhorse. The sheathing for *The House,* as indicated in the specifications, is to be 1x8 shiplap, nailed horizontally with two 8-penny (8d) nails at each stud crossing. The joints should be broken after every second board, and the boards driven tightly together. It is advisable to allow the sheathing to extend from 2 to 4 inches into the fireplace and chimney opening. This procedure will permit cutting of the sheathing down the entire length of the wall, after the bricklayer has laid out the exact opening size. This insures a straight, tight joint. Cut the sheathing flush with the studs on all door and window openings.

After four or five feet of sheathing have been applied to the main part of the building, the walls may be framed for the first-floor bedroom; that is, around the addition (*B*), Fig. 54. The studs for the east and west walls of the addition should be the same length as the studs for the bearing partition between area (*A*) and area (*B*), Fig. 54. The east and west walls of this room can be framed on the floor and raised into place, then plumbed and braced. After the studs in the end gable are framed to the end joists, the ceiling joists should be cut to the correct length and nailed into place. The window openings should then


1X6 BRACE
DOUBLE PLATE
2X4 BRACE
DORMER WALL TO CARRY RAFTERS
WINDOW HEADER TIGHT UP AGAINST PLATE
GABLE RAFTER
DOUBLE 2X6 HEADER
SUBSILL

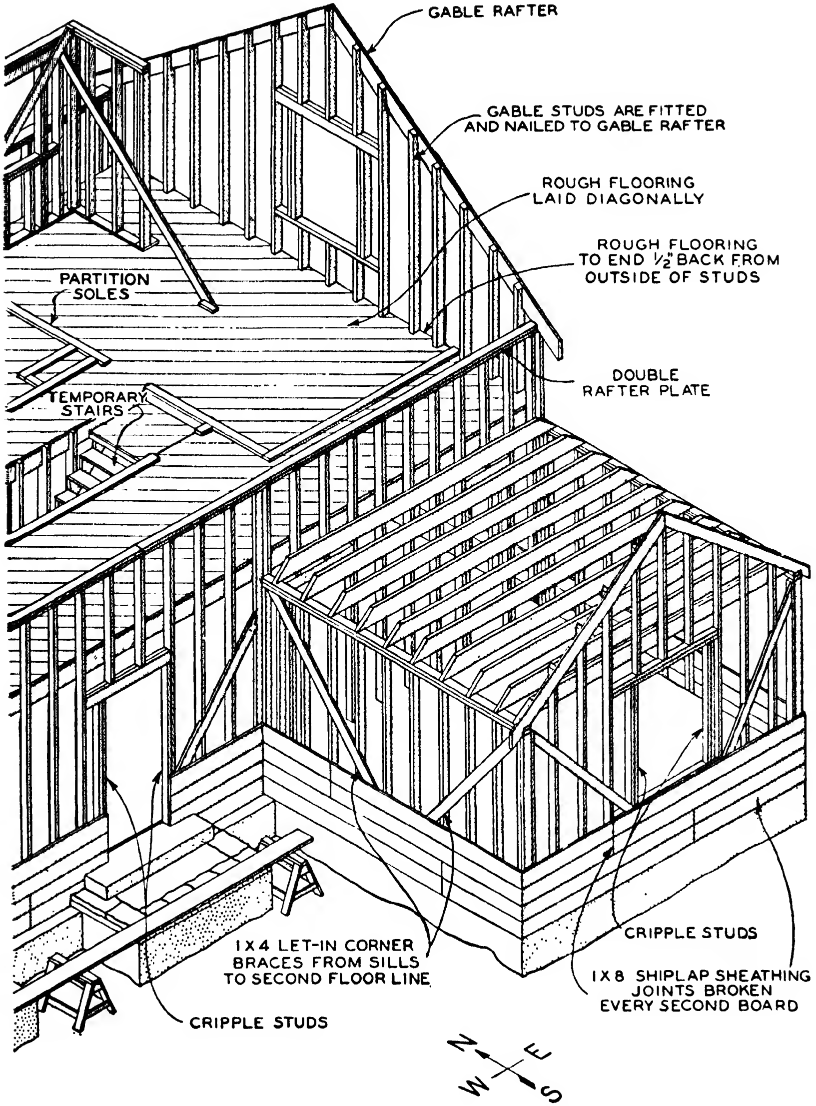


Fig. 56. Third Stage in Framing *The House*—Studs for North Dormer Up and Rough Flooring Laid for Second Floor

Note: Isometric drawing for pictorial purposes only.
For dimensions and details see blueprints and detail illustrations.

be cut, the diagonal corner braces fitted and nailed, and the walls sheathed.

The sheathing for the rest of the building can now be carried up as high as the second-floor joists. You should erect the necessary scaffolding as the work progresses above the reach of the workmen when standing on the ground. After the framing has been completed in the gables, the sheathing should be carried all the way up to the peak of the gables and the boards cut flush with the end rafters. On the eave side of *The House* the sheathing should be carried up to the bottom of the plates, allowing for fitting of the rafters to the plates. However, after the rafters are in place, the sheathing should be carried on up between, and to, the top of the rafters. Care should be taken to insure a good tight fitting of the sheathing at this point to keep out cold air, fine sifting snow, and dust or sand.

Scaffold Building. As the construction work of the building rises above the reach of workmen standing on the ground, scaffolds or staging, are necessary to carry on the work. Hence, it is timely at this point to consider the construction of such scaffolds, which should be carefully planned and carefully built. Although they are only temporary structures, nevertheless, scaffolds must be designed and built to carry the required load with a reasonable degree of safety, permitting the workmen to reach and perform his work with ease and safety.

Contractors and builders use various types and designs of scaffolds. The type you should select for your job depends upon the nature of the needs the scaffold must serve, the weight it must carry, as well as the distance above the ground the platform is to be erected. Wooden scaffolds are still in common use, although steel brackets and other forms of steel scaffolding are rapidly gaining in favor with many builders.

The minimum requirements for a light wooden scaffold demands a 2x10 plank resting on 1x6 cross ledgers, which should not be more than 10 feet apart. Such a scaffold will serve the needs of a carpenter for work to be performed at relatively low heights, a light load and simple construction. However, a bricklayer's work requires a scaffold with 2x6 or 2x8 cross ledgers. These ledgers should be set not more than 4 feet apart and with four or five 2x10 planks laid across the ledgers to serve as the platform on which the workmen stand. This platform should, also, include a toeboard to keep materials and tools from falling off the edge, with possible injury to workmen below. A scaffold, for outside carpenter work at heights not exceeding 18 feet, is illustrated in Fig. 57. Instructions for building such a scaffold follow.

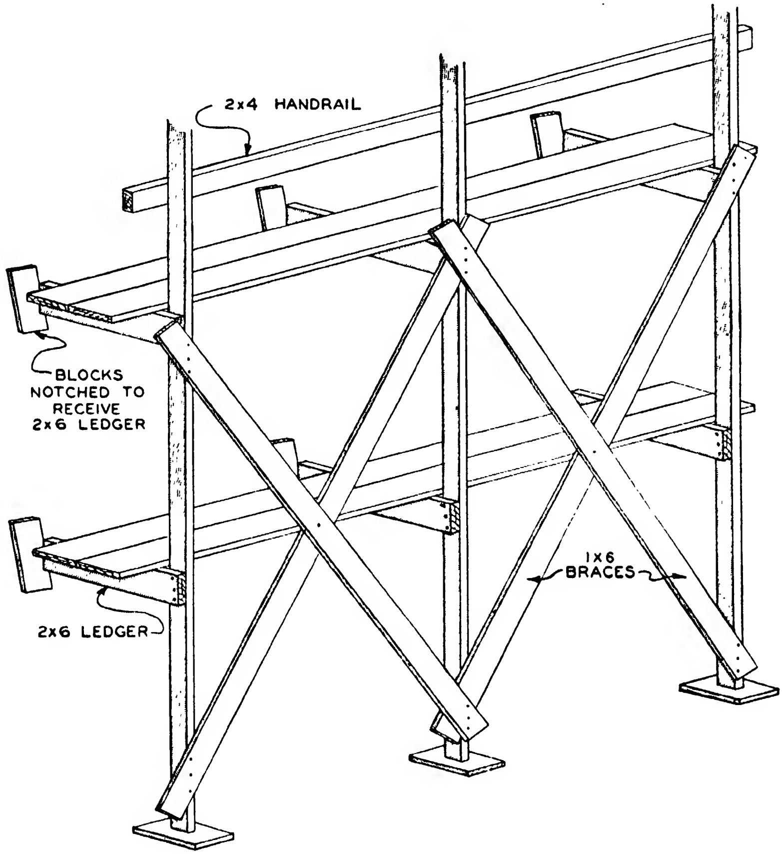


Fig. 57. Carpenter's Scaffold with Single Uprights and Block Fastened to Wall

PROCEDURE

1. Select sound pieces of 2x4's for uprights. These uprights should be set not more than 7 feet apart for 16-foot planks. The uprights should be placed along the side of the building, with the lower end of the 2x4's resting upon pieces of board to keep them from settling into the mud.

2. For the cross ledgers, select sound straight-grained 2x6's four feet long. Spike one end of each cross ledger to an upright with no less than three 16-penny (16d) nails. The other end of the cross ledger should be nailed to a 2x6 block nailed securely to the wall. The block should be about 18 inches long and be notched to receive the ledger, which also should be nailed to a stud in the wall with three or four 16-penny nails.

3. At the corners of the building, ledgers should be constructed so they will extend diagonally away from the building. Supports for the ledgers should be provided from both sides of the corner of the building.

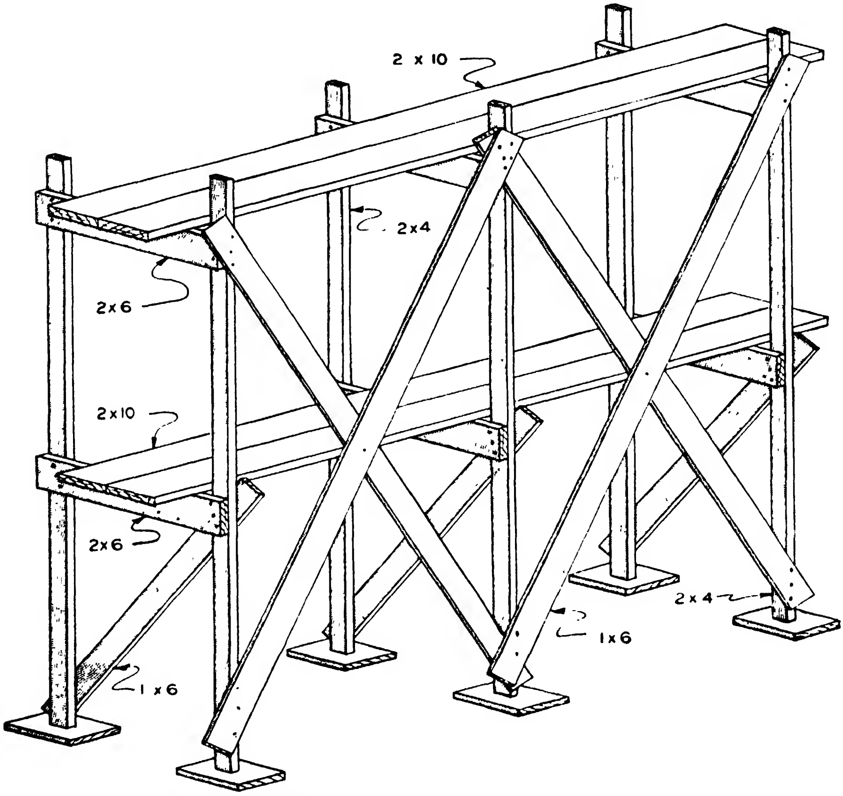


Fig. 58. Carpenter's Scaffold with Double Uprights—Scaffold Free from Wall

4. All platforms or staging erected at a given height should be on a level and should extend along all sides of the building at the same level.

5. As the building rises higher and higher above the ground it becomes necessary to erect more platforms at a higher level. The distance between the successive platforms should be about 5 or 6 feet, the distance depending upon the nature of the work.

6. The uprights should be braced with 1x6 cross braces. These braces should extend from the top cross ledger to the extreme bottom end of the upright, and be nailed with at least two 8-penny nails at each upright crossing.

7. The platform should consist of two structurally sound 2x10 planks.

These planks should be selected from a strong species of timber, and also be of a good grade of lumber. Lap the planks about 18 inches at each end and spike them to the cross ledger to keep them from slipping or sliding.

8. For platforms erected at heights greater than 10 feet above the ground, hand rails should be provided. The handrails should be made of 2x4's nailed to the uprights about 42 inches above the platform level.

When the exterior finish of a building is to be of shingles, or if siding is to be applied, it may be advisable to erect a scaffold with double uprights as shown in Fig. 58. This type of scaffold leaves the walls clear so work can later be started at the bottom after the sheathing has been finished. The work can also be carried to the top of the wall without building a second scaffold.

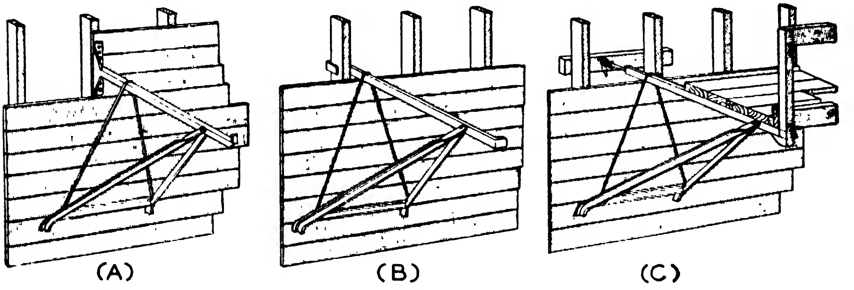


Fig. 59. Three Different Kinds of Steel Wall Brackets Used for Scaffolding

Other Types of Scaffolding. Scaffoldings of the bracket type have certain advantages over other types still in common use. Since they are easy to erect, require less material, and involve less labor, bracket scaffolding are economical to use. They have gained rapidly in favor with builders and contractors in recent years. These brackets can be obtained in steel or they can be made of wood. Three different kinds of steel brackets are illustrated in Fig. 59. When fastening steel brackets in place, the nails must be driven carefully so as not to break the heads. Broken heads on nails make a scaffold unsafe. The bracket shown at (*A*), Fig. 59, is fastened to the wall with spikes. The bracket shown at (*B*) is hooked around a stud. This type of bracket is safe, but requires the making of a hole in the sheathing for withdrawal of the bracket. The bracket shown at (*C*) requires the boring of a hole in a 2x4 crosspiece nailed to the inside of the stud.

The wooden bracket shown in Fig. 60 is simple yet sturdy and can be constructed by the carpenter on the job. The wooden bracket illustrated in Fig. 61 is not fastened to the wall, but is supported by 2x4's set at an angle of 45 degrees. Cross braces of 1x6 material hold the brackets in place and keep them from tipping or sliding on the wall.

Bay-Window Framing. After the outside walls have been sheathed up to the second-floor level, the bay window of the dining room can be framed. The framing detail is shown in Fig. 54 at left. See also the elevation and sectional views of the bay window shown on the west-elevation drawing (blueprint). Prepare the top plate, or header,

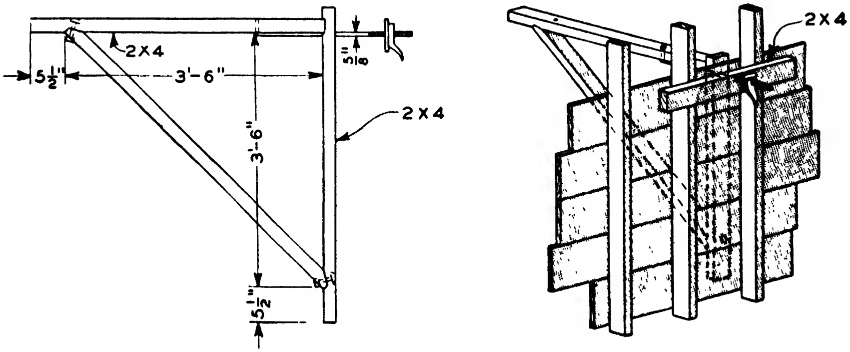


Fig. 60. Safe Wood Bracket for Carpenter's Scaffold

which is a double 2x8 set on edge. This top plate extends around the bay window and forms the window headers. The 2x8's for these headers are spiked together, mitered at the corners, and made to fit the shape of the bay at the sill level. Cut six 2x4 studs to correct length and erect them at the corners of the bay window. Place and nail the header, or top plate, in position. Frame the subsill and cripple studs below the window, then sheathe up the walls.

Second-Floor Framing. Not much framing can be done on the second floor until the roof has been framed (see Fig. 56). Any partitions which may be set are liable to be in the way when the rafters are raised. However, it is necessary to frame the walls of the large north dormer, as short rafters are to be nailed against the dormer and rafters must rest on the top plate. According to the detail of the wall construction as shown in the sectional view (*B-B*) (blueprint), this dormer wall is set in from the outside wall with studs extending from the second floor to the rafter plate.

For the sole of the wall, cut 2x4's to the correct length and nail the sole to the floor in the proper location. Then lay out the stud locations on the sole. Cut a piece for the top plate to the same length and lay it alongside the sole. Transfer the stud locations. Cut as many studs as are required for the wall. Frame the wall on the floor, with the window and cripple studs in the correct position. Then raise the wall in position, nail the studs at the bottom, and plumb the studs. Brace the wall to hold it in the proper place.

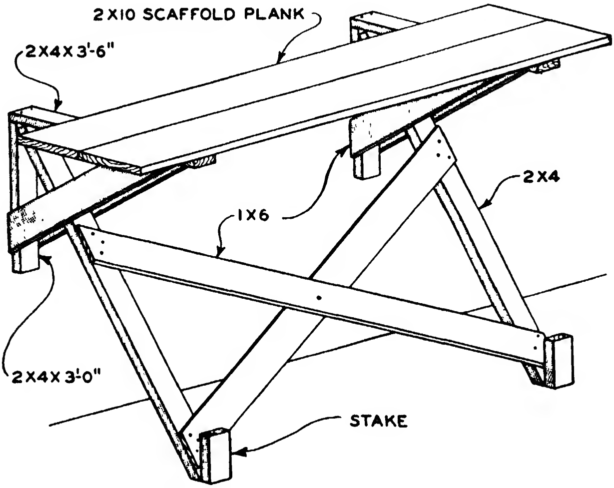


Fig. 61. Wood Bracket for Scaffolding Which Does Not Need To Be Fastened to Wall

To complete the framing of the studs in the end gables it is necessary to lay out and cut two pairs of rafters. (The layout of rafters is treated in the next chapter.) Nail the rafters in position, plumb and cut each gable stud to fit against the rafter, then nail the studs securely into place. There is a tendency to crown or drive out the end rafters when nailing the gable studs. This difficulty can be overcome by driving a nail through the rafter into the stud, then after all studs have been nailed into place they can be more securely nailed by driving nails through the studs into the rafters. The windows can now be framed in the gables according to dimensions required for these windows and locations as indicated on the working plans or blueprints.

There are certain partitions on the second floor which add strength and stability to the roof, but are not required for framing the roof. The open-floor space permits ease in handling material for the roof.

Therefore, it is of advantage to the workmen to leave out these partitions until after the roof has been framed and sheathed. These partitions can then be erected. It is also to the advantage of the workmen to complete the roof of the house as soon as possible, as this will provide them with a dry place in which to work in case of rain or snow. Therefore, as soon as the rafters of the roof and the sheathing are in place, only those partitions which add strength to the roof should be erected. Leave out the others until after shingling is completed.

However, it will not be convenient to begin shingling the roof until certain exterior cornice work has been finished (see chapter on Exterior Finish). Hence, the framing work is temporarily held up until after the exterior cornice work has been completed and the roof shingled.

Framing Odds and Ends. Up to this time, only the most essential part of the framework of *The House* has been erected. Our aim has been to erect the skeleton of the building and cover it with sheathing and shingles. With the walls sheathed and the roof overhead, the workman is in a good position to continue his work regardless of weather conditions. Much still remains to be done on the inside of the building before the framing is completed. Minor partitions must be set, plumbed, tied securely in place, and the corners well nailed to avoid cracking of the plaster. The backing in the corner of walls and ceiling must be installed (see Figs. 28, 30, and 32). Arches must be framed (see Figs. 46 and 47). The rough stairs must be erected and the insulation put in place. Plaster grounds shown in Fig. 42 must be nailed in position straight and true. All these odds and ends of framing may be carried on when weather conditions will not permit outside work. If, on the other hand, weather conditions are favorable over an extended period of time, it may be to the advantage of the carpenter to complete the interior framing so other tradesmen, such as the electrician, lathers, plasterer, and furnace man can do their work. In such a case the carpenter can work on the exterior while the other tradesmen are installing their work.

In other words, a carpenter should plan his work so neither the weather nor the work of other tradesmen will force him to remain idle for any long period of time. Not only does such enforced idleness cut the carpenter's income but it also hinders the progress of the erection of the building, and may inconvenience the owner.

SAFETY MEASURES

As a building rises higher and higher above the ground the danger to the workmen from falls and falling objects correspondingly increases. The importance of proper construction of scaffolds has been emphasized previously. However, it is not out of place here to again call attention to the fact that scaffolds must be carefully designed and properly built. Another common hazard in the building industry is the careless building and improper use of ladders.

Ladders. As the height of a building increases, it becomes necessary to bring ladders into use. Frequently one or more ladders are built on the job. When building a ladder, the side rails should be of good sound 2x4's. For the steps, sound 1x3 or 1x4 lumber should be used. The steps should be housed into the side rails, then nailed at each end with two 8-penny (8d) nails. Steps should be spaced at a uniform distance apart; 12 inches is the accepted standard. However, for specific uses the spacing may be shortened, but should not be less than 8 inches. Many carpenters prefer the 10-inch spacing, while mason laborers prefer 8-inch spacing.

The National Safety Council has suggested the following as safe practices in using ladders:

1. No ladder should be used for any job which involves the use of both hands, other than for holding to the ladder. One hand should be free at all times to allow a firm grip on the ladder.

2. Do not go up or down a ladder without free use of both hands. If material has to be handled, use a rope.

3. Ladders should not be used for working bases except in case of emergency or for short periods of time. Ladders are primarily for ascending or descending from one level to another. Where work requires the use of tools and materials, or where the job is of considerable duration, it is advisable to use a platform ladder, ladder tower, scaffold, or some other acceptable working base.

4. Workers should not ascend higher than the third rung from the top on straight or extension ladders nor more than the second rung from the top on stepladders.

5. Use care in placing ladders. If there is danger of a ladder slipping, have someone hold it, or otherwise securely anchor it. The best angle at which to place a ladder is that in which the horizontal distance from the top support to the base of the ladder is approximately one-fourth the length of the ladder between supports. In other words, a 12-foot ladder should be placed so the bottom is three feet away from the wall or object against which the top is leaning.

6. Never place a ladder in front of a door opening toward the ladder unless the door is locked or otherwise blocked or guarded.

7. Be sure that ladder feet are not placed on movable objects but rather on a substantial and level base.

8. Never use broken or weak ladders or ladders with missing rungs. Before using a ladder, inspect it for broken rungs, split side rails, broken or loose safety feet—never use a defective ladder.

9. Short ladders should not be spliced together, as they are not built strong enough to be used as long ladders.

10. Ladders should be kept clean and free from dirt and splashing of paint which might conceal imperfections and defects.

11. Never lean a ladder against an unsafe backing such as loose boxes, barrels, or round objects.

12. Ladders should not be used during a strong wind except in case of emergency, at which time they should be securely lashed or tied in position.

13. Ladders should not be left standing unattended, especially on the outside, for long periods of time unless securely anchored at both top and bottom to prevent falling in case of sudden wind storms.

14. Ladders used on roofs should be securely lashed or otherwise fastened to prevent slipping.

15. Ladders used in aisles or over streets where there is considerable traffic of shop vehicles, or pedestrians, should be guarded by an attendant or the space be roped off or otherwise barricaded.

16. Workmen should not climb ladders if their shoes are greasy, muddy, or otherwise slippery. Shoes should be cleaned before using ladders.

17. When carrying ladders, keep the front end elevated high enough to clear a man's head and the back end near the floor; be careful when carrying a ladder through doorways, passageways, and around blind corners.

18. Ladders should be handled carefully in being lowered. They should not be allowed to drop on the side nor to fall heavily endwise on one rail. The failure to recognize this safe practice has resulted in serious damage to many ladders.

19. Get the habit of being sure a ladder is safe before using it.

Falling Objects. Tools and materials must be carefully handled to avoid dropping them. This precaution is especially important if others are working below you. Some form of decks or overhead protection should be built over traffic lanes if prolonged work is to be carried on for some time.

Saws should be hung on a nail rather than laid on the planks of a scaffold where the wind or a jar of any kind may cause them to drop, endangering workmen or others below. Other small tools, such as hammers, block planes, and others which cannot be hung up, should be carefully guarded to keep them from falling and injuring someone. Avoid leaving unguarded tools lying on ladders, scaffolds, or on top of walls; all such tools are an ever-present source of danger. Never carry sharp-edged tools, such as chisels or a shingle hatchet, in your pockets or on your person without proper protection for the sharp edge.

When sawing off roof boards, or other pieces of material, always hold the waste end while sawing, then drop it where it will cause no damage. In the handling of materials at a dangerous elevation above the ground, brace yourself and make sure of a solid footing. Always plan a means of escape before passing material overhead in case it should fall back toward you.

Other Hazards. Portable electric saws and other power tools and equipment, which now play an important role in modern construction, must be handled wisely in order to prevent accidents to yourself and other workers. The guard on a machine is put there for your safety. Never take it off or tie it back out of your way, unless for some good reason it becomes absolutely necessary to do so. If removed for some specific operation it should be replaced immediately after that operation has been performed.

Electric equipment frequently becomes defective, causing shorts and grounds; to protect yourself against electric shock, especially when working on wet footing, ground the machine or insulate yourself from the ground with rubbers or dry boards.

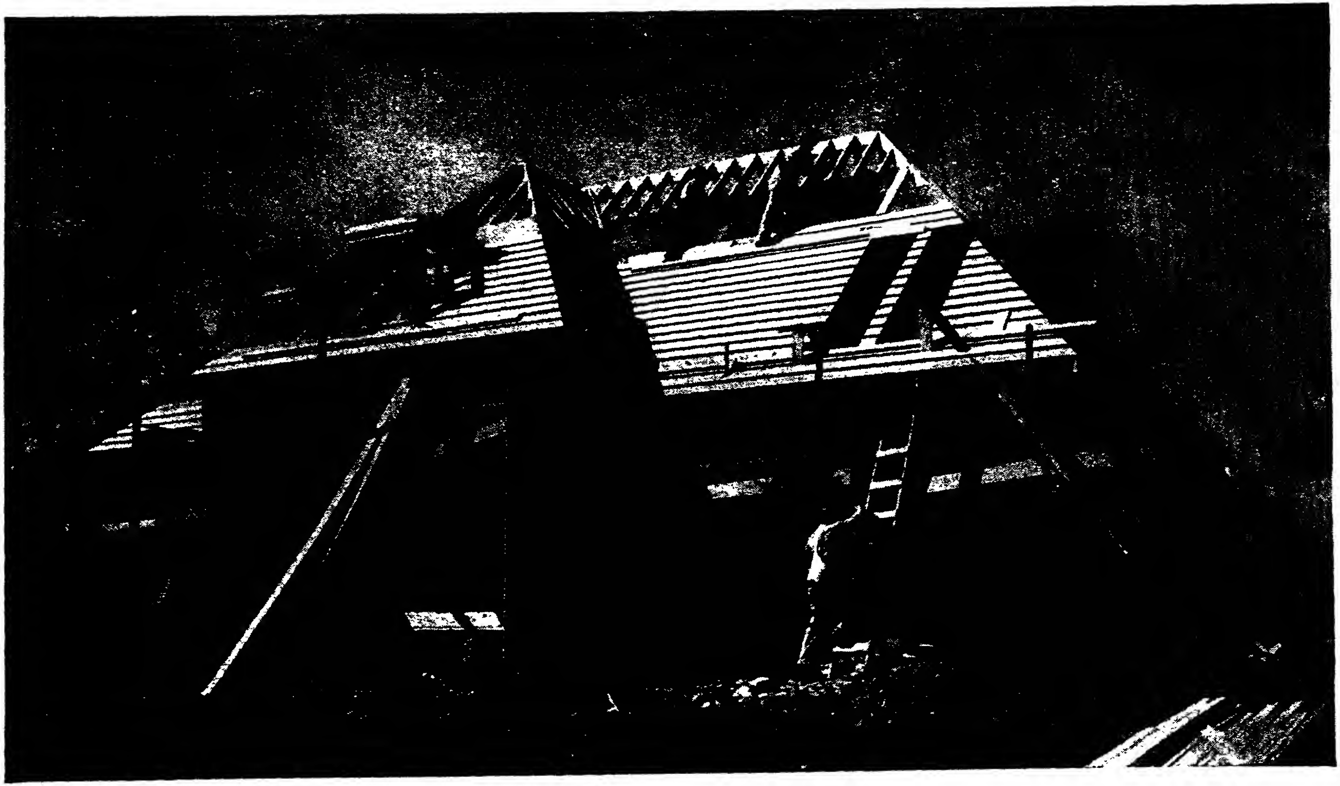
Good housekeeping on the part of the carpenter is essential for the safety of the workmen, and also increases production. Therefore, the carpentry student should learn early the importance of keeping his materials in an orderly manner, and the ground or floor free from debris or rubbish of any kind.

CHECKING ON YOUR KNOWLEDGE

The following questions give you the opportunity to check up on yourself. If you have read the chapter carefully, you should be able to answer the questions. If you have any difficulty, read the chapter again so you will have the information well in mind before you go on with your reading.

DO YOU KNOW

1. Why it is important to frame a house so the shrinkage of timbers will be equalized?
2. The three most important parts of any structure?
3. How to determine the size of girders required for a new building?
4. Three different methods of construction for supporting joists on girders?
5. In what type of framing, ribbons are commonly used to support the ends of joists?
6. What is meant by the term *bridging?*
7. Where *headers* are commonly used in a building?
8. What type of steel beam is used in *The House of the Book,* and where it is located?
9. What type of sheathing gives both rigidity and insulation values to a building?
10. Why the foundation walls of *The House* are not all of the same thickness?



CARPENTERS APPLY FIR-TEX ASPHALT-COATED RIGID INSULATION SHEATHING TO THE ROOF AND SIDES OF THIS HOUSE

Courtesy of American Builder

CHAPTER IV

Roof Framing

QUESTIONS THIS CHAPTER WILL ANSWER

1. *What style of roof is the simplest in construction?* 2. *What style of roof is most commonly used for small houses?* 3. *What is the meaning of the term bird's-mouth, as used by carpenters?* 4. *What names are given to the five different kinds of rafters commonly used when framing a roof?* 5. *Do you know the relationship between the span, rise, and run of a rafter?* 6. *What is meant by the term basic triangle so commonly used in roof framing?*

INTRODUCTION TO CHAPTER IV

The roof, which includes the entire construction closing the top of a building, serves an extremely important purpose as a protective covering. In addition to protecting the building and its occupants against rain, snow, and extremes of heat or cold, the roof is important, also, as a decorative feature of the house. The importance of its value as a decorative feature must not be minimized when choosing the style of roof for a new house.

The framing of the roof, or covering, of a building is one of the carpenter's most difficult problems of construction. Although roof framing does not involve a great many complicated details, the proper fitting together of the various members is considered by some a difficult process. Hence, it is especially important for the beginning carpentry student to learn the names of the various parts of a roof and how to frame these parts, so the roof will serve the purpose for which it is intended. In this chapter the author has explained the principles of roof framing. Definite instructions are given as to how to proceed when solving a *basic triangle,* and how to apply the principles of the basic triangle to roof framing. Of special value to a carpentry student are the directions on how to cut, not only the common rafter, but also the hip, valley, jack, and cripple rafters.

To the average individual, roof framing seems extremely complicated. However, if a carpenter thoroughly understands a few simple rules of geometry and knows how to apply them to roof framing, he will be able to solve the problems involved in roof construction. It is especially important for the carpenter to have in mind an over-all picture of the finished roof before he begins construction work on it. If he is able to establish such a picture firmly in his mind, then the problems of roof framing will become less difficult for him.

The method of roof construction presented in this chapter should be read carefully by the carpentry student. The author of this text has given step-by-step instructions for laying out and framing various kinds of rafters. He has told how to find the various angle cuts for fitting together different beveled members used in roof framing. Explanations are given for finding the run, rise, and pitch of a roof. Also many other details of roof framing are discussed.

THE ROOF

The primary purpose of the roof of any building is to perform the important function of shedding water from either rain or snow. However, in addition to its primary purpose, the roof also serves as protection against the cold of winter and the heat of summer. The roof must be constructed to shed falling water as quickly as possible; consequently, it should be sloped or inclined. The most economical roof to build is undoubtedly the nearly flat roof. This type of roof serves the needs for all practical purposes in warm climates. In cold climates snow may pile up on a roof, putting an excessive load upon a flat surface, and unless special provision is made for carrying such a snow load, the roof will collapse. Regardless of where a flat roof is built, it must be made stronger than would be required for a sloping or inclined roof. A flat roof has no decorative features and does not add to the beauty of a building, hence this type of roof has been used chiefly, in the past, on commercial or industrial structures. However, in recent years the modernistic house, designed chiefly for utility and convenience, has incorporated the economy of the flat roof. The simplicity of exterior of these houses encourages the use of such a covering.

STYLES OF ROOFS

Important as its utility value may seem, the roof, if carefully designed, also adds greatly to the beauty of a building. The style of roof is important when identifying a building with the architecture of a certain historic period or of various nations. Different types of curved roofs are common in the Old World, especially in Asia, while in America straight lines seem to prevail. A few common types of roofs used in the construction of houses in this country are: *shed, gable, hip, gambrel,* and *mansard,* shown in Fig. 1.

Shed or Lean-To Roof. The simplest type of roof is the *shed* or *lean-to,* usually employed for small sheds, porches, or other places where appearance is not a matter of great importance. In circumstances where, because of necessity or convenience, it is desirable to obtain shelter as cheaply and easily as possible, the shed roof is employed.

The shed roof consists of a plain surface with one side or end raised to a higher level than the other side or end. The roof is supported in this position by means of two posts on one side and a wall against which it leans on the other side; or by posts at all four corners. The position or slope of the surface enables rain water to drain off freely.

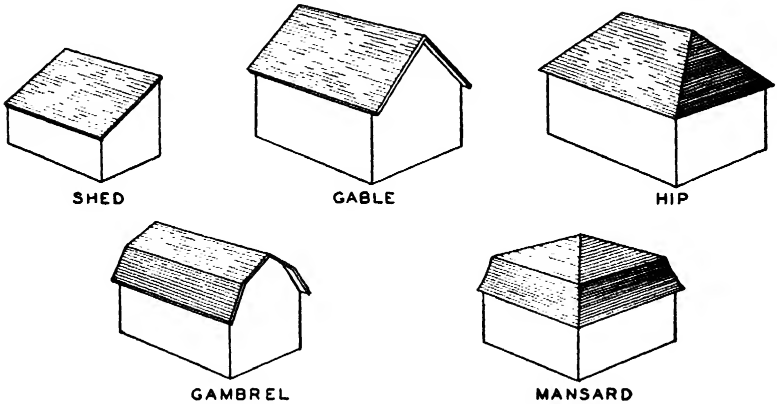


Fig. 1. Styles of Roofs in Common Use

Thus the lean-to or shed fulfills the requirements of a roof as long as it remains watertight.

Gable Roof. The ordinary *gable roof* has two sloping surfaces—one on each side of the center line of the building. These two surfaces come together in the middle of the roof at the ridge, forming a gable. Because of its simplicity of design and relatively low cost of construction, the gable roof is most commonly used for small houses. The pitch or inclination of the surface to the horizontal of the gable roof may be varied from an almost flat surface to an extremely steep slope. This type of roof can be used in combination with other types and has been so often the base of other roofs that it is sometimes difficult to distinguish the simple gable roof from among the other types which have added to the traditional styles of roofs.

Hip Roof. The *hip roof* has four sides, all sloping up toward the center of the building. The line where two adjacent sloping sides of a roof meet is called the *hip*.

Gambrel Roof. A variation of the simple gable roof is the *gambrel* *roof,* which has its roof surface broken near the middle, on both sides of the building. This type of roof is the so-called *Dutch-Colonial* house design. See Fig. 1.

Mansard Roof. A form of double-decked roof commonly used in America during Colonial days is known as the *mansard roof.* The name is supposed to have been taken from the architect, François Mansard (1598–1666), its designer. The lower slope of this roof approaches the vertical, while the upper slope is usually more or less flat. This type of roof has the advantage of providing additional space for attic rooms.

Oftentimes, a combination of two or more of these various types of roofs is used, to enhance the appearance of a building and give character to the house. Also, some definite need or purpose may require a combination of different types of roofs.

ROOF-FRAMING TERMS

Roof construction requires the use of a terminology or set of names of its own. These names must be learned and understood by a carpenter before he can proceed intelligently with the framing of a roof. The names of the various roof members are given in Fig. 2. The carpentry student should become familiar with the names of these different members, or parts of a roof, so he can readily identify them.

Ridge. The highest horizontal roof member is the *ridge,* which helps to align the rafters, and tie them together at the upper end.

Rafter Plate. The framing member upon which the rafters rest is known as the *rafter plate.*

Rafters. The sloping structural timbers of a roof designed to support roof loads are called *rafters.* These roofing members extend from the ridge or hip to the plate. In all roofs the pieces which make up the main body of the frame work are the rafters. They are to the roof what the joists are to the floor, and what the studs are to the walls. In the construction of roofs, different kinds of rafters are used. These are known as *common rafters, hip, valley, jack, and cripple rafters.*

Common Rafter. The series of framing members which extend at right angles from the plate line to the ridge or purlin of the roof are called *common rafters.* The common rafter is so-named because it is *common* to all types of roofs. It is also used as the basis for laying out other kinds of rafters used in the roof.

Hip Rafter. The roof member extending diagonally from the corner of the plate to the ridge is known as a *hip rafter.* The hip rafters form the ridges or hips where adjacent slopes of the roof meet.

Valley Rafter. The rafter extending diagonally from plate to ridge at the line of intersection of two roof surfaces is called a *valley rafter,* because it is located where adjacent roof slopes meet to form a hollow or *valley.*

Jack Rafter. There are three kinds of *jack rafters* which are a part of the common rafter. These are known as the *hip jack rafter,*

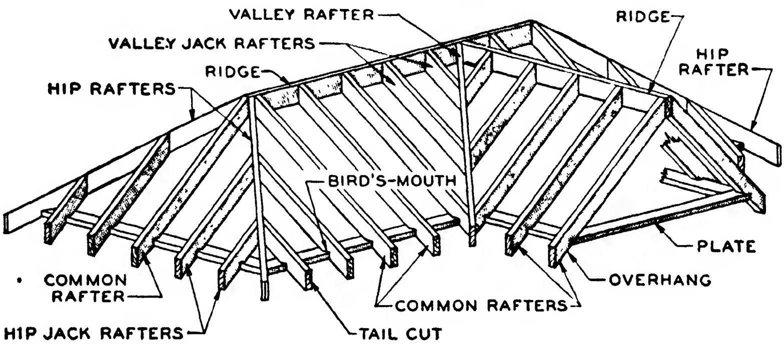


Fig. 2. Names of Various Roof Members

valley jack rafter, and *cripple jack rafter.* Two of these are illustrated in Fig. 2. The hip jack rafter extends from the plate to the hip rafter, and the valley jack rafter extends from the ridge to the valley rafter.

Cripple Rafter. A rafter which extends from a hip to a valley rafter is called a *cripple rafter,* and sometimes is called a *cripple jack rafter.* This rafter is also a part of the common rafter, but touches neither the ridge of the roof nor the rafter plate of the building.

Overhang, Lookout, or Tail Piece. The three names *overhang, lookout,* or *tail piece* refer to the same part of the roof. This is the portion of the rafter extending beyond the outside edge of the plate or walls of the building. When laying out a rafter this portion is an addition to what is considered the length of the rafter, and is figured separately.

Bird's-Mouth. The cutout near the bottom of the rafter which fits over the rafter plate is known as the *bird's-mouth.*

PRINCIPLES OF ROOF FRAMING

When you begin the study of roof framing it may seem extremely complicated. However, if you will take the trouble thoroughly to master a few basic principles, you will find your problems of roof construction considerably simplified. In addition to learning these basic principles, it is also necessary for you to be able to visualize the roof as a whole. You should be able to locate the position each rafter will have in that particular roof. Roof framing is the practical application of *geometry,* that branch of mathematics which treats of the properties and relations of lines, surfaces, and solids.

Basic Triangle. The underlying principle involved in roof framing is the right triangle, Fig. 3. The *base* of this triangle represents actual or theoretical level or horizontal lines and measurements of the roof. The *altitude* represents plumb or vertical lines or measurements, while the *hypotenuse,* which in most cases would represent the length of the rafter in question, is the bridge measure or the measurement between the base and the altitude sides of the triangle.

When the measurements or lengths of these three sides are known, we have *solved the triangle.* To solve a right triangle, we must know the value of two sides or of one side and one acute angle. In roof framing we usually have or can easily find on the drawings the values of two sides—the *rise* and *run* of the rafter.

Solving a Right Triangle. A carpenter on the job rarely resorts to the use of the mathematical method for computing the length of a rafter, yet the good mechanic should know how this is done.

In geometry we have a proposition known as the *Pythagorean Theorem,* which states that *the square of the hypotenuse of a right triangle is equal to the sum of the squares of the other two sides, or legs.* In roof framing the *legs* of the right triangle are the base or *run* of the rafter and the altitude or *rise* of the rafter. The formula for the *Pythagorean Theorem* is written as follows: $c^2 = a^2 + b^2$, when *c* represents the *hypotenuse; a* represents one leg or the *altitude;* and *b* represents the other leg or *base.*

The application of this formula is shown graphically in Fig. 4. In the right triangle, *A B C,* the value of the base, *b,* is given as *4.* When this number is squared or multiplied by itself the result is *16.*

The value of the altitude, *a,* is given as *3*. This number squared or multiplied by itself is *9*. When 9 is added to 16 the sum is *25,* the square of the hypotenuse, *c*. The final step in solving this triangle is to find the value of *c* by extracting the square root of the sum *25*. In

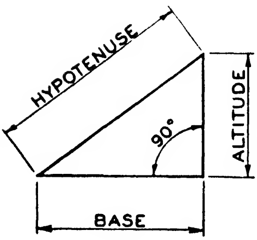


Fig. 3. Right Triangle—Basic Triangle Used in Roof Framing

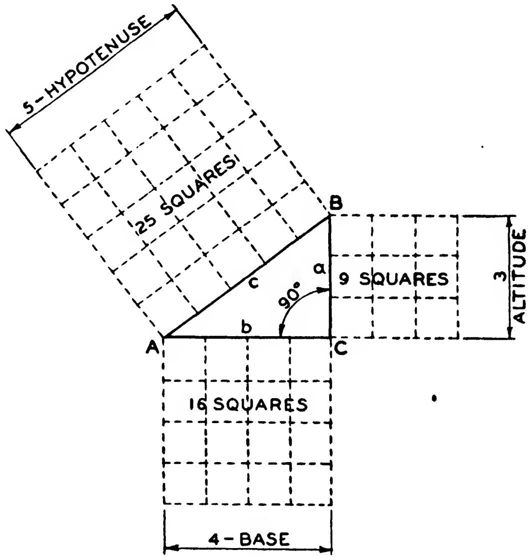


Fig. 4. Right Triangle Showing Relation between Values of the Three Sides

other words, it is necessary to find a number which when multiplied by itself equals 25. In this case it is easy to find that number, which by simple arithmetic we know to be *5*. The method of extracting the *square root* of a number of three figures or more is shown in Fig. 5.

EXAMPLE

To find the value or measurement of *c*, the hypotenuse, in the formula $c^2 = a^2 + b^2$, when *a*, the altitude, is 14 and *b*, the base, is 20. Substitute these values in the formula: $c^2 = 14^2 + 20^2$. Since 14 squared equals 196 and 20 squared equals 400, then c^2 equals 596, the sum of 196 and 400. The final step in this process is to find the value of *c,* the hypotenuse, by extracting the square root of *596*.

PROCEDURE

Square Root. **The process of finding one of the two equal factors of a number is called *extracting the square root.* The symbol used to indicate the**

root of a number is √ and is called the ***radical sign.*** The number of which the root is to be found is placed under the radical sign. Hence our problem is to find $\sqrt{596.}$

	2 4. 4 1 3
	5′96.00′00′00
	4
Trial divisor is.............. 4	1 96
Complete divisor is......... 44	1 76
Trial divisor is............. 48	20 00
Complete divisor is........ 484	19 36
Trial divisor is............ 488	64 00
Complete divisor is....... 4881	48 81
Trial divisor is........... 4882	15 19 00
Complete divisor is...... 48823	14 64 69

$\sqrt{596} = 24.413$

Fig. 5. Method of Finding Square Root of a Number

1. The first step in finding the square root of a number is to separate the number into periods or groups of two figures each, beginning at the right if the number is a whole number. Place a mark between the periods. When the root of a number containing a decimal is to be found, the division of the number into periods is made by starting at the decimal point and marking off the periods to both the right and left from the decimal point. (The two figures of a period must never be separated by a deeimal point.)

2. Since the number 596 is not a perfect square, the root contains a decimal fraction. Place a decimal point at the right of the number, then add six zeros. Beginning at the decimal point, mark off the periods both to the right and left of the decimal point. Place a mark between the periods. The left-hand period has only one figure.

3. Consider the first period at the left, which is 5. Then find the largest number which, multiplied by itself (or squared), is equal to, or a little less than, 5. The number is 2. Now draw a straight line over the number 5 96.00 00 00, as shown in the illustration, Fig. 5. Place the figure 2, which is the first figure of the root, above the line in the position shown in Fig. 5. Square the 2 and place the result, 4, under the 5, and subtract. The remainder is 1. Place the next period, 96, to the right of 1, as shown in the illustration.

4. Draw a vertical line to the left of the number 596.000000, as shown in Fig. 5. Multiply 2, the first figure of the root, by 2 and place the product, 4, as ***trial divisor,*** to the left of the vertical line and opposite 196. Divide 19, the first two figures of 196, by 4. The lowest number of times that 4 will go into 19 completely is 4. This 4, then, is the second figure in the root. Place this figure in the root in the position shown in Fig. 5, and also to the right of the trial divisor, giving 44 as the *complete divisor.* Multiply 44 by the 4 just placed in the root, and place the product, 176, under the 196, and subtract.

The remainder is 20. Bring down the next period, 00, and place it to the right of this 20, giving 2000. Proceed with the process of finding the root, disregarding the decimal at this time.

5. Multiply the 24, which is now in the root, by 2, and place the product, 48, the new *trial divisor,* to the left of the vertical line, opposite to 2000.

6. Divide 200, the first three figures of 2000, by 48. The result, or quotient, is 4. Now place 4 as the third figure in the root, and also at the right of the trial divisor, giving 484 as the *complete divisor.* Multiply 484 by the 4 just placed in the root, and place the product, 1936, under the 2000, and subtract. The remainder is 64. Bring down the next period, 00, and place it to the right of the 64, giving 6400.

7. Multiply the 244, which is now in the root, by 2, and place the product, 488, the new *trial divisor,* to the left of the vertical line and opposite to 6400.

8. Divide 640, the first three figures of 6400, by 488. The quotient is 1. So place 1 as the fourth figure in the root, in the position shown in the illustration, and also at the right of the trial divisor, giving 4881 as the *complete divisor.* Multiply 4881 by the 1 just placed in the root, and place the product, 4881, under the 6400, and subtract. The remainder is 1519. Bring down the next period, 00, and place it to the right of the 1519, giving 151900.

9. Multiply the 2441, which is now in the root, by 2, and place the product, 4882, the new *trial divisor,* to the left of the vertical line, opposite to 151900.

10. Divide 15190, the first figures of 151900, by 4882. The quotient is 3. Place 3 as the fifth figure in the root, and also to the right of the trial divisor, giving 48823 as the *complete divisor.* Multiply 48823 by the 3 just placed in the root, and place the product, 146469, under the 151900. If it is necessary or desirable to find additional figures of the root, the same procedure can be continued by adding more zeros. However, for most practical purposes carrying the root to three decimal places will be sufficient.

11. We must now place the decimal point in the root. To do this correctly it is necessary to remember there are always just as many figures in the whole number in the root as there are periods in the whole number of which we are finding the root; and there are always just as many figures in the decimal part of the root as there are periods in the decimal part of the number of which we are finding the root. In this problem there are two periods in the whole number, 596, so there will be two figures in the whole number of the root. There are three periods in the decimal part of the number, so there will be three figures in the decimal part of the root. The required root is 24.413.

12. To prove the root found, multiply it by itself, that is, square the root. Since 596 is not a perfect square, the proof will not give the exact square, but will be close to it.

Right Triangle Applied to Roof Framing. When framing the roof, the basic triangle, that is, the right triangle, is formed by taking the *total run* or *base,* which is one-half of the span, the *total rise* or *alti-*

tude, and the *total length of the rafter,* the *hypotenuse,* as shown in Fig. 6.

The Span. The spread of the roof, or the shortest distance from outside to outside of the rafter plates of the building, is known as *the span.* The span distance is always given on the blueprints, where it is easily found. The span measurement can also be found by actually measuring the distance between the outside walls of the building under construction.

Total Run. The base of the triangle, or the shortest distance which a rafter extends in a horizontal or level line, is known as *the run.* In equally pitched roofs, as the gable roof, with the rafter plate at the

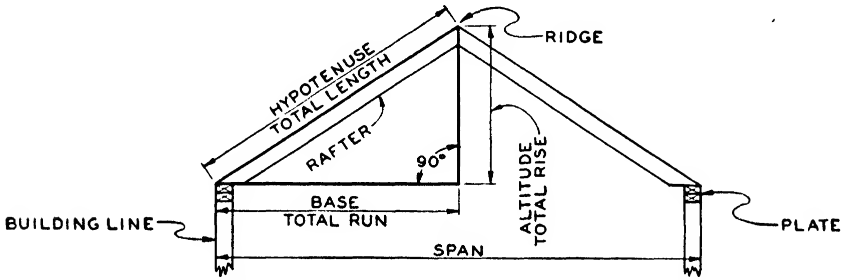


Fig. 6. Basic Right Triangle Applied to Roof Framing

same height, the run is always equal to one-half of the span, which usually is one-half the width of the building. The *total run* is measured from a plumb line through the center of the ridge or highest point of the rafter to the outer edge of the plate.

Total Rise of Rafter. The altitude of the triangle is the vertical or plumb distance a rafter extends upward from the plate. This vertical distance is known as the *total rise of a rafter,* as shown in Fig. 6. The total rise is seldom shown on the drawings or blueprints of a building, but the *rise* can be found by scaling the drawing or by the process of computation.

Total Length of the Rafter. The hypotenuse of the triangle, the distance between the edge of the rafter plate and the ridge, is known as the *total length of the rafter.* The length of a rafter can be found by different methods, as (1) by the mathematical process previously explained in finding the square root; (2) by laying the rafter out by the *step-off* method with the framing square; (3) by using the tables stamped on the rafter-framing square; or (4) scaling the rafter by using the 1/12th scale found on the outer edge of the back of the framing square.

You will observe that the rafter is the hypotenuse, and is the only visible part of the triangle shown on the roof. The base (total run) and the altitude (total rise) are only theoretical; that is, although they have actual values they are not actually seen on the roof. Hence they must be visualized by means of a mental picture of the triangle when applied to roof framing. Since the illustrations will help you to fix such a picture in your mind, you should study the illustrations carefully.

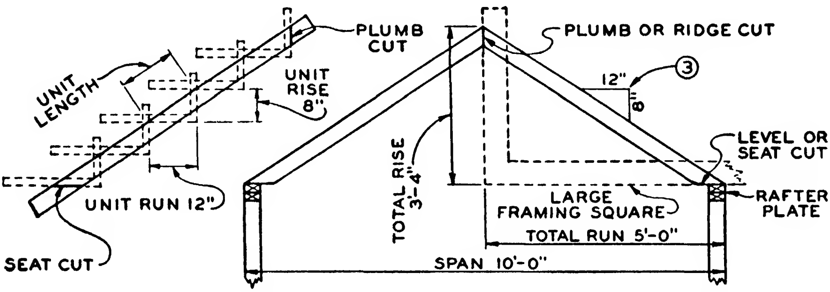


Fig. 7. Relation of Unit Measurement to Total Measurement of Whole Roof

Unit Measurements. If we had a framing square large enough so we could hold it against the side of a common rafter, as shown in Fig. 7, then we could find the total run on the blade of the square and the total rise on the tongue. The seat of the rafter, which fits on the plate, could be found on the blade of the square, and the plumb, or ridge cut, could be found on the tongue. The bridge measure, that is, the distance between these two cuts, would be the *total length of the rafter*. The use of such a large-size framing square would greatly simplify the rafter layout, but since no such square is available, we must use the standard-size framing square in different positions, as shown in Fig. 7, using the same figures on the blade and tongue of the square in each position. The smaller measurements are units or parts of the whole. They are called *unit run, unit rise,* and *unit length,* Fig. 7.

Unit measurements play an extremely important role in rafter layout; by the use of unit measurements the rafter length can be determined. The cut at the ridge, the cut at the rafter plate, and the overhang of the rafter are always laid out by use of unit measurements. Side cuts and other necessary information can be obtained, also, by using the unit measurements. In other words, the unit measurements, when used in connection with the framing square, will give practically all the facts and figures necessary in the framing of a roof. Unit measurements are the basis for rafter layout.

Unit Run. Any unit of linear measure may be used for the *unit run.* However, the foot is an established unit of measurement and since building measurements are based upon the foot and fractions thereof, it is only natural that the foot, or 12 inches, be accepted as the unit of run in roof framing.

Unit Span. Since the run of a rafter is one-half of the span of the building, and since in general practice the unit run of 12 inches has been accepted, it follows, then, that the *unit span* would be twice the unit run or 24 inches.

Unit Rise. The rise in inches that the rafter extends in a vertical or plumb direction for every foot of unit run is the *unit rise.* The slope of a roof is usually expressed in terms of unit rise, indicated as at (*3*), Fig. 7, rather than in terms of total rise.

Unit Length of Rafter. The bridge measure or the hypotenuse of the right triangle, formed by the unit run (12 inches) and the unit rise, is the *unit length of the rafter.*

Application of Unit Measurements. In a building with a total span of 10 feet and a unit rise of 8 inches there are 5 units of 12 inches each in the total run, since the total run is 5 feet (one-half the span), as shown in Fig. 7. Five units of rise (8 inches) will equal a total height of 40 inches, which is the *total rise* of the roof. The unit rise and unit run, when taken on the square, will give a unit of length. Five units of this length taken together will be equal to the *total length of the rafter* that has a total run of 5 feet. The *seat cut* is laid out along the blade of the square and the *plumb,* or *ridge cut,* on the tongue. Thus by taking these unit measurements 5 times we can obtain the same results we would obtain if we had a large-sized square on which the total run and total rise could be found.

Pitch. The slope or angle of the roof from the ridge to the plate is called *the pitch.* It is the ratio of the *total rise* of the roof to the *total width* of the building, which is the *total span,* or it is the ratio of the *unit rise* to the *unit span.*

RULE I. *To find the pitch of a roof, divide the rise by the span.*

RULE II. *To find the rise of a roof, multiply the pitch by the span.*

EXAMPLE

As shown in the illustration, Fig. 7, the total span or width of a building is 10 feet; the total rise of the roof is 3 feet 4 inches; the unit rise of the roof is 8 inches; and the unit span is 24 inches.

Note: The unit span of 24 inches is the same for all buildings or roofs, but the unit rise varies in different buildings.

PROCEDURE

1. *Find the pitch of a roof when the total rise and total span are given.* Apply Rule I—$\frac{\textit{total rise}}{\textit{total span}} = \textit{pitch};$ then in our problem—$\frac{3\frac{1}{3}}{10} = \frac{1}{3}$. Therefore, the pitch of this roof is $\frac{1}{3}$.

2. *Find the pitch of a roof when the unit rise and unit span are given.* Again apply Rule I—$\frac{\textit{unit rise}}{\textit{unit span}} = \textit{pitch}.$ Then in our problem—$\frac{8}{24} = \frac{1}{3}$, the pitch of this roof is again shown to be $\frac{1}{3}$.

3. *Find the total rise of a roof when the pitch and total span is given.* Apply Rule II—*total span* × *pitch* = *total rise.* Then in our problem—$10 \times \frac{1}{3} = 3\frac{1}{3}$. Therefore, the *total rise* of this roof is 3 feet and 4 inches.

4. *Find the unit rise of a roof when the unit span and pitch are given.* Again apply Rule II—*unit span* × *pitch* = *unit rise.* Then in our problem—$24 \times \frac{1}{3} = 8$. Therefore, the *unit rise* of this roof is shown to be 8 inches.

The roof pitches in common use are indicated in Fig. 8. The pitch or slope of a roof may be indicated also in terms of degrees. For example, as shown in the illustration, Fig. 8, when the unit rise is 12 inches and the unit run is also 12 inches, the angle of pitch is 45 degrees. However, finding the pitch in degrees is not common practice.

The Cut or Layout Unit. The *cut of a roof* is the unit of rise in inches and the unit of run (12″), as shown in Fig. 9. In the illustration, Fig. 8, the unit of run is measured on the tongue of the square and the unit of rise is measured on the blade. However, in common practice, when laying out the *cut,* the unit run (12″) usually is taken on the blade of the square and the unit rise is taken on the tongue,

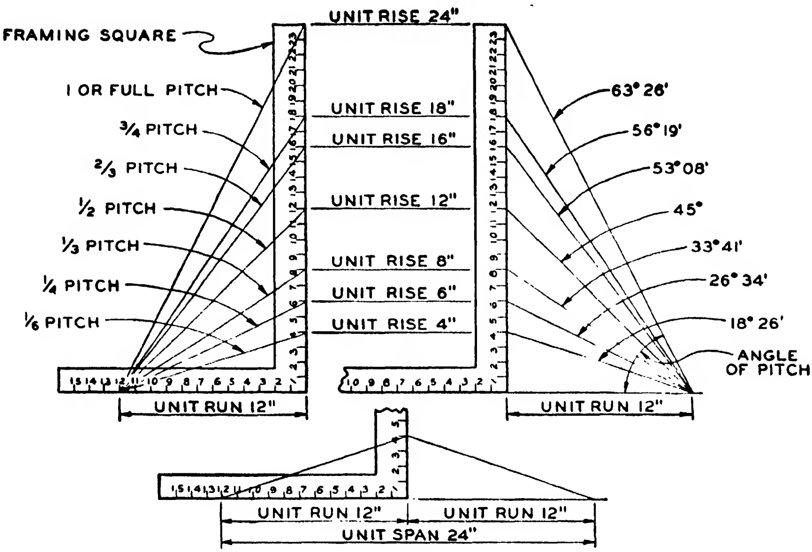


Fig. 8. Common Roof Pitches with Unit Rises and Degrees of Angles Formed

as indicated in Fig. 9. The unit of run usually is greater than the unit of rise, and in layout work, as shown in Fig. 9, the square has a better balance when the unit of run is taken on the blade and the unit rise is taken on the tongue.

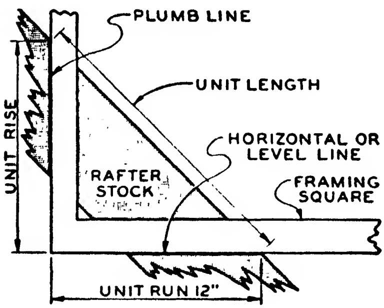


Fig. 9. Cut of the Roof—Unit Run and Unit Rise

The *plumb cut* is marked along the tongue, as indicated in Fig. 9. The *seat cut,* or *level line,* is marked along the blade. A *plumb line,* Fig. 9, is any line that is vertical when the rafter is in position in the roof. Any line that is horizontal or level when the rafter is in the proper position is called a *horizontal* or *level line,* as shown in Fig. 9.

Therefore, it is necessary for the workman, while laying out a rafter, to think constantly of how that rafter will fit into the roof; that is, the carpenter must visualize that particular rafter as it will appear when in its final position in the completed roof. Forming this habit of visualizing the rafter in its proper position will prevent the occurrence of errors in layout.

ROOF PLAN

In the framing of any roof, regardless of how simple the construction may be, a plan of the roof is necessary. This does not mean that the workman must necessarily *draw* such a plan, but he must have the plan in his mind and be able to visualize the roof and see how it is to be framed. However, the inexperienced carpenter will find it difficult to visualize the general position of the main members of the roof, such as the *ridge, hips, valleys,* and *decks,* by merely looking at the architectural plans or elevation drawings. Even though simple, a more detailed plan will be a great help to the carpenter in his efforts to analyze the roof and to understand how the various roofing members are to be fitted together. For a complicated roof for a new building the architect frequently supplies a roof plan. When such a plan is not included in the architectural drawings the carpenter must develop his own plan. This can be accomplished without much difficulty by drawing the main framing members (ridge, hips, valleys, and decks) on the second-floor plans of the working drawings. This roof plan will give the inexperienced carpenter a general idea of how to proceed with his framing work.

For a roof such as the one shown in Fig. 2, a roof plan will look like the plan shown in Fig. 10. This drawing shows the over-all dimensions of the building and the amount of the overhang, also the location of the major framing members. The plan also shows the type of construction at the intersection of hips and ridge, together with the type of construction at the intersection of the valley and ridge.

The Ridge. The highest framing member of a roof is called *the ridge.* The ridge piece serves a twofold purpose; it helps to align the various roof members and ties them together at the top. The shed roof does not require a ridge piece, and the simple gable roof can be built without such a piece. However, the erection of any type of gable roof will be simplified by the use of a ridge piece.

Gable Ridge Lengths. Finding the length of the ridge on a gable roof is a simple process, since for a two-slope gable roof the ridge piece is always the same length as the length of the building.

Hip-Roof Ridge Lengths. In an equal-pitch hip roof such as the one shown in Fig. 10, there are two lengths on the ridge—the theoretical length and the true length of the ridge. The theoretical length of a ridge on a hip roof is equal to the length of the building minus the run of the common rafter on each hipped end. A full-hipped roof requires rafters on all four corners, as in Fig. 10. In an equal-pitch

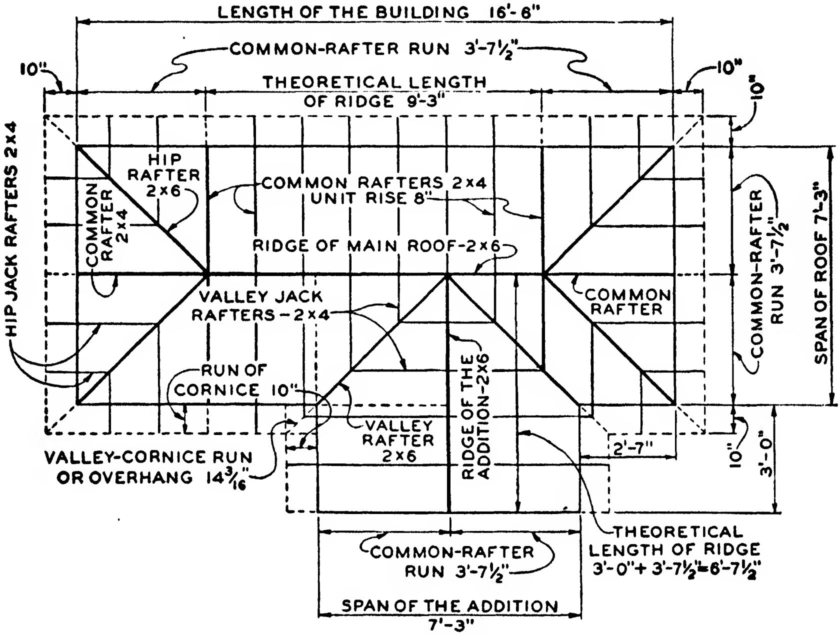


Fig. 10. Plan of the Roof Illustrated in Fig. 2

roof, such as the one shown in Fig. 10, the theoretical length of the ridge is found by subtracting the width or span of the building from the length of the building. For example, as illustrated in Fig. 10, when the length of the building is 16 feet 6 inches and the span or width is 7 feet 3 inches, the theoretical length is 9 feet 3 inches (16′6″ minus 7′3″).

True Lengths for Hip-Roof Ridge. Two common methods of framing hip rafters at the ridge are illustrated in Figs. 11 and 12. In Fig. 11 the hip rafter is shown framed against the common rafters. When using this method, one-half the thickness of the common rafter must be added to each end of the theoretical length of the ridge, as shown in the illustration, Fig. 11.

In an equal-pitch hip roof the hip rafter always meets the ridge at an angle of 45 degrees. In a plan view such as Fig. 10 the length of the intersection of a hip rafter with the ridge is called *the 45-degree*

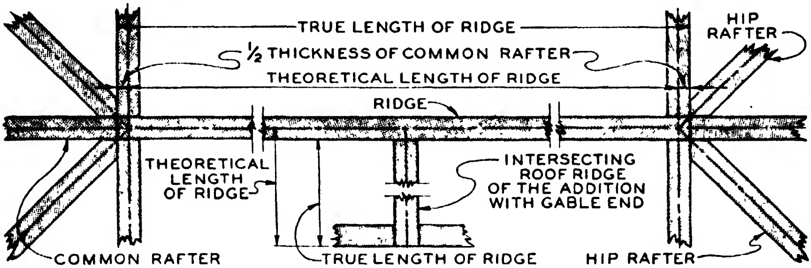


Fig. 11. Theoretical and True Ridge Lengths with Hips Framed against Common Rafter and Ridge Length for Intersecting Roof with Gable End

thickness of the rafter. This is shown in Fig. 12, where the hip rafters are framed against the ridge piece. When using this method of framing the hip rafter, one-half the thickness of the ridge piece plus one-half the 45-degree thickness of the hip rafter must be added to each end of the theoretical length of the ridge, as shown in Fig. 12.

Intersecting Roof Ridge. On an intersecting roof that has a gable end, and a pitch equal to that of the main roof, as in Fig. 10, the theoretical length of the ridge is equal to the length of the rafter plate of the addition plus the run of the common rafter of the addition. If the addition has the same span as the main roof, as in Fig. 10, the run of the common rafters of each roof will be the same and the ridges of the two roofs will meet on the same level.

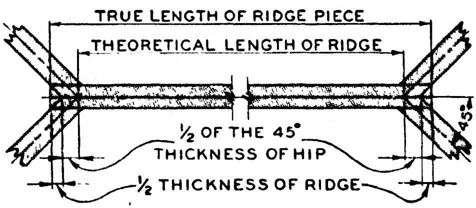


Fig. 12. Theoretical and True Ridge Length with Hips Framed against Ridge

True Length of Intersecting Roof Ridge. The true length of the intersecting roof ridge is equal to the length of the rafter plate, plus the run of the common rafter, minus one-half the thickness of the ridge piece on the main roof, Fig. 11.

If the addition has a hip roof, then the theoretical length of the ridge is equal to the rafter-plate length. The true length of the ridge, if the hips are framed as in Fig. 11, is equal to the rafter-plate length, minus one-half the thickness of the ridge piece of the main roof, plus one-half the thickness of the common rafter. If the ridge of the main roof is of the same thickness as the common rafter, then the true length of the ridge of the addition will be the same as the length of the rafter plate of the addition.

When the span of the addition or intersecting roof is smaller than that of the main roof, the ridge of the addition will be lower and

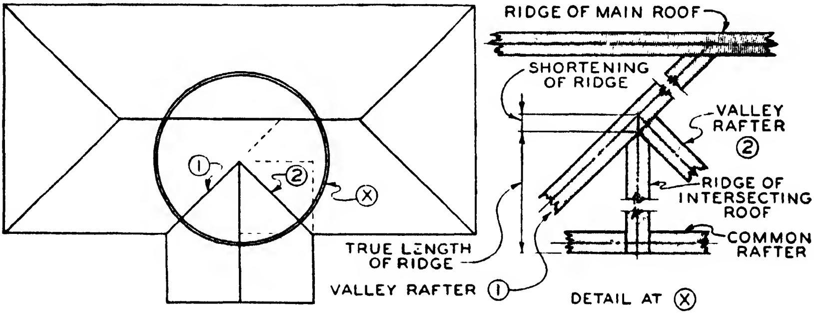


Fig. 13. Relatively Small Intersecting-Roof Ridge Framed against Valley Rafter Which Extends to Ridge of Main Roof

will not meet the ridge of the main roof. In such a case, the ridge of the addition can be extended through the main-roof slope and be suspended from the main-roof ridge; or one valley rafter can be carried up all the way to the ridge of the main roof, as shown by the dotted lines in Fig. 13. If the addition has a gable end, and the valley rafter is carried up to the ridge, the true length of the ridge on the addition will be equal to the length of the rafter plate, plus the run of the common rafter of the addition, minus one-half the 45-degree thickness of the valley rafter, as shown in the detail drawing at (X), Fig. 13.

Common Rafter. The common rafter is that member of the roof which extends at a right angle from the rafter plate to the ridge piece or to a purlin. It takes its name, *common rafter,* from the fact that it is common to all types of roofs and is used as a basis for the *layout* process when finding the length and cuts of other rafters.

There are several different methods used to find the lengths of rafters. However, the step-off method seems to be the most commonly used, and this is the first method to be considered in this discussion. This method employs the unit measurements and other roof-framing principles previously explained in detail.

Laying Out a Common Rafter. When a certain procedure for doing some specific job is to be repeated frequently, it will help to

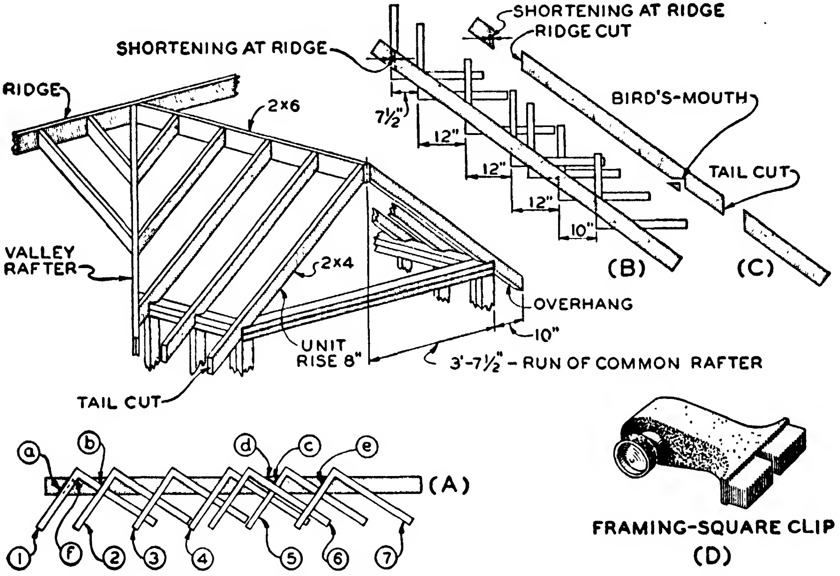


Fig. 14. Step Method Used in Laying Out Common Rafter for Gable Roof
(*A*) Position of Rafter and Square When Laying Out Rafter; (*B*) Relation of Layout to Rafter in Roof; (*C*) Rafter Pattern Showing Cut Outs for Ridge, Tail, and Bird's-Mouth

reduce the number of errors of omission, and consequently speed up production, if the workman develops a system or method for that particular procedure. The following steps of procedure for laying out a common rafter are set up with these advantages in mind.

When laying out the rafter pattern by the step-off method the framing square is applied to the piece of timber as shown at (*A*), Fig. 14. The workman must be able to visualize the relation of this layout to the position of the rafter in the roof, as shown at (*B*), Fig. 14. When completed and cut out the common-rafter pattern will appear as at (*C*), Fig. 14.

EXAMPLE

Lay out a common rafter for a roof which has a span of 7 feet 3 inches, a unit rise of 8 inches, a 2½-inch heel, an overhang run of 10 inches, a 2x6 ridge, and a plumb tail cut. (Figs. 2 and 10.)

1. Find the total run of the rafter.
2. Determine the unit rise.
3. Selecting rafter stock.
4. Stepping off the rafter length.
5. Bird's-mouth and heel.
6. Layout of overhang and tail cut.
7. Shortening rafter at ridge.

1. Find the Total Run of the Rafter. In a gable roof the total run of the common rafter is equal to one-half the span, as shown in Fig. 7. In our problem the span of the building is given as 7 feet 3 inches. Then *the total run of the rafter* is 3 feet 7½ inches or one-half the span, as shown in Fig. 14.

2. Determining the Unit Rise. The unit rise is usually indicated on the drawings for the building, as shown at (*3*), Fig. 7, or it is stated in the specifications. In our problem the unit rise is given as 8 inches. In case the unit rise is not given, the carpenter can find the rise by drawing a *level line* through the roof on the drawings of the elevation. Then measuring the distance of the unit run (12″) from the roof line, using the same scale as that of the drawing and locating a point on the level line. Through this point, which will be 12 inches from the roof line, draw a vertical line to the roof. The length of this line will be the unit rise of the roof. For example, see Fig. 14, where the unit rise is given as 8 inches.

3. Selecting Rafter Stock. From the stock of lumber available, select a piece of the correct size for the rafter pattern. This should be the best straight piece in the entire pile of stock. Lay the piece on a pair of sawhorses with the crowned edge, or curved side of the stock, turned toward you (the workman). It is a good plan to make a record of all the necessary information about the rafter which is to be laid out. This can be done easily by writing the necessary information, such as the length of the span, rise, and run, on the piece of stock near to the left end where you will begin the layout, as shown at (*D*), Fig. 15.

4. Stepping Off Rafter Length. When using the step-off method, proceed as follows.

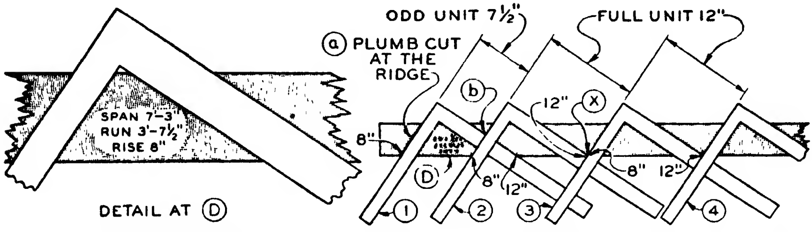


Fig. 15. Laying Out Ridge Plumb Cut, Odd Unit, and Full Unit of Common Rafter

PROCEDURE

a) Lay the framing square on the piece of stock to the *cut of the roof,* that is, 8 inches the unit rise and 12 inches the unit run, near the left end of the piece, Fig. 15. Take the unit rise on the tongue and the unit run on the blade of the square. Extreme exactness is of great importance in this operation. To insure accuracy, it will be necessary to use either a sharp hard pencil or a knife. The figures taken on the square (8 on the tongue and 12 on the blade) must be on the edge of the stock turned toward you (the workman). Greater accuracy can be obtained by the use of framing-square clips, such as the one shown at *(D),* Fig. 14.

b) Hold the square in position *(1),* Fig. 15. Draw the plumb or ridge line *(a)* along the tongue of the square.

c) *Odd Unit.* When the total run of a rafter is given in feet and inches, the inches become what we will call the *odd unit.* To avoid omission it is advisable to allow the first step to be the odd unit. Therefore, while the square is in position *(1),* Fig. 15, locate 7½ inches on the blade (the run side of the square) and mark the stock at this point *(b),* Fig. 15.

d) *Full Units.* Move the square to position *(2),* holding it to the *cut* and up to the *odd-unit* mark. Then draw a line along the blade on the edge of the stock at *(X),* Fig. 15, thus laying out the first full unit. Continue with two more full units *(3)* and *(4),* Fig. 15, holding the square exactly to the marks each time. This will give three full units which are equal to the three feet of run of the rafter. The point *(Y)* of the last full unit, Fig. 16, is the building line on which the bird's-mouth is to be laid out.

5. Bird's-Mouth and Heel. When the rafter has an overhang, the rafter piece is cut out at the plate with a *seat* or *level cut* and a *plumb cut* to fit around the plate. This cut out is called the *bird's-mouth,* Fig. 16. The plumb line of the bird's-mouth, extended up, forms the *heel* of the rafter, as shown in Fig. 16. It is the heel which establishes a measuring point in laying out the main rafter lengths. Therefore, the heel is of considerable importance.

The size of the heel at the building line is governed by the strength required to carry the overhang. If the overhang is long, the thickness of the rafter at this point must be relatively greater. A heel of 2½ inches, as given in our problem, is sufficient for the average overhang and will leave a good-sized seat or horizontal cut in the bird's-mouth for fastening the rafter to the plate.

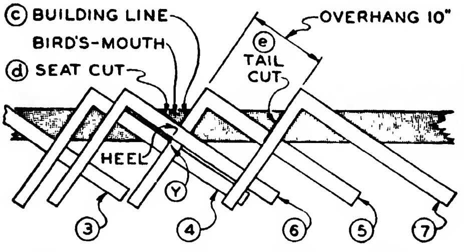


Fig. 16. Laying Out at Building Line Bird's-Mouth, Tail Cut, and Overhang

The heel on the rafter will raise the rafter, but will not alter the pitch of the roof nor the shape of the basic triangle, Fig. 6; neither will it affect the length of the rafter. The length of the rafter at (*B*), Fig. 17, is the same as at (*A*), Fig. 17, its theoretical length, because the ridge cut and the heel cut of (*B*) are both plumb cuts. Therefore, the lines are parallel. The heel, then, merely raises the entire rafter straight up without affecting it in any other way.

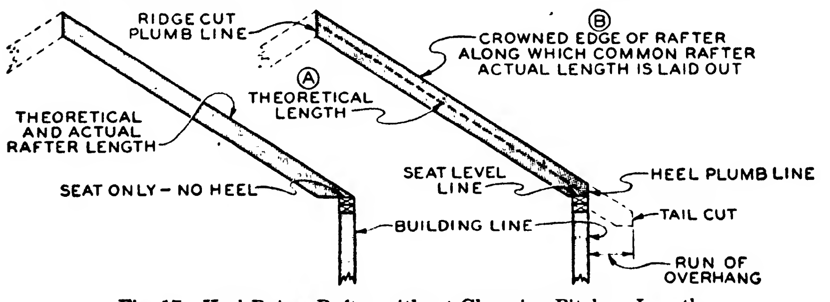


Fig. 17. Heel Raises Rafter without Changing Pitch or Length

To lay out the bird's-mouth, move the square to position (*5*), Fig. 16. Then draw the building line (*c*), which is a plumb line parallel with the ridge line. Lay out the heel on this line, measuring from point (*Y*). Move the square to position (*6*) and draw the seat cut (*d*). The bird's-mouth is thus formed by the seat cut and the building line below the heel.

This will complete the layout of the theoretical length of the rafter that has a run of 3 feet 7½ inches, with an 8-inch unit rise.

6. Layout of Overhang and Tail Cut. At the lower end of the rafter, that part which extends beyond the building line known as the *overhang*. In the layout process, this portion of the rafter is treated separately, since it is an addition to the theoretical length of the rafter. In our problem, the run of the overhang is given as 10 inches. Therefore, hold the square in position (*5*), Fig. 16. Take the figure 10 on the blade of the square and place the tongue on the building line coinciding with it. Mark the stock at the point 10 on the blade of the square. Then move the square to position (*7*), cut of rafter, and draw the line for the tail cut (*e*), Fig. 16. This line will be parallel to the building line, Fig. 17, and will allow for an overhang run of 10 inches, the overhang run called for in the example.

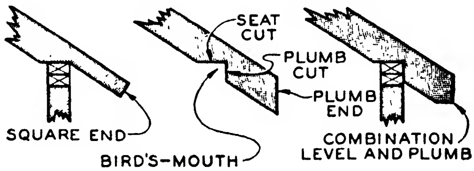


Fig. 18. Three Types of Finish for Tail Cuts for Ends of Rafters on Overhang

The tail cut or rafter end may be finished in one of various ways. Three different methods are shown in Fig. 18. When the finish for the overhang of a roof rafter is not shown on the architectural drawings nor mentioned in the building specifications, then the carpenter or builder must decide upon the type of design to use. The rafter ends are sometimes enclosed by a cornice. In such a case, the cornice construction will determine how the rafter ends should be cut.

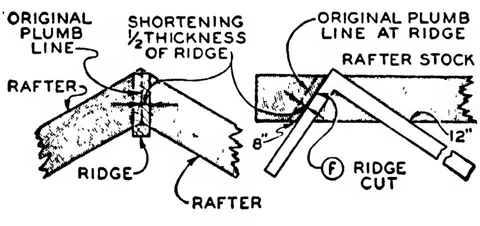


Fig. 19. Shortening Rafter at Ridge

7. Shortening Rafter at Ridge. The ridge piece for a roof can be of either 1- or 2-inch material. However, the 2-inch stock will provide a good nailing base for the rafters, and will also insure better alignment of the various roof members. On a roof without a ridge piece, the common rafters will meet as shown by the dotted lines in Fig. 19. When a ridge piece is used, a part of the rafter stock must be cut away so the rafter will remain in the same position. The ridge cut, then, will be a second line parallel to the first line, at a point on the rafter back one-half the thickness of the ridge piece.

In our problem the ridge piece is specified as a 2x6, of which the exact thickness will be 1¾ inches. Therefore, the rafter pattern must be shortened ⅞ of an inch, or one-half the thickness of the 2x6. Measure ⅞ of an inch at right angles to the original plumb ridge line. Lay the square to the *cut* of the rafter (8 for unit rise on the tongue and 12 for the unit run on the blade) and draw the plumb line (*f*), which will be the true ridge cut; that is, the line on which to cut the rafter. Since the shortening measurements are always taken at right angles to the plumb cut, the slant, or pitch, of the roof does not affect the shortening measurements.

This completes the entire layout of the common-rafter pattern. Before cutting the rafter pattern it is advisable to cross out all lines on the rafter-pattern stock, except the marks needed for making the cuts. This precaution will help to prevent errors when making the various rafter cuts. It is always advisable to check the rafter length layout by the 12th-scale method.[1] This is an approximate method which will help you to detect serious errors if any have occurred during the process of laying out the rafter pattern. If you find your first pattern is not correct in every detail, then a new pattern should be cut in order to avoid undue waste of materials.

Hip Rafters. Whenever two roof surfaces slope upward from the tops of two adjoining outside walls of a building, the sloping roof surfaces will come together in a sloping line known as a *hip*. If both roof surfaces slope upward at the same angle, the two roofs are said to be of *equal pitch*. If the roofs slope upward at different angles, they are said to be of *unequal pitch*. An equal-pitch hip roof is illustrated in Fig. 2. In this type of roof the rafters which extend diagonally from the corners of the building to the ridge board form ridges, or hips, where the adjacent roofs meet. These rafters are called *hip rafters*.

In a plan view, where the observer looks directly down on the roof plan, as in Fig. 10, a hip rafter is the diagonal of a square, as

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[1] Walter E. Durbahn, *Fundamentals of Carpentry, Vol. 1—Tools, Materials, Practice* (Chicago: American Technical Society, 1947), p. 90.

shown in the illustration. If the two roofs coming together in the hip line are of equal pitch, then the total run of the common rafters of both roofs will be the same. These two common-rafter lengths form two sides of a square of which the other two sides are outside corner walls, as shown in Fig. 10. The diagonal of this square is the total run of the hip rafter. What the plan view really shows, then, is the total run of the hip and common rafters. Therefore, it is readily seen that the run of the hip rafter is the diagonal of a square formed by two common rafters and two adjacent rafter plates of the building. If the total run of the hip rafters is the diagonal of a square formed by the total run of the common rafters, then the unit run of the hip rafter will be the diagonal of a square formed by the unit run of the common rafters. Since the unit run of the common rafter is 12 inches, the unit run of the hip rafter will be the diagonal of a 12-inch square, which is 16.97 inches, as shown in Fig. 20. The number 16.97 is so close to 17 that for all practical purposes you will find it quite satisfactory to use the number 17 instead of 16.97. Hence for every unit of common rafter run (12 inches), the hip rafter has a unit run of 17 inches. It is extremely important for you to remember this fact, because the unit run of 17 inches is as important a factor when laying out the hip rafter as the unit run of 12 inches is when laying out the common rafter.

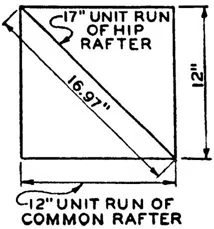

Fig. 20. Method of Finding Unit Run of Hip Rafter

To find the *plumb cut* of the hip rafter, take the unit run of 17 inches on the blade of the framing square and the figure indicating the unit rise of the common rafter on the tongue of the square. Lay the square on the rafter stock in the position shown in the illustration, Fig. 21, with the tongue near the left end of the piece. A line drawn along the outside edge of the tongue will give the angle for the *plumb cut* of the hip rafter. To find the *seat cut* of the hip rafter, hold the square to 17 inches on the blade, and to the figure indicating the unit rise on the tongue, in the same position on the rafter stock as shown in Fig. 21. A line drawn along the outside edge of the blade of the square will give the angle for the *seat cut* of the hip rafter.

Basic Right Triangle Applied to Hip Rafter. In laying out the common rafter only one right triangle is involved, as shown in Fig. 6. However, in laying out the hip rafter two right triangles must be considered, as shown in Fig. 22. The hip rafter is the diagonal of a

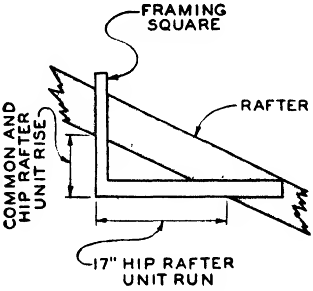

Fig. 21. Finding Cut for Hip Rafter

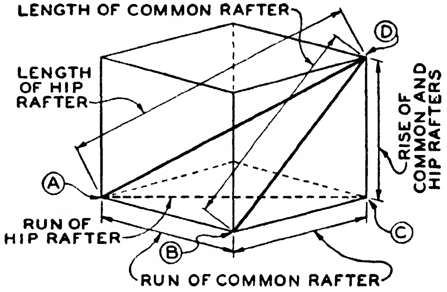

Fig. 22. Basic Right Triangle Applied to Hip Rafter

square prism which has three dimensions, while the common rafter lies entirely within one plane with only two dimensions.

We have previously found that in an equal-pitch roof, *the length of a common rafter* is the hypotenuse of a right triangle, the base of which is the total run of the rafter, and the altitude is the total rise

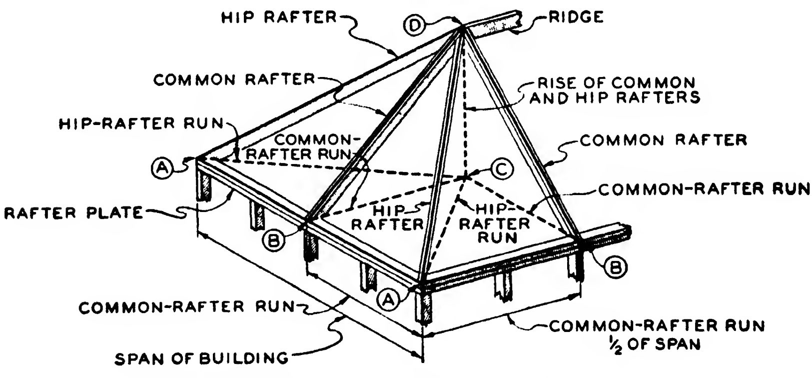

Fig. 23. Visualizing Basic Right Triangle on Roof

of the rafter, as shown in Fig. 6. *The run of a hip rafter* is the hypotenuse of a right triangle, *A B C*, Fig. 22, of which the base and the altitude are the same; that is, they are both equal to the run of the common rafter. *The length of a hip rafter* is the hypotenuse of a right triangle, *A C D*, Fig. 22, of which the base is the run of the hip rafter and the altitude is the rise of the common and hip rafters. The rise of the hip rafter is the same as the rise of the common rafter.

The relation of these basic right triangles to the rafter of a hip roof is illustrated in Fig. 23. As a carpenter, you should learn how to visualize the position of these triangles, since to be able to do this will help you to understand the principles involved in the framing of a hip roof.

Laying Out a Hip Rafter. The layout for a hip rafter, as shown in Fig. 24, is similar to the layout for the common rafter, shown in Figs. 15 and 16. However, when laying out the hip rafter, the figures taken on the framing square must be different from those used when laying out the common rafter. Also, the hip rafter has *side cuts* which

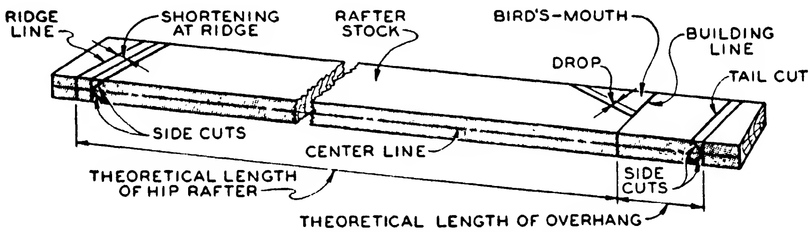

Fig. 24. Layout of Hip-Rafter Pattern

makes it necessary for the carpenter to work to a *center line,* as shown in Fig. 24.

EXAMPLE

The following layout problem is based on the roof plan shown in Fig. 10. This roof has a unit rise of 8 inches and a total common-rafter run of 3 feet 7½ inches.

1. Find the unit rise and total run of the common rafter.
2. Find the total run of the hip rafter.
3. Stepping off length of hip rafter.
4. Find the total length of the hip rafter, mathematically.
5. Backing the hip rafter.
6. Shortening hip rafter at ridge.
7. Side cuts.
8. Layout for run of the overhang.
9. Checking the hip-rafter lengths.

1. Find the Unit Rise and Total Run of the Common Rafter. In our problem the unit rise is given as 8 inches and the total run of the common rafter is given as 3 feet 7½ inches. Hence, the unit rise and total run of the common rafter are the same as those given for the equal-pitch hip roof shown in Fig. 10.

Note: When selecting hip-rafter stock, follow the same procedure as when selecting common-rafter stock. The best straight pieces of stock available should be chosen for both common and hip rafters.

2. Find the Total Run of the Hip Rafter. As shown in Fig. 22, the run of the hip rafter is the hypotenuse of a right triangle whose base and altitude are each equal to the run of the common rafter. In our problem, the run of the common rafter is given as 3 feet 7½ inches. Since the hypotenuse squared equals the sum of the squares of the other two sides of a right triangle, then $(3' 7\frac{1}{2}'')^2 + (3' 7\frac{1}{2}'')^2 =$ the square of the hypotenuse of the triangle. Reducing 3 feet 7½ inches to inches gives 43.50 inches as the run of the common rafter. Then, $2 \times (43.50)^2$ equals 3784.50 inches, the square of the hypotenuse. Extracting the square root of this number by the method explained in Fig. 5 gives 61.51 inches, or approximately 5 feet 1½ inches as the *total run of the hip rafter* in our problem.

3. Stepping Off Length of Hip Rafter. For any rafter, the basis of the step-off method is the unit of run. As previously pointed out, the unit of run for the common rafter is 12 inches. The unit of run for the hip rafter is 17 inches, as shown in the illustration, Fig. 20. For a given roof, the number of steps taken in the layout is the same when stepping off either a common or a hip rafter. However, the size of the steps are different; that is, for every 12-inch run of the common rafter, the hip rafter has a unit run or step of 17 inches.

When laying out the hip rafter, use the same method of procedure as when laying out the common rafter; that is, begin at the top end of the piece of rafter stock and work toward the lower or seat end of the piece. To find the *odd unit* of the hip rafter proceed as follows:

PROCEDURE

a) *Odd Unit.* The run of the hip rafter, as shown at *(AC)*, Fig. 22, is the diagonal of a square whose sides are formed by the run of the common rafter. Therefore, the odd unit of the hip rafter is a diagonal of a square whose sides are formed by the run of the odd unit of the common rafter, as shown in Fig. 25. The length of the odd unit of run for the hip rafter can be found by holding the square in the position shown in Fig. 26. Take the length of the odd unit of the common rafter (7½ inches in our problem) on both the tongue and blade of the square, then mark the rafter stock at those points on both sides of the square, as shown in Fig. 26. Measure the distance between these two points. This will give you the length of the odd unit for the hip rafter. In this problem, this length is 10⅝ inches.

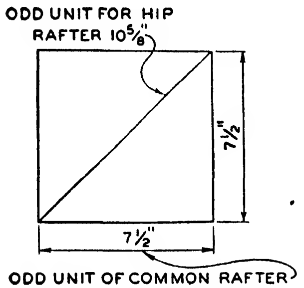

Fig. 25. Finding Odd Unit for Hip Rafter

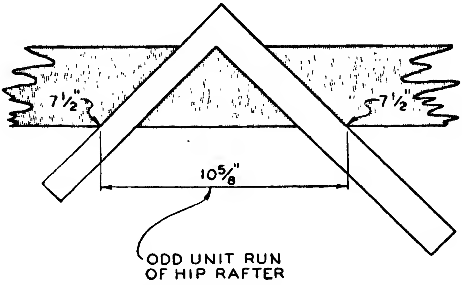

Fig. 26. Laying Out Odd Unit of Hip Rafter with Framing Square

b) Draw a center line on the crown edge of the rafter stock.

c) Hold the framing square to the hip rafter cut, in the position shown in Fig. 27. Take the figure 8 (unit rise) on the tongue of the square and the figure 17 (unit of run of hip rafter) on the blade. Draw the plumb line for the ridge at *(A)*, Fig. 27, along the tongue of the square. Then, on the blade side of the square, mark the point *(B)*, Fig. 27, indicating the length of the odd unit of the hip rafter. This odd unit is 10⅝ inches, as shown in the illustration, Fig. 27.

d) Move the framing square to the position *(2)*, Fig. 27. While holding the tongue of the square to the odd-unit point *(B)*, Fig. 27, mark off on the

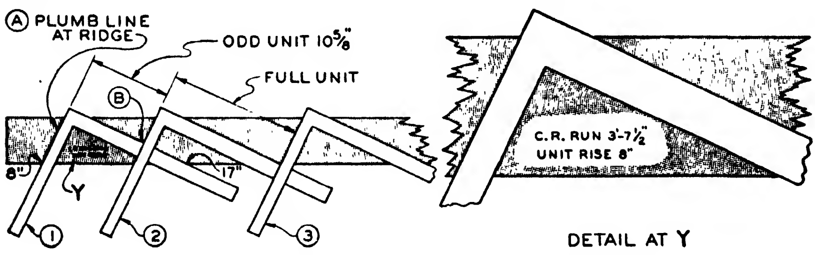

Fig. 27. Laying Out Hip Rafter by Step-Off Method

rafter stock the first full unit on the blade side of the square, then move the square to position *(3)*, Fig. 27. Now move the square to positions *(4)* and *(5)*, Fig. 28. As the square is shifted from one position to the next, mark off the unit lengths until the full three units have been stepped off, in addition to the odd-unit length.

e) While holding the square to position *(5)*, Fig. 28, draw the building line as indicated at *(C)*, along the tongue of the square. On the building line, measure the height of the heel, which is the same as that for the common rafter previously explained. Move the square to position *(6)* and draw the seat line, as shown at *(D)*, Fig. 28.

The total length of the hip rafter may be found by the mathematical process if desired. The method for doing this follows.

4. Find the Total Length of the Hip Rafter Mathematically. As shown in Fig. 22, the length of the hip rafter (AD) is the hypotenuse of a right triangle whose *base* is the total run of the hip rafter (AC), and whose *altitude* is the total rise of the common or hip rafter (CD). In our problem the unit rise is given as 8 inches, and the run of the common rafter is 3 feet 7½ inches. We have found the total run of the hip rafter to be 61.51 inches (5′ 1½″). To find the total rise of a rafter, multiply the span by the pitch of the roof. In an equal-pitch roof, such as the one shown in Fig. 10, which has a unit rise of 8 inches, the pitch is ⅓. The span of this particular roof is 7 feet 3 inches, that is, 2 times 3 feet 7½ inches, the run of the common rafter. Expressed in inches, the span equals 87 inches. Then $87 \times \frac{1}{3} = 29$ inches (2′5″), the total rise of the roof. The square of the hypotenuse equals $61.51^2 + 29^2 = 4625.50$. Extracting the square root, using the method explained in Fig. 5, we find the *total length of the hip rafter* is 68.01, or approximately 5 feet 7.9 inches.

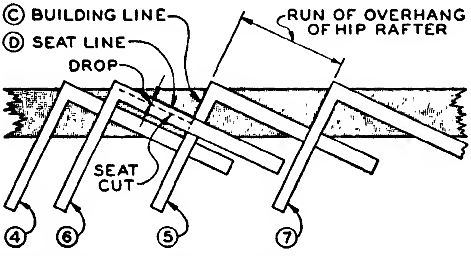

Fig. 28. Laying Out Bird's-Mouth and Overhang of Hip Rafter

5. Backing the Hip Rafter. The *center line* of the hip rafter is the theoretical line where two roof slopes meet. In rafter layout work, all measurements are considered as taken on the center line. To prevent the hip rafter from projecting above the jack rafters, as shown in Fig. 29, the top edge of the rafter must be *backed*, or the rafter may be *dropped*. A rafter is backed by placing each side of the top edge on a bevel, with the high point of the bevel being in the center of the hip, as shown in Fig. 30. If the hip rafter is dropped, as shown in Fig. 31, there will be an open space at the top when the sheathing boards are applied.

To determine the amount of backing required, lay the framing square to the cut of the hip roof. Take the unit rise of 8 inches on the tongue of the square and the unit run of 17 inches on the blade, as

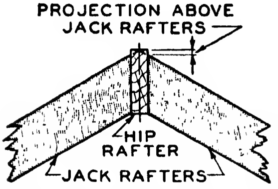

Fig. 29. Projection of Hip Rafter above Jack Rafters

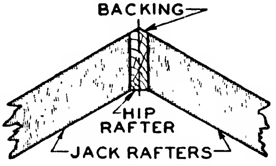

Fig. 30. Backing the Hip Rafter

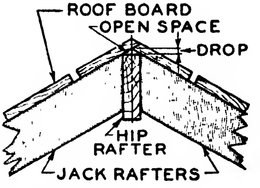

Fig. 31. Dropping the Hip Rafter

shown in Fig. 22, then draw the line (*A*) along the outside edge of the blade. On the rafter stock, along the crown edge and back one-half of the thickness of the hip rafter, draw the line (*B*) parallel to the edge of the rafter stock, as shown in Fig. 32. The amount of backing required is found by drawing a diagonal line from the center line of the hip rafter to the line (*B*), shown in the detail drawing, Fig. 32.

If the hip rafter is to be dropped, the amount of drop required can

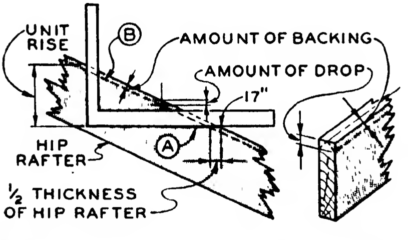

Fig. 32. Finding Amount of Drop for Hip Rafter with Framing Square

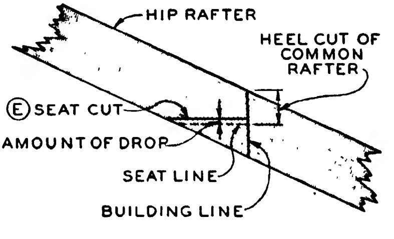

Fig. 33. Amount of Drop Measured Up from Seat Line

be determined by drawing a vertical, or plumb, line from the edge of the hip rafter to the line (*B*). The amount of drop is also shown in the detail drawing at right in Fig. 32. Use the same method to find the drop needed at the plate.

After finding the amount of drop necessary for the hip rafter at the plate, measure the amount of the drop on the building line up from the seat line and draw the line for the seat cut. See Fig. 33.

6. Shortening Hip Rafter at Ridge. If the rafters and the ridge piece were merely lines or planes without thickness, as they appear on the plan view, Fig. 10, these framing members would all meet at a point (*X*), as shown in Fig. 34. Since these framing members have thickness, the rafters must be shortened at the ridge.

When the hip rafter is framed against the common rafters, as in Fig. 34, the shortening of the hip rafter will always be one-half of the

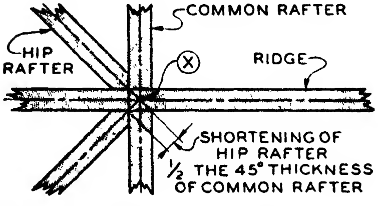

Fig. 34. Shortening of Hip Rafter When Framed against Common Rafter

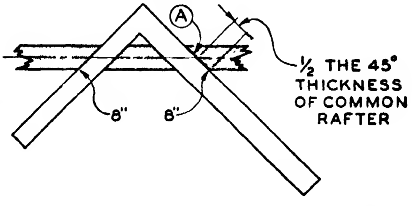

Fig. 35. Method of Finding the 45-Degree Angle with Framing Square

45-degree thickness of the common rafter regardless of whether or not the ridge is 1-inch or 2-inch material.

To find one-half of the 45-degree thickness of the common rafter, lay the framing square across the edge of the rafter stock, using the same figures on each side of the square, as shown in Fig. 35. Draw a

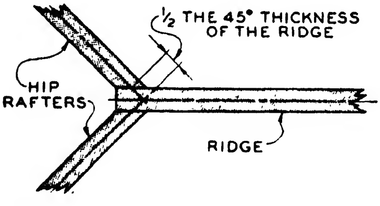

Fig. 36. Shortening of Hip Rafter When Framed against the Ridge

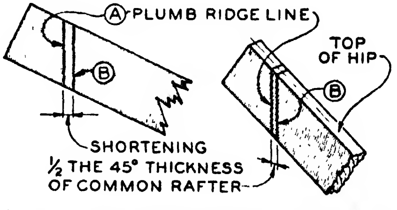

Fig. 37. Shortening of Hip Rafter Measured on Level Line from Line of Plumb Ridge

line, as (*A*), and measure the distance from the edge to the center of the stock. This gives one-half the 45-degree thickness of the common rafter.

When the hip rafter is framed against the ridge, as shown in Fig. 36, the hip rafter is shortened one-half of the 45-degree thickness of the ridge piece. This is an important fact to remember, since the ridge piece is sometimes of 1-inch material instead of 2-inch material. After determining the required amount of shortening of the hip rafter at the ridge, lay out this distance on a level line at right angles to the plumb cut, shown at (*A*), Fig. 37. Draw a second plumb line (*B*) and square both lines across the top edge of the hip-rafter stock.

7. Side Cuts. If the hip rafter did not have rise and met the common rafter on a level plane, the angles of the side cuts would be 45 degrees. Since the hip rafter, like any other rafter, has rise, the angle of the side cut becomes longer; that is, the angle becomes more pointed in proportion to the pitch of the roof.

Side Cuts at the Ridge. Measure off one-half the hip-rafter thickness on a level line; that is, at right angles to the shortening line (*B*), as shown in Fig. 38. Draw a third plumb line (*C*), and square all three lines (*A*), (*B*), and (*C*), across the top edge of the hip-rafter stock.

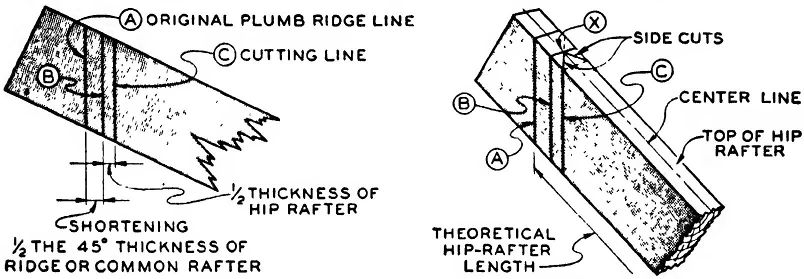

Fig. 38. Laying Out Side Cuts on Hip Rafter

Draw the side cuts from the point where the line (*C*) intersects the edge of the stock to the center (*X*). If the hip rafter has a double side cut, draw another side cut from the opposite side of the rafter stock. For a single side cut, one of these side-cut lines should be extended all the way across the stock. Which of the side-cut lines should be extended will depend upon which side of the hip rafter is to fit against the ridge.

Side Cut at Bird's-Mouth. A side cut is seldom made at the bird's-mouth except on work which must be carefully finished. The angle of the side cut at the bird's mouth is the same as the angle of the side cut at the ridge. The cut for the bird's mouth is shown at the left, Fig. 39.

Draw a center line on the bottom edge of the rafter stock and square the building line (*A*) across the bottom edge, as shown in the drawing at the right, Fig. 39. Lay off one-half the thickness of the hip rafters on a level line on the side of the building line toward the ridge cut. Then draw the plumb line (*B*) and square it across the bottom edge of the piece of stock. Draw side cuts from the line (*B*) to the center line at the point (*X*), as shown in drawing at right, Fig. 39.

Side Cuts at Tail. The side cuts at the lower end of the rafter are necessary to accommodate the fascia of the cornice. These cuts have

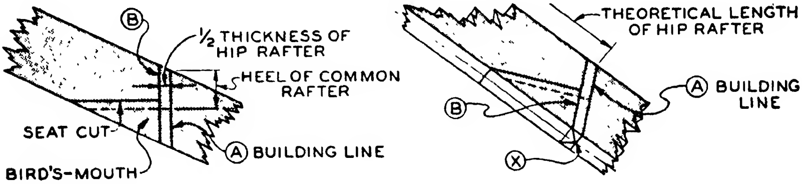

Fig. 39. Layout of Side Cuts of Hip Rafter at Bird's-Mouth

the same angle as the side cuts at the ridge and bird's-mouth, and run in the same direction as side cuts at the bird's-mouth. See Fig. 40.

8. Layout for Run of the Overhang. The run of the overhang of the hip rafter is the diagonal of a square formed by the common-rafter run of the cornice. You can find the run of the overhang of the hip rafter in the same way you found the run of the odd unit of the hip rafter, as shown in Figs. 25 and 26. In the plan-view shown in Fig. 10, the cornice has an overhang of 10 inches. The diagonal of a 10-inch square is approximately 14$\frac{3}{16}$ inches which is the run of the overhang of the hip rafter for this building.

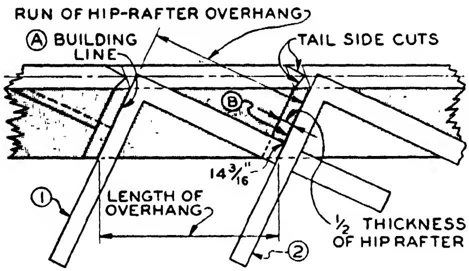

Fig. 40. Layout of Overhang of Hip Rafter with Angle Tail Cut on End

Lay the framing square on the hip-rafter stock to the position (*1*), Fig. 40. Hold the square to the figures 14$\frac{3}{16}$ on the blade of the square. The tongue of the square should be held to the building line (*A*) and coinciding with this line. While holding the square in this position, make a mark on the stock at 14$\frac{3}{16}$. Then move the square to position (*2*) and hold it to the cut of the hip. Then draw the line (*B*). Square this line across either the top or bottom edge of the rafter stock, and lay out the tail *side cuts* on the end of the overhang.

9. Checking the Hip-Rafter Length. The theoretical length of the hip rafter can be checked quickly by using the 12th scale found on the back of the framing square.[2] First find the total run of the hip, then find the total length of the hip rafter with the 12th scale. The practice of making such a check is recommended because it will help you to detect any gross errors in layout and will prevent the spoiling of expensive rafter stock.

After the check has been made, any lines used in the layout should be erased or crossed out, if not needed later. To avoid confusion, leave only those lines on which cuts are to be made.

Valley Rafters. The *valley rafter* is that roof-framing member extending along and under the valley or angle formed by the meeting of two roof slopes, as shown in Fig. 2. In an equal-pitch roof, the basic right triangle, as applied to the hip rafter, shown in Fig. 22, has the same application to the valley rafter; that is, the run of the valley rafter is the hypotenuse of a right triangle whose base and altitude equal the run of the common rafter. The length of the valley rafter is the hypotenuse of a right triangle formed by the run and rise of the valley rafter. You can find the total rise of the valley rafter in the same way you found the total rise of the hip rafter. The unit rise of the valley rafter is the same as the unit rise of the common rafter in an equal-pitch roof.

The intersection of two roof slopes of equal pitch may present any one of four different rafter-framing situations. Which one of these particular situations you may have to deal with will depend upon the span of the addition and the method used in framing the ridge of the intersecting roof.

1. When the span of the addition is the same width as the span of the main roof, the ridge of both roofs will meet on the same level, as shown at (*A*), Fig. 41. In such a building, the common rafter of both the main roof and the addition will have the same run. Therefore, the run of the valley rafter can be obtained by using either the run of the main-roof common rafter, or by using the run of the common rafter of the addition. The run of the valley rafter will be the hypotenuse of a right triangle whose base and altitude are equal to the

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[2] Walter E. Durbahn, *Fundamentals of Carpentry, Vol. I—Tools, Materials, Practice* (Chicago: American Technical Society, 1947), Chap. IV.

run of the common rafters. The valley rafters will have double side cuts to fit against both ridges, as shown in the detail at (*A*), Fig. 41.

2. When the span of the addition is less than the span of the main roof, one of the two valley rafters can be framed against the ridge of

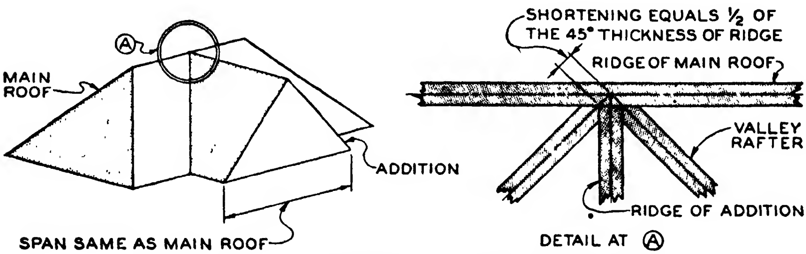


Fig. 41. Intersecting Roofs with the Same Ridge Heights

the main roof with a single side cut, as shown in the detail at (*A*), Fig. 42. The length of this valley rafter can be found by the same method used in finding the length of the hip rafter; that is, using the basic right triangle. The other valley rafter is then framed against the main valley rafter with a square plumb cut, as shown in the detail drawing at right, Fig. 42. The run of this valley rafter must be found by using the run of the common rafter of the addition. The run of this rafter is the hypotenuse of a right triangle whose base and altitude

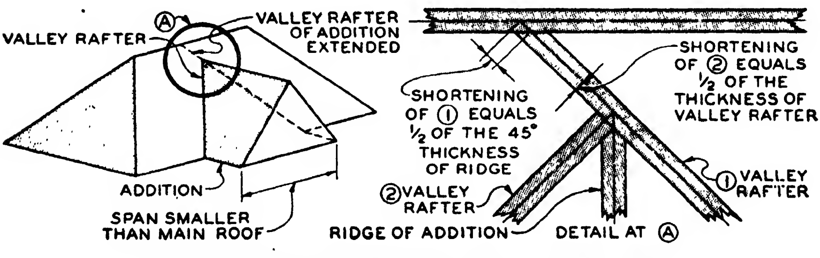


Fig. 42. Intersecting Roofs with Different Ridge Heights

equal the run of the common rafter of the addition. The length of this valley rafter will be the hypotenuse of a right triangle whose base and altitude are the rise and run of the valley rafter.

3. When the addition has a span less than the span of the main roof, the ridge of the addition can be extended into the main roof

and suspended from the main ridge, as shown in Fig. 43. Note detail of construction shown at (*A*), Fig. 43. In this type of construction, the run of both valley rafters will be found by using the common-rafter run of the addition. Both valley rafters are framed against the ridge of the addition, with a single side cut.

4. On small roofs such as dormers the ridge is usually framed against a header between the common rafters of the main roof, as

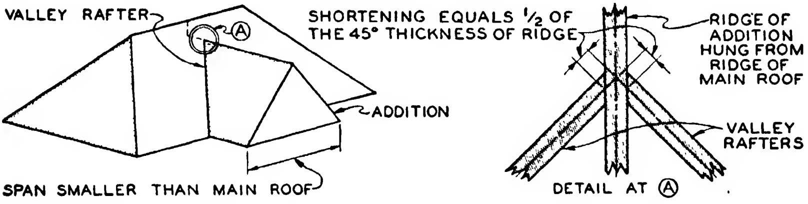


Fig. 43. Ridge of an Addition Suspended from Ridge of Main Roof

shown in Fig. 44. Note particularly the detail drawing shown at (*A*), Fig. 44. The run of these valley rafters can be found by using the run of the common rafters of the dormers and using the basic right-triangle method. These valley rafters are framed against the ridge and the header, with a double side cut.

Laying Out a Valley Rafter. As previously pointed out, hip rafters are the heavy rafters which slope up and back from the outside cor-

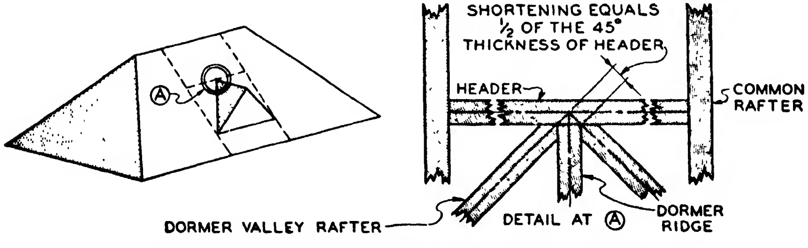


Fig. 44. Valley Rafters of Dormers or Small Additions

ners of a hipped-roof building to the ridge. The valley rafters are similar heavy rafters, which also slope up and back from the outside wall to the ridge, but differ from the hip rafters by starting from the angle between the main roof of a building and a projecting addition. While the hip rafter is located where two roof planes meet in a ridge, the valley rafter is located where two roof planes meet in a gutter, or valley. The instruction given here is based upon an equal-pitch roof such as the one shown in plan view, Fig. 10.

EXAMPLE

Work out the following problems for an equal-pitch roof which has a unit rise of 8 inches and a total common-rafter run of 3 feet 7½ inches.

1. Find the unit rise and total run of the common rafter.
2. Find the total run of the valley rafter.
3. Stepping-off length of the valley rafter.
4. Find the total length of the valley rafter.
5. Shortening valley rafter at ridge.
6. Laying out the bird's-mouth.
7. Side cuts.
8. Layout for run of the overhang and tail cut.
9. Checking the valley-rafter lengths.

1. Find the Unit Rise and Total Run of the Common Rafter. In our problem the unit rise is given as 8 inches and the total run of the common rafter is given as 3 feet 7½ inches. Hence, the unit rise and total run of the common rafter are the same as those given for the equal-pitch roof illustrated in Fig. 10.

Note: Valley-rafter stock must be selected with great care, because the valley rafter must support the weight of the valley jacks and the roof load in the near-by area. Therefore, the valley-rafter stock must be at least one or two sizes larger than the common rafters. In roofs of large span, the valley rafters are often doubled to add strength for carrying the load upon them.

2. Find the Total Run of the Valley Rafter. You can find the total run of the valley rafter by proceeding as you did when finding the total run of the hip rafter. Refer to Figs. 22 and 23 and apply the basic right-triangle method. You will find *the total run of the valley rafter* is the hypotenuse of a right triangle whose base and altitude are equal to the run of the common rafters. In this particular problem, the run of the common rafters of the addition is the same as the run of the common rafters of the main roof.

3. Stepping-Off Length of Valley Rafter. As has been previously pointed out, the basis of the step-off method for any rafter is the unit of run. The unit of run for the common rafter is 12 inches and the unit of run for the hip rafter is 17 inches. The unit of run for the valley rafter is the same as the unit of run for the hip rafter, since as shown in the plan view, Fig. 10, the valley rafter is at an angle of 45 degrees to the plate line of the building. The diagonal of a square whose sides are 12 inches is approximately 17 inches, therefore, the unit run of the hip and valley rafters is 17 inches. When stepping off the valley rafters, proceed the same as you did when stepping off the hip rafters. First, lay the rafter stock on two sawhorses with the crown edge turned toward you (the workman). Lay the framing square on the stock near the left end, which will be the upper end of the rafter. Hold the square to the unit rise, 8 inches in our problem, on the tongue and the unit run, 17 inches on the blade, as shown in Fig. 27. Draw the plumb line along the tongue of the square, and lay off the odd unit. Continue as you did when laying out the hip rafter, with the square in the positions shown in Figs. 27 and 28. In addition to the odd unit step off three full units.

4. Find the Total Length of the Valley Rafter Mathematically. You can find the total length of the valley rafter in the same way you found the total length of the hip rafter. Again refer to Figs. 22 and 23. Also observe Fig. 41, which shows the total length of the valley rafter to be the same as the total length of the hip rafter. In Fig. 10, it is also evident that the hip and valley rafters in this roof plan are the same length, since they are opposite sides of a parallelogram. By again applying the basic right-triangle method, you will find *the total length of the valley rafter* is the hypotenuse of a right triangle whose base is equal to the total run of the valley and hip rafters, with an altitude equal to the total rise of the valley and hip rafters. In this type of roof it can be seen that the total rise of the valley and hip rafters is the same as the total rise of one of the common rafters. To find the total rise of any of these rafters multiply the pitch by the span as previously explained.

5. Shortening Valley Rafter at Ridge. The amount the valley rafter should be shortened at the ridge will be one-half the 45-degree thickness of the ridge piece, when the span of the main roof is the same as the span of the addition, as it is in our problem, Fig. 41. The shortening of the rafter is measured on a level line, as shown in Fig. 45.

6. Laying Out the Bird's-Mouth. When laying out the cuts for the valley rafter, the methods used are much the same as for the hip rafter. However, the valley rafter does not need to be dropped at the bird's-mouth, and the side cuts usually are laid out on the valley rafter so it will fit into the corner of the building. The side cuts at the plate run from building line toward the overhang instead of toward the

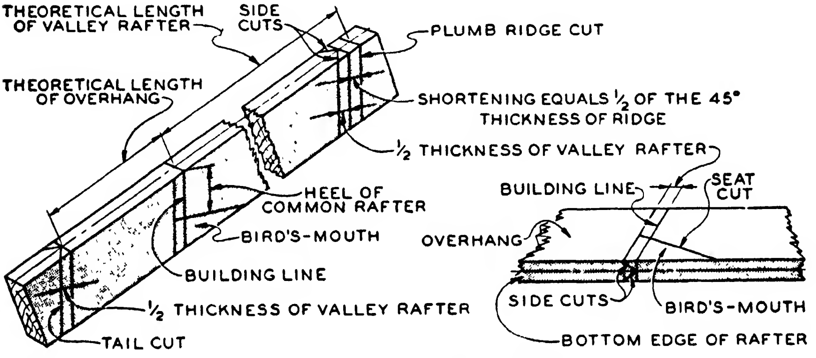


Fig. 45. Layout of Valley Rafter

ridge as in the hip rafter. For method of laying out the cut at the bird's-mouth see Fig. 45.

7. Side Cuts. The side cuts for the valley rafter are laid out in the same way as for the hip rafter; that is, by measuring one-half the valley-rafter thickness on a level line from the shortening line, as shown in Fig. 45.

8. Layout for Run of the Overhang and Tail Cut. The run of the overhang of the valley rafter is the hypotenuse of a right triangle whose two sides are equal to the run of the overhang of the common rafter. Since the run of the overhang of the common rafter, as shown in Fig. 10, is 10 inches, the run of the valley-rafter overhang will be approximately 14$\frac{3}{16}$ inches. This length is laid out from the building line in the same way as for the hip rafter, as shown in Fig. 40.

The tail cut at the end of the overhang consists of two side cuts to receive the fascia board of the cornice. These cuts are laid out in the same direction as at the bird's-mouth; that is, the side cuts at the end of the overhang (the tail cut) are also reversed to receive the fascia board of the cornice. When the layout for the valley rafter is complete it will appear as shown in Fig. 45.

9. Checking the Valley-Rafter Lengths. The theoretical length of the valley rafter can be checked by the 12th scale, the same as for the hip rafter. After checking the length of the valley rafter again, erase or cross out all lines except those which will be needed for cutting lines.

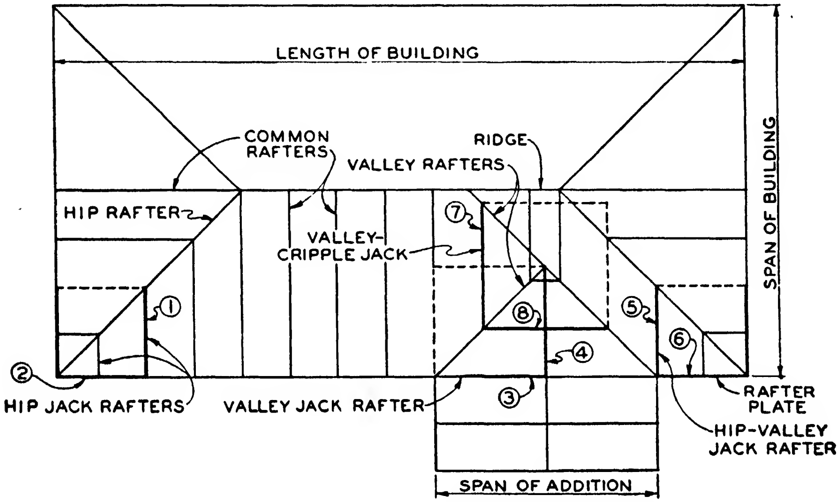


Fig. 46. Run of Jack Rafter Is One Side of a Square

Jack Rafters. The *jack rafter* is a *discontinued common rafter;* that is, it is a common rafter cut short because of the intersection of a hip or valley rafter, or both.

There are three types of jack rafters. Two of these types—the hip jack and the valley jack—are shown in Fig. 2. The *hip jack* extends from the rafter plate to the hip rafter, as shown at (*1*), Fig. 46. The *valley jack* extends from the valley rafter to the ridge of the roof. The third type of jack rafter is the *cripple jack,* of which there are two kinds—the *hip valley cripple* and the *valley cripple* (see Fig. 55). Neither one of these cripple jack rafters touches the ridge or the plate. The hip-valley cripple extends between the valley and the hip rafters. When the ridges of the two roofs are on different levels, and when the main valley rafter is framed against the ridge of the main roof, the valley cripple jack is framed from the main valley rafter to the valley of the addition, as shown at (*7*), Fig. 46. (See also *B*, Fig. 55.)

The unit run, unit rise, and unit length of all jack rafters are the same as the unit run, unit rise, and unit length of the common rafters. Like the common rafter, the run is the basis for jack-rafter layout. Therefore, it is important that you know how to obtain the total run. The run of any one of the various jack rafters is one side of a square, as shown in Fig. 46. In each case, one of the sides of the square is known or can easily be found. When once the total run of any jack rafter is known, its length and the cuts can be easily laid out.

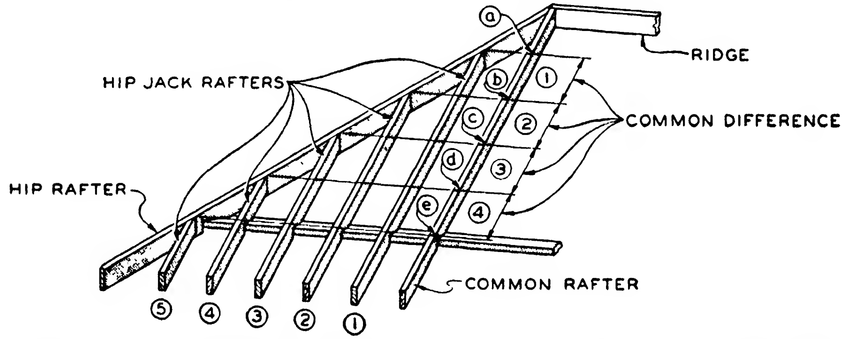


Fig. 47. Hip Jack Rafters Are Series of Common Rafters with a Common Difference

The total run of the hip-jack rafter (*1*), Fig. 46, is the same as the distance (*2*), Fig. 46, which is the distance the jack is set from the corner of the building.

The total run (*3*) of the valley jack is equal to the distance (*4*), which is the same as the distance the valley jack is set from the point of valley and ridge intersection.

The total run (*5*) of the hip-valley jack rafter is equal to the rafter-plate length (*6*), Fig. 46, which is the distance the hip-valley jack is set from the corner of the building.

The total run (7) of the valley-cripple jack is twice the run of the valley jack (8), Fig. 46. Since the valley jack-rafter run is the same as the distance the jack is set from the valley and ridge intersection, therefore, the cripple jack-rafter run (7) is twice the distance the adjoining valley jack is from the end of the ridge.

Hip Jack-Rafter Layout. The jack rafters of a hip, as shown in Fig. 47, are a series of rafters spaced the same distance apart as the common rafters. This uniform spacing is necessary to accommodate finished material on the underside of the roof. Since this spacing is uniform, the length of each successive jack rafter will be uniformly shortened. This shortening is known as *the common difference of jack rafters,* as shown in Fig. 48. To insure this equal spacing and uniform common difference, a jack rafter pattern should be laid out for the longest jack rafter, as shown in Fig. 48. Then on this pattern the different lengths for the jacks needed are marked off. Also, the cutting lines for the bird's-mouth and the overhang are marked out, as shown

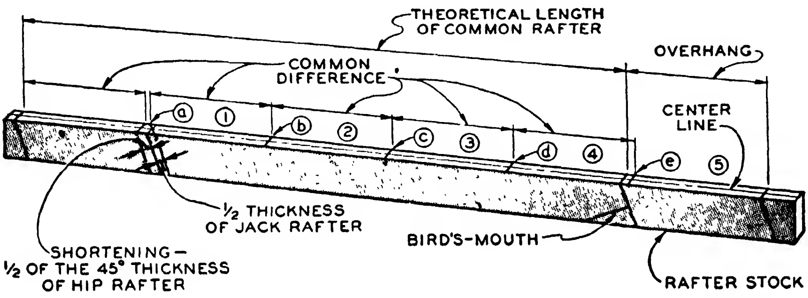


Fig. 48. Layout of Pattern for Hip Jack Rafter

in Fig. 48. This jack rafter, then, becomes a layout pattern from which as many pairs of jacks can be cut as are needed for the roof under construction. Each hip requires one pair, or two jacks, for each of the jack rafter lengths found.

EXAMPLE

Work out the following problems for a roof with an 8-inch unit rise and with the common rafters spaced 16 inches on center (O.C.).

1. Lay out pattern for the longest hip jack-rafter length.
2. Find the common difference for the jack rafters.
3. Lay out the first common difference from the ridge line.
4. Shorten the jack for the hip rafter.
5. Lay out the side cuts.
6. Lay out lengths of other jack rafters from longest point.
7. Lay out and cut jack rafters.

1. Lay Out Pattern for the Longest Hip Jack Rafter Length. The total run, unit rise, and overhang for the jack rafter must be determined as they were for the common rafter. To do this, a full-length common rafter should first be laid out. This layout should include the plumb cut at the ridge, the cut for the bird's-mouth, the length of the overhang, and the tail cut. However, there should be no shortening at the ridge, since this rafter length is the theoretical length of the common rafter, as shown in Fig. 48.

Since the jack rafter has a side cut, a center line is required along the top edge of this pattern, as indicated in the illustration, Fig. 48.

2. Find the Common Difference for the Jack Rafters. The jack rafters vary in length because they fill a triangular-shaped space in the roof. Beginning with the shortest jack rafter, these rafters increase in length regularly, the second rafter being twice as long as the first, the third three times as long as the first, and so on. You can find this common-difference length of the jack rafters by the following procedure.

PROCEDURE

a) Place the framing square on a piece of rafter stock having a straight, smooth edge. Hold the square to the cut of the common rafter (8 inches on the tongue and 12 inches on the blade), as shown at *(A)*, Fig. 49.

b) While holding the square in this position, draw a line along the blade of the square. Then slide the square along this line to the figure 16 on the blade, position *(B)*, for 16-inch spacing.

c) While holding the square in this position, mark at *(X)* on the tongue side of the square, as shown in Fig. 49.

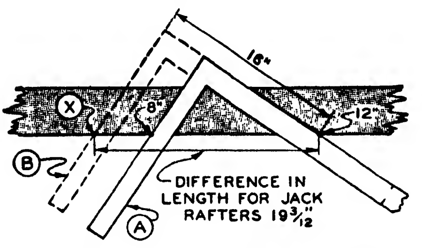


Fig. 49. Method of Finding Common Difference of Jack Rafters Spaced 16 Inches on Center

d) The distance between these two points will be 19 3/12", the common difference in length for jack rafters, spaced 16 inches on center and having a unit rise of 8 inches.

3. Lay Out the First Common Difference from the Ridge Line. Square the line for the plumb-ridge cut across the top edge of the jack rafter stock, as shown at (*1*), Fig. 50. Measure the length of the common difference (19 3/12") from the point (*X*) along the center line, and mark point (*Y*), Fig. 50. Square a line along the edge of the rafter stock, then through the point (*Y*) draw a second plumb line, as shown at (*2*), Fig. 50. This will give you the first unit of common difference of the jack rafter, measured from the ridge line.

4. Shorten the Jack for the Hip Rafter. Since the hip rafter has thickness, this prevents the jack rafter reaching to the center of the hip rafter. Therefore, it becomes necessary to shorten the jack rafter one-half the 45-degree thickness of the hip rafter stock, as shown in Fig. 51. Measure this required shortening distance on a level line from the plumb line and draw a third plumb line, as shown at (*3*), Fig. 50. Square this line across the top edge of the rafter stock. This will give

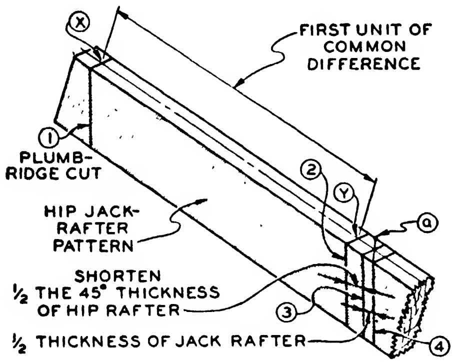


Fig. 50. Layout for First Common Difference, Shortening, and Side Cut for Hip Jack Rafter

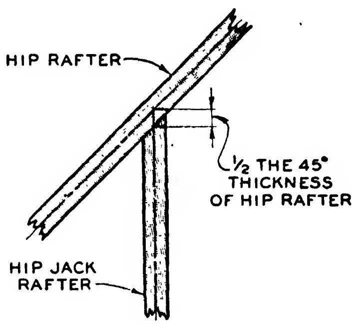


Fig. 51. Plan View of Intersection of Hip and Jack Rafters

you the amount of shortening necessary for the jack rafter which fits against a hip rafter.

5. Lay Out the Side Cuts. The side cuts for jack rafters are laid out in the same way as side cuts for any other rafter. Take one-half the thickness of the rafter stock, measured on a level line, as shown in Fig. 50. Draw a fourth plumb line (*4*), Fig. 50. Extend the side cut across the top edge of the rafter stock through the center point. This will give you the side cut at the top for the longest hip jack rafter. It will be 16 inches on center (O.C.), measured from the first common rafter. For position of these rafters see Fig. 47.

6. Lay Out Lengths of Other Jack Rafters. It is an established practice to lay out jack rafters from the longest point of their side cut. Therefore, measure from the point (*a*), Fig. 50, the longest point of the side cut, the common difference of all successive jack rafters. Square lines across the top edge of the rafter stock at each point, as shown in Fig. 48.

7. Lay Out and Cut Jack Rafters. Lay out a pair of jacks, or as many as required, for each jack length found by marking off the length of the rafters, the bird's-mouth, and the length of the overhang. The side-cut layout can be simplified by the use of a *layout tee* (illustrated in Fig. 88).

Valley Jack Rafter Layout. The valley jack rafters, as shown in Fig. 52, like the hip jacks, are a series of rafters spaced the same distance apart as the common rafters. This spacing is uniform and is measured from the common rafter. This uniform spacing is necessary to accommodate finished material on the under side of the roof. The valley jacks have a common difference, or uniform shortening, obtained in the same way as the common difference was obtained for the hip jack rafters. First, a pattern is laid out for the longest valley jack, then on this pattern spacings are laid out for the different valley-jack lengths.

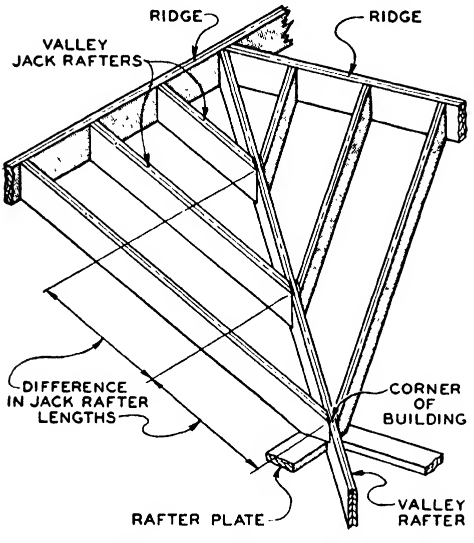


Fig. 52. Valley Jack Rafters Laid Out from Bottom End

The valley jack extends from the valley rafter to the ridge. Therefore, the valley jack does not have a bird's-mouth cut nor an overhang, but it does have a ridge cut to fit against the ridge piece and a side cut to fit against the valley. From the valley jack pattern, a pair of jacks is cut for each jack length found, the same as for the hip jacks.

EXAMPLE

Using the same figures, 8-inch unit rise and common rafter spaced 16 inches on center, work out the following problems.

1. Lay out the longest valley jack-rafter length.
2. Shorten the valley jack rafter.
3. Lay out the side cuts for the valley jacks.

4. Lay out the common difference of the valley jacks.
5. Shorten the valley jack at the ridge.
6. Lay out and cut the necessary valley jack rafters.

1. Lay Out the Longest Valley Jack-Rafter Length. The total run and unit rise of the longest valley jack rafter is the same as the total run and unit rise of the common rafter. The run of the valley jack starts at the corner of the building where the valley rafter meets the plate. Therefore, a full common-rafter length is laid out with a plumb line at the ridge and a plumb line at the building line. There is no

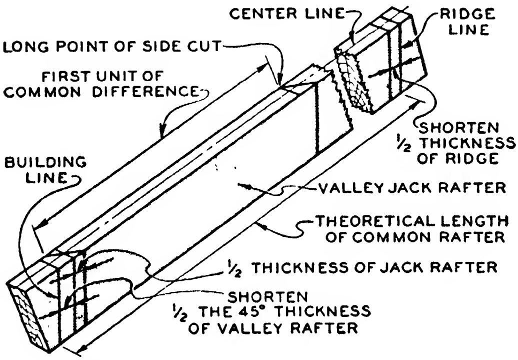


Fig. 53. Layout for Valley Jack Rafter Shortened at Bottom

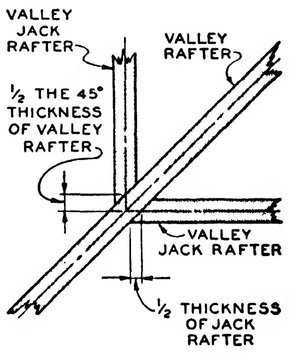


Fig. 54. Method of Shortening of Jacks at Valley Rafter

bird's-mouth cut nor any overhang, as shown in Fig. 53. Since the valley jack has a side cut, it becomes necessary to draw a center line on the top edge of the rafter stock.

2. Shorten the Valley Jack Rafter. Since the valley jack rafter is intersected by the valley rafter, the valley jack must be shortened at the bottom end one-half the 45-degree thickness of the valley rafter stock, as shown in Fig. 54.

3. Lay Out the Side Cuts for the Valley Jacks. The side cuts for the valley jack rafters are laid out like any other side cut. From the shortening plumb line, measure one-half the thickness of the jack-rafter stock on a level line, as shown in Figs. 53 and 54.

4. Lay Out the Common Difference of the Valley Jacks. To find the common difference of the valley jacks, proceed in the same way as you did when obtaining the common difference for the hip jacks. The common difference for the valley jack is laid out from the longest point of the first side cut, as shown in Fig. 53, then square lines across the top edge of the rafter stock to indicate the different lengths of subsequent valley jack rafters. See Fig. 52.

5. Shorten the Valley Jack at the Ridge. The valley jack must be shortened to fit against the ridge piece. To find the cutting line for this shortening, measure one-half the thickness of the ridge piece on a level line from the plumb line of the ridge in the same way as for any common rafter. See Figs. 52 and 53.

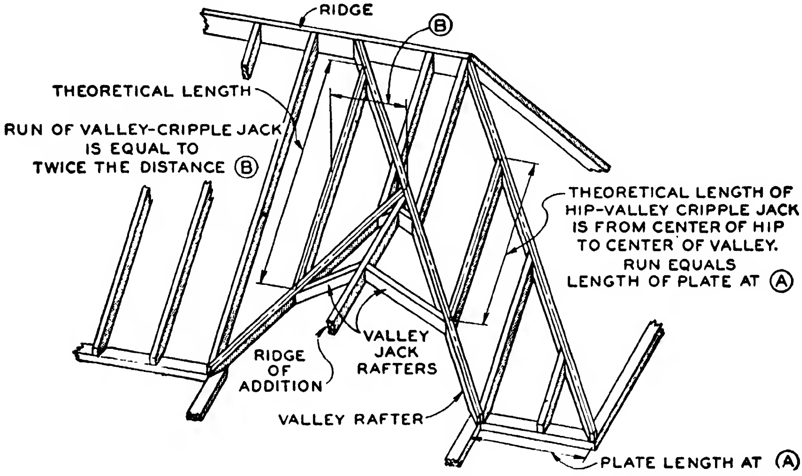


Fig. 55. Location of Valley-Cripple Jack Rafters in a Roof

6. Lay Out and Cut the Necessary Valley Jack Rafters. After the pattern for the valley jack rafter has been laid out, make the cut at the top where it fits against the ridge piece, then make the side cuts at the bottom end where the jack fits against a valley rafter. The remainder of the valley jacks needed should be laid out in pairs. Use the pattern to find the length and the cutting line at the ridge. The side cuts can be laid out by using a layout tee. (See illustration, Fig. 88.)

Valley-Cripple Jack Rafter. The rafter framed between the shortened valley rafter and the supporting or main valley rafter is known as the *valley-cripple jack,* as shown in Fig. 55. The angle of the cut at the top end, where the jack fits against the main valley rafter, is the reverse of the angle of the cut at the lower end, where it fits against the shortened valley rafter. The run of the valley-cripple jack is one side of a square, as shown at (*7*), Fig. 46. This run is twice the distance of the valley-cripple jack from the intersection of the two valley rafters, as shown at (*8*), Fig. 46. The theoretical length of the valley-cripple jack is the distance from center to center of the two valley rafters, as shown in Fig. 55.

The *cut* for the common rafter is used when laying out the valley-cripple jack. The length can be obtained by using the step-off method, previously explained, and illustrated in Figs. 27 and 28. The valley-

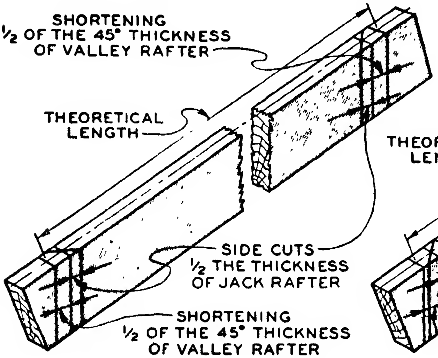


Fig. 56. Layout for a Valley-Cripple Jack Rafter

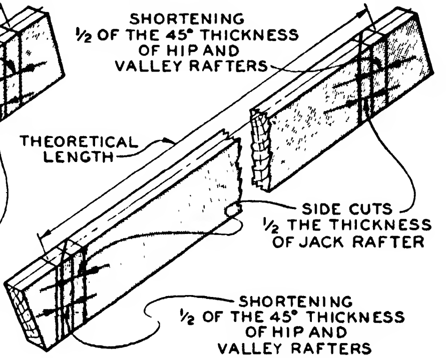


Fig. 57. Layout for Hip-Valley Cripple Jack Rafter

cripple jack must be shortened at both ends, one-half the 45-degree thickness of the valley-rafter stock, as shown in Fig. 56. When the two valley rafters are of the same thickness, as is usually the case, twice the 45-degree thickness of the rafter can be taken off one end, thus saving one operation.

The side cuts, one at each end, are laid out in the same way as the side cuts of any other jack rafter. However, you must remember that the angles for these side cuts extend in opposite directions, as shown in Fig. 55.

Hip-Valley Cripple Jack. The run of the hip-valley cripple jacks is one side of a square, as shown at (*5*), Fig. 46. The theoretical length of the hip-valley cripple jack is from the center of the hip to the center of the valley rafter, as shown in Fig. 55.

In laying out the hip-valley cripple jack, use the *cut* of the common rafter. The length of this rafter can be obtained by the step-off method. The hip-valley cripple jack must be shortened at both ends, one-half the 45-degree thickness of the hip and valley rafter stock, as shown in Fig. 57. If the hip and valley rafters are of the same thickness, twice this thickness can be taken off one end of the rafter, thus saving one operation.

The hip-valley cripple jack has a side cut on each end, as shown in Fig. 55. These cuts are parallel to each other and are laid out in the same way as any other side cut.

ERECTION OF ROOF FRAMES

The assembly of a roof frame, which has a ridge, usually requires the erection of a scaffold or staging similar to the one shown in Fig. 58. To make this scaffold, build as many two-legged horses as will

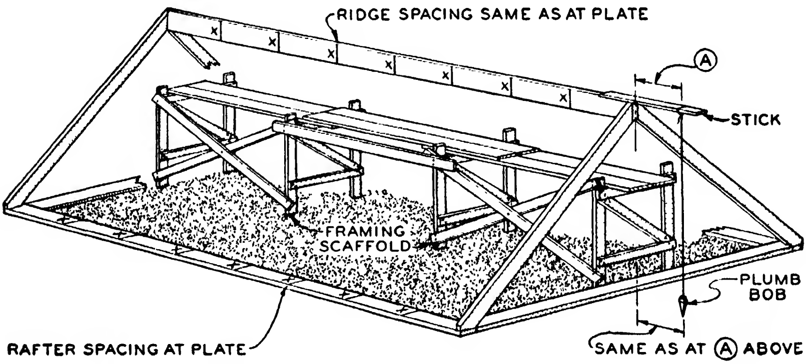


Fig. 58. Method of Erecting a Gable Roof

be needed for the entire length of the roof. These horses should be spaced about 10 feet apart. The height of the cross ledgers for the scaffold can be determined by finding the ridge height on the building plans. The staging should be about 4 feet below the top of the ridge piece.

Erecting Gable-Roof Frame. The construction of any roof involves certain special features peculiar to that particular type. The various types of roofs, from the simple pitch to the most complicated combinations of hips and valleys, are all developed from a few simple forms. For the erection of the ordinary gable roof with two sloping surfaces you may proceed as follows.

PROCEDURE

a) Lay out the rafter spacing on one of the rafter plates, by squaring lines across the plate and placing an *(X)* on the side of each line, where the rafter is to be nailed, as shown in Fig. 58.

b) Select a straight piece of ridge stock. Set this ridge piece on edge on the rafter plate flush with one end of the building, then transfer the rafter spacing to the ridge piece. The length of the ridge piece for a gable roof is equal to the length of the building, measuring from outside to outside of the rafter plates. If more than one piece of stock is required to satisfy the ridge length, the joint must be made on the center of a rafter.

c) Select a pair of straight rafters for each gable end. Three men can work to advantage when erecting the four end rafters. Two men standing on the scaffold can hold the ridge piece in position while a third man nails the rafters at the bird's-mouth.

d) Brace this frame and fill in the rest of the rafters by nailing them opposite to each other. As the nailing progresses, sight the ridge for trueness.

e) After all the rafters are in place, plumb the ridge at the gable end with a straightedge and level, or by hanging a plumb bob on a stick fastened to the top of the ridge. The plumb bob should be held at the same distance from the plate, at plate level, as the line is from the ridge at the top, as shown at *(A)*, Fig. 58. After the gable has been plumbed, brace the roof frame securely in position.

Erecting a Hip Roof. On an equal-pitch hip roof, the run of the hip rafter is the diagonal of a square formed by the run of the common rafters, which is equal to one-half the span of the building, as shown in Fig. 10. The first full common rafter is placed at a distance equal to one-half the span, from the corners of the building. The following procedure may be used when erecting a hip roof.

PROCEDURE

a) From the corner of the building, measure and mark on the rafter plate of the building a distance equal to one-half of the span. This point will locate the center of the first common rafter. The thickness of the common rafter is laid out at this point, one-half on each side of this line. All other rafters, both common and jacks, are spaced from this rafter and their location marked by squaring a line across the plate, with an *(X)* on one side of the line to indicate the side on which the rafter is to be nailed.

b) Select the ridge stock and lay out its length as previously explained, then transfer the spacings from the plate to the ridge piece.

c) Erect a set of common rafters at the end of the ridge and place one common rafter at a distance of one-half the span from each corner of the building, as shown in Fig. 59.

d) Fill in all the other common rafters, nailing them opposite to each other, keeping the ridge piece straight as the nailing progresses.

e) Nail the hip and jack rafters in place.

f) The ridge of a hip roof does not need to be plumbed, as it automatically will be placed and held in the proper position by the end common rafters and the hip rafters.

Erecting Intersecting Roof. When a building is to have an addition, or intersecting roof, the main roof is partly framed before the

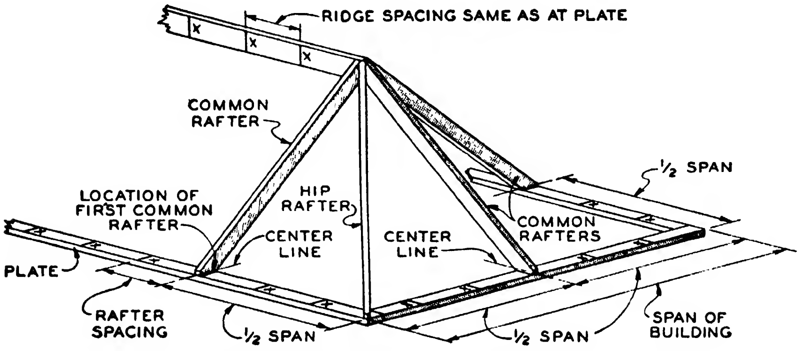


Fig. 59. Spacing of Rafters on Plate and Ridge Piece of Hip Roof

frame of the addition is started. As shown in Fig. 60, a point must be located on the main ridge where the main valley or ridge of the addition is to intersect with the main roof. Then the ridge piece of the addition and a set of end rafters are erected. Then follows the work of framing the valley rafters.

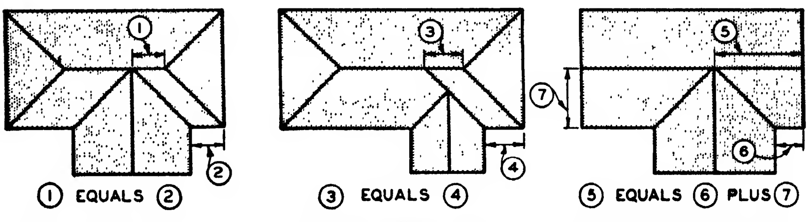


Fig. 60. Location of Point Where Ridge or Main Valley of an Addition Will Intersect with the Main Ridge

Hip jack rafters are nailed flush with the top of the hip rafter, but the valley jacks must be held up so the top will line up with the center of the valley rafters. The method of nailing the valley jack rafters in position is shown in Fig. 61.

Shed Roof. The single-slope roof, such as the shed or lean-to, has several applications in building construction. Some of which, as illustrated in Fig. 62, are the roof of an independent building, the roof of a porch, a dormer roof, and a lean-to roof. The single-slope roof has only one type of rafter, the common rafter, which involves all basic principles of the regular common rafter.

In framing a shed roof, such as the one shown in Fig. 63, it is necessary to establish the plate height of the highest wall according to the pitch of the roof desired. The difference in plate height is found by multiplying the unit rise of the rafter by the number of feet in the run of the rafter. The run of the rafter is equal to the span minus the width of the plate of the highest wall.

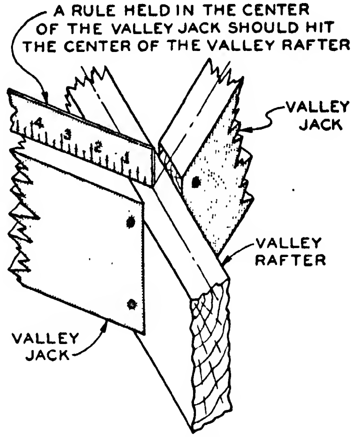


Fig. 61. Method of Nailing Valley Jack Rafters in Position

The rafter is laid out by starting with the tail cut (laying the square to the unit rise and unit run of the rafter), then laying out the overhang and bird's-mouth at the lower plate. The length of the rafter is stepped off the same as for any common rafter. The bird's-mouth at the top plate is laid out the same as at the lower end. To this must be added the width of the plate and the over-

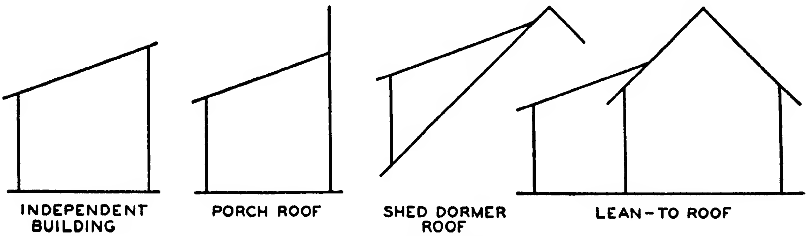


Fig. 62. Different Types of Shed Roofs Used in Building Construction

hang at the top, and finally the plumb cut at the top end of the rafter.

Porch Roof. A shed roof such as the one illustrated in Fig. 64 is commonly used on porch roofs. The rafters for this roof are laid out in the same way as the rafters for the shed roof, except there is no bird's-mouth cut at the top end. The total rise of such a roof frequently is governed by a second-story window sill. In such a case the total rise is determined by taking into consideration the heel and the thickness of the roof sheathing, also the thickness of the shingles. It is necessary for the carpenter to know the thickness of the finished porch roof in order to make sure it will come under the window sill.

Dormer Roof. A dormer roof such as the one shown in Fig. 65 presents three different problems for the carpenter: (*a*) determining the meeting point of two slopes; (*b*) finding the top cut of the dormer rafter; and (*c*) finding the common difference of the stud lengths.

a) *Meeting Point of Two Slopes.* The location of the meeting point of the dormer roof and the main roof is determined by the run of the

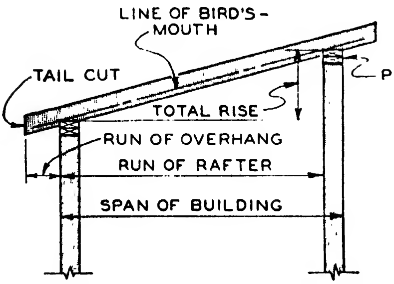


Fig. 63. Shed-Roof Rafter with Bird's-Mouth at Top and Bottom

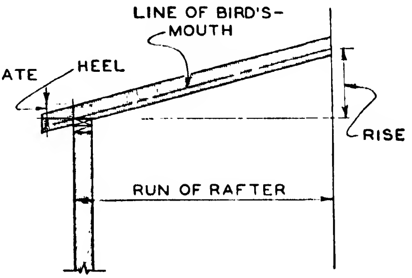


Fig. 64. Porch-Roof Rafter with Bird's-Mouth at Bottom

dormer rafter. Dividing the height of the dormer (expressed in inches) by the difference in unit rise of the two roof slopes will give the number of feet in the run of the dormer rafter.

For example, take the dormer roof illustrated in Fig. 65; in this case the unit rise of the dormer rafter is 4 inches per foot of run, and the unit rise of the main-roof rafter is 14 inches per foot of run. As the two rafters approach the meeting point at the main roof they are closer together at the end of each unit of rafter run. If the dormer rafter were on a level line and did not have a rise, the two rafters would be 14 inches closer together at the end of each unit of run. However, since the dormer rafter has a rise of 4 inches per foot run, the two rafters are only 10 inches closer together at the end of each unit of run. This 10 inches is the difference in the rise of the two rafters.

Since the height of the dormer is 4 feet, or 48 inches, this number divided by 10, the difference in rise of the two rafters, gives 4.8 feet. Therefore, it will be necessary for the dormer rafter to have a run of 4 feet $9\frac{5}{8}$ inches before it will meet the rafter of the main roof.

b) *Finding Top Cut of Dormer Rafter.* In a dormer such as the one shown in Fig. 65 the dormer rafter must fit against a roof with a different pitch. Therefore, it is necessary to make a dormer-roof cut on the top end of the dormer rafter. This is done by laying the framing square on a straight piece of rafter stock in the position shown in Fig. 66. The square is laid to the unit rise of the main roof (14 inches) and the unit run (12 inches). While holding the square in this position

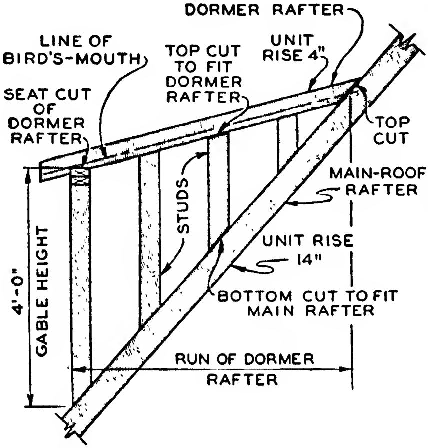


Fig. 65. Rafter for a Shed-Dormer Roof Showing Top Cut and Seat Cut

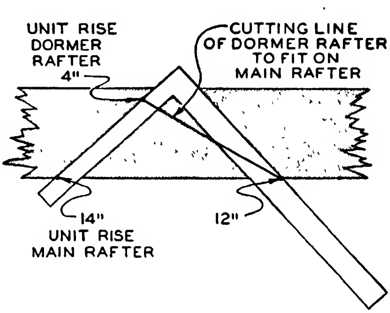


Fig. 66. Method of Finding Top Cut for Rafter of Shed Dormer

make a mark on the blade side at 12 and another mark on the tongue side to the number 4, the unit rise of the dormer rafter. Draw a line through the points at 4 and 12. This gives the angle for the top cut of the dormer rafter.

c) *Finding the Common Difference of Stud Lengths.* For a dormer such as the one shown in Fig. 65 the top cut on the side studs is the same as the plumb cut of the dormer rafter. The cut at the lower end of the same stud is the plumb cut of the main-roof rafter.

The common difference in lengths of the side studs for every 12 inch spacing is the difference between the rise of the two roofs, or 10 inches, in this case. When the studs are spaced 16 inches on center (O.C.), the difference is found by sliding the square in a way similar to that used in the case of the jack rafters illustrated in Fig. 49. This is done by taking the difference in unit rise (10″) on the tongue side of the square and the unit run (12″) on the blade of the square. Draw a line along the blade, then slide the square along this line to the number 16 (the spacing) on the blade, and read the figure on the tongue. This will be 13⅜ which, then, is the *common difference* of the stud lengths for the dormer shown in Fig. 65.

Lean-To Roof. The layout for the lean-to roof rafter is similar to the layout for the shed-dormer rafter. However, as shown in Fig. 67, only part of the rafter for the lean-to roof extends over the main roof. Also, the rafter plates for the lean-to roof and the main roof are usually at different heights, Fig. 67. Because of these differences, some changes are necessary when making the layout for the lean-to rafter.

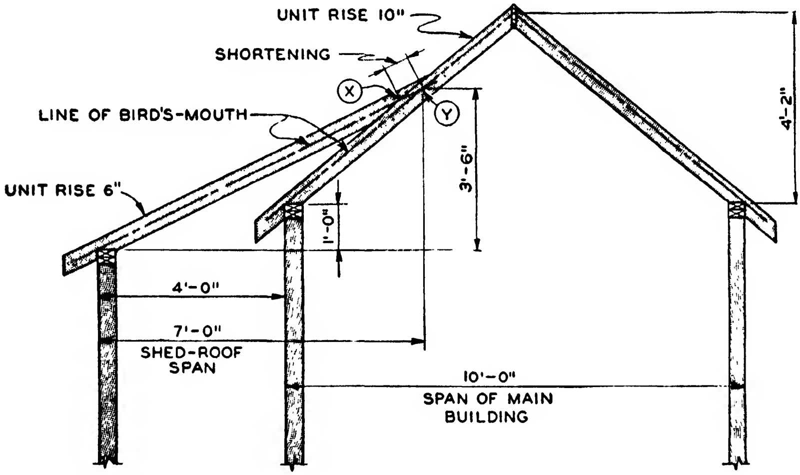


Fig. 67. Rafter for Lean-To Roof

In the example shown in Fig. 67 the lean-to rafter has a unit rise of 6 inches and the main-roof rafter has a unit rise of 10 inches. Therefore, in the 4 feet of run outside of the main building, the lean-to rafter will have a rise of 2 feet. The two rafters, then, will be 12 inches apart directly over the building line of the main building. The difference between the unit rise of these rafters is 4 inches (10″—6″). The difference in the total rise at the building line, or 12 inches, divided by 4, the difference between the unit rise of the two rafters, equals 3. Therefore, the lean-to rafter will have an additional 3 feet of run before it meets the rafter of the main roof.

Beginning at the tail cut, the lean-to rafter is laid out the same as the shed-dormer rafter. However, a shortening must be made where the two rafters meet, to allow for the distance point (*Y*), the intersection of the bird's-mouth lines, is in from the point (*X*), the point where the bird's-mouth line of the lean-to rafter meets the top surface of the main-roof rafter, as shown in Fig. 67. The cut at the top end of the lean-to rafter is found in the same way as for the dormer rafter illustrated in Fig. 66.

Gambrel Roof. The method used in framing a gambrel roof is much the same as for any gable or hip roof. However, the slope of the roof is broken at a point somewhere between the plate and the ridge, as shown in Fig. 68. The part of the roof above this break makes

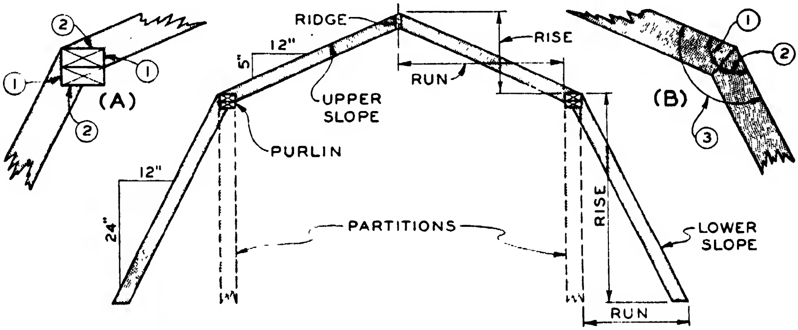


Fig. 68. Gambrel Roof Showing Joint with and without Purlin

an angle with the horizontal plane of less than 45 degrees, usually about 30 degrees, while the portion below this break makes an angle greater than 45 degrees, which in most cases is about 60 degrees.

In reality, the gambrel roof is two separate roofs, with the unit rise of the upper slope usually much less than the unit rise of the lower slope. The only difference in the method of framing this type of roof, from the method used in the framing of an ordinary gable or hip roof, is at the point where the rafters of the two slopes join. This point may be framed in one of two ways, either with or without a purlin plate.

With Purlin. The use of a purlin is desirable in situations where it can be supported by partitions, as in a house with partition walls. The rafters of both slopes of a gambrel roof are cut to fit around the purlin. The cuts (*1*) and (*2*) of each rafter, as shown at (*A*), Fig. 68, are plumb and level cuts the same as the ridge and seat cuts of a common rafter.

Without Purlin. When framed, as shown at (*B*), Fig. 68, without a purlin, the angles (*1*) and (*2*) of the cut on each rafter is the same;

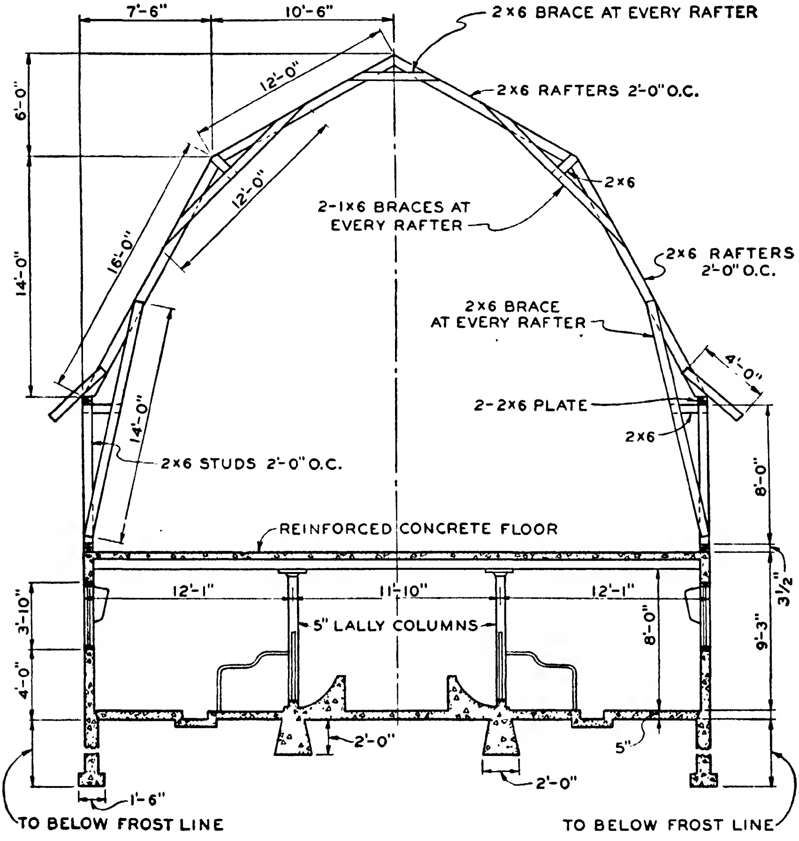


Fig. 69. Gambrel Roof as Used in Barn Framing

that is, one-half of the angle (*3*) formed by the joining of the two rafters. This type of construction can be used on houses but it is most frequently used on barns where large *bents* are formed, leaving the floor free from posts or partitions, as shown in Fig. 69.

Angle of Cut on Bents. The angle where the two rafters meet can be laid out with the framing square, as shown in Fig. 70. On a roof with a 24-inch unit rise of the lower slope and a 5-inch unit rise of the upper slope (Fig. 68), the square should be laid in position along the edge of the board, as shown at (*A*), Fig. 70. The figures are 24 and 12, unit rise and unit run, but since smaller figures are more convenient to use, one-half of the unit rise and unit run, 12 and 6, can be used. The line (*1*) drawn along the tongue of the square will give the angle of the lower slope. The square should then be placed in position (*B*), Fig. 70, using the figure 12 on the blade and 5 on the tongue, the unit run and unit rise of the upper slope. Draw the line (*2*), which is the slope of the upper roof. The lines (*3*) and (*4*) should be drawn parallel to lines (*2*) and (*1*) to show the width of the rafter stock. The line (*5*) is the bisector of the angle. If the square is then placed along the line (*3*), in position (*C*), the angle of the cut (*5*) can be found on the square by taking the figure 12 on the blade and holding the tongue on a line parallel to, or coinciding with, line (*5*). In this case the figure on the tongue will be 4½. This will give the angle of the cut, and when used on the top of the lower rafter the cut will fit against a similar cut made on the bottom of the upper rafter.

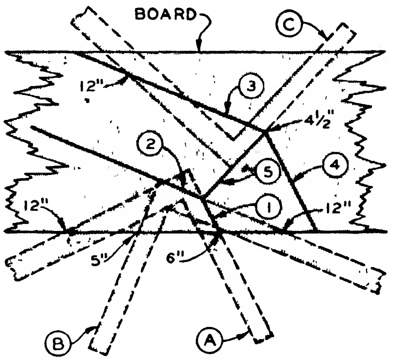


Fig. 70. Layout for Angle Cut for Gambrel Roof

CHIMNEY SADDLES

If you know the width of the chimney and the unit rise of the main roof, it is a simple matter to cut the various members of a chimney saddle, to nail them together, and then slip the saddle behind the chimney in the position shown in Fig. 71. All of this work can be done on the ground or the floor of the building, where it is more convenient to work. The same principle can be applied in the building of a small gable which does not require a valley rafter. A 1x4 or 1x6 can be nailed on the roof sheathing in place of a valley rafter. This *valley strip*, shown at (*B*), Fig. 71, serves as a ledge to which you can nail the rafters and the roof sheathing of the dormer.

Common-Rafter Run for Saddle. The width of the chimney is the span of the saddle. One-half of the span is the run of the common rafter. It is necessary to shorten the run of the common rafter a distance

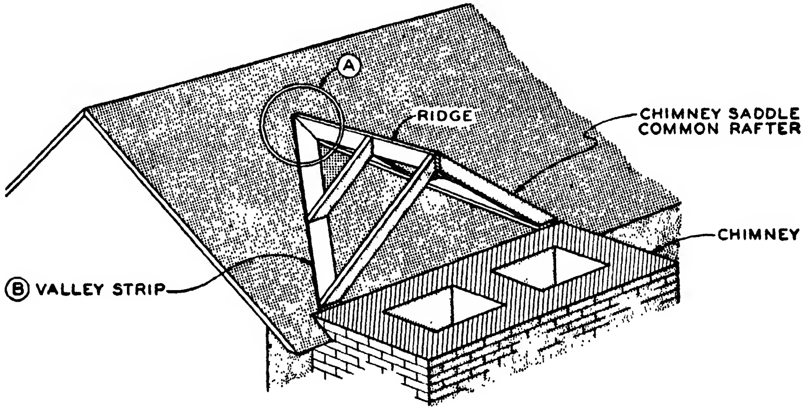


Fig. 71. Chimney Saddle like Small Dormer without a Valley Rafter

shown as (*5*), Fig. 72, to allow for the valley strip and roof boards; otherwise the flashing will extend beyond the sides of the chimney.

PROCEDURE

The distance (*5*) is found by laying the square on a board, with a straightedge, to the cut of the roof, as shown in Fig. 73. Draw the line (*1*) along the blade, or run side, of the square. From the line *(1)* measure the thickness of the roof board and draw the line *(2)*. From the edge of the board, measure back the thickness of the valley strip and draw the line *(3)*,

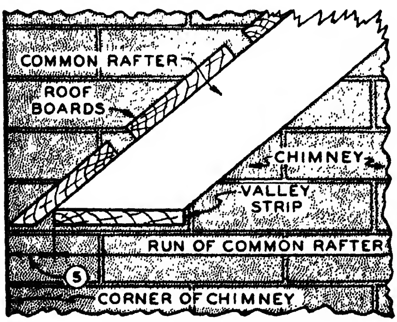


Fig. 72. Shortening Run of Common Rafter

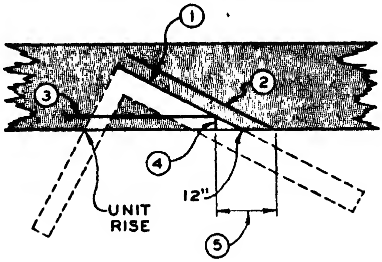


Fig. 73. Method of Finding Shortening Required for Common-Rafter Run

then draw the line *(4)*. The distance shown as *(5)* is the amount to deduct from the run of the common rafter, to prevent the roof boards from extending beyond the sides of the chimney.

Valley Strips for Saddle. To find the valley strip required for the saddle, proceed as follows:

PROCEDURE

Take a piece of 1x4 or 1x6 and step off the length of the valley strip shown at *(B)*, Fig. 71, using the same method as for laying out a valley rafter (no shortening required). Take the unit rise on the tongue of the square and 17 on the blade and step off as many units as there are feet in the run of the common rafter. To get the top cut, use the unit length of the common rafter on the tongue of the square and 12, the unit run, on the blade. Mark along the tongue side of the square, that is, the length side, as shown in Fig. 74. Use the same figures for the bottom cut, but mark along the blade, or run side, of the square, as shown in Fig. 74.

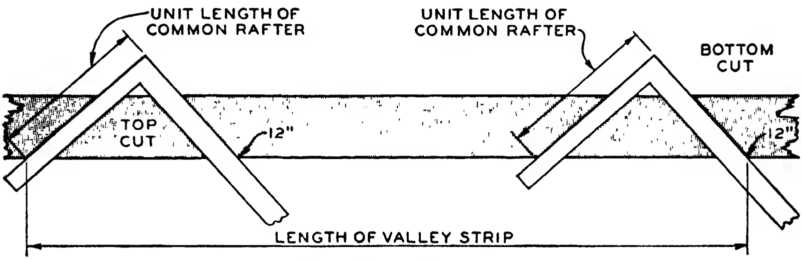


Fig. 74. Layout of Valley Strip for Chimney Saddle

Ridge Piece of the Saddle. The ridge of the saddle fits against the valley strip, as shown at (*A*), Fig. 71. To make this cut, lay the square on the ridge piece, using the figures for the cut of the main roof and mark along the blade, or run side of the square (the seat cut for the common rafter of the main roof). The length of the ridge is equal to the run of the common rafter less about 5/8 of an inch to allow for the drop of the ridge, if the ridge is made out of one-inch material.

Rafter Layout for the Saddle. The rafters for the saddle are in reality only valley jack rafters with a seat cut, instead of a plumb cut, at the lower end. To lay out the saddle rafters, step off the length of the common rafter. Then deduct 1/2 the thickness of the ridge piece. Lay out the side cut, as shown at (*6*), Fig. 75, which is the same as the side cut for any valley jack rafter. Instead of a plumb cut, lay out the seat cut, as shown at (*5*), Fig. 75.

Length of Other Rafters for Saddle. Find the common difference for the jack rafters. Then lay out this common difference on the longest rafter and cut as many pairs of rafters as will be required for the saddle.

BAY-WINDOW ROOF FRAMING

The bay window presents a roof-framing problem common to all buildings which have corners that are not at right angles. The roof plan and the method employed to find the total rise, total run, and lengths of the various rafters, as well as the side cuts for these rafters, are similar to the square-cornered building. This also applies to any polygon roof, regardless of the number of sides.

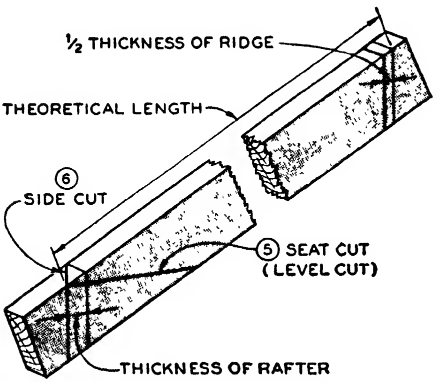


Fig. 75. Layout of Common Rafter for Chimney Saddle

Bay-Window Roof Plan. The roof plan, Fig. 76, shows the location and the number of various rafters of the bay window. This roof plan naturally must be laid out accurately to scale. When the bay is a part of an octagon, the distances (*Ob*) and (*Oe*) are equal. The run of the hip rafter on any polygon must always bisect the

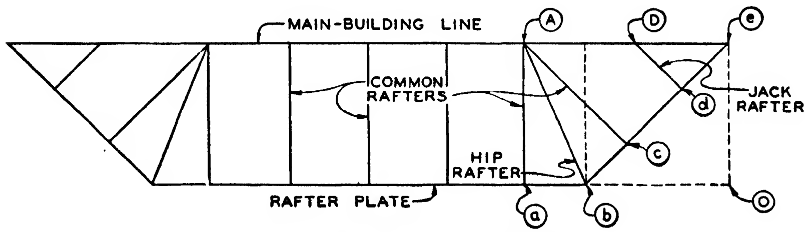


Fig. 76. Roof Plan for Octagon Bay Window

angle at the plate. Therefore, the angle (*abc*) is divided into two equal angles (*Aba*) and (*Abc*), each of the lines (*Aa*) and (*Ac*) represent the run of a common rafter, while (*Dd*) is the jack-rafter run.

The unit run and unit rise of the common rafter is the same as for any square-cornered building. The unit rise and total rise of the hip are the same as that of the common rafter, but the unit run and total run will differ from the common rafter. On the octagon roof the unit run of the hip is 13 inches for every 12 inches of common-rafter run, as shown in Fig. 77. The relation of this 13 inches of the octagon hip-rafter run to the 12 inches of common-rafter run is the same as that of the 17 inches of hip-rafter run to the 12 inches of common-rafter run on the square-cornered building. The miter cut at the plate of an octagon can be found by taking 5 inches on the tongue of the square and 12 inches on the blade, as shown in Fig. 77. Draw the line for the miter cut along the tongue side (*5*) of the square.

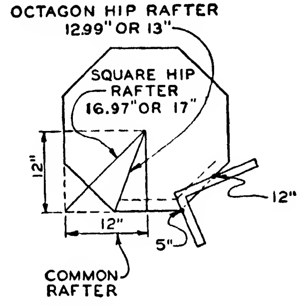


Fig. 77. Unit Run for Octagon Hip Rafter

The necessary dimensions and cuts of the rafters can be found by making a scale drawing, as shown in Fig. 78. This scale drawing should be made as large as convenient for handling. For large buildings the 12th scale is used, but for small buildings or parts of a building it is advisable to use a larger scale, such as 3 inches to the foot. The outline of

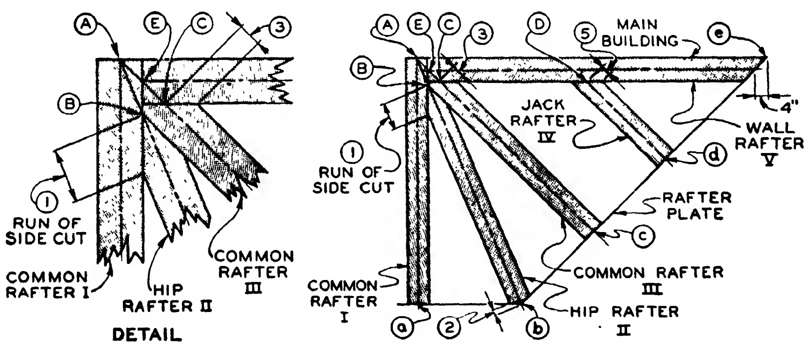


Fig. 78. Layout of Corner of Octagon Bay for Rafter and Side-Cut Runs

the corner of the bay-window roof is drawn first, then the center line for each rafter is drawn. The center lines of the rafters (I), (II), and (III) converge at the point (*A*), while the center line of the jack rafter (IV) is drawn at the required spacing (usually 16″) and parallel to rafter (III). The wall rafter (V) is nailed against the building and acts as a roof-board support. Each rafter is drawn to the *full width of the rafter stock,* in order that the full-size run can be obtained for each rafter side cut, as shown at (*1*), (*2*), (*3*), (*4*), and (*5*), Fig. 78.

Since there are a number of dimensions which must be worked out, it is advisable to make a schedule, as shown in Fig. 79, where the different dimensions can be recorded for later use. The total run of each rafter is scaled from the drawing shown in Fig. 78, and listed

	Total Run	Total Rise	Total Length
(I) Common Rafter (*A*) to (*a*)			
(II) Hip Rafter (*B*) to (*b*)			
(III) Common Rafter (*C*) to (*c*)			
(IV) Jack Rafter (*D*) to (*d*)			
(V) Wall Rafter (*E*) to (*e*)			

Fig. 79. Schedule for Rafter Dimensions

under the heading *Total Run.* The pitch of the roof is found on the drawings for the building the same as for any roof. The total rise and total length can be worked out by sliding the framing square as previously explained. These dimensions can then be recorded in the schedule above.

Laying Out the Rafters. To find the *cut* for the common and jack rafters (I), (III), and (IV), take the unit rise and unit run of the common rafter. Rafter (I) has a square cut at the top. Rafters (III) and (IV) have side cuts at the top. The bottom cut, both seat and heel, are the same on all three rafters.

For the *cut* for the hip rafter, take the unit rise of the common rafter, and a unit run of 13. This hip has a double side cut at the top and bottom. The run of these side cuts, shown at (*1*) and (*2*), Fig. 78, is taken from the scaled drawing and measured at a right angle to the plumb cut, as shown in Fig. 80. It is not necessary to shorten the rafter, since this is taken into consideration when the run of the rafter is worked out. The hip rafter must be dropped. The amount of drop can be found in the same way as for any hip rafter, with the exception that the figure 13 is used instead of 17.

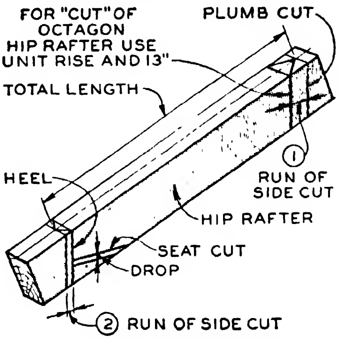


Fig. 80. Layout for Octagon Hip Rafter

Rafter (V) has a square cut at the top and a side cut at the bottom. The *cut* of this rafter is different from that of any of the others. However, the proportions of this cut are the same as its total rise and total run. Since this rafter is not at a right angle to the plate, it must be dropped also.

COLLAR BEAMS AND CEILING JOISTS

The horizontal framing members used to stiffen the rafters of a roof are known as *collar beams*. Where rafters form part of the walls of a second-floor room, these collar beams become the ceiling joists of such rooms. The length of these collar beams, or ceiling joists, depends upon the span of the building, their distance above the plate, and the unit rise of the roof.

Layout for Collar Beam. The length of the collar beam is shorter than the span of the roof. The amount to shorten the beam is indicated by (A), Fig. 81. To find (A) divide the distance (B), the height at which the beam is set above the plate, in inches by the unit rise per foot of run of the common rafter. The result will be the number of feet in (A), the amount the beam must be shortened.

EXAMPLE

The span of a building is 16 feet; the unit rise of the common rafter is 10 inches. What will be the length of a collar beam placed 4 feet above the rafter plate level?

PROCEDURE

To find the length of the collar beam, divide the distance of the beam above the rafter plate, 48 inches, by 10 inches, the unit rise of the common

rafter. The result is 4.8 feet, or 4 feet 9⁹⁄₁₆ inches, which is the amount of shortening required on each end of the piece shown as *(A)*, Fig. 81. Twice 4 feet 9⁹⁄₁₆ inches equals 9 feet 7³⁄₁₆ inches. Subtracting this amount from the length of the span, 16 feet, leaves 6 feet 4¹³⁄₁₆ inches, the length of the collar beam at its longest point. If the rafter has a heel and you wish to have the

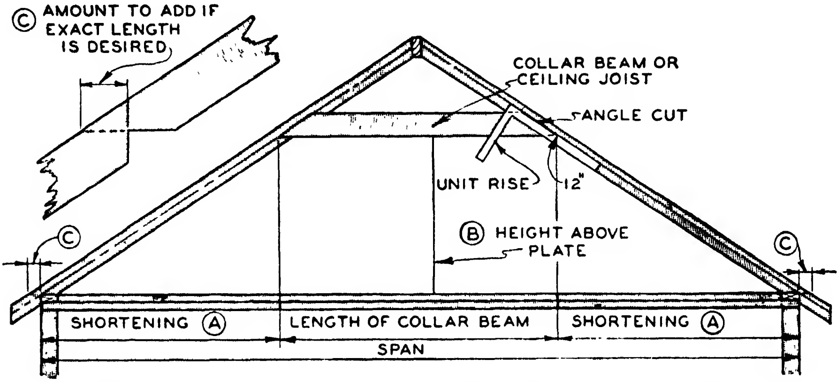


Fig. 81. Length and Angle Cuts of Collar Beams and Ceiling Joists

collar beam fit tightly against the roof boards, it will be necessary to add twice the distance *(C)*, Fig. 81, to the length of the beam.

At each end of the collar beam, the angle cut for fitting the beam against the roof is the same as the seat cut of the rafter against which the beam is framed.

GABLE-END FRAMING

The studs on the gable end of a roof have a common difference in length. If the studs are spaced 12 inches on center (O.C.), then the common difference will be the same as the unit rise of the rafter. For other spacing, for example, 16 inches on center (O.C.), the common difference can be found by sliding the square, as shown at (*A*), Fig. 82. Place the square to the cut of the roof, taking 8 inches (the unit rise) on the tongue and 12 inches (the unit run) on the blade, as shown in the illustration, Fig. 82. Draw a line along the blade, or 12-inch side of the square, then slide the square along this line to 16 inches. Hold the square on the line and read the figure on the tongue side of the square to find the common difference of stud lengths when the studs are spaced 16 inches on center (O.C.). When the unit rise is 8 inches, the unit run 12 inches, and the stud spacing is 16 inches (O.C.), then the common difference of stud lengths is 10¾ inches, as shown in Fig. 82.

The angle cut on any stud or board in a vertical position, on gable ends, is the same as the ridge, or plumb, cut of the rafter. This cut will fit against the rafter and have the same slope as the roof. Therefore, to find the top cut of a gable stud to fit against the rafter, hold the square to the figure 12 on the blade and the unit rise on the tongue, as shown in Fig. 82 at ridge. Draw a line along the tongue or rise side of the square to find the correct angle for the cut.

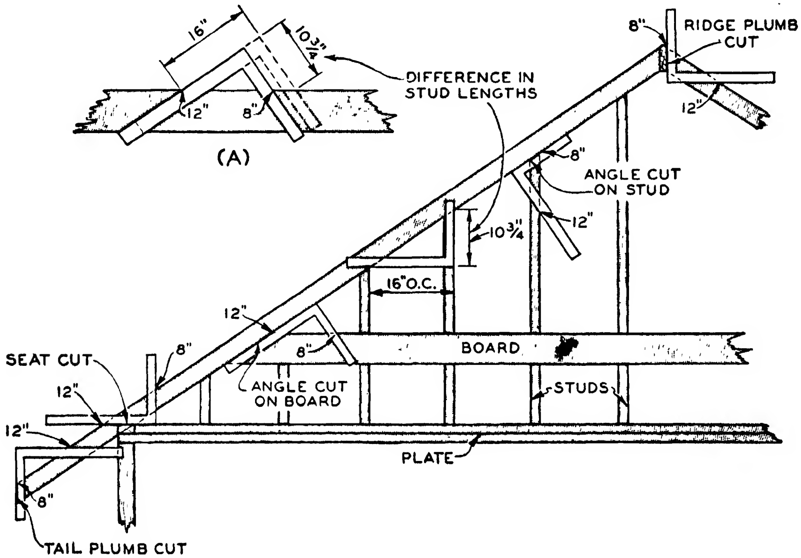


Fig. 82. Angle Cuts and Common Difference of Studs in Framing Gable Ends

For a horizontal board, or any framing member in a level position, which is to fit against the rafter, the end angle cut is the same as the seat cut of the rafter. Also, this angle is the correct cut for horizontal sheathing boards.

LAYOUT TEE

The framing of every roof requires the duplication of rafters. These rafters usually are laid out from a pattern which is made for each kind of rafter needed. The length of the common rafter can be laid out from the pattern, as can also the over-all lengths of any of the other rafters, such as the hip, valley, or jack rafters. However, the hip, valley, and jack rafters have side cuts which cannot be so readily laid out from the master pattern. The carpenter will find it to his advantage, then, to make a *layout tee,* as shown in Fig. 83. With the use of such a *tee,* he can lay out more accurately not only the side cuts but also all of the other cuts required, such as the ridge, bird's-mouth, and tail cuts.

On roofs having hip or valley rafters, it is advisable to make two *layout tees:* one for the common and jack rafters and another for the hip and valley rafters. The correct length of the overhang can be laid out on the *tee* if the length of the overhang is not too great.

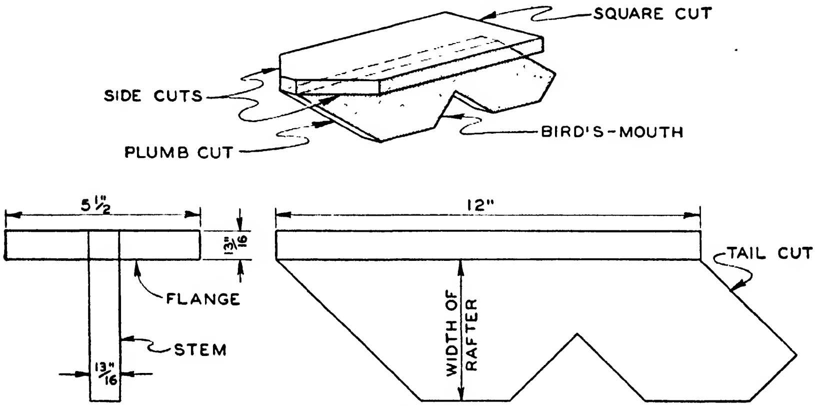


Fig. 83. Layout Tee—Handy Rafter-Layout Tool

It is also advisable to make the layout tee from one-inch material, so it will be light in weight and easy to handle. The 12-inch length is convenient unless a longer overhang is to be included. The stem should be as wide as the rafter stock, while the flange, or top, must be at least twice as wide as the thickness of the rafters, plus the thickness of the stem of the *tee.* The cuts on the *tee* are transferred from the rafter pattern with the framing square or **T** bevel. If these cuts are accurately laid out, cut and planed smooth to the lines, better layout results will be obtained.

FRAMING THE ROOF OF THE HOUSE

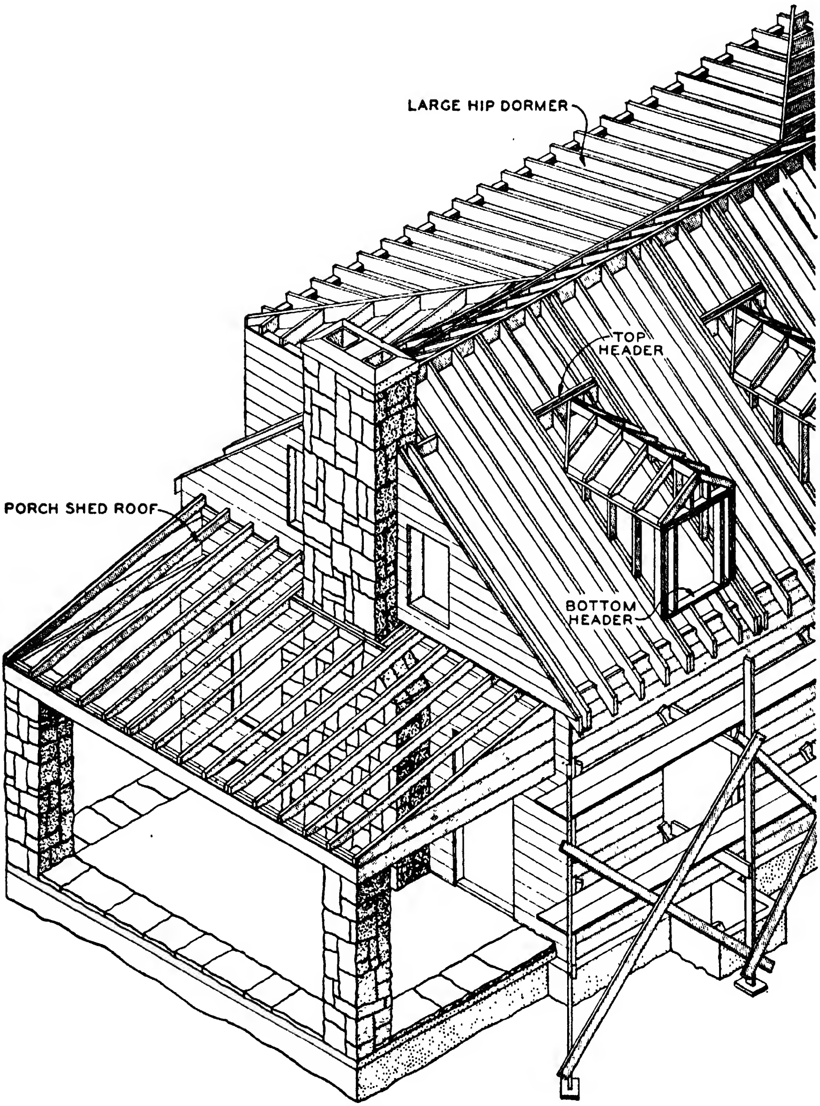
The roof of *The House,* illustrated in Fig. 1, Chapter I, presents six different roof-framing problems, and each of these problems must be treated separately.

1. Main-roof—gable-roof—framing.
2. Large dormer with a different pitch—a hip roof.
3. Gable roof over front addition—partly framed onto main roof.
4. Porch—shed roof.
5. Three small dormers—gable roof framed against a header.
6. Bay window—polygon roof.

This roof, illustrated in Fig. 84, is not as simple in construction as it may at first appear. The large dormer on the north side, with its unequal-pitch hip roof, involves several problems. Also, special problems are involved in framing the bay window on the north side, with its polygon roof; and the addition at the front, with its roof partly framed onto the main roof, presents other problems. Therefore, it is advisable to make a scaled plan of the roof, as shown in Fig. 85. This plan shows the run and location of the rafters. Double framing is indicated by two lines; otherwise each line represents the center of each roof member.

The measurements for the layout of this roof plan were taken from the drawings for *The House*, shown in Fig. 1, Chapter I. Like most drawings for small houses, these drawings do not give all of the necessary dimensions. Therefore, it will be necessary for the carpenter to scale the drawings. Even though the drawings may have been carefully and accurately made, and the builder exercises every possible precaution in following them, slight variations from the measurements given are apt to occur. Hence, it is always advisable to check your work with a steel tape on the building under construction, measuring the size of each roof section to insure accurate roof layout. These measurements should be taken after the walls have been framed and before the layout of the rafter patterns are made.

The angle of the roof usually is indicated on the elevation drawings as unit rise per foot of run, or indicated as of a certain pitch on the working drawings or in the building specifications. If such information is not found on the drawings or specifications, the carpenter must determine the angle of the roof. This angle can be found by scaling the drawings to find the total rise and total run of the rafter. With these measurements the unit rise can be found with the framing square by using the 12th scale. The square should be laid



on a board with a straight edge, with the 12th-scale side upward. Take the total run on the blade of the square and the total rise on the tongue. Draw a line along the blade of the square, then slide the square along this line to the figure 12 (unit run) and read the figure

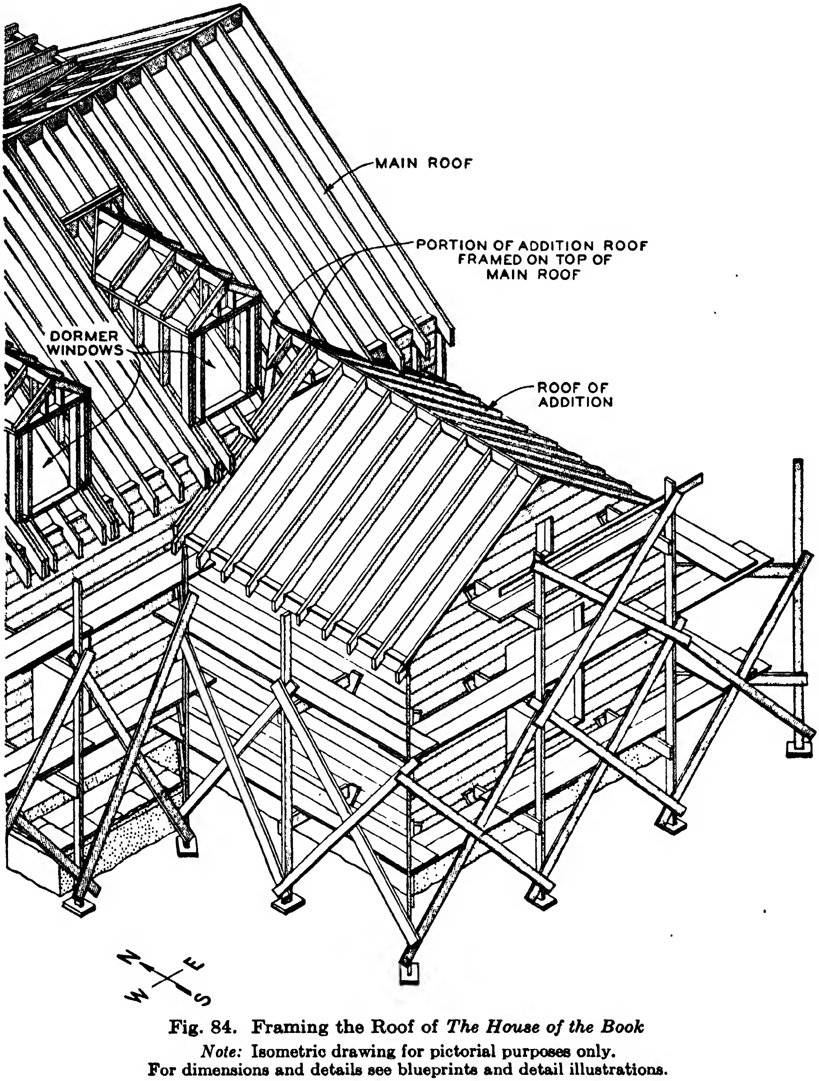


Fig. 84. Framing the Roof of *The House of the Book*
Note: Isometric drawing for pictorial purposes only.
For dimensions and details see blueprints and detail illustrations.

on the tongue. This figure will be the unit rise per foot of run.

The drawings for *The House* show the unit rise of the main roof as 10 inches, and the unit rise of the main dormer as 2¼ inches. The unit rise for the addition is given as 8 inches, and for the porch roof the unit rise is shown as 2½ inches. For the three small dormers the unit rise is 8 inches.

1. Main-Roof—Gable-Roof—Framing. The main part of *The House* is 36 feet 6 inches long and 21 feet wide. Therefore, theoretically, the run of the common rafter will be 10 feet 6 inches. According to the wall details, shown in sections (*A–A*) and (*B–B*) of the blueprints, the rafters for the main roof are to be 2x6, spaced 16 inches on center (O.C.), with a slight overhang. The east and west elevation drawings show a boxed-in cornice for the main roof.

Rafter Pattern. The span of the roof is taken from the outside of the south wall to the outside of the north-wall plate. According to the plans of *The House,* the span is about 20 feet and 5 inches, as the plate is set back 1 inch on the north side and 6 inches on the south side. However, it will be advisable for you to find the exact span measurements with a steel tape. To keep the ridge in the center of the building, the rafters on both the roof slopes will be of the same length, but the layout of the bird's-mouth will differ since the south wall is set back 6 inches to allow for the stone veneer. Therefore, the run for the north rafter should be 10 feet and 5 inches, and for the south side 10 feet (no inches) from the center of the ridge to the outside of the plate, or building line. The overhang, that is, the distance from the building line to the end of the rafter, must be taken from the detail drawings. The overhang on the south wall is 5 inches greater than the overhang of the north wall because of the stone veneer on the south wall.

The rafter pattern is laid out beginning at the ridge cut, then the odd unit, if any, is laid out, followed by as many steps as there are feet in the run of the rafter to the building line. Follow the rafter layout procedure as previously explained. With the pattern, lay out and cut as many full rafters as are required for the main part of the building. The exact number, or count, should be taken after the rafter spacings have been laid out on the plate.

Rafter Spacing. For the south wall, the rafter spacings, 16 inches on center (O.C.), should be laid out by beginning at one end and continuing the entire length of the plate, regardless of the three small dormer windows. Then the double rafters required on each side of the dormers should be laid out and marked for identification when needed later.

The rafter spacings on the north wall must be the same as on the south wall, so the ceiling joist can be nailed to the rafters and have a uniform spacing. Since the north wall has two sets of wall plates—the regular plate and the large dormer plate—spacing for the rafters must be laid out on both plates. The spacing must be started from the same end of the building as the spacings for the south wall, so the rafters of the two walls can be kept directly opposite each other.

Ridge Layout. The plumb cut at the ridge of a 2x6 rafter is relatively long; thus the roof will require at least a 2x8 ridge piece. To allow for the joint, a building 36 feet 6 inches long will require one 18-foot and one 20-foot piece of ridge stock, or three shorter pieces. Good straight stock should be selected, the ends squared, and the piece cut to correct length, so one-half of the joint will come on a rafter. The ridge piece should then be tacked on edge to the rafter plate and the spacings, which have been laid out on the plate, transferred to the ridge piece for the entire length of the ridge. On a gable roof, the length of the ridge is equal to the length of the rafter plate and must have the same rafter spacings.

Rafter Erection. A scaffold must be built for the workmen to stand on while erecting the rafters. The scaffold must be built along the entire center of the building and the rafters erected as previously explained. On the south slope the rafters are omitted temporarily, where the three small dormers are to be located. On the north slope of the roof, only a few full-length rafters can be raised on each side of the large dormer. Since the rafters for the large dormer on the north slope are also omitted temporarily, this will leave the ridge with rafters only on the south side, for the entire length of the large dormer. (You can visualize this situation more easily by referring to the pictorial view, Fig. 84.) Therefore, it will be necessary to place several supports under the ridge to hold it in position until the large dormer has been framed, and ceiling joists and partitions are set. The chimney opening should not be framed until the entire roof has been framed and partly sheathed.

Headers and Cripple Rafters. The large dormer, on the north slope of the roof, is framed against a double 2x8 header between the rafters shown as (*1*) and (*2*), Fig. 85. This header must be supported in the middle temporarily until the partitions of the second floor, which will afford a permanent support, are set.

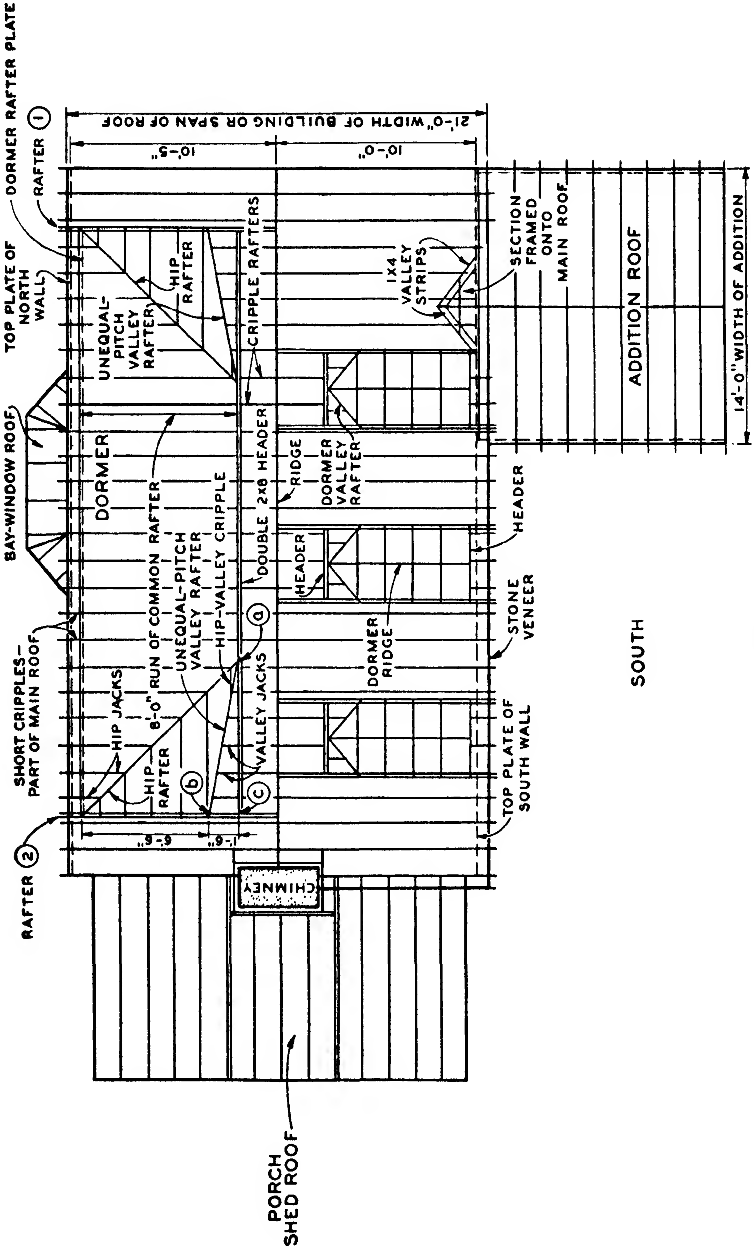


Fig. 85. Roof Plan of *The House*

The double headers for the three small dormers, on the south slope of the roof, should be nailed between the rafters. The headers at the top must be set at dormer-ridge height, as shown at (*A*), Fig. 44. The bottom header should be set in line with the dormer wall forming the subsill for the dormer window.

The cripple rafters above these headers have a square plumb cut on each end; the length of the cripples is taken from the main rafter. All cripples should be cut to the same length for each opening, so the headers will remain straight after the cripple rafters are nailed in place. The cripple rafters below the dormers are laid out with a bird's-mouth and overhang at the bottom, and a plumb and seat cut to fit around the window subsill at the top.

2. Large Dormer with Different Pitch—Hip Roof. Since the large dormer on the north slope has a hip roof with a unit rise of 2¼ inches, this makes it an unequal-pitch, roof-framing problem, because the main roof has a unit rise of 10 inches. The unequal-pitch, roof-framing problem arises whenever two intersecting-roof slopes have different pitches. The peculiar triangle-shaped roof section, shown as (*abc*), Fig. 85, where the dormer roof intersects with the main roof, is where the unequal-pitch framing is encountered.

Large-Dormer Common Rafter. The common rafter of the large dormer has a unit rise of 2¼ inches and a total run of 8 feet from the rafter plate to the face of the header. This rafter should be laid out in the same way as any other common rafter. The *cut* of this rafter is 2¼ inches (rise) and 12 (run) with 8 full units in the layout. The layout at the plate can be found on the detail drawing shown in section (*B–B*) of the blueprints. No shortening is required at the ridge since the run is taken to the face of the header.

Large-Dormer Hip Rafter. The hip rafter of the large dormer should be laid out in the same way as any regular hip rafter. The layout will require 8 full units. The *cut* can be found by taking 2¼ inches (unit rise) on the tongue of the square and 17 inches (unit run) on the blade. A single side cut, as shown in Fig. 38, will allow the hip to fit against the header.

Large-Dormer Jack Rafters. All of the jack rafters for this hip should be laid out in the same way as for any regular hip jack rafter. However, those jack rafters which are framed against the valley rafter must be given special consideration since they are a part of the unequal-pitch framing. The exact layout is explained later.

Unequal-Pitch Valley-Rafter Run. The *valley* is the line of intersection of two different roof slopes, one having a unit rise of 10 inches, the other a unit rise of 2¼ inches. The valley rafter, as shown in Fig. 85, starts at (*b*), where the dormer plate meets with the main-roof rafter. From this point it extends upward to meet the top of the hip rafter at the point (*a*), where it rests against the dormer header. The regular hip is the diagonal of a square prism, while this valley is the diagonal of a rectangular prism. This rectangular prism has a width (*bc*), a length (*ac*), and a height of 1 foot 6 inches, which is equal to the total rise of the regular common and hip rafter of the dormer.

The run of the dormer common rafter is 8 feet and since the run of a regular hip is the diagonal of a square, then (*ac*) is also equal to 8 feet. The side rafter plate of the dormer meets the main-roof rafter 6 feet 6 inches from the corner; thus (*bc*) equals 1 foot 6 inches. Then the run of the valley rafter is the diagonal of a rectangle that is 1 foot 6 inches wide and 8 feet long. Your problem then is to find the hypotenuse of a right triangle whose base is 8 feet and altitude 1 foot 6 inches.

Unequal-Pitch Valley-Rafter Length. When the total run and total rise of any rafter is known, then the total length can be found by the mathematical computation (square root) or by the 12th-scale method. However, carpenters frequently find the length of a valley rafter by measuring with a steel tape.

Unit Run and Unit Rise of Unequal-Pitch Valley Rafter. The unit rise of any rafter for each foot of run can be found by sliding the square. Take the total rise on the tongue of the square and the total run on the blade. Draw a line along the blade, then slide the square along this line to 12. Read the figure on the tongue to find the unit rise. To find the plumb and seat cut of the rafter, take the unit rise on the tongue of the square and 12 on the blade.

Side Cuts on Unequal-Pitch Valley Rafter. Draw a rectangle to scale (reduced size), on a board (using as large a scale as the size of the board will permit), that is, 1 foot 6 inches wide (*bc*) and 8 feet long (*ac*), Fig. 86. Then draw a diagonal from corner (*b*) to corner (*a*); this will represent the center line of the run of the valley rafter of the large dormer, as shown in Fig. 85. Then draw the valley rafter (full scale) along this center line, as shown in Fig. 86.

Since the valley will be framed against the regular hip rafter, it will be necessary to draw the full width of the hip at 45 degrees from the point (*a*), Fig. 86. This will cut off part of the valley rafter. Therefore, the distance (*1*) is the amount the valley rafter must be shortened before the side cuts can be laid out.

The run of the side cut on a valley rafter which will fit against the large dormer header is the distance (*2*) taken from the center of

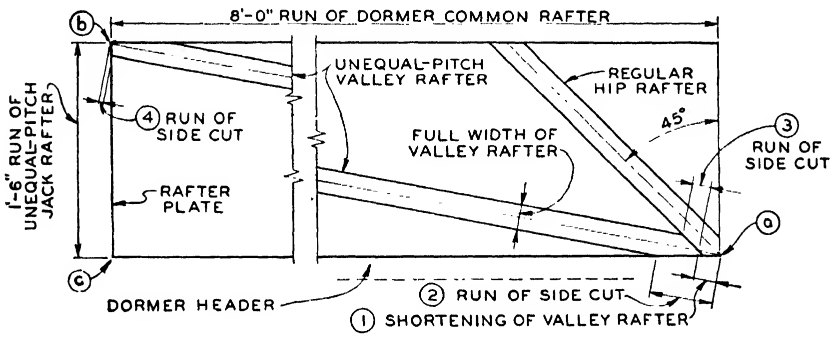


Fig. 86. Layout for Unequal Pitch of Valley-Rafter Run

the valley rafter to a point where the side of the valley touches the header. The run of the side cut (*3*) which will fit against the regular hip is taken from the center of the valley rafter, as shown in Fig. 86, to a point where the side of the valley touches the side of the hip. These distances should be taken parallel to the run of the valley rafter.

The bottom cut of the valley rafter, resting on the plate, must have a side cut parallel to the plate. The run of this side cut is a distance shown as (*4*), Fig. 86, measured parallel to the valley rafter from the center to the point where the edge of the valley rafter meets the plate.

Layout of Unequal-Pitch Valley Rafter. The layout of the side cuts of the top of the unequal-pitch valley is somewhat out of the ordinary, because it must be framed against a hip and a header. However, when a carefully made scale drawing has been laid out, showing the run of each side cut, as in Fig. 86, and these runs are laid out on a level line from the plumb cuts, as in Fig. 87, the results will be satisfactory. Draw a line for the plumb cut near the end of the rafter stock, taking the total rise on the tongue of the square and the total run on the blade, to find the correct angle of the line.

Note: The point of the rafter does not come on the center line, but all side cuts are laid out from the edge of the stock to the center

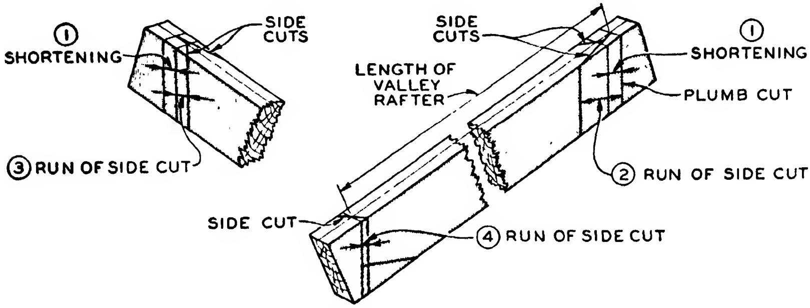


Fig. 87. Layout of Length and Cuts of Unequal-Pitch Valley Rafter

line. The procedure of layout is the same as previously explained for any valley rafter, except that instead of being stepped off, the rafter is measured.

Unequal-Pitch Jack Rafters. The large dormer-roof layout illustrated in Fig. 85 shows two kinds of jack rafters—the hip-valley cripple jack, extending from the regular hip to the unequal-pitch valley rafter, and the valley jacks, extending from the header to the unequal-pitch valley rafter. The same scaled rectangle drawn to find the valley-rafter run, shown in Fig. 86, can be used to find the runs of the rafter side cuts. When the jacks are drawn to full width, they will appear as shown in Fig. 88. The runs of these side cuts, shown at (*1*), (*2*), and (*3*), are measured parallel to the jack rafter from the center to a point where the edge of the jack rafter intersects the other rafters, as shown in Fig. 88.

Note: A cripple jack rafter extends from the hip to the valley rafter without touching either the ridge or rafter plate.

Layout of Unequal-Pitch Jack Rafters. The simplest way to find the length of the unequal-pitch, hip-valley, cripple jack rafter shown at (*A*), Fig. 88, is to make actual length measurements on the roof. A common difference exists for the jack rafters shown at (*B*), Fig. 88.

This common difference can be found in a way similar to that used to find the common difference for regular jack rafters by sliding the square.

The *cut* for the cripple jack (*A*), Fig. 88, will be the same as the cut for the regular common rafter of the large dormer. This can be found by taking 2¼ on the tongue of the square and 12 on the blade. Each end of this rafter, shown at (*A*), Fig. 89, has a plumb cut

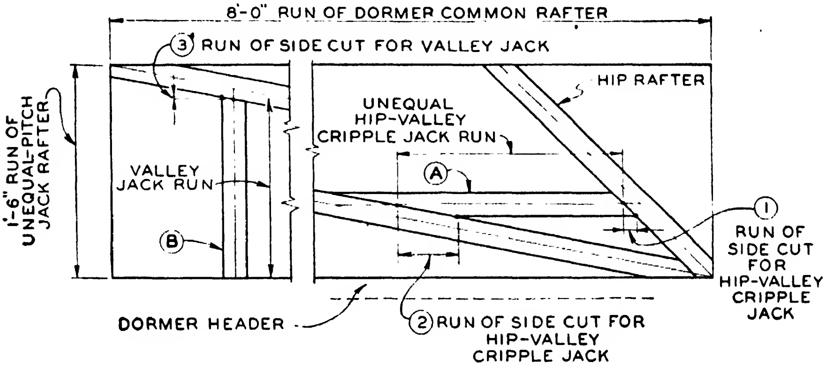


Fig. 88. Unequal-Pitch Jack-Rafter Run

from which the run of the side cuts is measured on a level line. The side cuts extend from this line to the center line of the rafter.

The *cut* of the valley jack rafter (*B*) will be the same as that of the main roof. This cut can be found by taking 10 (unit rise) on the tongue of the square and 12 (unit run) on the blade. The top cut will fit against the large dormer header with a square plumb cut. The bottom will have a plumb cut with a side cut laid out on a level line from the plumb cut, as shown in Fig. 90.

3. Gable Roof over Front Addition. The addition, as shown in the pictorial view, Fig. 84, has a gable roof. The rafter plate for this roof is 3 feet 6 inches lower than the rafter plate of the main roof. This will leave a short span to intersect with the main roof. You can find the length of this span in the same way that the length of the collar beam was found. The two roofs can be joined by using the regular valley-rafter construction. However, this kind of construction will weaken the main roof. A more practical plan is to frame the addition roof on top of the main-roof sheathing, using the method described for framing the chimney saddle.

4. Porch Shed Roof. The shed-roof rafter for the porch can be laid out in the same way as any shed-roof rafter, without an overhang at the top. The run of the rafter is from the face of the sheathing to the outside of the porch beam which supports the porch roof. A 2x4 can be fastened to the sheathing against which the rafters can be nailed, or the 2x4 can be lowered and the rafters framed so as to rest on top of the 2x4. Greater strength can be obtained by nailing the rafters to the side of the wall studs, as shown in Fig. 56. However, this can only be done when the studs line up with the rafter positions.

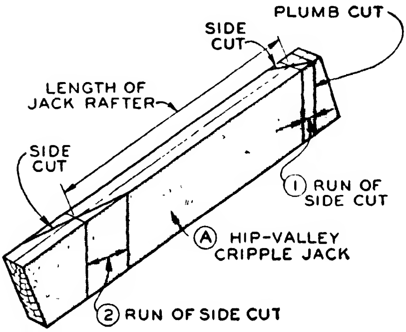


Fig. 89. Layout of Unequal-Pitch Hip-Valley Jack Rafter (*A*)

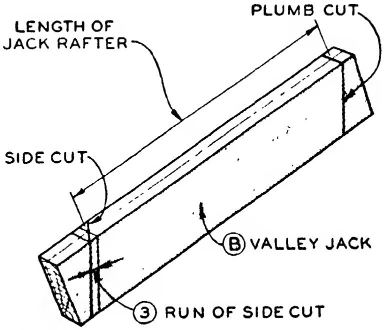


Fig. 90. Layout of Unequal-Pitch Valley-Cripple Jack Rafter (*B*)

The unit rise of this roof is given as 2½ inches on the working drawings. It might be more advisable to determine the location of the top of the roof in relation to the second-floor windows and from this measure the total rise and then find the unit rise by sliding the square.

The rafters must be headed out around the chimney, as shown in Fig. 85. This will necessitate the doubling of the rafters on each side of the chimney opening to carry the load.

5. Three Small Dormers Framed against Header. The gable roof of the three small-dormer windows have the ridge framed against a header which is between two main-roof rafters. The header is necessary because the ceiling is carried almost to the ridge of the dormer.

The wall studs of these dormers can be framed either on top of the double main rafters, as shown in the pictorial view, Fig. 84, or they can be framed down to the floor of the second story. Use of the last-named method will depend upon the room arrangement of the second floor.

The size of the window will determine the height of the rafter plate, and the height of the plate in turn will establish the length of the plate and the height of the header against which the ridge and the valley are framed.

Since the roofs of the small dormers intersect with the main roof, the construction of the dormer will demand a valley which is laid out and framed in the same way as any unequally pitched valley. Framing the rest of the roof is relatively simple. The method of making the layout and framing the common and jack rafters and the ridge have been explained previously.

6. Bay Window—Polygon Roof. The side of a bay window usually is the diagonal of the square. In the bay window for *The House,* each side is the diagonal of a rectangle, measuring 2 feet 6 inches by 2 feet (no inches), as shown on the basement plan of the blueprints. However, the method of framing the roof of this bay remains the same as that used in any type of bay window. The details of the rafter at the plate and the pitch of the roof will be found in the detail drawings, section (*B–B*), of the blueprints.

CHECKING ON YOUR KNOWLEDGE

The following questions give you the opportunity to check up on yourself. If you have read the chapter carefully, you should be able to answer the questions. If you have any difficulty, read the chapter over until you have the information well in mind before you go on with your reading.

DO YOU KNOW

1. The names of five styles of roofs commonly used in the construction of small homes and other buildings?
2. What style of roof is frequently used in combination with other types of roofs?
3. The meaning of the following roof-framing terms: *hip roof, gambrel roof, common rafter, jack rafter, hip-valley jack rafter, ridge, plate, overhang, tail cut?*
4. The difference between the total run and unit run of a roof? How you can find the total run of a common rafter?
5. The relation between the span, rise, and pitch of a roof? How to find the pitch when you know the rise and span?
6. How to find the pitch of the roof which has a unit rise of 8 inches and a unit run of 12 inches?

7. The angle of pitch for a roof which has a unit rise of 12 inches and a unit run of 12 inches?

8. Whether or not a cripple jack rafter ever touches the plate or ridge?

9. Where the heel cut of a common rafter is located?

10. Whether or not a bird's-mouth cut is ever found at the top of a rafter?

11. How to find the unit run of a building when the span is given? Where you can usually find the span of a building?

12. What is meant by the term *cut of a rafter?*

13. The difference between a hip-valley jack rafter and a hip-valley cripple jack rafter?

14. What important scale often used in roof framing is found on the back of the framing square?

15. When laying out a rafter, which part of the framing square is often referred to as the *run side?* Which part is frequently called the *rise side?*

16. What six special roof-framing problems are involved in framing *The House of the Book?*

17. What feature of the roof of *The House* causes an unequal-pitch valley rafter problem?

18. Where to find the span of *The House?*

19. What type of roof is used on the porch?

20. Why the framing of the roof of the bay window of *The House* is more difficult than the framing of an ordinary bay?

21. Why the framing of the addition of *The House* presents an unequal-pitch valley-rafter problem?

22. Why the common rafters on the south slope of the main roof of *The House* has a longer overhang than the common rafters on the north slope of this roof?

23. When framing the three small dormer windows on the south slope of *The House,* what determines the height of the rafter plate? What determines the length of the rafter plate?

24. What style of roof is used on the small dormers of *The House?* Of the large dormer?

25. What size of rafter stock is used for the common rafters of the main roof of *The House?* What size ridge piece is required?

CHAPTER V

Exterior Finish

QUESTIONS THIS CHAPTER WILL ANSWER

1. *When constructing a house, is the roof covering applied before or after the cornice work is done?* 2. *Are the window and door frames put in place before or after the wall covering is applied?* 3. *What is the difference between a bargeboard and a verge board?* 4. *Where is a box gutter located?* 5. *What kind of material is used for the flashing of an open valley at the intersection of two roof slopes?* 6. *Which type of shingle is the most durable—wood, asphalt, or asbestos-cement?* 7. *Where are the water tables located in a building? Why are they important?*

INTRODUCTION TO CHAPTER V

The material presented in this chapter deals with the roof and wall covering of a house. The exterior finish of a new building is an extremely important factor in the construction process. Not only does the outside finish serve as a protection against the weather for the interior construction, but this covering also provides shelter for the occupants of the dwelling. In addition to these advantages, the exterior finish either adds appreciably to, or detracts from, the external appearance of a residence. It is possible for the outside finish to increase the value of a house considerably, in comparison with the actual value of the building as an investment.

In this chapter you will learn about the best materials to use for roof and wall covering. Among many other details discussed in connection with the special features of roof and wall construction are: cornice and ridge trim, methods used to prevent leaking of the roof around dormer windows and along the valley between two roof slopes, and methods of applying sheathing materials. The finish of exterior door and window frames involves problems which are explained by the author.

Another feature of construction given careful consideration is that of framing of a roof at the eaves. The author has given valuable information here concerning the different types of gutters and how to construct them. Attention is also given to the water table, which is of special importance because it protects the foundation of a building by carrying away rain water from the masonry walls. The water table is important, also, because it is the first part of a building to meet the eye of an observer.

Because of the importance of the foregoing facts, in connection with the exterior finish of a new building, you should study this chapter with unusual care. You will find the information and instruction given here of great value to you as a carpenter when you begin the construction of a house on your own responsibility.

COVERING FOR ROOF AND WALLS

The exterior finish of a building is intended to serve three purposes: (1) to protect the vital parts of the structure—the framework; (2) to seal all cracks and crevices to prevent infiltration and escape of air; (3) to decorate this framework and make it as pleasing as possible in appearance. All of these purposes must be borne in mind when designing or applying any exterior finish, as all are important, and none of them should be neglected when building a new house.

The principal parts of the outside finish include the *cornice trim,* or *overhang, gutters, roof covering, door* and *window frames, water table, corner boards, belt courses,* and *wall covering.* The application of this outside finish follows after the walls and roof have been sheathed. The order in which the work is done depends to some extent upon the type and design of the building, the trim used, and the relation of the different members to each other. For example, the roof cannot be covered until the cornice work has been done; the application of the belt courses and water table usually precedes corner boards; the window and door frames must be set before wall covering can be applied. However, as a rule, the roof covering is of the greatest importance. Therefore, the cornice work usually is the first of the outside trim to be applied.

MATERIALS

For exterior finish, the material used varies with the design, the locality, and other conditions. There are many different materials used for exterior finish, such as wood, brick, stone, slate, stucco, and the various manufactured products, including steel units and compo-materials. However, it is the wood (boards and shingles) which is of chief concern to us at this time. Even if other materials are used for wall and roof covering, wood ordinarily is used for the trim of the building.

Wood for Exterior Finish. In choosing the wood for the exterior finish, several factors must be taken into consideration—decay resistance, paint-holding quality, and lumber grade. This selection will depend to a great extent upon the kind of wood available in your locality.

Woods commonly used for outside finish and carried in stock by local lumber yards include white pine, cypress, western cedars, redwood, and Douglas fir. For temporary or cheap buildings, spruce and Georgia pine are sometimes used, but these woods are too inferior for outside finish where durability is desired.

When considering the paint-holding quality of wood, not only the species but also the density is important. The paint-holding property of light spring wood is better than that of the heavier summer growths. Edge, or vertical-grain, boards also are found to hold paint better than the flat or plain-sawed boards; likewise, the bark side of flat-grain boards is superior to the pith side in paint-holding qualities.

Any defect which mars the appearance of wood makes it undesirable for exterior trim. Also, a defect in wood impairs its durability and paint-holding property. Therefore, it is advisable to select and use only the high-grade woods for finishing and trimming the exterior of any permanent building.

Building Paper. An important material, which is almost indispensable in connection with outside finish, is *building paper.* This paper serves two useful purposes: (1) waterproofing, and (2) reducing the infiltration of air and dust. However, building paper is not considered as of much value as a thermal-insulation material. All such paper should be applied carefully around windows and door frames. Special care should be taken when applying building paper over wall sheathing and roof boards for certain types of roof covering. Care should also be exercised when placing paper under siding and shingles or other wall covering. The value of building paper for reducing air infiltration varies for different types of frame-wall construction, as shown in Table I.

When selecting building paper, the physical and mechanical properties to be considered are: strength (resistance to tearing and tensile breaking), rate of air penetration, and its moisture-proof properties. Classified according to groups, building paper includes tarred felt, asphalt saturated, paraffin saturated, laminated kraft papers, and machine-finish papers, each with different properties for serving different situations. The asphalt saturated and laminated kraft papers seem to be used principally to cover walls to reduce infiltration of air. Tarred felt is no longer in general use for this purpose.

TABLE I. AIR INFILTRATION THROUGH FRAME WALLS*
(Average wind velocity of 15 miles per hour)

Type of Construction	Infiltration in Cubic Feet per Hour per Square Foot Area
D and M sheathing	12.3
Insulation A, coarse fiber	16.1
Insulation B, fine fiber	9.1
Corrugated steel siding	26.8
Drop siding, paper, and sheathing	.19
Bevel siding, paper, and sheathing	.28
16-inch shingles, paper, and shiplap	.17
24-inch shingles, paper, and sheathing	.13
Sheathing and paper	.31
Wood lath and plaster	.17
Wood lath, plaster, and wall paper	.10
Metal lath and plaster	.23
Siding with two coats paint, paper, sheathing, wood lath, and plaster	.16

*The air infiltration through frame-wall construction, containing building paper or plaster properly applied, is negligibly small, as found by experiments at the University of Wisconsin.

Wood Shingles. Since the days of the Pilgrim Fathers, American homes have been covered with wood shingles. In the early days of our country, these shingles, which were rived from blocks of wood, were called *shakes*. These rough-hewn shakes were the same thickness from end to end. Later, an improvement was made in the shingle by shaving it with a draw knife. The shaved shakes, or shingles, were then made thicker at one end, as they are today. Although the hand-shaved process was slow and expensive, it was an important step forward and eventually led to the invention of machines for sawing shingles. From time to time these machines have been changed and improved until we now have the modern shingle machine which manufactures the amazing number of 30,000 first-class shingles in a period of eight hours.

The best woods for making shingles are: western red cedar, redwood, and cypress. To some extent shingles are made from eastern white cedars, white pine, longleaf pine, and sugar pine. Shingles are graded by length and thickness. The length is given in inches and the thickness in the number of butts which, when placed together, will measure 2 inches when green. Manufactured in three standard lengths, shingles measure 24 inches, 18 inches, and 16 inches. The four standard thicknesses are: 4 butts to 2 inches, 5 butts to 2¼ inches, 5 butts to 2 inches, and 6 butts to 2 inches. The best-grade shingles manufactured are strictly vertical grain, and are made from wood free from sap and all other defects, as shown in Fig. 1. These grades include Royals, 4 butts to 2 inches, length 24 inches; Perfection, 5 butts to 2¼ inches, length 18 inches; Eurekas, 5 butts to 2 inches, length 18 inches; XXXXX (5X), 5 butts to 2 inches, length 16 inches; XXX (3X), and all others 6 butts to 2 inches, length 16 inches. Lower grades permit flat grain, sapwood, and certain defects above 10 inches from the butts, as shown in Fig. 2.

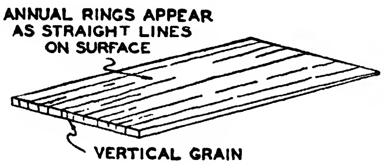


Fig. 1. Best-Grade Shingle

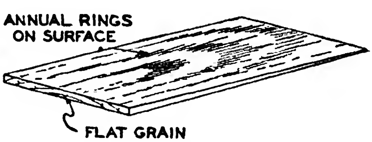


Fig. 2. Second-Grade Shingle

Shingles come in bundles so packed that 4 bundles when laid according to standard weather exposure will cover 100 square feet of surface. Standard weather exposures are: 16-inch shingles exposed 5 inches to the weather, 18-inch shingles exposed 5½ inches, and 24-inch shingles exposed 7½ inches to the weather. For covering on other exposures, see Table II. The ordinary shingles come packed in bundles, in *random widths,*[1] ranging from 2½ inches as a minimum to 12 inches or wider. Shingles known to the trade as *dimension shingles* are cut to uniform widths of exactly 4 inches, 5 inches, and 6 inches. These shingles come packed in convenient paper cartons and are used almost exclusively for side-wall coverings.

Wood Siding. The only difference between clapboards and common siding, often called *bevel siding, is in the length of the pieces.* Bevel sidings come in lengths of from 6 to 16 feet, while clapboards are only 4 feet long. Sidings are available in widths varying from 4 to 12 inches and ranging from 7/16 to ¾ of an inch in thickness. The 8-inch, or wider, bevel siding is often called *bungalow* or *Colonial siding.* Table III will be an aid in estimating quantities required for a new building.

Since siding is exposed to the weather, durability of the wood is an important factor to consider when selecting siding material. Among the

---

[1] Odd sizes considered together are called *random sizes,* as shingles of *random widths.*

TABLE II. COVERING CAPACITY OF A SQUARE* OF SHINGLES FOR DIFFERENT EXPOSURES

Weather Exposure (Inches)	Covering Capacity in Square Feet of One Square of Shingles						Required Lbs. Nails to Lay 100 Sq. Ft. (Hot-Dipped Zinc-Coated, Cut Iron Type)		Estimated No. Hrs. Carpenter Labor per 100 Sq. Ft.		Weather Exposure (Inches)
	24 in. Shingles		18 in. Shingles		16 in. Shingles		2½d	3½d	Roofs	Side Walls	
4	Exposure for Roofs	...	Roofs	58.0	Roofs	82.0	2⅞	3½	2.5	4.5	4
4½		...		83.2		92.4	2½	3⅛	2.3	4.0	4½
5		...		92.4		102.8	2⅜	2⅞	2.0	3.6	5
5½		...		101.6	Walls	113.2	2	2½	1.9	3.3	5½
6		81.0	Walls	110.8		123.2	1⅞	2⅜	1.7	3.0	6
6½		87.6		120.4		133.6	1⅞	2¼	1.6	2.7	6½
7		94.5		129.2		144.0	1⅝	2	1.5	2.5	7
7½		101.1		138.8		154.0	1½	1⅞	1.4	2.4	7½
8	Exposure for Walls	108.0		148.0		...	1⅜	1¾	..	2.3	8
8½		114.6		157.2		...	1⅜	1⅝	..	2.1	8½
9		121.5		...		...	..	1½	..	2.0	9
9½		128.1		...		...	..	1⅜	..	1.9	9½
10		135.0		...		...	..	1⅜	..	1.8	10
10½		141.9		...		...	..	1⅜	..	1.7	10½
11		148.2		...		...	..	1⅜	..	1.6	11
11½		155.1		...		...	..	1¼	..	1.5	11½

*Four bundles of standard-size shingles.

most durable woods for this purpose are cypress, cedar, and redwood. In addition to the durability of the wood, paint-holding qualities must also be considered. Siding, as well as other wood used for finish work, should be kiln dried to the correct moisture content, and kept dry on the job until the building is completed and prime painted.

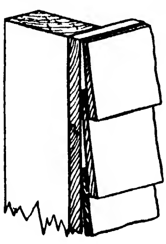
Early in our Colonial history, *clapboard,* or bevel siding, came into use and is still used extensively by builders and contractors. In the illustration, Fig. 3, a section of bevel siding, or clapboard, is shown. Colonial carpenters, using hand tools, frequently beaded their bevel siding. This beading added greatly to the softness and refinement of the shadow lines in wood side walls where it was applied. *Beaded-bevel*

TABLE III. SIZE OF VARIOUS SIDING AND THE PERCENTAGE TO ADD TO THE SURFACE AREA WHEN FIGURING QUANTITIES

Type of Siding	Size in Inches	Lap in Inches	Percentage to Add†
Bevel siding	1x4	3/4	45
	*1x5	7/8	38
	1x6	1	33
	1x8	1 1/4	33
	1x10	1 1/2	29
	1x12	1 1/2	23
Rustic and Drop	1x4	shiplap	28
	*1x5	shiplap	21
	1x6	shiplap	19
	1x8	shiplap	16
Rustic and drop	1x4	D and M	23
	*1x5	D and M	18
	1x6	D and M	16
	1x8	D and M	14

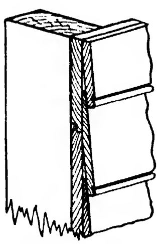
*Unusual sizes.
†An additional 3 to 5 per cent should be allowed for cutting and fitting around openings and under the eaves

siding is illustrated in Fig. 4. *Rabbeted-bevel siding* is a popular and economical siding pattern which fits tightly against the wall sheathing. An illustration of this type of siding is shown in Fig. 5. *Drop siding,* which is usually thicker than bevel siding, makes a strong, tight wall which in itself is well insulated against wind and cold. For illustration see Fig. 6.



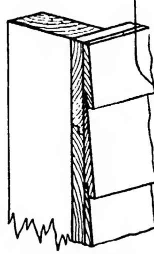
CLAPBOARD OR BEVEL SIDING

Fig. 3. Lapped Siding Thicker on One Edge



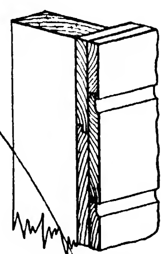
BEADED-BEVEL SIDING

Fig. 4. Ornamental Beaded Siding



RABBETED-BEVEL SIDING

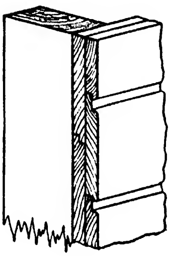
Fig. 5. Rabbeted Tight-Fitting Siding



DROP SIDING

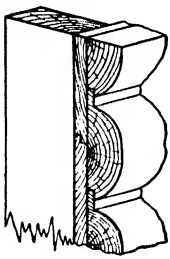
Fig. 6. Tongue-and-Groove Matched Siding

A type of siding wall adapted to formal architecture is the *formal shiplap siding* shown in Fig. 7. Decorative effects may be obtained by scoring the siding vertically with a grooving tool. The rustic effect of a real log wall, without the attendant structural difficulties, is produced by the *log-cabin siding* illustrated in Fig. 8. This type of siding may be applied either horizontally or vertically with equally good effect. A simple and sturdy wall covering can be made with wide boards placed vertically and the joints covered with battens of 1x2's, as shown in Fig. 9. The battens may be molded for added effect. Vertical battens may also be placed behind the joints of wide boards used as vertical siding, as shown in Fig. 10. This type of construction provides a double air space in the wall, thereby improving its insulation value.



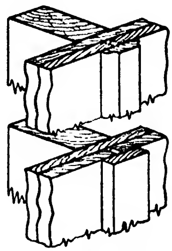
FORMAL SHIPLAP SIDING

Fig. 7. Weatherboards Rebated on Opposite Edges



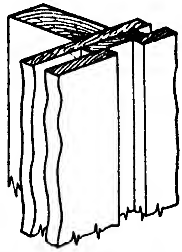
LOG-CABIN SIDING

Fig. 8. Siding Which Gives Rustic Log-Cabin Effect



WIDE BOARDS WITH BATTENS

Fig. 9. Siding Applied Vertically with Battens over Joints



BATTENS BEHIND WIDE BOARDS

Fig. 10. Another Method of Applying Boards and Battens

Plywood Wall Covering. For building purposes, large panels of plywood are now available on the market for exterior use. In this plywood material the various layers of wood are bonded together with waterproof resin glues. For residential construction the standard sizes of plywood panels are 4x8 feet, with varying thicknesses. In addition to increasing the rigidity of a building, another advantage in the use of these large-sized plywood units is the reduction in labor costs. These panels can be applied either horizontally or vertically on a stud frame wall in which cross pieces must be framed to serve as nailing strips along the edges of the panels. Plywood panels placed horizontally, with a detail (*A*) of the vertical joint treatment, are shown in Fig. 11.

Composition Material for Roof Coverings. The exposed surface of composition roofing usually is covered with a coating of crushed slate in various colors. This type of composition material is made of felt saturated with asphalt. In a similar manner, asphalt shingles are made and coated with a thin sheet of copper.

Asphalt roof coverings are available in several different styles, including rolls 36 inches wide known as *rolled roofing,* rolled strips about 15 inches wide with edges of different designs, flat strips about 3 feet long consisting of 3 or 4 shingles, and individual shingles. Various thicknesses of the different styles also are available. The individual

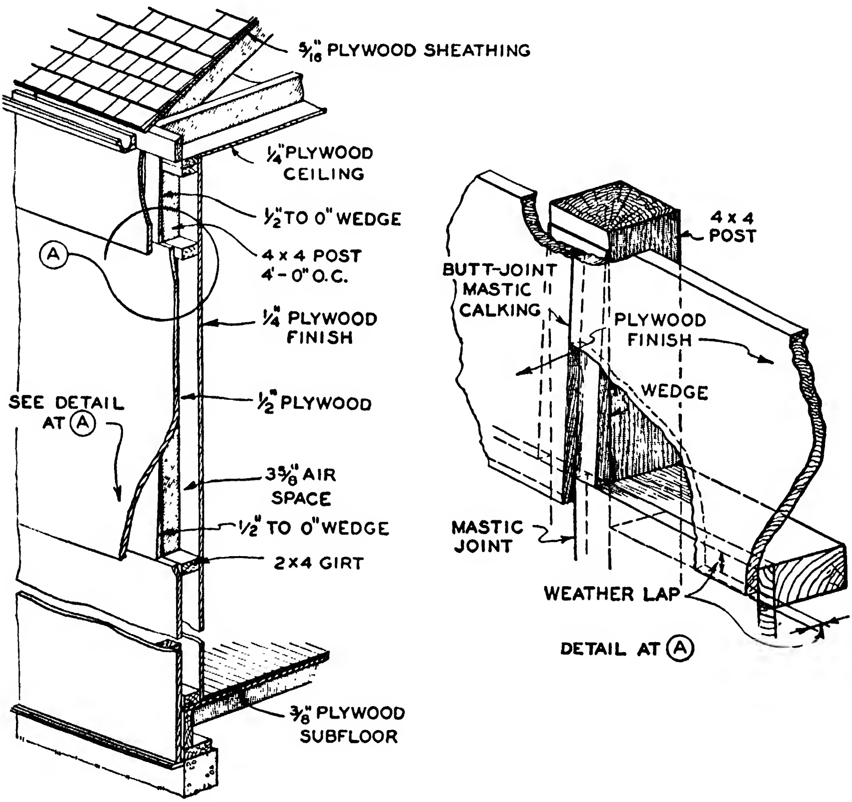


Fig. 11. Wall Construction of Plywood Panels Applied Horizontally

shingles, which produce a roof covering of good quality and appearance, are the most expensive of the composition roof coverings. However, the most popular style is the flat strip. This covering is laid quickly but produces a roof with a monotonous appearance. This style of roofing is shown in the illustration, Fig. 12. One of the cheapest and most quickly applied types of composition roofing is the rolled strip illustrated in Fig. 13.

Composition Siding. Wall-covering material composed of felt and asphalt usually comes in the form of imitation brick, illustrated in Fig. 14. This material can be obtained in 31-inch rolled strips which can be divided into two 15½-inch strips, each 43 feet long; or in flat strips measuring 14x43 inches. This type of asphalt siding also comes in brick-siding strips, 4 bricks long, which are laid in courses. This covering is available in a variety of brick patterns, coated with mineral granules of different colors.

Asbestos-Cement Shingles. Available in various colors and textures, the asbestos-cement shingles are rigid and produce a roof cover-

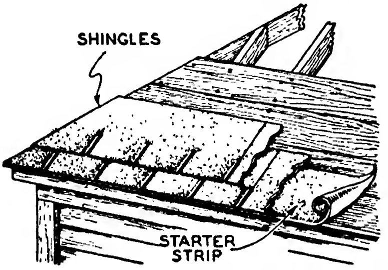


Fig. 12. Application of Asphalt Flat-Strip Shingles

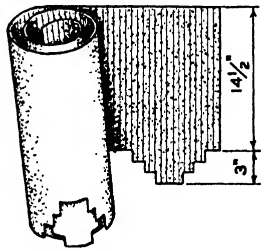


Fig. 13. Asphalt Rolled-Strip Roofing

ing which is fire resistant as well as attractive. The individual shingle is used chiefly for roof covering, while the strips are used more extensively for wall covering. Like slate, the asbestos-cement shingle is a protective covering for a roof. Its water resistance depends to a great extent upon the asphalt paper placed under the shingles.

Asbestos-Cement Siding. Because of its fire-resistant qualities, asbestos-cement siding, a rigid wall covering, is gaining in favor with contractors and builders, especially for remodeling purposes. This siding, illustrated in Fig. 15, is made in pieces 12 inches wide and 24 inches in length. When made of asbestos fiber and Portland cement, these pieces may be even more than 24 inches long. A grain is embossed on the exposed surface to represent wood shingles. This siding material is available in various colors and designs.

CORNICE TRIM

The exterior finish on a building at the line where the sloping roof meets the vertical wall is known as the *cornice trim;* it is the horizontal projection which finishes the top of the wall of a building where the wall meets the roof. In addition to its practical value, the cornice trim may add materially to the architectural beauty of a building. There are various styles of cornice construction especially for houses and each style has its own particular advantage or disadvantage. Although more expensive than the narrow cornice, the wide cornice gives

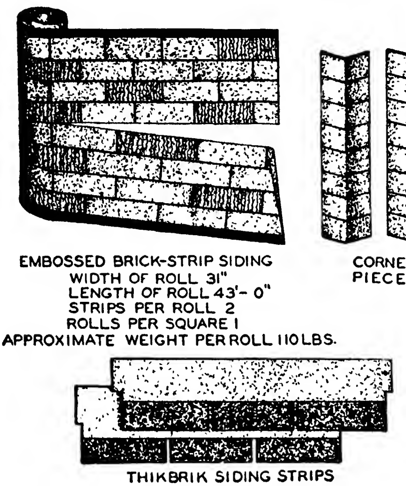


Fig. 14. Asphalt Siding of Brick Design in Roll or Strip Form

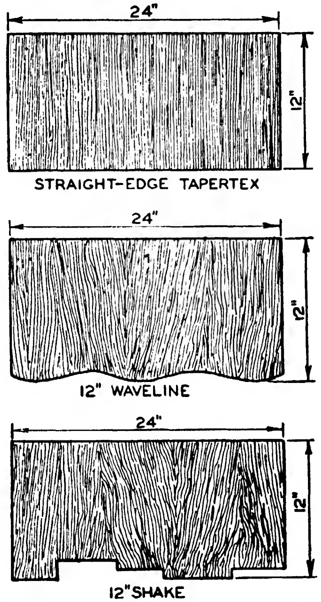


Fig. 15. Rigid Asbestos-Cement Siding

greater protection to the building, not only from rain and snow but also from the hot summer sun. The wide cornice also provides a means for fastening gutters that carry away water as it runs off the roof.

In a broad sense, cornices may be divided into three commonly used styles—*simple type, open cornice,* and *boxed cornice.* The cornice trim may be extremely simple in construction or it may be elaborate and ornamental. However, regardless of the type used, the cornice should be made to harmonize with the architectural design of the building. A cornice which requires only a frieze and a simple molding is shown in Fig. 16. This is a *simple type* of cornice. There are two other common types, the *open cornice* and the *boxed cornice.*

Open Cornice. The rafter overhang is exposed on the open cornice illustrated in Fig. 17. Frequently an ornamental design is cut on the bottom edge and end of the rafter overhang. Since the under side of the roof boards, on an open cornice, is exposed, it becomes necessary to use roof boards of a good finished quality. Either beaded ceiling boards or 6-inch dressed and matched boards are suitable in this case.

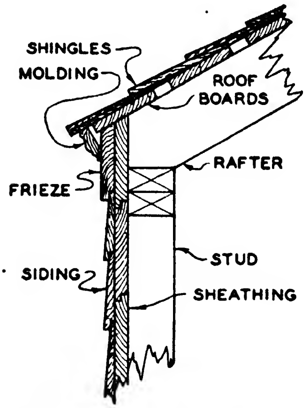


Fig. 16. A Simple Cornice Needs Only Frieze and Molding

Boxed Cornice. Another type of cornice, the closed-in or *boxed cornice,* is illustrated in Fig. 18. This type of cornice requires a greater amount of material and labor than the open cornice. The boxed cornice also may be extremely elaborate in design. When framing for this type of cornice the ends of the rafters, both end and bottom cuts, must be in line. *Lookouts* must be nailed level against the bottom of the rafters and against the wall to carry the *plancier.* The fascia must always extend below the plancier $\frac{1}{4}$ to $\frac{1}{2}$ inch to act as a water drip to prevent water from getting into the cornice. On the better grades of work, each member of the cornice is fitted into the other members with tongue and groove. On cheap construction, butt joints are used.

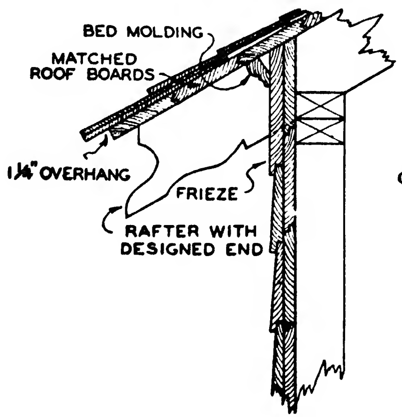


Fig. 17. Open Cornice

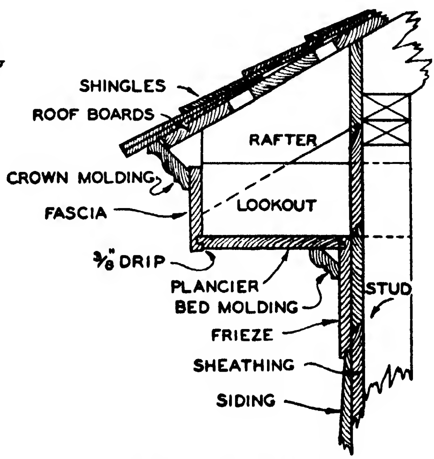


Fig. 18. Closed Cornice

However, regardless of which type or style of cornice is used, there are two important factors of construction which must be carefully observed. (1) The cornice must be tight enough to prevent water from above finding its way into the cornice and walls of the building. This protection against rain and snow is accomplished by extending the shingles no less than 1¼ inches over the top cornice member and then making all other members of the cornice overlap so as to shed water. (2) The cornice must be constructed so that it will be airtight as well as watertight. Pressure is sometimes built up under the eaves by

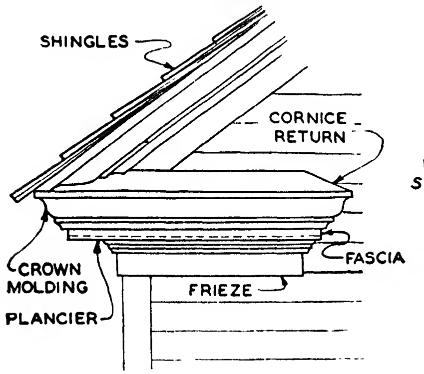


Fig. 19. Box-Cornice Return against Building on Gable End

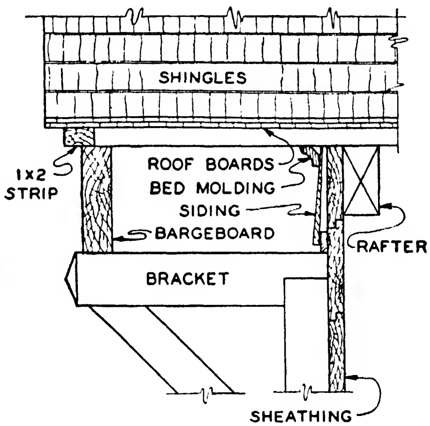


Fig. 20. Open-Cornice Construction on Gable End

wind which causes infiltration of air at this point. To prevent this air infiltration, the sheathing boards should be extended to the roof boards. Building paper over the sheathing should be carefully fitted in, and fastened around, the rafters. Moldings should be nailed into corners between the frieze and the plancier, and between the fascia and the shingles. The lower edge of the frieze should be rabbeted to receive the wall finish of siding or shingles, as shown in Fig. 17.

Gable Trim. The edge of the roof at a gable must receive treatment similar to that at the eaves. The frieze and crown molding of the simple cornice are carried along the roof edge of the gable by mitering them at the corner of the building, as shown in Fig. 19. When the plancier is in a level position, the box cornice is returned against the building on the gable end, as illustrated in Fig. 19. The cornice at the roof line in the gable usually has the same design as at the eaves. It does not miter with the eaves cornice members but ends on top of the eaves cornice return.

The gable trim on an open cornice has a *verge board,* or *bargeboard,* fastened to the roof boards, the same distance out from the building as the overhang at the eaves, as shown in Fig. 20. The bargeboard may be supported by brackets from the wall or merely hung from the roof boards. The bargeboard is placed along the projecting sloping

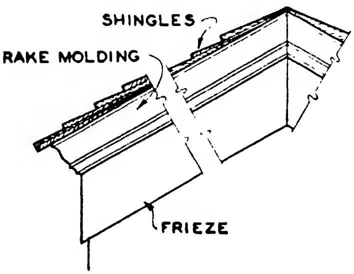


Fig. 21. Location of Rake Molding on Gable End

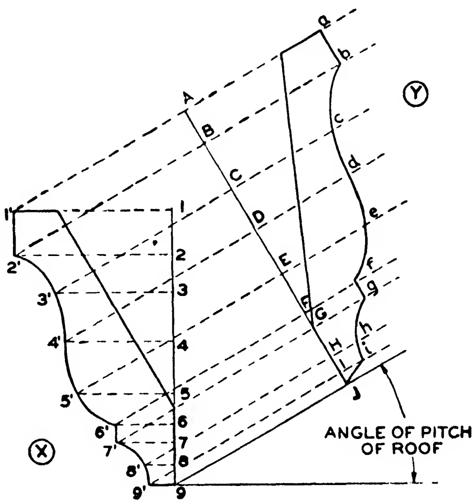


Fig. 22. Layout of Rake Molding for Gable End

edge of a gable, and is often elaborately ornamented, usually concealing or taking the place of a rafter. A 1x2-inch piece of finish material is nailed against the ends of the roof boards, when the molding is omitted, to give a more finished appearance.

Rake Moldings. A problem arises when a molding resting in one plane, as a crown or bed molding at the eaves, is mitered at the corners and extended up the gable, as shown in Fig. 21. One of two methods may be used in solving this type of problem. (1) The edge of the molding at the eaves can be tipped forward at the top until the various members of the molding line up with the members of the molding in the gable; or (2) a molding with a longer face can be worked out for the gable whose members will line up with the eaves molding. This is known as a *rake molding*. The development of the cross section of this rake molding is shown at (*Y*), Fig. 22. A pattern can be developed as follows:

PROCEDURE

1. Make a full-size drawing of a cross section of the molding (*X*). A simple method for doing this is to cut off a piece of the molding and trace around this section.

2. Draw a number of horizontal lines through important reference points of the molding, as 1′, 2′, 3′, etc.

3. Draw the vertical line from *1* to *9*, intersecting the horizontal lines.

4. Draw a second set of lines from the reference points (1′, 2′, 3′, etc.) at an angle parallel to the pitch of the roof.

5. Draw the line from *A* to *J*, intersecting these lines at right angles.

6. Lay off the distances *Aa* equal to 1′–1; *Bb* equal to 2′–2, and so forth.

7. A curve traced through points *a–b–c,* and so on, will give the shape of the rake molding for the gable. From this pattern the molding is developed, either on the job with molding planes or in the mill on a shaper.

GUTTERS

The installation of a well-designed drainage system is an important factor in the construction of any roof. Practical purposes require that some kind of a gutter must be provided to catch the water which falls on the roof and runs off at the eaves. The primary purpose of gutters is to carry the water off as fast as possible to prevent its storage on the roof. The gutter may be built into the roof or it may be hung against the cornice. It can be made of wood or metal. Galvanized iron or copper, or a combination of these two metals, may be used for metal gutters.

If kept well painted, wooden gutters give good service for a long time. They have the advantage of holding their shape well, provided they are correctly placed and cared for properly. Though more expensive, copper linings in gutters are worth the extra cost in the long run. If these linings are properly placed and are not damaged by tearing or puncturing, they will last as long as the building on which they are used. Galvanized sheet metal is cheaper than copper but costs more in the long run unless it is kept well painted. A good quality of tin, if kept well painted, will also give good service for gutter lining.

Box Gutter. The concealed, or *box gutter*, is built into the roof, as illustrated in Fig. 23. The chief value of the box gutter lies in its architectural effect. From a practical viewpoint it is inferior to the

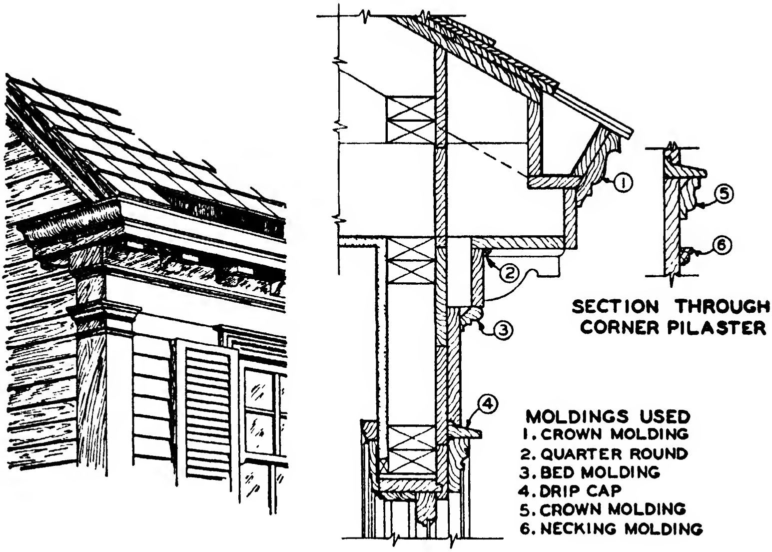


Fig. 23. Concealed Box Gutter and Detail

open gutter because in case of a leak, water may seep into the wood frame of the cornice and wall. This moisture may cause considerable damage before it is detected and corrected.

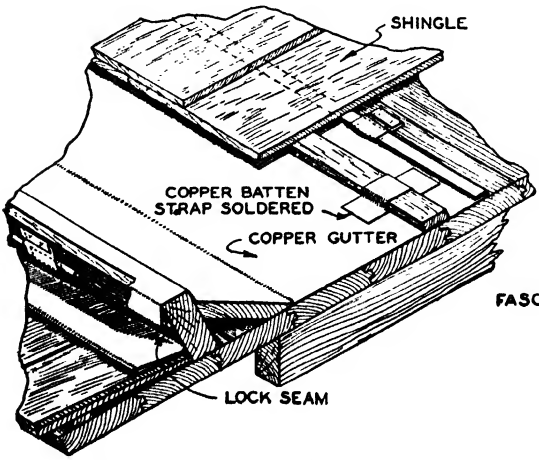


Fig. 24. Roof Gutter

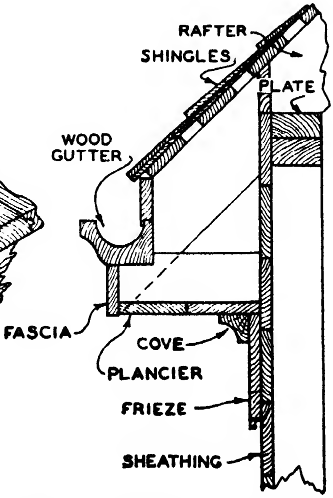


Fig. 25. Attached Wood Gutter

In box-gutter construction, the cornice must be framed to receive a square wooden gutter which is pitched so as to drain off the water quickly. This gutter is built on the job and later lined with either galvanized iron, tin, or copper to make it watertight.

Roof Gutter. The *roof gutter* is a barrier or dam set up near the bottom of the roof slope. This type of gutter usually consists of a narrow board about 3 inches wide set at right angles to the roof boards. The gutter is lined with metal to make it watertight, as shown in Fig. 24.

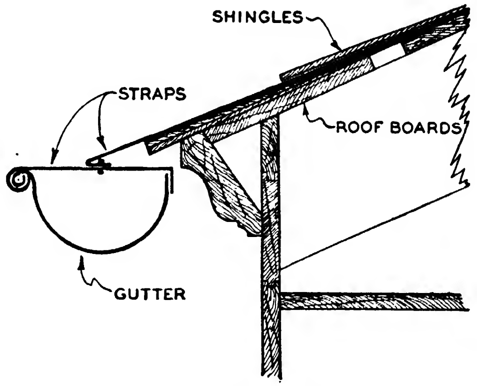


Fig. 26. Half-Round Attached Metal Gutter

Attached Gutter. This type of gutter is prefabricated and is fastened to the roof at the eaves line. If the *attached gutter* is of wood, it can be incorporated in the cornice construction as shown in Fig. 25. Wood gutters are available in a variety of designs and sizes. They are made of Douglas fir, cedar, cypress, or white pine. The life of a wood gutter, according to some authorities, is considerably longer than that of certain metals, especially in areas where smoke and fumes are present in the atmosphere.

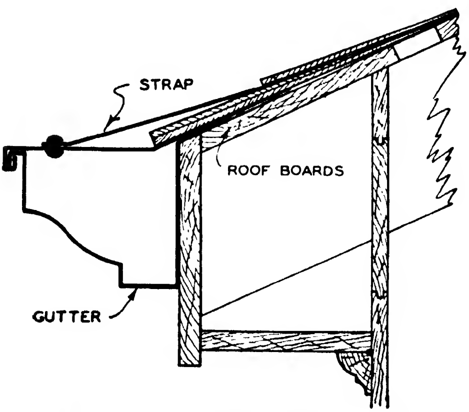


Fig. 27. Formed Attached Metal Gutter

Attached metal gutters are made in two different designs, the *half-round gutter,* Fig. 26, or the *formed gutter,* Fig. 27. The formed gutter adds to the architectural lines of the cornice, is attached to the fascia, and has the advantage of taking the place of the crown molding.

ROOF COVERING

The main purpose of any type of roof covering is to keep out moisture such as rain and snow. The roof must also provide protection against wind and dust. In addition to these features the roof acts as a cold and heat insulator and, if properly designed, it can add materially to the architectural beauty of a building.

Many different kinds of roof-covering materials are available today, including tile, slate, built-up roofing, asphalt impregnated felt covered with slate, asbestos-cement shingles, and wooden shingles. However, carpenters are concerned chiefly with the last three named.

The length of life and value of any type of roof covering depends to a great extent on the way in which it is laid. The best material, if poorly applied, will give unsatisfactory service and begin to disintegrate in a comparatively short time.

Specifications for a Forty-Year Wood-Shingle Roof. The shingles should be of the best vertical grain, free from defects, and must not be more than 5 butts to 2 inches in thickness. All shingles wider than 8 inches should be split before laying. Roof boards can be laid tightly or openly. Usually the better method is to leave from 1 to 2 inches space between the roofing boards. Paper is not required except in severe climates.

Preparation of Shingles. Shingles require room to expand, since they absorb moisture from rain or snow. Before they are laid, shingles should be water soaked thoroughly. The soaking causes expansion, which prevents buckling later, due to the shingles being laid too close together. If room is not allowed for expansion, buckling results.

Nails. Good rust-resisting nails should be used for shingling. The best nails for this purpose are hot-dipped, zinc-coated (galvanized). The next best are cut or copper-bearing nails. If neither of these types are available then use the best galvanized-wire nails obtainable. For shingles with a thickness of 5 butts to 2 inches use 3-penny nails, and for all thicker shingles use 3½- to 4-penny nails.

Laying Shingles. Starting at the eaves, the first course of shingles should be 2 ply, or double, to cover the joints of the first course. To prevent any possibility of leakage at the eaves or cornice, a triple layer in the first course can be used. When laying shingles, allow a

1¼-inch projection over the crown molding and a 1-inch projection at the gables. Sixteen-inch shingles should be laid with not more than 5 inches to the weather. The exposure of 18-inch shingles may be 5½ inches to the weather, and the exposure of 24-inch shingles may be 7½ inches to the weather. The slope of the roof should not be less than ¼ pitch or a unit rise of 6 inches. Where less pitch is used, exposure of the shingles should be less. All shingles should be spaced at least ⅛ of an inch apart.

Break all joints 1½ inches (sidelap), taking care that no break comes directly over another break on any three consecutive courses. For a serviceable roof, breaking the joints is extremely important. This method of procedure will also cover all nails.

Nails are set 6½ inches from the butt on 16-inch shingles and 7 inches from the butt on 18-inch shingles. Each shingle must be fastened with two nails. These nails should be set from ⅝ to ¾ of an inch from each edge of the shingle. The head of the nail must not be driven into the shingle.

Shingling Unobstructed Roof Surfaces. The first essential in shingling a roof is to build a 2-plank scaffold below the edge of the roof. The distance between the stage of the scaffold and the eaves should be about waist high to the men who do the shingling. Before beginning work on laying the shingles, several bundles of shingles should be distributed along the roof and held in place with a bracket, or by sticking the shingles between the roof boards.

PROCEDURE

1. For the first course, nail each shingle so that it will project at least 1¼ inches over the eaves molding. Along the outer edges of the roof, nail the shingles so they will project about 1 inch over the rake of the roof, as shown in Fig. 28. Double the shingle in the first course with a smaller one, keeping the bottom edge and the gable edge flush with the first shingle. Drive a nail into the butt end of the first shingle laid, and fasten a line to the nail.

2. Following the same procedure, lay another shingle at the other end of the roof. Double this shingle and drive a nail into the butt end in the same way as you did the first shingle laid. Then take the line which you fastened to the first nail, draw it taut and fasten it to the second nail. If the roof is long, it will be necessary to support the line by nailing shingles, with the correct overhang, at several points between the two nails placed first. This line will serve as a guide to keep the lower edge of the shingles in a straight line.

3. Continue to lay and nail the first row or course of shingles along the entire length of the roof. The nails on the first course should be set about 3 inches up from the edge of the butts.

4. Double this first course by laying and nailing a second row of shingles, breaking joints with about 1½ inches sidelap. In this course the nails must be set up from the edge of the butts 6½ inches, so they will be covered by the next course of shingles. When doubling a course of shingles, the second course must align with the first layer at the lower edge, as shown in the illustration, Fig. 28.

5. Take enough pieces of straight 1x6 boards for the entire length of the roof. Fasten the boards with shingle nails so that the top edge will be 5

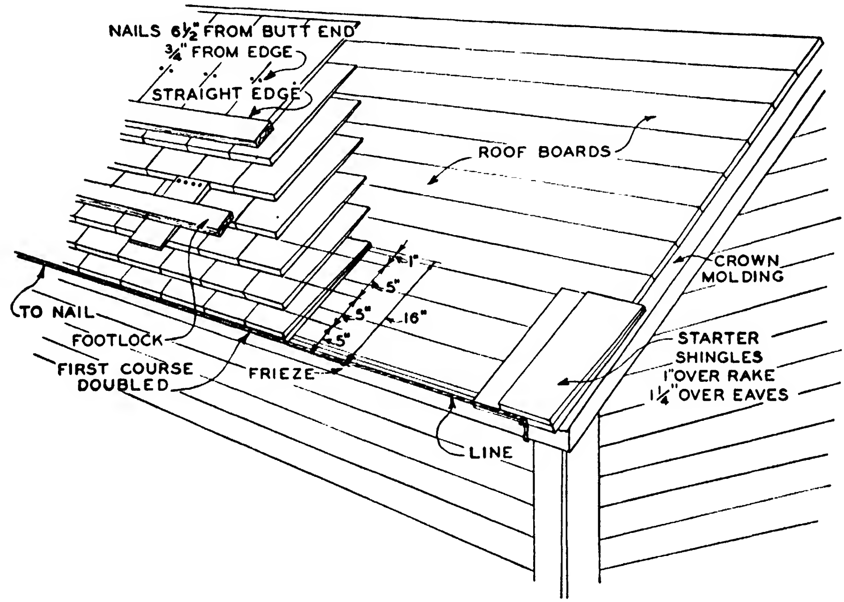


Fig. 28. Shingling a Flat Surface

inches—or the desired exposure—from the lower edge of the butts of the first course. It is advisable to make the measurement on both ends of the roof, then after sighting the straightedge, fasten it along the middle with nails. Some carpenters, instead of using boards, prefer to use a chalk line. However, the chalk-line method is slower.

6. Begin the second course of shingles by nailing the outside shingles at the rake first. Then take an armful of shingles, select and lay them in place against the straightedge of the board for the entire length of the roof. Joints must be broken with at least 1½ inches sidelap. Two men can work to advantage if one man distributes and lays the shingles while the other man does the nailing. The nailing is done with a shingle hatchet. The sharp edge of the hatchet provides a handy tool for splitting and shaving of the shingles when fitting them.

7. After a few courses have been laid, the work of shingling gets beyond the reach of the men when standing on the scaffold. This makes it necessary for a *footlock* to be fastened to the roof. A simple footlock can be made by nailing shingles, 6 inches wide, on one side of a 2x4. The shingles should be spaced 6 feet apart with the butts extending above the 2x4. Then the 2x4 is placed on the roof with the shingles on the underside and butt end projecting upward. Four shingle nails through each of the butts ½ inch from the ends of the shingles will hold the footlock securely to the roof, providing reasonable safety for the workmen. A footlock is shown in Fig. 28.

8. An occasional check should be made of the distance from either the ridge or the eaves to keep the courses parallel with the roof lines. When within four or five feet from the ridge, the remaining space should be checked so that the courses will come out with the correct exposure; at least, the exposures should appear relatively uniform after the ridge boards have been nailed into place.

When 16-inch shingles are laid with a 5-inch exposure, the coverage is divided as shown in Fig. 28. Breaking the joints for three successive courses will insure a tight roof.

Ridge Finish. Some provision must be made for a satisfactory finish at the ridge line where the two slopes of the roof meet. A ridge-

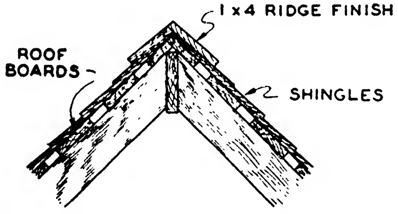


Fig. 29. Simple Ridge Finish

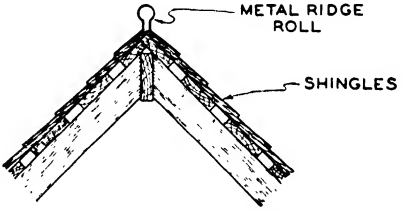


Fig. 30. Galvanized-Iron Ridge Finish

line finish is necessary not only to make the roof watertight but also for the sake of appearance. There are several different ways in which the ridge line can be finished. The simplest of these is shown in Fig. 29. Here, two boards (1x4) are shown nailed together and then nailed down over the ridge. A more elaborate ridge finish is made by using various types of metal similar to that shown in Fig. 30.

The Boston type of shingle ridge is more in keeping with the materials used in covering the roof. Therefore, this type produces a more artistic finish, as shown in Fig. 31. In making this type of ridge it is advisable to nail a straightedge to each side of the roof slope with the proper shingle exposure. A piece of heavy building paper is cut and laid over the ridge and shingles are fitted and nailed as illustrated, lapping them alternately.

Hip Finish. On a hip roof, since two slopes meet, the hips require treatment similar to the ridge of the roof. Two boards, as shown in Fig. 29, or a metal finish, as shown in Fig. 30, can be used; or a Boston-type hip can be made, as illustrated in Fig. 32. The method of shingling the Boston hip is the same as that used for the Boston-type ridge shown in Fig. 31.

Another method of finishing a hip is to miter the shingles; that is, to fit them together tightly, then cement and nail the shingles in place. This type of hip does not require any other form of covering, but shingle-tin flashing must be used between courses.

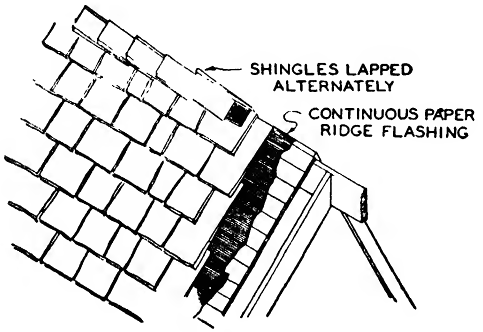


Fig. 31. Boston-Type Shingle Ridge with Shingles Lapped Alternately

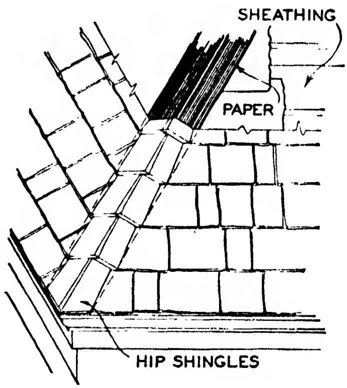


Fig. 32. Boston-Type Shingled Hip Ridge

Valley Finish. The valleys are the weakest points of any roof and the source of most of the trouble caused by leaks. Therefore, the proper laying of the roof covering at the valley is a matter of great importance. The ridges and the hips form outstanding angles in the roof surfaces which will shed water naturally, but the valleys form depressions toward which large quantities of water are drained and in which snow will lodge and ice will form, resulting in the damming up of the roof water when the snow and ice melt. This dammed-up water will find its way through weak points in the roof covering unless this covering is put on with the greatest care and is properly flashed at the valleys.

In finishing a roof, either of two types of valleys—*the open* or *the* *closed*—may be used. The *open valley* is by far the more practical because it allows the water to run off the roof more freely, and since the shingles are exposed to the air, they dry more quickly. However, the valleys are sometimes closed in order to obtain certain architectural effects.

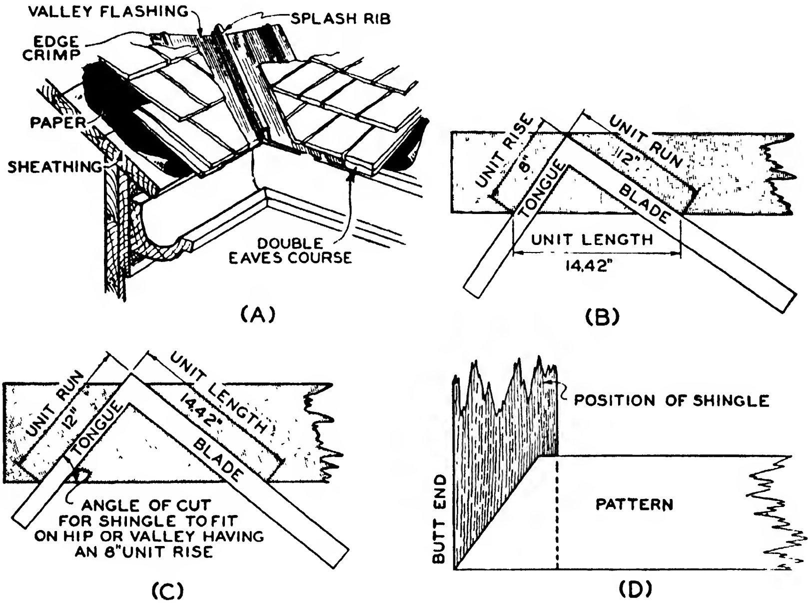


Fig. 33. (*A*) Shingling and Flashing of Open Valley; (*B*) Layout for Finding Unit Length of Common Rafter; (*C*) Layout for Finding Angle of Cut for Shingle to Fit in Valley; (*D*) Pattern Applied to Shingles for Cutting

Open Valley. A metal flashing is required in an open valley. The flashing may be of galvanized iron, copper, or zinc about 20 inches wide with a *splash rib* or *ridge* in the center and a slight *crimp* on the edges, as shown at (*A*), Fig. 33. Before placing the metal flashing in the valley, a careful check should be made to make sure that no nail heads project above the roof boards. Serving as a cushion, a piece of red resin paper under the flashing will increase the length of its life. The flashing should be held in place at the lower end by a few nails driven near its outer edge, and should extend beyond the roof boards at the eaves the same distance as the shingles.

Wide shingles are the best to use for the hip and valley shingles. Therefore, when opening a bundle of shingles, a good practice to follow is to lay aside the wider shingles for use at the hips and valleys. When preparing shingles for the hips and valleys, time can be saved by cutting several shingles at one time. This can be done by tacking four or five of the wide shingles together with the butts and one edge flush. Then, with the correct angle laid out, the entire bunch can be cut at the same time.

Different methods may be used to determine the proper angle at which to cut shingles so they will fit at the valley and hips. A common practice is to make a pattern by using a framing square and a board with a straight edge. A 1x6 board about 4 feet long is suitable for this purpose. Place the square on the board, as shown at (*B*), Fig. 33, with the *body,* or *blade,* of the square to the right and the *heel* pointing away from you (the workman). Take the figure indicating the unit length of the common rafter on the body of the square and the figure 12 on the tongue, as shown at (*C*), Fig. 33. Adjust the square so that a straight line drawn through these two points will coincide with the straight edge of the board. Then the edge of the board will form the hypotenuse of a right triangle with the square. A line drawn along the outer edge of the tongue of the square will give the correct angle for cutting the shingles. Lay the shingles with the butt end flush with the straight edge of the board, as shown at (*D*), Fig. 33, and cut according to the pattern. Make sure your pattern is correct before cutting the shingles. If you do not understand why you follow the foregoing procedure when finding the cut for the shingles to fit at the valley, turn back to Chapter IV, Figs. 7, 22, and 23. This will help you to visualize the position of the various roof members and the relation of the angles of the roof slopes.

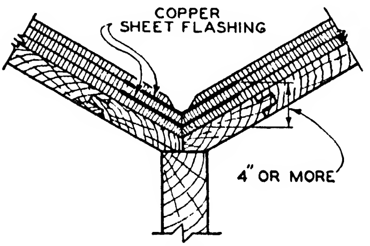


Fig. 34. Flashing in Closed Valley

EXAMPLE

To find the angle of the shingle cut to fit on the hip or valley of a roof having an 8-inch unit rise.

PROCEDURE

1. Find the unit length of the common rafter, as shown at (*B*), Fig. 33, by taking 12 inches, the unit run, on the body of the square and 8 inches, the unit rise, on the tongue. The bridge measure or unit length of the common rafter will be 14.42 inches.

2. Then take 14.42, the unit length of the common rafter, on the body of the square, as shown at (*C*), Fig. 33, and 12 on the tongue.

3. Draw a line along the tongue of the square. This will give the angle for the cut of the valley or hip shingles.

Care must be taken in nailing the shingles at the valley: (1) to avoid splitting the shingles; and (2) to prevent the nails from passing through the flashing and puncturing it. Puncturing of the flashing may result in valley leaks. When shingling a roof with a valley, always begin at the valley and work out on the roof, away from the valley line. Using this method will insure a better fit of the shingles along the valley.

Closed Valley. In the closed valley, no metal is exposed because it is covered entirely by the shingles, as shown in Fig. 34. The sheet-metal flashing is cut into small sheets measuring about 8x10 inches. These sheets are laid in place in each course as the shingles are laid. First, a course of shingles is laid at the eaves, then the first metal sheet is placed on top of this course. The second course of shingles at the eaves is placed over the first course, making a double course at the eaves and completely covering the sheet metal. Then the second course of sheet metal is laid over the shingles in such a position that the metal will be covered by the next course of shingles. After the third course of shingles is laid, the following courses of sheet metal and shingles are laid alternately. In this way the entire length of the valley is covered by the metal sheets.

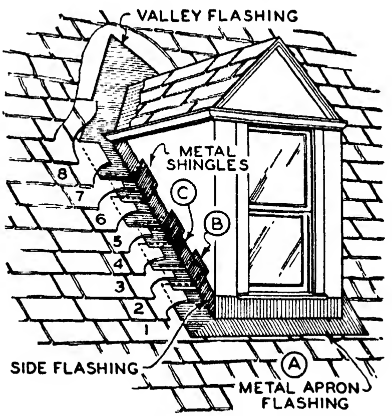


Fig. 35. Flashing around Dormer Windows

Flashing around Dormers and Chimneys. When shingling against a wall or vertical projection, such as dormer windows or chimneys, the flashing must be worked in with each course of shingles to prevent leakage behind the courses.

Dormer Flashing. On some dormers an apron at the bottom and a valley on the roof, as well as side flashing, are required. The metal apron flashing on the dormer, as shown at *A*, Fig. 35, is placed after the shingle course shown at *1*, Fig. 35, has been laid. This is followed by laying shingle course *2* and the flashing or shingle tin *B* against the wall. Shingle tins measure about 5x7 inches in size and should be bent at right angles so as to fit snugly against the dormer wall and the roof.

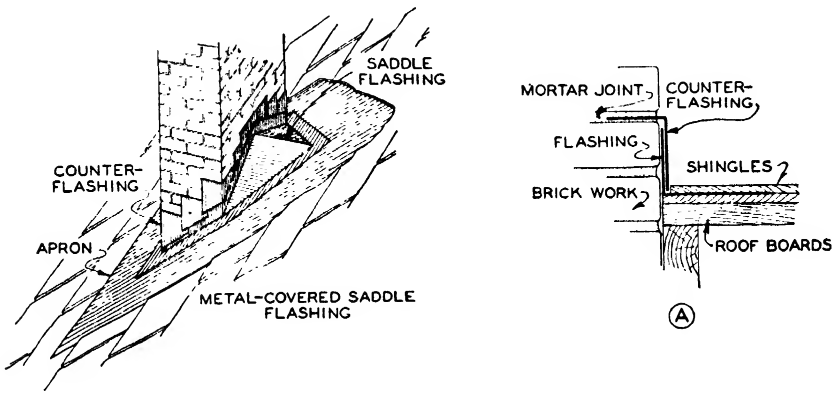


Fig. 36. Flashing and Counterflashing around Chimneys

Shingle course *3* is then laid and shingle tin *C* placed on top of it. In this way each shingle tin is covered by a shingle course. This will cause the water to run down on top of the shingle course below.

After shingle course *8* has been laid, the *valley flashing* for the roof is fastened in position and the shingling is continued in the same way as for any ordinary roof valley.

On the dormer side wall, the wood covering will overlap the wall flashing. However, to insure drying out, the wood covering of the dormer should be cut short enough so that about ¾ of an inch of the metal flashing will be exposed where the dormer wall meets the roof.

Chimney Flashing. The same order of procedure is used for *chimney flashing* as for the dormer windows. To prevent water from getting in back of the side flashing on a chimney, *counterflashing* must be applied, as shown at detail (*A*), Fig. 36. This counterflashing extends into the mortar joints and is held in place with shingle nails and pointed up with cement mortar.

Hand-Split Shakes. An interesting and rather artistic roof covering can be made by using *hand-split shakes* or shingles. These shingles are hand split with a resawn back giving them the necessary taper. A variety of lengths are available ranging from 18 inches to 37 inches in length and a butt thickness ranging from 3/8 inch to 1 inch. Hand-split shakes also come in a great many different colors to match most any color shade desired.

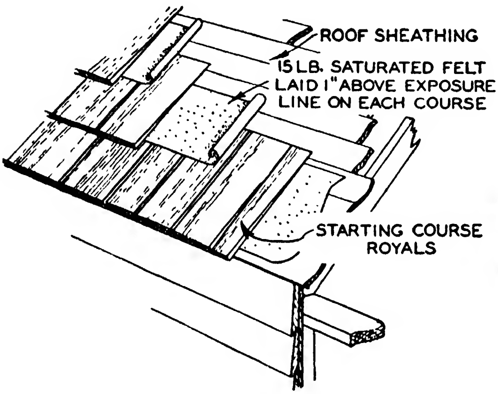


Fig. 37. Applying Hand-Split Shakes on a Roof for Artistic Effect

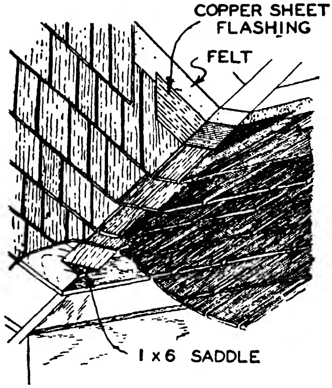


Fig. 38. Shingling a Valley with Hand-Split Shakes

The application of hand-split shakes varies somewhat from that of ordinary shingles. A layer of heavy building paper is laid between successive shingle courses, as shown in Fig. 37. The rounding valley effect can be obtained with a wood strip or saddle, as shown in Fig. 38. The Boston-type hip, illustrated in Fig. 32, is often used, although the hips can be mitered.

Thatched Roof. A type of roof shown in Fig. 39 has gained a certain amount of popularity throughout the country in recent years. This roof is an attempt to obtain with wood shingles something of the appearance of the thatched-roof cottages to be seen in Europe. In the best examples of this type of roof, the entire roof surface is slightly curved so that it is about 6 inches higher at the center of each slope than it would be if the slope were straight. The framing for a roof which is to be shingled in a thatched effect is shown in Fig. 40. All rafters are furred up about 6 inches, halfway between eaves and ridge and cut to give the roof a convex surface. A curved furring strip

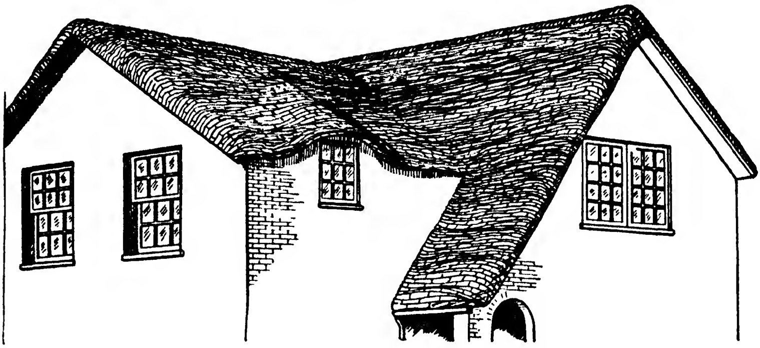


Fig. 39. The Use of Shingles to Obtain a Thatched-Roof Appearance

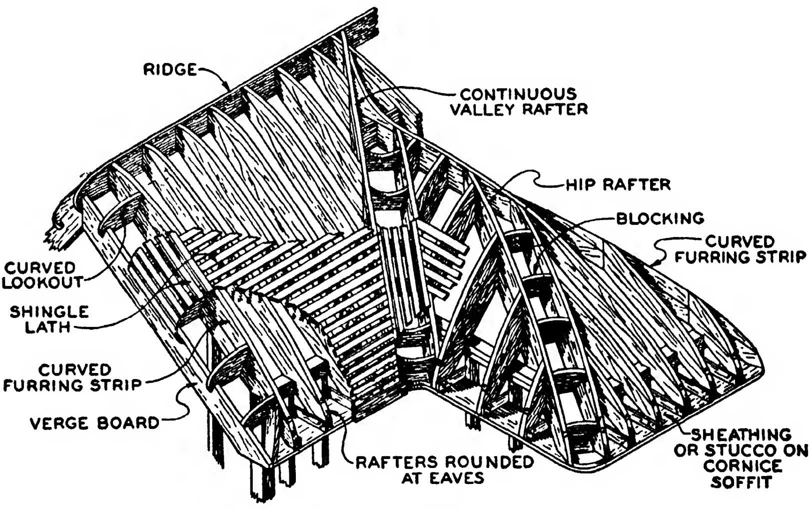


Fig. 40. Framing Details for a Thatched Roof
Courtesy of Creo-Dipt Company, Inc., Chicago, Ill.

is added on top of each rafter, and instead of the usual single rafter at each hip or valley there are two rafters placed a small distance apart. At the eaves, the ends of all the rafters are cut to a curve of about a 20-inch radius. Curved lookouts or blocks are inserted at the gable ends to form a curved-gable finish. Shingling strips or lath, which take the place of roof boarding, are placed on top of the rafters and at right angles to them. These 1x4 shingling strips are placed with open spaces between them. Shingle strips or lath are laid horizontally on rafters and vertically on gable hip and valley. At the curved eaves, valleys, and gables, 1x2 strips are used. The shingles are placed on top of the strips. Special shingles are used with the lower edges or butts cut to curve so as to produce wavy horizontal lines on the roof surfaces. The verge board has less slope than the rafters and the lookouts decrease in projection as they approach the eaves. On account of the curved eaves, valleys, hips, and gable finish, the wood shingles must be

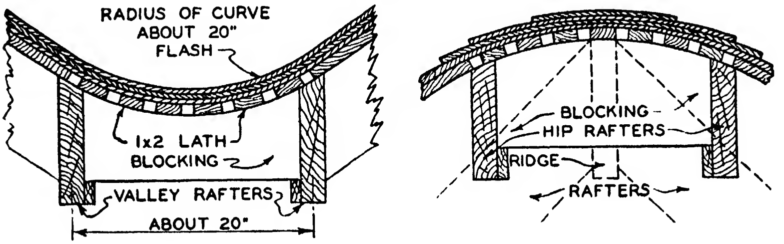


Fig. 41. Section through a Valley and Hip of a Thatched Roof

soaked or steamed to make them flexible enough so they can be bent to these curves. Shingles already bent to the proper curves are now on the market. A typical section through the valley and hip is illustrated in Fig. 41. The gable ends and eaves are finished in a similar manner.

Applying Asphalt Shingles. Shingles are not always made of wood, and different types require the use of different methods when laying them. There are on the market today various kinds of shingles which have certain advantages over wood. Among these are the asphalt shingles, a distinctly American product of the twentieth century. These are manufactured from asphalt-saturated and coated felt in which is embedded a permanent mineral surfacing of crushed slate or flint. In some cases the exposed surface is covered with a coating of powdered slate. Similar asphalt shingles, coated with a thin sheet of copper, also are manufactured. Because they eliminate much of the danger from fire, asphalt shingles have the advantage of saving on the cost of insurance. Since they can be laid over sheathing or old shingles there is also a saving in cost of labor.

Asphalt shingles are sometimes cut into strips of from two to four shingles in a strip, making them easy to lay. The strips measure 3 feet in length and from 10 to 13½ inches in width. Sometimes the shingles are cut into individual units of 9x12 inches and 12x16 inches.

The strip shingles are cut at the butts in slots and other patterns to simulate individual units and come in a variety of shapes ranging from diamond to hexagonal designs. They can be made to order both in shape and color, and give a roof a pleasing appearance. When framing a roof for asphalt shingles, the pitch does not need to be as great as that required for a roof framed for wood shingles.

A starter strip, as shown in Fig. 12, of the same material as the shingles should be laid along the edge of the eaves when applying asphalt shingles. The first course of shingles should then be laid over the starter strip. Asphalt shingles in individual units are all of the same width, and should be laid so that in each successive course the joints come exactly in the middle of a shingle in the preceding or lower course. This is accomplished by cutting a shingle into two parts lengthwise at the middle with a pair of tin snips. One half of the shingle is then used as a starter shingle along the rake of the roof for the second course. A half shingle is used also as a starter shingle for each alternate course following the second. A carpenter's chalk line is usually snapped to give the proper guide for keeping the shingles in a straight line.

Nail holes in wood shingles will close during a rain; but this is not true of holes in asphalt shingles, and special care must be taken not to injure the material of the shingles in any way. Hot weather softens asphalt and the surface of asphalt shingles is liable to be damaged by the toes of the workmen's shoes. This damage can be avoided by the use of adjustable roof brackets and a flat plank for the shinglers to stand on while working. Roof brackets, available for supporting footlocks, are of two types, as shown in Fig. 42. The use of either type will simplify the problem of supports for footlocks. These brackets should be held in place by nails driven through the upper part of the shingles so they will be covered by the next course of shingles. After the brackets have been removed, the nails should be left in the roof. When roof brackets are not available, supports for a 2x4 footlock can be made from wires fastened around the nails. Low-pitched roofs require no footlock, since the surface of asphalt shingles provides friction enough for the workmen to be able to proceed without danger from slipping.

Applying Asbestos-Cement Shingles. Since ancient times the extraordinary and varied qualities of asbestos have been known to men. However, it is only within comparatively recent years that this material has been utilized as a roof covering. Since the beginning of the twentieth century there has been a constantly increasing demand for asphalt-cement shingles for roofing purposes. Neither wood nor asphalt shingles provide a permanent roof covering since both these materials are perishable and a roof shingled with either of them will eventually

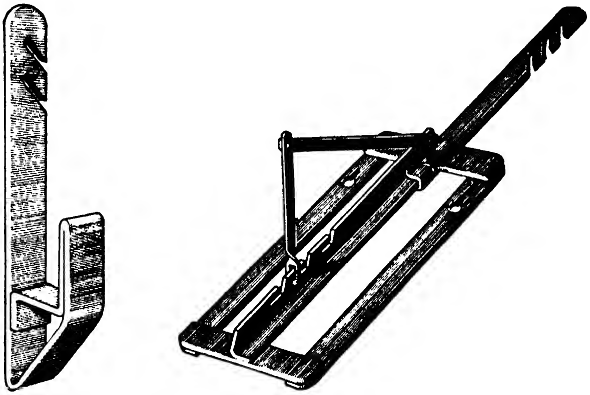


Fig. 42. Two Types of Footlock or Roof Scaffold Brackets for Asphalt, Asphalt-Cement, or Slate Shingling

deteriorate. On the other hand, composition shingles made of asbestos and Portland cement make a roof covering which will last more than a lifetime. This material is incombustible and does not deteriorate through decay. Therefore, if asbestos-cement shingles are manufactured without flaws, and are properly laid, they will last as long as the structure which they cover.

The original cost of asbestos-cement shingles is greater than that of either wood or asphalt shingles; but the longer life and other superior qualities of asbestos shingles make them cheaper in the long run. On cheaply constructed buildings, asbestos shingles are not commonly used. However, their more durable qualities fully justify their use as a roof covering on the best and most permanent structures, regardless of the greater original cost.

Individual asbestos-cement shingles are rigid and, like slate shingles, are laid over a heavy slater's felt which must be well lapped at the joints. The starter strip should extend over the eaves at least $1\frac{1}{2}$ inches. Adjustable roof brackets, Fig. 42, for supporting footlock planks provide a suitable scaffold for workmen to stand on while fitting and nailing the shingles in place. The scaffold also provides a place for storing material used on the job. If at all possible, while still in packages, asbestos shingles should be kept in a dry basement and only enough removed each morning for one day's work. This precaution is necessary to protect the shingles against undue moisture, which causes discoloration and blooming.

A guillotine cutter designed for the purpose is used for cutting the shingles, or a piece of 3x3x12-inch *angle iron* fastened to a wood base can also be used for cutting. Before beginning the cutting process, the standing edge of the angle iron should be ground sharp, then the shingles can be laid over this sharp edge and cut by a blow with a hammer. Asbestos-cement shingles may also be cut by scoring with a sharp tool such as a hatchet or chisel, then bending the shingle over a piece of board along the scored line where it is cut.

Work is begun after a chalk line has been snapped on the roof boards to serve as a guide for keeping the shingles in a straight line. The shingle courses are then laid along the chalk line. Nails should never be driven down tightly against an asbestos shingle because each shingle requires a certain amount of space for freedom of movement caused by changing weather conditions. The shingles will break if crowded together too tightly.

PLACING DOOR AND WINDOW FRAMES

Door and window frames are assembled at the factory or mill where they are manufactured. They are then brought to the job ready for placing in the rough openings provided for them, or they may be purchased knocked down (K.D.), in which case the carpenter on the job must assemble them before putting them in place. A carpenter of today seldom is called upon to make the frames on the job. This practice was discontinued after sash and door factories, or mills, became common.

After the walls have been framed and sheathed, the frames for the doors and windows are put in place before the exterior wall finish is applied. The rough openings should be of the correct size and ready

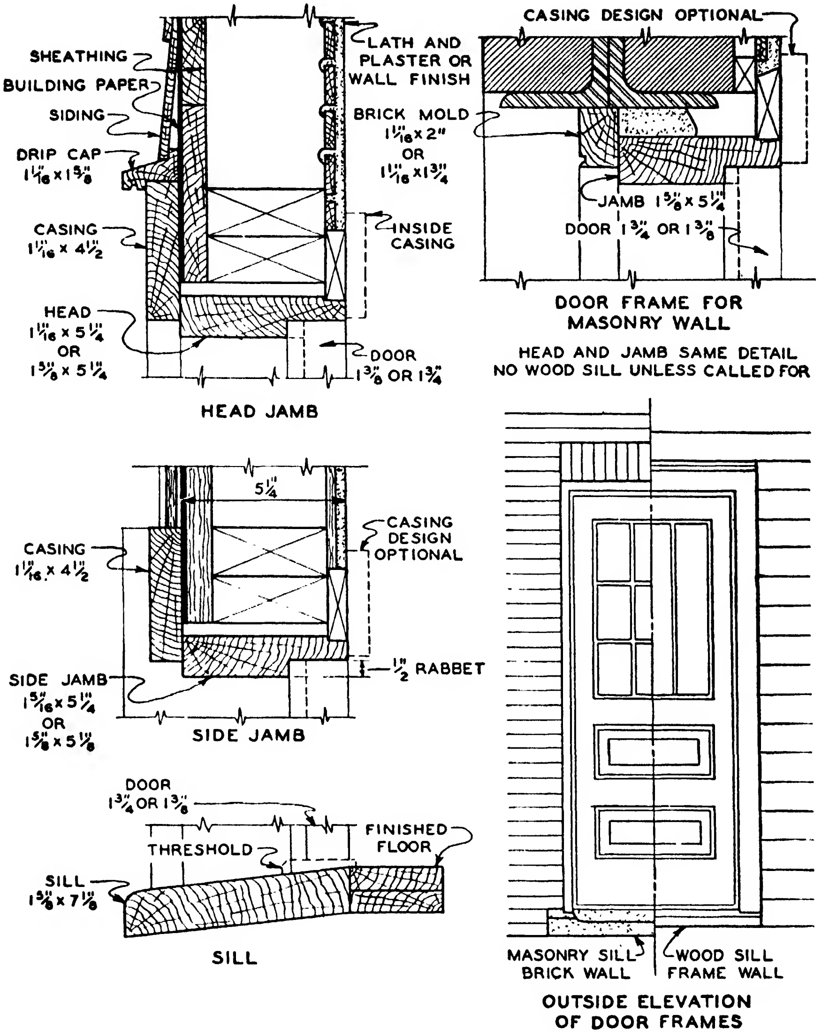


Fig. 43. Outside Door Frames for Both Frame and Masonry Construction

to receive the frames when they come from the factory. Framing the rough openings has been discussed previously in Chapter III. Frames designed and made for the various openings should be selected, distributed, and prepared for setting in place.

Exterior Door Frames. The details of door frames may vary, but the construction in general is the same for all of them. A typical door frame for both wooden and masonry construction is shown in Fig. 43. The jambs, head, and side are rabbeted ½ inch to receive the door. The outside doors of residences swing inward. Therefore, the rabbet must be on the inside. The outside doors of most public buildings must swing outward as a safety measure.

The jambs and casings of doors are usually made of durable soft woods. The sills of the better frames are made of white oak to withstand wear. Where durability is especially desirable, cut stone or concrete also is frequently used for door sills.

Setting Door Frames. Before setting a door frame, it should be squared and braced. The bracing is important if the frame is to be handled a great deal before setting. However, if the frame is set without preliminary moving, the bracing is not necessary. Proceed with the placing of frames as follows:

PROCEDURE

1. As soon as the door frames are delivered to a job, they should be treated with a coat of priming paint. Not only does paint protect the wood, but paint also helps to hold the frames in shape until the carpenter is ready to set them in place in the rough openings previously prepared for them.

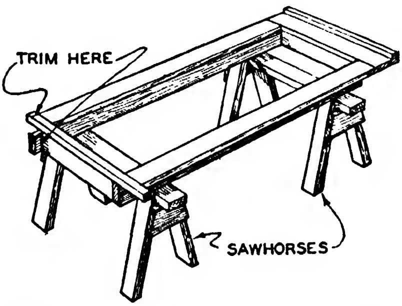


Fig. 44. Diagram Shows Window Frame Resting on Sawhorses

2. Before placing a frame in the rough opening, check the various dimensions of the frame and compare them with the corresponding dimensions of the rough opening. This procedure will insure the fit of the frame when you are ready to set in place.

3. Place the frame on a pair of sawhorses and cut off that part of the sill which projects beyond the side of the casings, as shown in Fig. 44. Also trim the side jambs if they extend more than ¾ of an inch beyond the head jambs and door sill.

4. Tack a strip of heavy building paper 10 or 12 inches wide against the sheathing around the rough wall opening, as shown in Fig. 45.

5. After placing the frame in the rough opening, brace the frame to prevent its falling out while you are adjusting it.

6. The door sill must be level. After the frame is set in place, adjust it by using wedge-shaped blocks at each side and the bottom, shown in Fig. 46. The tip of the sill on inside must be flush with line of finished floor.

7. The frame should be adjusted at the bottom and end so the spacing between the frame and the rough opening is the same on both sides. Drive a nail through the casing into the wall at the bottom on each side to hold the frame in place. When fastening a frame in position, never drive any of the nails completely into the wood until all nails have been placed and a final check has been made to determine if any readjustment is necessary.

8. Check both sides of the frame by placing the level against the inside edge of the casing, as shown in Fig. 47. This test will show whether or not the frame is plumb. Then hold the frame in position by driving a nail through the casing near the top on each side. Frames, or any other exterior finish, should be fastened with small-headed nails, such as casing or finishing

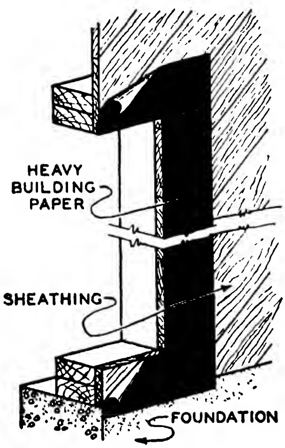


Fig. 45. Building Paper Tacked around the Wall Opening

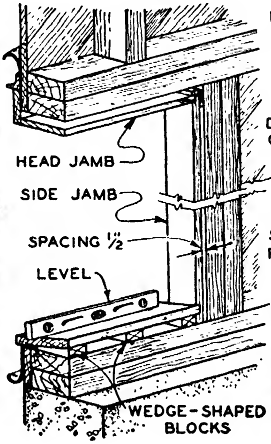


Fig. 46. Wedge-Shaped Blocks Used to Level Door Sill

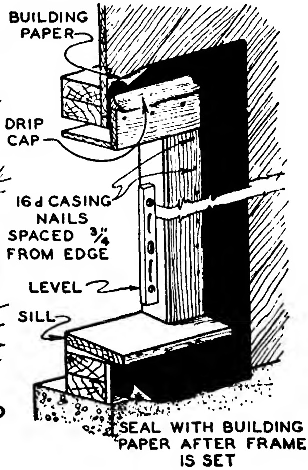


Fig. 47. Plumbing Sides of Door Frame with the Carpenter's Level

nails, set below the surface of the wood. If available, the galvanized casing nail is ideal for this purpose. Next in order of choice is the coated casing or finishing nail. Weather has a drawing effect upon exposed boards. Therefore, it is advisable to use longer nails for exposed boards than is customarily used for holding boards. Frames, with casings 1⅛-inch thick, can be held in place most satisfactorily with 16-penny (16d) nails, spaced 16 inches on center, ¾ inch in from the outer edge.

9. After fastening a frame at the top, check it again to make sure the sides are plumb and the sill and head jamb are level. Such a check will also reveal any error in the manufacture of the frame, such as being out of proper proportion at either top, bottom, or sides. When the sides are plumb and the top and bottom are level, then all the four corners of the frame will be square.

10. Finally, fasten the frame securely with nails placed ¾ of an inch in from the outer edge of the casing and spaced about 16 inches apart. Then set all nails with the nail set.

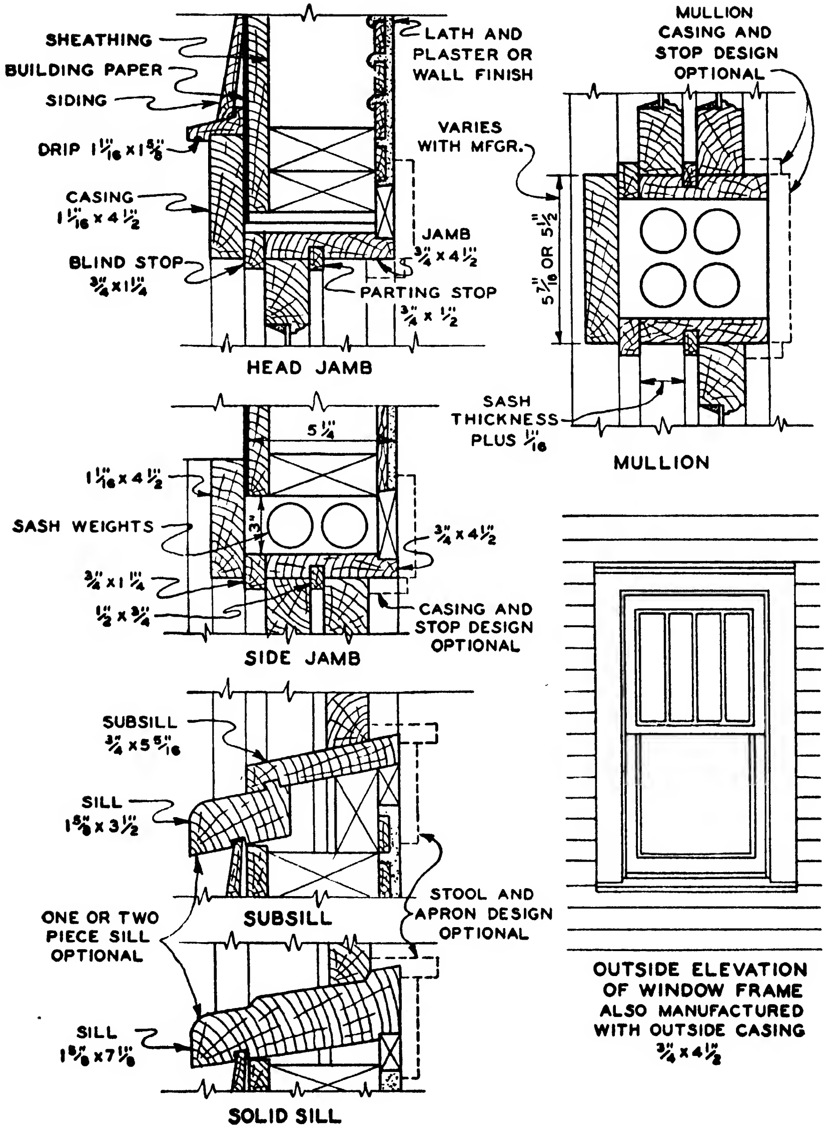


Fig. 48. Double-Hung Window Frame for Wood Walls

When nailing any trim, whether outside or inside, the nails should never be driven so far that the hammer will touch the surface of the wood. To prevent marring the finished surface of the wood, the final drive and setting of the nails should always be done with a nail set.

Window Frames. The two general classifications of windows for residences are: (1) the double-hung sash which moves up and down, balanced by weights or springs on each side; and (2) the casement sash which is hinged at the side. Casement-sash windows can be hung so they will swing inward, or they can be hung so they will swing outward.

Double-Hung Frames. The construction of the double-hung window frame is shown in Fig. 48. The jambs are ¾ of an inch in thickness. They have a parting stop to separate the top from the bottom sash and also a blind stop which produces a groove in the frame in which the window slides. The outside casings are of the same width and thickness as those of the door and casement frames. The joints on ordinary construction are butt joints. On the better-built frames, tongue-and-groove joints are used. Some of the better frames have the blind stop wide enough to reach the studs on the side of the rough opening. The frame is strengthened by this wide blind stop, which also helps to prevent infiltration of air around the window.

Windows in pairs, triples, or quads are separated by mullions which are of a box construction on the double-hung windows. The weights which balance the windows are suspended in these mullion boxes.

The construction of the double-hung window frame for masonry walls is shown in Fig. 49. This construction is slightly different from that in wooden walls. The outside casing is replaced with a brick mold, and a box is provided for the sash, or window weights on each side jamb the same as at the mullion. Provision must also be made for the jamb and stool extensions or plaster returns on the inside because of the greater thickness of the walls.

Window frames for a brick veneer construction have a wide blind stop, wide enough to fasten the frame against the sheathing around the rough opening. A brick mold on the blind stop is used instead of a casing, the same as for solid masonry.

Casement-Sash Frame. The construction and thickness of materials

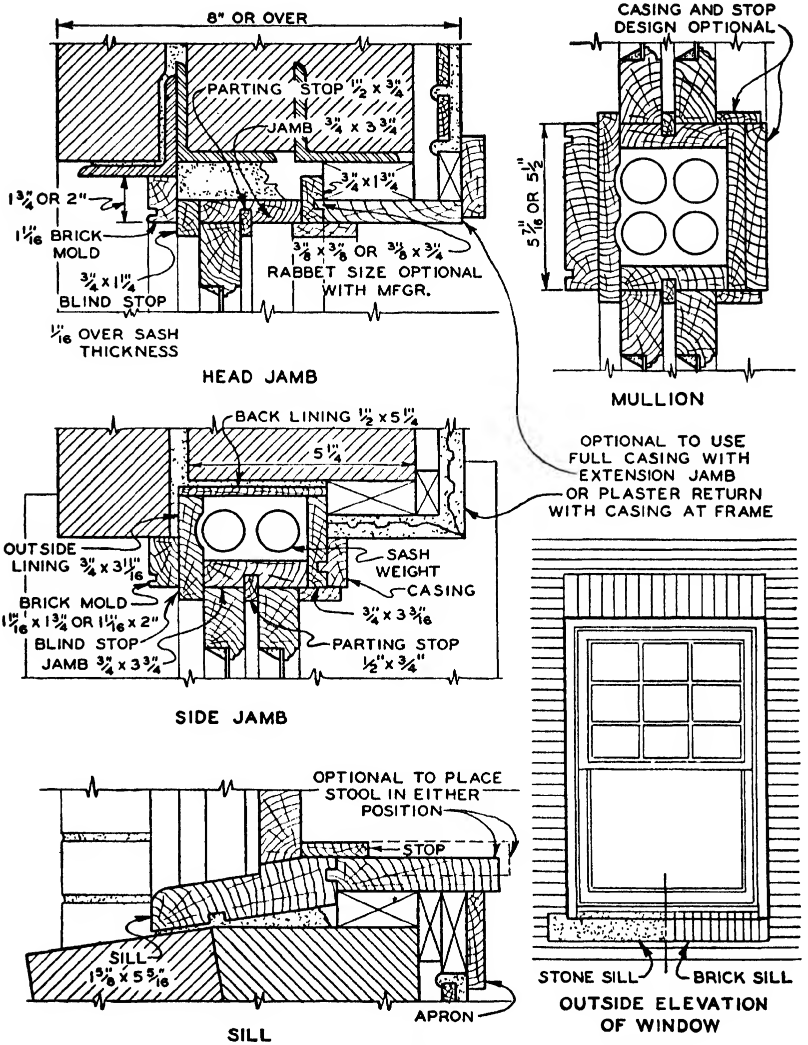


Fig. 49. Double-Hung Window Frame for Masonry Walls

of the casement-sash frame is similar to that of an outside door frame with rabbeted jambs.

Setting Window Frames. Similar methods are used in setting window frames as are used for setting door frames. When the window frames first arrive on the job from the factory, they should be treated to a coat of priming paint. When the paint is dry, the frame should be placed in position and braced, then to set the frames, proceed as follows:

PROCEDURE

1. Check the dimensions of the window frame with the corresponding dimensions of the rough opening. A space of at least ½ inch must be left on

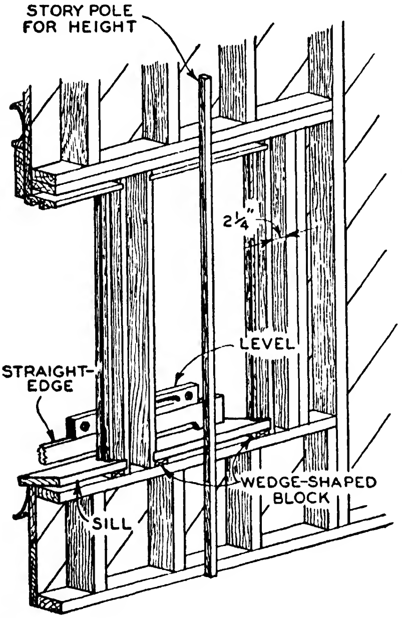


Fig. 50. Setting and Plumbing Window Frame with Straightedge and Level

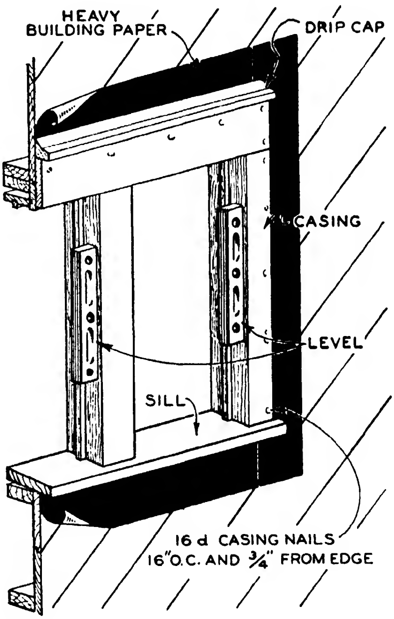


Fig. 51. Plumbing Sides of Window Frame with the Level

each side of the frame between the casement side jamb and the stud of the rough opening, to make room for adjusting the frame. For double-hung windows, this space must be 2¼ inches in width to allow for free movement of the sash weights.

2. Place the frame, casing up, on a pair of sawhorses or on the floor. Trim the ends of the sill flush with the outside of the casing. Turn the frame over, with the casings down, and trim the ends of the side jambs to within ¾ of an inch from the sill and head jamb, just the same as when preparing a door frame, as shown in Fig. 44.

3. Tack a 10- or 12-inch strip of heavy building paper over the sheathing around the rough wall opening in the same way as for a door frame, as shown in Fig. 45. Omit the paper strip under the window frame until after the frame has been set.

4. The exact height between the head jamb and the rough floor can be determined by using a story pole, or rod, or a vertical layout pole. The story rod is also used to make sure all windows are the same height and are placed according to the drawings.

5. Set the frame in the rough opening and hold it in place by tacking one end of a temporary brace to the side of the jamb near the top. The other end of the brace should then be tacked to a block of wood nailed to the floor for that purpose.

6. Place wedge-shaped blocks under the sill and adjust the frame to the correct height indicated on the story pole; at the same time use blocks to level the sill. Remember to keep the same spacing (2¼″) between the jamb and the rough opening on each side of the frame, as shown in Fig. 50.

The leveling of the sill must be accomplished by placing blocks at points near the outside jambs. On narrow windows, the sill can usually be relied upon to be straight, but the center will usually sag on windows that are in pairs, triples, or quads. A straightedge for leveling is necessary to prevent sagging.

7. The frame can be held in position by nails placed near the bottom on each side. The nails should be driven through the casing and into the sheathing. Block the window along the center until the sill is perfectly straight and level.

8. Plumb both side jambs by testing them with a carpenter's level. To hold the frame in position, drive nails through the side casing into the sheathing near the top of the window, as shown in Fig. 51.

9. Then check the entire frame again with a carpenter's level to make sure all sides of the window are plumb, and the sill straight and level.

10. When you are certain the frame is plumb, nail it securely in place against the wall, using 16-penny (16d) nails. Space the nails 16 inches apart, on center (O.C.), and ¾ of an inch from the outside edge of the casings. Use a nail set for a final setting of the nails. Lastly, apply a strip of heavy building paper under the sill and into the groove of the sill.

WATER TABLE

The first part of the outside finish of a wooden structure which meets the eye is the water table. It is usually composed of a projecting horizontal board at the bottom of the building where the masonry foundation wall stops and the wooden framework begins. It is called the *water table* because its purpose is to protect the foundation by throwing rain water away from the wall. Without this sloping protecting board the foundation would be damaged by water running down the sides of the building directly into the masonry. Therefore, an important member of any wooden structure is the water table which must be constructed with great care so that rain water will be directed away from the top of the foundation wall. In protecting the foundation wall from damage by water, the wood construction on top of the wall also is protected by the water table. There are several different methods of constructing the water table. Some of these methods are described and illustrated in the following paragraphs.

Since the outside wall covering begins at the water table, it must be constructed so as to receive the outside covering material. To prevent air infiltration, the water table also should cover and seal the joint where the masonry foundation and the wood construction meet.

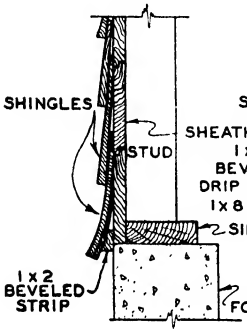


Fig. 52. Beveled Strip Used on Shingled Wall to Cover Joint

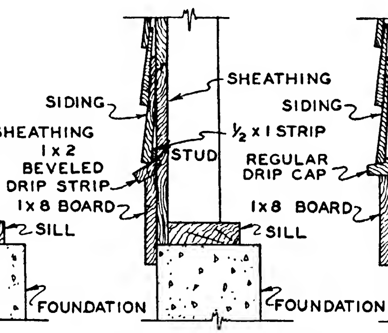


Fig. 53. Water Table with Beveled Drip Strip on Siding Wall

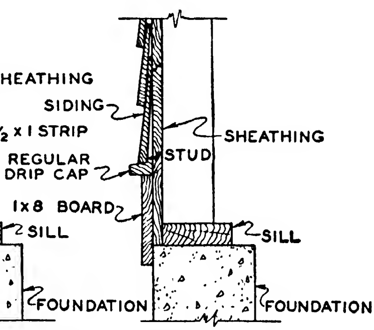


Fig. 54. Water Table with a Regular Drip Cap on Siding Wall

A slightly beveled 1x2-inch drip strip nailed over this joint makes a simple form of watershed at the foundation, as shown in Fig. 52. This method is usually employed when shingles form the side-wall covering.

When common siding or clapboards are used, it is advisable to build a water table with a 1x8-inch board. This board should be beveled on top to give pitch to the drip strip, as shown in Fig. 53. The back of the 1x2-inch drip strip is beveled to fit against the wall. A ½x1-inch strip under the first piece of bevel siding will give this piece of siding the same pitch as all of the others. However, this type of construction requires considerable labor, and is used only when the regular drip cap shown in Fig. 54 cannot be obtained. The little ledge on top of the regular drip cap will give the siding the necessary pitch and will also help to keep out water.

CORNER BOARDS

At the corners of the building the wall covering, whether shingles or siding, can be treated in one of several ways. The siding or shingles can be beveled and fitted together. The shingles can be lapped alternately, the siding can be butted and covered with metal caps, or a corner board can be applied and the siding or shingles butted against this board.

A corner board is made up of two pieces of 1⅛-inch stock, one piece 4 inches wide and the other 3 inches, if a butt joint is used, as

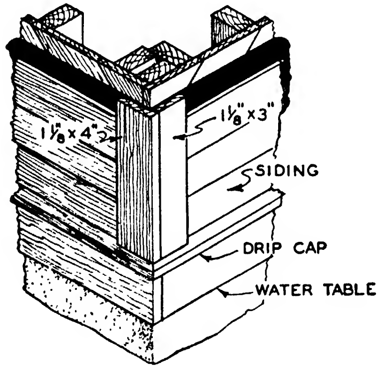


Fig. 55. Corner Boards Butted and Fitted on Water Table

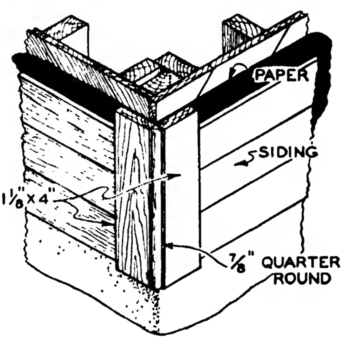


Fig. 56. Corner Board with Quarter-Round Finish

shown in Fig. 55. When a quarter-round mold is used, then both boards are 4 inches wide, as shown in Fig. 56, or the width of the boards may vary according to the taste of the designer.

When butted, the corner boards usually are cut to the correct length and fitted onto the water table, if there is one. The two corner boards then are nailed together before being nailed to the corner of the building. This procedure insures a good tight joint. When a quarter round is used, each board is fitted and nailed into position. The quarter round is then fitted tightly into place and nailed.

A strip of building paper should be tacked over the corner before placing the corner board in position for nailing. To avoid a rounding corner on the paper, fold it lengthwise and crease it along the middle before applying it to the corner of the building.

It is not necessary to have corner boards when the walls of the building are covered with shingles. The shingles can be brought together at the corner in the same way as for a Boston hip roof, as shown in Fig. 32.

BELT COURSES

To protect the lower part of the walls of a building or for decorative purposes, it is often desirable to arrange a horizontal projecting band, or course, which slightly overhangs the lower part of the wall. This is called the *belt course* and usually is placed at, or near, the

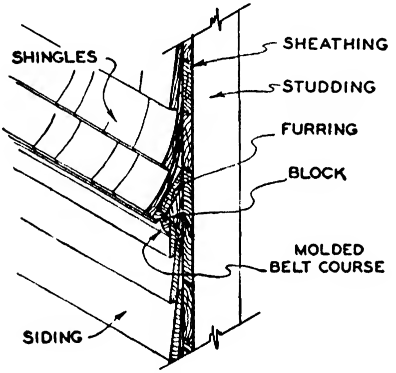


Fig. 57. A Molded Belt Course Separating Shingles and Siding

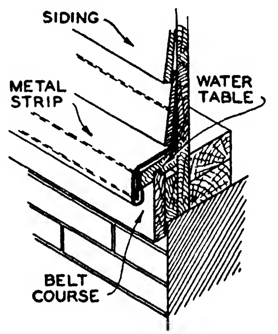


Fig. 58. Belt Course with Metal Flashing

second-floor level; or it may be placed across the gable end of a building at the level of the eaves. Belt courses are required when different kinds of wall-covering material are used; that is, the lower part of the building may be covered with one kind of material and the upper part may be covered with another kind of material. For example, the lower part of the building may be covered with drop siding, while the upper part may be covered with bevel siding or shingles. In such cases, a molded belt course is placed on the wall where the different materials or covering meet. A belt course is formed by placing blocks or brackets at intervals against the face of the outside boarding. The blocks are cut to the shape required to support this piece of molding. This arrangement is shown in Fig. 57. Here the shingles come down over the belt course and the furring supports the finish and provides nailing surface for the first course of shingles. A similar belt course may be placed on a building with any other kind of wall covering, the principle being the same in every case, and the purpose always is to form a projecting ridge from which the water will run off or drip without injury to the wall surface below.

In some instances the wall covering is not brought out over the top of the belt course, but ends immediately above it. In such cases care must be taken to see that the top of the course is well finished with galvanized iron or copper so that the water cannot get through the wall around it. The best method to use in this type of finishing is to cover the entire top of the belt course with the flashing and to run it up onto the vertical wall 4 or 5 inches with counter flashing over it. Since the wall covering breaks at this point, the use of the metal strip or flashing, as shown in Fig. 58, is advisable to prevent water infiltration. The belt course is constructed similar to that of the water table with a drip cap to divert the water away from the wall.

WALL COVERING

The walls of a frame building may be covered with many different types and kinds of materials which may be applied in a great variety of forms. Among the masonry coverings are brick veneer, stone veneer, and stucco. The composition materials include asphalt shingles and papers, also rigid asbestos-cement shingles and siding. Even though the application of composition materials is the work of the carpenter, he is more concerned with the various forms of wood coverings—siding and shingles—which have been in use for centuries, and a third type, plywood, which has been introduced in recent years.

The application of side-wall covering must wait until the window and door frames are set and the necessary trim has been placed. The trim includes cornices, water table, belt courses, and corner boards. Regardless of the kind of materials used in side-wall covering, there are two important factors which must be given careful consideration: (1) proper application of a good building paper over the wall sheathing; and (2) flashing with metal or similar material over openings, such as water tables and belt courses. A competent builder will never neglect these two important features of building construction.

Side-Wall Shingling. Shingles are used extensively for side-wall covering. They have a long life, have considerable insulation value, and require little upkeep. Though the original cost of shingles is greater than siding, there is a saving on paint. Other advantages are in the appearance of the work, the variety of effects which may be obtained, and also in the fact that the shingles in bundles may be dipped in stain before applying.

The specifications for side-wall shingles are similar to those of roof shingles previously explained. However, a greater variety of design has been developed for side-wall covering and as a rule the amount of exposure is greater than for roof covering. (See Fig. 61.)

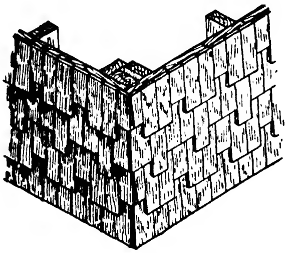


Fig. 59. Staggered Method of Side-Wall Shingling

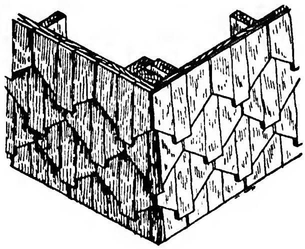


Fig. 60. Interesting Pattern for Side-Wall Shingling

The customary method used in laying shingles on the side wall is in straight courses. The monotony of the straight course lines can be overcome by staggering the shingles; that is, raising alternate shingles from ½ to 1 inch, as illustrated in Fig. 59. To add variety, another method used is that of alternating narrow and wide exposures.

An unusual wall pattern, suited only to certain types of architecture, can be developed by cutting two shingles at an angle and using these with one square-edged shingle, as shown in Fig. 60.

Laying the shingles in a double course, as shown in Fig. 61, increases insulation, and it is claimed that this method lessens the cost of covering a wall. The deep-shadow line secured in this way also adds much to the appearance of the house. Hand-split shakes add character and a soft, pleasing appearance to a dwelling. A method of applying hand-split shakes on a side wall is illustrated in Fig. 62.

Applying the Shingles. Shingles must be nailed to a solid base, such as a one-inch wood sheathing board. The use of rigid insulation

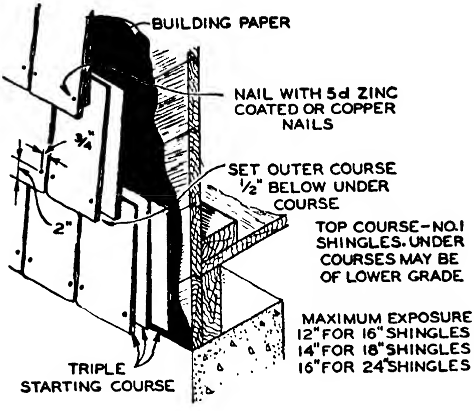


Fig. 61. Double-Course Side-Wall Shingling Improves Insulating Qualities

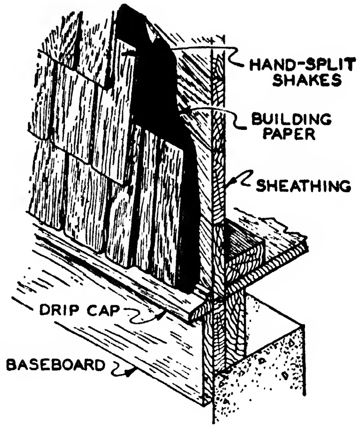


Fig. 62. Method of Applying Hand-Split Shakes on Side Wall

board for sheathing requires the application of 1x2-, 1x3-, or 1x4-inch wood strips over the sheathing, as shown in Fig. 63. The spacing of these wood strips is equal, center to center, to the exposure of the shingles. Thus, if the side-wall shingles have an 8-inch exposure, then the nailing strips will also be spaced 8 inches on center (O.C.). These

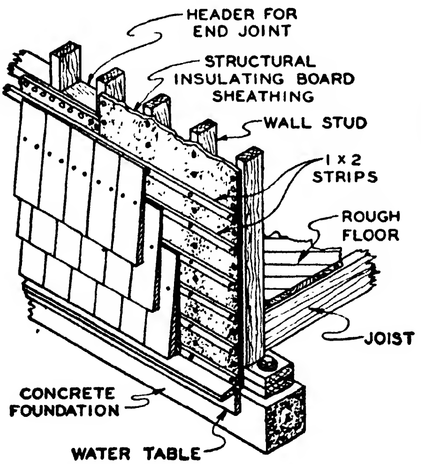


Fig. 63. Structural Insulation Board Used as Sheathing under Shingles

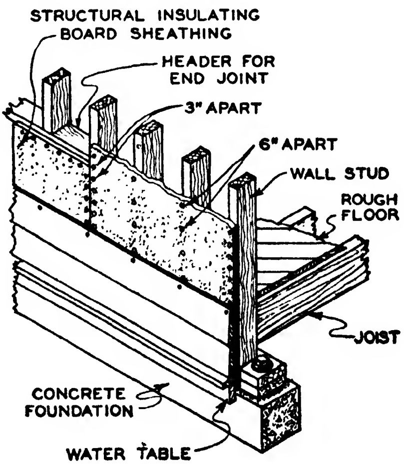


Fig. 64. Structural Insulation Board Used as Sheathing under Wood Siding

furring strips are not necessary when siding is used for wall covering, as shown in Fig. 64, because the wall studs furnish an adequate nailing base every 16 inches.

In the application of shingles, consideration should first be given to the necessary flashing over the water table or any other form drip, such as the one for siding shown in Fig. 65. The need for flashing depends upon the type of water-table construction used. Application of the flashing is followed by the application of a strip of good building paper lapped over the flashing. A good paper for this purpose is *slater's felt,* which is waterproof, but permits vapor to pass through it. As the shingling progresses, the courses of paper should be applied horizontally and be allowed to lap at least 2 inches.

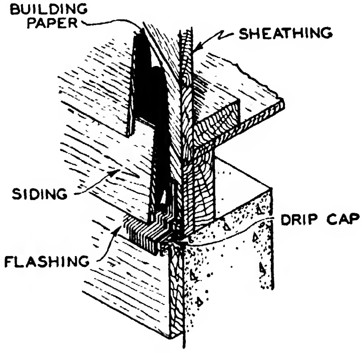


Fig. 65. Drip Cap Covered with Metal Flashing

The first course of shingles is doubled the same as in roof shingling, or tripled, as shown in Fig. 61. Following the laying of the first course, a careful study should be made of the wall in relation to its total height, the size and height of windows and other openings. A *story rod,* or pole, on which the different courses are indicated, should then be laid out. If possible, all the courses should have the same exposure. However, it is desirable to have the courses line up with the top and bottom of window and door openings. To make such an alignment possible may require a slight adjustment of the exposure of the courses. Such adjustment is permissible if it does not become too noticeable. Use of the story rod will insure uniform spacing for all courses of the entire wall. The spacing indicated on the story rod should be marked off on each shingle course at both ends of the wall, then the shingles are laid in accordance with this spacing by using a straight-edge or by snapping a chalk line as a guide line. Corners can be laced or butted against corner boards. For both methods, see Fig. 66.

Siding. The siding cannot be applied until the door and window frames are set, and the water table and corner boards have been fitted and nailed into place; that is, if this type of trim is used. Sidings should be lapped so as to shed water and to make the wall covering windtight and dustproof. The minimum amount of lap which is required for bevel siding is tabulated as follows:

Siding Width in Inches	Minimum Lap for Beveled Siding
4	¾ inch
5	⅞ inch
6	1 inch
8	1¼ inch
10	1½ inch

This lapping may vary slightly, if necessary, to make the siding line up with the bottom of the window sills and the tops of drip caps at windows and door heads. In order that the exposure of the siding may be as nearly uniform as possible, it is advisable to lay out a

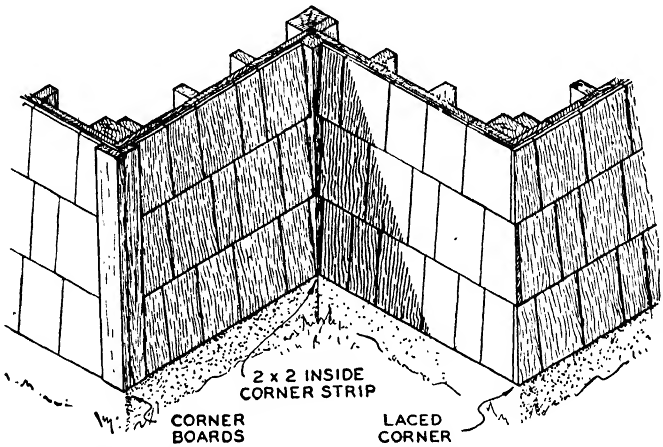


Fig. 66. Different Types of Corner Joints Used in Shingling Side Walls

story rod, or spacing pole, for the entire height of the wall, the same as for shingling side walls. The square butt joints between adjacent pieces of siding, in successive courses, should be staggered as widely as possible.

A regular siding nail should be used: 6 penny (6d) for ½-inch bevel siding and 8 penny (8d) for ¾-inch siding. Either zinc-coated or copper nails should be used because neither of these will rust. Use of the nonrustable nails not only adds to the life of the wall covering but also prevents staining of the painted surface of the wood with rust streaks.

Applying Siding. The first piece of siding applied must be beveled on the bottom edge so it will fit tightly on top of the drip cap. When corner boards are used, the siding should be cut to fit against them. After cutting, the ends of the siding boards should be smoothed with a block plane to insure tightly fitting joints that will keep out wind, dust, and water. For accurate cutting of siding, so it will fit at these important joints, use a simple wood-marking gauge made from a 1x2-inch piece. While laying out and marking siding pieces for cutting, the board should rest on nails set on the line of correct exposure, as shown in Fig. 67. A pencil indicates the cutting line.

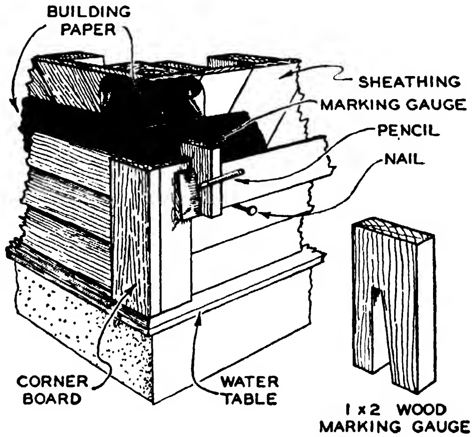


Fig. 67. Fitting Siding to Corner Boards

It is difficult to make mitered joints that will not open under the influence of changing weather conditions. Plain mitered corners, if they are to look well, must fit closely and stay in place. Properly seasoned lumber, which has been kept dry on the job, as well as good workmanship are important factors. Painting the ends of these joints will prevent absorption of moisture and its consequential damage. The miter box, Fig. 68, made on the job, the inside of which is about one inch higher than the width of the siding, will be a great aid in cutting miters. The small strip of wood will hold the bevel siding to the correct pitch while cutting.

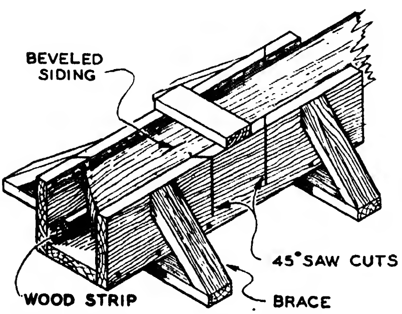


Fig. 68. Mitering Beveled Siding for Corner Joint

Plywood Wall Covering. When applying large panels of plywood, two men can work to advantage. The framing members must be spaced so the large sheets can be nailed at the joints without much cutting and fitting, see illustration Fig. 11. The ⅜-inch thick material requires 6-penny (6d) nails; the ½-inch thick material or over requires 8-penny (8d) nails. The nails should be spaced 6 inches on center (O.C.) around the edges and 12 inches on center on intermediate studs.

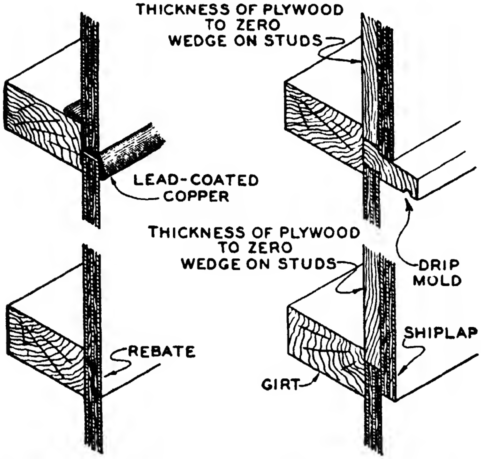


Fig. 69. Different Methods Used in Sealing Horizontal Joints in Plywood Construction

Various methods used in sealing horizontal joints are shown in Fig. 69. Some methods of sealing vertical joints are illustrated in Fig. 70. A good grade of calking compound should be used in these joints. Before applying the calking compound, brushing down the edges of the joints with a slow-drying varnish is advisable. In order to forestall the possibility of the compound spreading on long vertical joints, the flow can be checked by

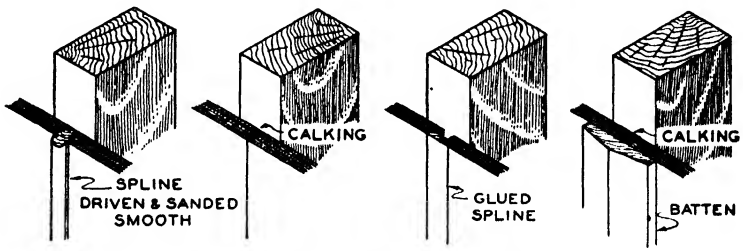


Fig. 70. Different Methods Used in Sealing Vertical Joints for Plywood Construction

driving two 8-penny nails side by side into the stud at two-foot intervals, leaving their heads slightly below the level of the plywood face.

For plywood siding, the priming coat of paint should be a clear resin sealer, of which there are several on the market. The paint should be applied on both sides and the edges of each panel before it is erected.

Various Kinds of Composition Siding. There is a variety of kinds of composition siding on the market today. Complete instructions for the application of each particular product usually is included by the manufacturers of that product. To insure satisfactory results, these instructions should be followed carefully.

EXTERIOR FINISH OF THE HOUSE

In the foregoing chapters of this book, instructions for work on *The House* have been carried to a point where the building has been framed and sheathed completely. In this chapter consideration is given primarily to the exterior trim, the roof, and wall coverings. However, before the roof covering can be applied, it is necessary to nail the cornice trim in place. A careful study should be made of cornice details by referring to the elevation drawings for *The House*.[2] It will be observed that the cornice construction of the main roof differs from that of the addition, the dormers, the porch, and the bay window. Differences also exist in the construction of the four last-named cornices. However, these cornices are rather simple in construction when compared to the box cornice of the main roof. The main-roof cornice should be trimmed first so that shingling can be started while the dormers are being trimmed.

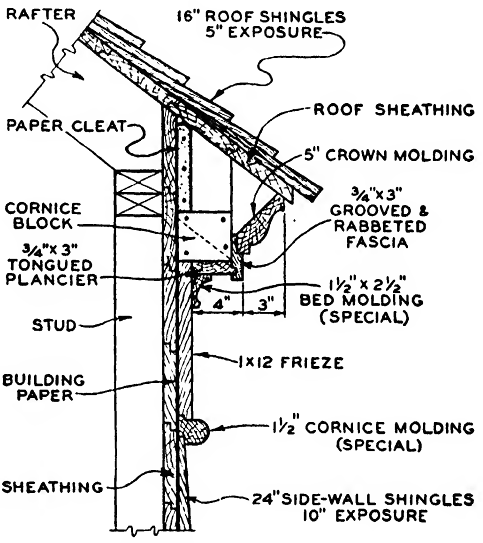


Fig. 71. Construction Detail for Main Cornice

Trimming Main Cornice. A cross-section detail is again reproduced in Fig. 71. This gives certain information not found on the general drawings. It will be noted that the *fascia* and *plancier* are tongue-and-groove material, also that the upper part of the fascia is rabbeted to receive the *crown molding*. The main cornice on the front of the house,

[2] See blueprints at back of book.

or south side, is not fitted against the roof boards of the addition. The cornice trim must be kept back ¾ of an inch from the roof boards to allow the roof shingles of the addition to pass under the trim.

PROCEDURE

1. Tack a piece of building paper up under the roof rafters. For easier handling, long strips of paper can be cut into shorter units. Make cuts in the paper with a knife directly under the middle of each rafter, as shown in Fig. 72. The length of each cut should be equal to the vertical width of the rafter shown at *(A)*, Fig. 72, plus about 1½ inches for folding over at the

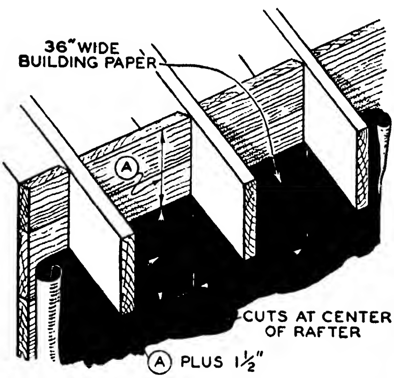


Fig. 72. Fitting Building Paper between Rafters

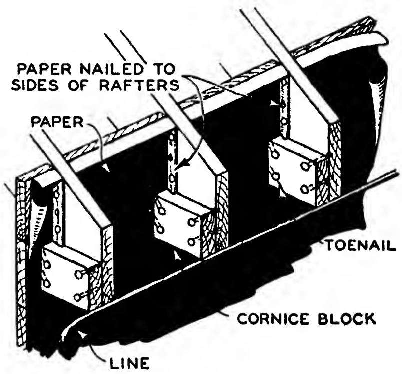


Fig. 73. Nailing Cornice Blocks Level and in Alignment

top against the roof boards as shown in Fig. 71. Push the paper up between the rafters, then fold the top over the cleats and tack the paper to the roof boards. If this procedure is followed carefully, the paper will prevent a great deal of air infiltration.

2. Line up the face and the lower edges of the ends of the rafters with a line, as shown in Fig. 73. Long points should be dressed down with a saw or plane until the ends of the rafters are in perfect alignment. Cut and nail the small *cornice blocks* in place. The bottom of these blocks must be level, in alignment with each other, and ready to take the plancier. Each block should be nailed first to the rafter and then be toenailed against the wall, as shown in Fig. 73. When putting the blocks in place, a chalk line snapped on the wall will help the workmen to keep the blocks in perfect alignment.

3. Fit the *frieze* in place against the lower edge of the cornice blocks and nail it lightly to the wall, as shown in Fig. 74. Before nailing the frieze securely, fit the *cornice molding* and nail it in position. All members of the cornice must be mitered on outside corners. All joints should be planed smooth with a block plane and fitted together tightly. Sometimes a coat of paint is applied to the joints before nailing the various parts together. To insure solid nailing, joints on the ends of boards should be made on studs.

The nails used should be either zinc-dipped, coated-casing, or finish nails. The length of the nails required will depend upon the thickness of the wood. When putting on cornice trim, the carpenter usually carries different sizes of nails to suit his purpose, including 4-penny, 6-penny, and 8-penny nails. After each cornice member has been fitted and lined up for the entire length of the cornice, all nails should be driven in and set with a *nail set.*

4. Cut, fit, and nail the *plancier* in place, as shown in Fig. 74.

5. Cut, fit, and nail the *fascia* in place, as shown in Fig. 75.

6. Cut, fit, and nail the *crown molding* in place, as shown in Fig. 75.

7. According to the construction detail drawing, Fig. 71, the roof board should project about ½ inch beyond the edge of the crown molding. If the

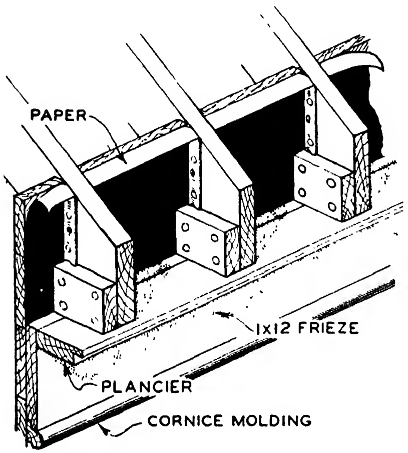


Fig. 74. Nailing Plancier, Cornice Molding, and Frieze in Place

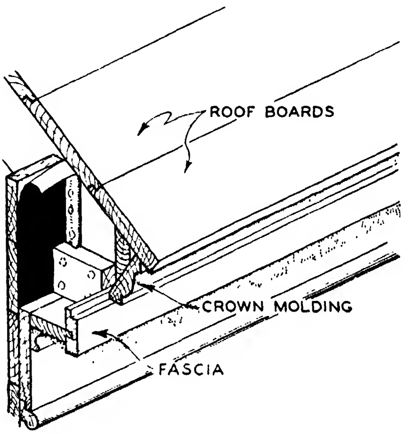


Fig. 75. Nailing Fascia and Crown Molding in Place

projection is longer than ½ inch, mark the under side of the roof board along the face of the molding. Remove the roof board and draw a cutting line the entire length of the board, parallel to the line just drawn, then cut and plane the edge. Replace the roof board and nail it to the rafters and also to the crown molding.

Gable Cornice Trim. The main cornice at the eaves is returned on the gable side of the house, as shown in Fig. 76. This cornice return has the same cross-section detail as the cornice on the eave side of the house. The distance the cornice return extends on the gable is governed by the length of the frieze which in this case, according to the detail drawing, Fig. 76, is 12 inches.

On the gable end of *The House*, the cornice along the rake of the roof is the same as at the eaves except the frieze and cornice molding are omitted. The rake cornice does not miter with the eave cornice but is merely fitted down on top of the eave cornice return, as illustrated in Fig. 76.

PROCEDURE

1. Tack a strip of building paper to the wall sheathing on the gable. This paper should extend up under the roof boards.

2. Small 2x4 cornice blocks equal in length to the width of the plancier should be cut and toenailed against the sheathing along the rake under the

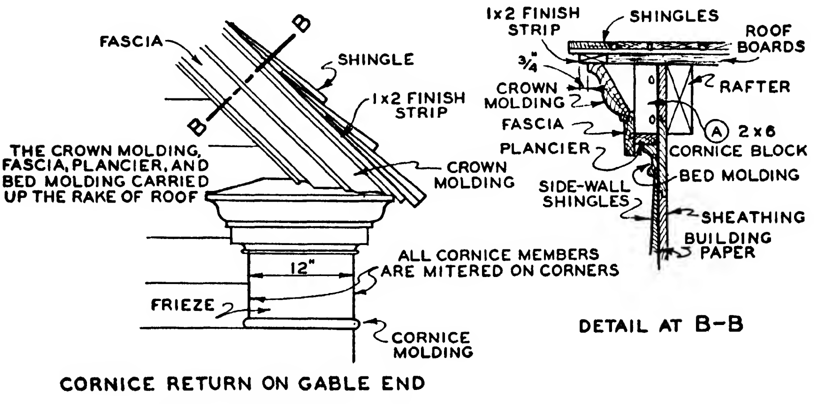


Fig. 76. Cornice Construction on Gable End of *The House*

roof boards, as shown at *(A),* Fig. 76, in detail at right. The same sized blocks should also be used for the cornice return.

3. The roof boards should be sawed off and a 1x2 strip of finish material nailed against the edges of the boards. The roof boards should be cut so the 1x2 strip will extend ¾ of an inch beyond the face of the crown molding. This strip will cover the rough ends of the roof boards.

4. The cornice return on the gable side is built in conjunction with the eave cornice, as all members must be mitered at the corner. The small roof over the cornice return should be covered with metal before the cornice members are put in place along the rake.

5. Fit and nail the plancier against the underside of the 2x6 blocks which have been nailed along the rake. After the plancier is nailed in place, the fascia and the crown molding should be fitted and nailed in place, as shown in detail *(B–B),* Fig. 76.

Note: Both sides of the gable cornice should be built at the same time so each set of members can be mitered and fitted at the ridge.

6. The bed molding should be omitted until the gable side wall has been shingled, then the bed molding should be nailed over the shingles against the plancier, as shown in detail *(B–B),* Fig. 76.

Large-Dormer Cornice. The construction of the cornice on the large dormer on the north side of *The House* is comparatively simple. This cornice consists only of a fascia and the crown molding, as shown in Fig. 77. The building paper should be brought up against the roof boards before the cornice is nailed in place.

Note: The lower edge of the fascia should be rabbeted to receive the side-wall shingles. The metal roof of the dormer should be laid when the shingles of the main roof have been brought up to the height

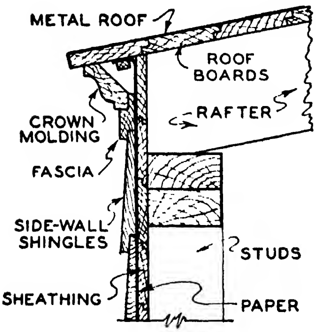


Fig. 77. Cornice Detail for Large Dormer of *The House*

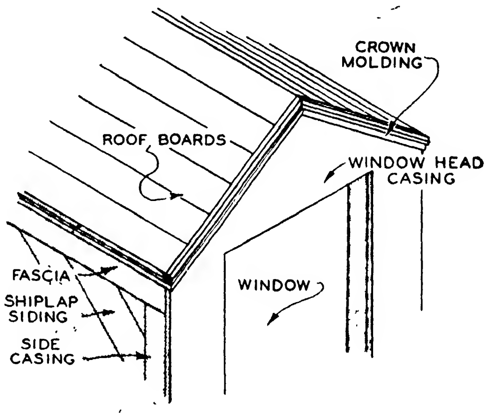


Fig. 78. Small Dormer Trim and Cornice for *The House*

of the dormer roof so the metal roof can be flashed over these shingles, and then under them above the dormer roof. Frequently such metal decks are laid before the shingling of the main roof reaches this point. In this case it will be necessary for the sheet-metal man to allow room enough to push the shingles under the metal flashing.

Small-Dormer Cornice and Trim. On the front of *The House* the face of each of the three small dormers and the cornice become one unit, as shown in Fig. 78. The window head casings of these small dormers should be built so they will also form the wall covering of the small dormers. The side casings should extend to the edge of the face of each of the dormer walls. Thus, when the window frame with its casing has been set, the face wall of each dormer is also completed. The crown molding of the cornice is fastened against the window head casing to complete the dormer trim, as shown in Fig. 78. Since the crown molding of the eave corners continues up the rake of the gable, it is necessary to have a rake molding so it will miter with the molding at the eaves, as shown in Fig. 78.

Porch Cornice. The cornice on the porch is a part of the trim which encases three 2x12 beams which form the main beam of the porch, as shown in Fig. 79. The side of the porch requires a rake molding to miter with the crown molding on the eaves. The gable end of the

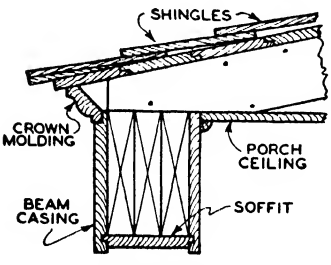


Fig. 79. Section through Porch Beam at Eaves

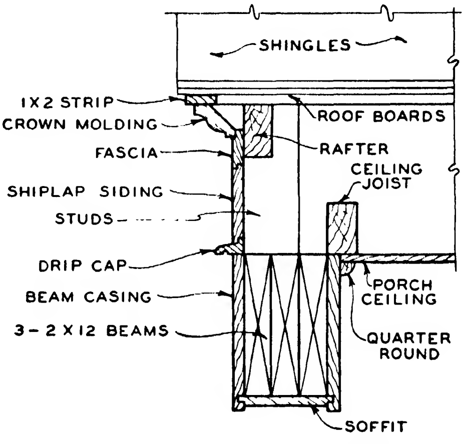


Fig. 80. Section through Porch Wall and Roof at the Side

porch is covered with *shiplap siding* which fits under the *fascia* of the cornice, and over the *drip cap* of the *beam casings*, as shown in Fig. 80.

Bay-Window Trim. The casings of the bay window of the dining room also form the wall covering around the windows the same as on the small dormers. Such windows usually come to the job completely assembled and require only slight fitting; but these windows must be set before cornice trim can be applied. The cornice trim is similar to the cornice of the large dormer. However, no rabbet is required on the bottom of the fascia as for the large dormer shown in Fig. 77.

Cornice Trim on the Addition. The cornice trim on the addition of *The House* is simple in construction, and is similar to that of the large dormer. The side-wall shingles on the gable end are butted against the fascia. This makes it necessary for the fascia to be at least 1⅛ of an inch in thickness, as shown in detail at (A–A), Fig. 81.

If a ¾-inch fascia is used it must be blocked out with two ⅜-inch strips. This blocking can be done by using a wood-lath detail, as shown in Fig. 81. A thicker fascia is required because the butts of the 24-inch shingles are rather thick, and when several thicknesses are built up, the butts of the shingles will stand out beyond the surface of the ¾-inch fascia. The crown molding of the gable must be a special rake molding so it will make a true miter with the crown molding at the eaves.

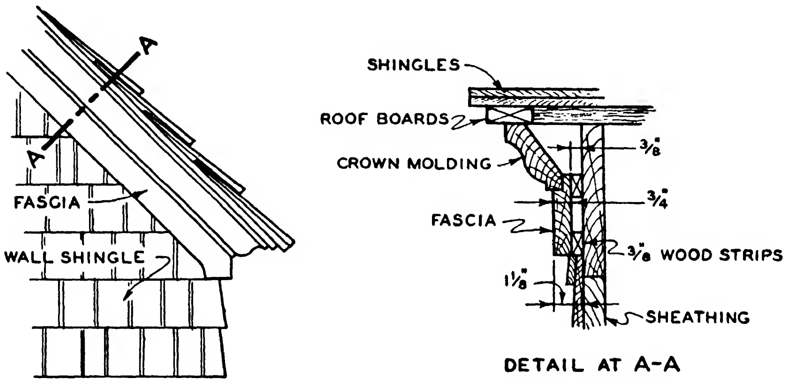


Fig. 81. Fascia of Cornice Trim on Gable of Addition

Roof Shingling. According to the specifications for *The House*, the shingles are 16-inch clear vertical-grain cedar shingles laid 5 inches to the weather. A double wood-shingle course is used as a starter with a 1¼-inch overhang at the eaves and a ¾-inch overhang at the rake. The method used in applying wood shingles has been explained previously in this chapter. Since this is a typical roof, no special instructions are necessary regarding the method of shingling. However, attention must be called to the dormer flashing for *The House*, which is the same as that shown in Fig. 35. Since the chimney comes out at the ridge, it will require only the regular side flashing, such as that shown in Fig. 36. Side-wall flashings also are required where the addition meets the main building. Here the shingle tins should be kept back about 5 inches from the main wall so the stone veneer will fit in behind the tins. After the stone work has been completed, counterflashing must be installed.

Unless other provisions are made, the metal roof on the large dormer of *The House,* also the roofs of the bay window and of the rear stoop, must be installed as the shingling of the main roof progresses. This procedure is necessary because each roof must be properly flashed into the shingle courses.

Setting the Door Frames. The rear entrance door and the porch door of *The House* are typical doors and the frames are set as explained earlier in this chapter. However, the front entrance door has an ornamental pilaster casing, also a monolithic (poured in place) concrete sill. Because of these special features, the frame of this door will be delivered to the job without a sill. The work of the stone mason will be somewhat difficult because the stone veneer will extend behind the pilaster casings. The workmen can always do a better job when the masonry is laid to the finish work, instead of the wood of the trim being fitted to the masonry. Hence, it is advisable to set the frame of this door before the masonry work is done.

When preparing the front-door frame for setting, it will be necessary to cut the side jambs to the height of the door—6 feet 8 inches—plus 5/8 of an inch for the threshold. The total height of the door jambs then will be 6 feet 8 5/8 inches, measured in the rabbet. The jambs should be cut to this length, and the side jambs should be trimmed to 3/4 of an inch above the headpiece. Paper 3 feet in width should be tacked around the rough opening for the door, and the frame then set so the bottom of the jamb will be of the same height as the top of the finished floor. In this case, the head jamb should be leveled instead of the sill, as there will be no sill, since the sill is cast in place after the frame has been set. After the head casing has been leveled and held in place by several nails and blocks under the jambs, the side jambs should be plumbed and well secured with nails. One or two courses, braces, or spreaders should be tacked between the jambs, one near the bottom and the other near the middle. These pieces should be left in place until the masonry work has been completed and the frame of the door has been securely anchored. To insure a uniform width for the door frame, top and bottom, the spreaders must be measured and cut to fit tightly at the top, and then be tacked in their respective places.

Setting of Window Frames. Setting of the window frames for *The House* presents no problems different from those already explained, except the frames for the small dormers and the bay window previously mentioned. However, it will be observed that the window heights to the head jamb are to be 6 feet 8 inches from the finished floor. Therefore, a story pole must be laid out for this height before the work of setting any of the window frames is begun.

Exterior-Wall Covering. Except on the sides of the small dormers, the gable side of the porch, the stone veneer on the south side and part of the porch wall, the exterior walls of *The House* are to be covered with shingles. The sidings used on the small dormers are to be of clear cypress shiplap which should be well fitted. As soon as it is applied the shiplap siding should be prime painted. These sidings should be held up ¾ of an inch above the shingles on the side of the dormers to insure the quick drying out of the wood after a rain.

The shingles used on the side walls are to be of 24-inch clear vertical-grain cedar shingles laid 10 inches to the weather. The methods commonly used in shingling, which have been previously explained, can be applied here, since this is a regular shingling job. There is no water table shown on the plans for *The House,* because all that is required in this case is merely a 1x2 beveled strip of wood to cover the wood-cement joint at the foundation and to pitch the shingles, as shown in Fig. 52. The wall sheathing is to be covered with a good waterproof asphalt building paper, lapped 2 inches. The paper should be carefully installed to prevent the infiltration of air and dust.

CHECKING ON YOUR KNOWLEDGE

The following questions give you the opportunity to check up on yourself. If you have read the chapter carefully, you should be able to answer the questions. If you have any difficulty, read the chapter over once more so that you will have the information well in mind before you go on with your reading.

DO YOU KNOW

1. What three factors are especially important when selecting wood for exterior-wall covering?

2. What important purpose building paper serves in the construction of the exterior walls of a house? What kind of building paper is specified for *The House?*

3. How wood shingles were made in early Colonial days in our country? What these shingles were called? How wood shingles are made today?

4. What kind of shingles are to be used on *The House?*

5. What type of shingles now on the market have fire-resisting qualities?

6. The names of three commonly used styles of cornices? What type of cornice is to be used on *The House?*

7. The difference between a *roof gutter and an attached gutter?* What type of gutters are to be used on *The House?*

8. The difference between an *open valley* on a roof and a *closed valley?* Which type is most practical for ordinary purposes?

9. Why flashing is used around dormer windows and chimneys? What kind of metal is commonly used for flashing?

10. Why the door frame for the front entrance of *The House* should be delivered to the job without a sill?

11. The meaning of the terms *double-hung windows, French windows,* and, *casement windows?*

12. What kind of exterior-wall covering is to be used on *The House?*

13. How many dormer windows are called for in the plans for *The House?* What kind of exterior covering is to be used on these dormers?

14. What type of covering is to be used on the roof of the porch of *The House?*

15. What is to be used in place of a *water table* on *The House?*

CHAPTER VI

Interior Finish

QUESTIONS THIS CHAPTER WILL ANSWER

1.*What work does the interior finish of a house include?* 2. *How is sheetrock used as interior finish?* 3. *What two members make up the base trim of a room? What third member is sometimes added?* 4. *How can you find the total run of a stairway?* 5. *At what angle should stairs be built to insure the greatest degree of safety?* 6.*Where are the cabinets for a home usually made?*

INTRODUCTION TO CHAPTER VI

Various construction problems dealing with the application of the interior finish of a house are discussed in this chapter. The interior finish includes wall, ceiling, and floor covering, as well as the trim members for doors and windows. Other interior finish work includes the adding of baseboards, installing of cabinets, cupboards, and stairs. Miscellaneous interior finish, selected according to the design of the architectural plans, include picture molding, chair rails, door and window stops, and any other trim members called for in the architectural drawings and building specifications.

Different types of wall and ceiling covering, now in use, are discussed in this chapter. Attention is called to the fact that lath and plaster, once commonly used as wall and ceiling covering, is being replaced to some extent by a variety of manufactured materials, such as plywood, sheetrock, and other insulating products. In recent years, wood covering, in the form of panels, has become popular with many builders. Instructions are given for the application of the different types of covering for walls and ceilings. Directions are given also for the laying of finish floors.

The proper fitting and hanging of doors and windows is stressed, because the comfort of a room depends largely upon the prevention of infiltration of cold air, snow, and dust. Then, too, cracks or open spaces around doors and windows will allow warm air from the heating plant to escape, which will increase the cost of heating the room. Careful instructions are given in this chapter for the proper procedure to follow when fitting and hanging doors and windows. You should study these instructions in connection with the illustrations, and note the step-by-step method used when giving directions for fitting the casings and trim around doors and windows. The installing of sash balances are discussed, and illustrations of some patented devices now on the market are shown.

As a carpentry student you should be interested especially in the discussion and methods described in this chapter on how to build stairways. Stair building is a special feature of carpentry work. Although this type of work is frequently done in a stair shop, stairs are sometimes built on the job, and the carpenter should be prepared to erect any stair he may be called upon to build in an ordinary house. The straight-flight stairway is the simplest and cheapest to construct. Instructions are given in this chapter for methods of building not only the straight-flight stairs but also more complicated stairs, such as the three-winder stairs and other designs. Instructions are given for the laying out, cutting, and fitting in place of treads, risers, and stringers.

Methods of mortising and fitting locks on windows and doors are explained. Instructions are given also for the assembling and installing of cabinets which must be fitted against the wall of a room. Cabinets and cupboards often are built in a shop and delivered to a job ready for fitting into place.

All instructions given in this chapter concerning the fitting and installing of interior trim should be given careful consideration by the carpentry student. If these instructions are followed closely the work of interior finish will be greatly simplified for you, if you are a newcomer to the trade.

PROCEDURE FOR INTERIOR FINISHING

The interior finishing of a building consists chiefly in covering the framework of the walls and ceiling with lath and plaster, or any of the various materials on the market today, suitable for the finishing of walls and ceilings. These materials include plywood, wood paneling, solid boards, and structural fiber-insulation boards designed for this purpose. Also included in the interior finish is the floor covering which not only gives a finished appearance to the floor but prolongs the life of the wearing surface. This two-fold purpose is accomplished by applying, over the subfloor, finished-wood flooring, linoleum, ceramic, asphalt or rubber tile. In addition to the wall, ceiling and floor covering, the interior finish includes stairs, cabinets, windows and doors, together with the trim around the windows and doors. Other trim members include the base, cornice, picture moldings, chair rail, and various special interior appointments indicated on the drawings or mentioned in the building specifications. However, the work of applying any interior finish should be left until the roof is completed and the outside walls are either finished or made watertight.

Most of the interior finish work mentioned in the foregoing paragraph is done by the carpenter except lathing, plastering, and ceramic work; and frequently the carpenter does the lathing. The order of procedure in finishing the interior of a building may vary according to the design, materials required, the relation of these materials to each other, and established practice. However, wall finish must be applied before other interior work can be done. Window fitting and trimming, the applying of picture and cornice molding, stair rail, and the installing of the stairs can be done before the floor covering is laid. If applying the floor finish is delayed until this work is done, less care is required to protect the finished surface. The setting of cabinets, installing door

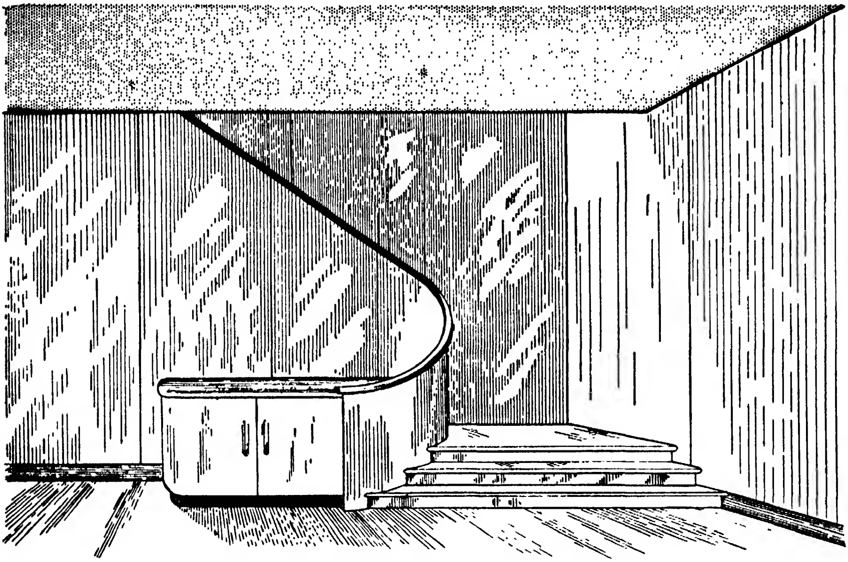


Fig. 1. Walls Finished with Plywood Panels

jambs, fitting doors and bases must follow the laying of the floor covering. The final work of interior finishing is the attaching of hardware and the fitting of screens and storm sash. Much of the hardware is fitted but is not installed until after the painting has been finished.

INTERIOR WALL COVERING

For many years the accepted wall finish for buildings was lath and plaster. However, today other materials have come into use for wall coverings, including sheetrock, plywood, boards with molded edges, and the structural fiber-insulation board. When plaster is used, the carpenter is concerned only with providing the necessary plaster grounds which serve as guides for the plasterer, making it much easier for him to build straight and true surfaces. All of the other materials mentioned are applied by the carpenter.

Plywood Wall Covering. Large plywood panels used extensively as interior wall covering can be obtained on the market in sizes from ¼ to 13/16 of an inch thick, 36 or 48 inches wide, and 60, 72, 84, or 96 inches long. The wood most commonly used for making these large panels of plywood is Douglas fir. However, one-face panels are available in various cabinet woods, such as oak, birch, mahogany, and other hardwoods.

Plywood gives a wall a wood-finish surface. If desired, the less expensive plywoods can be used and covered with paint or wallpaper, or be decorated in the same way as any other plastered surface. These large panels usually are applied vertically from floor to ceiling, as shown in Fig. 1. However, plywood panels can be applied horizontally;

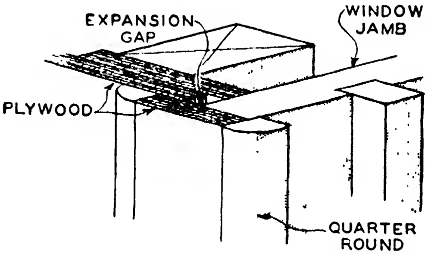


Fig. 2. Thin Plywood Trim for Window or Door

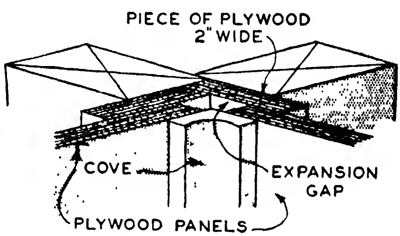


Fig. 3. Expansion Gap Back of Cove of Inside Corner

and sometimes a combination of both a vertical and horizontal application is used.

The dimensions are such that the panels can be nailed or glued to the framing members of the building, such as studs and joists which usually are spaced 16 or 24 inches on center (O.C.). The cheapest and quickest method of applying panels is to fasten them directly to these framing members. A more satisfactory method is to nail ¼-inch plywood furring strips 2 inches wide with the grain running the short way, (Fig. 3) to the framing members. The panels are then glued and nailed to these furring strips. Thus the individual plywood panels are formed into one unit and each wall then becomes essentially a single piece of plywood. This method eliminates joint movements due to swelling and shrinkage of the building frame. Since nails will give more easily than glue, the frame is permitted to move behind the finish without affecting the surface joints. Allowance for movements should be provided at corners, window casings, door casings, ceilings, and base molds, as shown in Figs. 2 and 3.

The panels can be random grooved at 4-, 6-, 8-, 10-, or 12-inch intervals with a grooving plane to give the effect of random boards. When this is done, the blade of the plane should be set to cut to a maximum depth of 3/32 of an inch.

Plywood Joints. The various methods of finishing the joints of the panels are illustrated in Fig. 4. The **V** joint is shown at (*A*), Fig. 4.

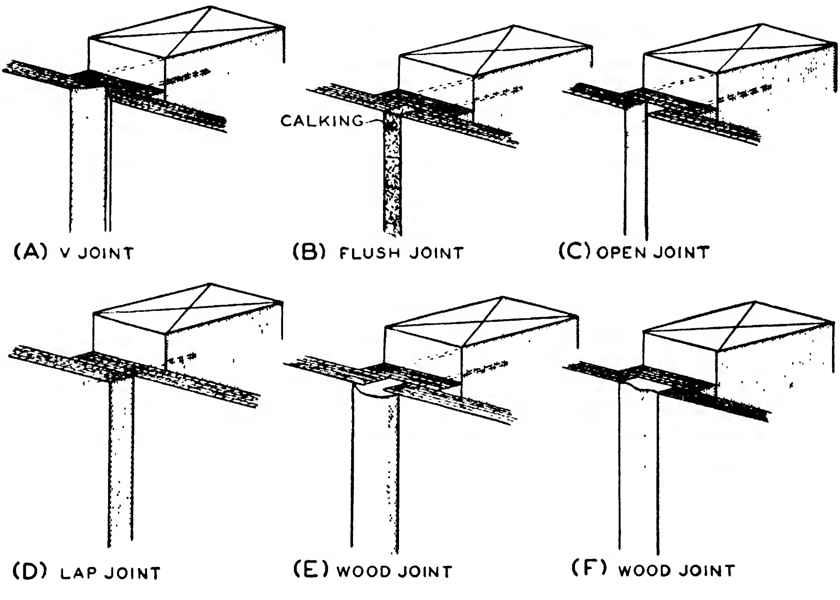
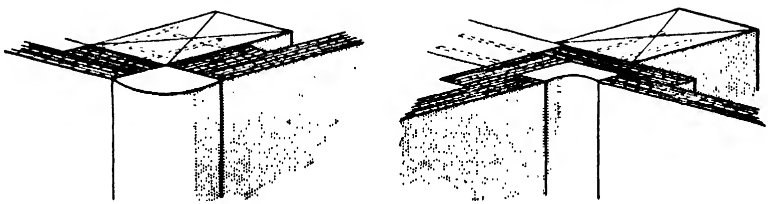


Fig. 4. Various Joints Used in Connecting Plywood Panels

Where the finish of the wall is to be paint, enamel, or wallpaper, the joints may be either tight or calked. A calked joint is shown at (*B*), Fig. 4. For tight butt joints, brush casein glue over the furring strips, nail the panel in place with just enough nails to hold it until the glue sets. Be sure to mix the glue according to directions. If the glue is too thin it is worthless. Enough glue should be used to provide a squeeze between the panels. When the squeeze, or glue, has hardened, block sand the joint; that is, make a smooth finish with sandpaper.

Where a calked joint is preferred, a gap of 1/8 to 1/4 of an inch should be left between the panels, and the calking compound should be forced into the joint with a knife. Then the joint should be block sanded until it is smooth. Where a natural or stained effect is desired, care must be exercised to prevent the glue from staining the faces of the panel. An open joint is illustrated at (*C*) and a lap joint is shown at (*D*), Fig. 4.

Joints can also be treated with moldings, as shown at (*E*) and (*F*), Fig. 4. These moldings can be either in the form of battens fastened over the joints, or they can be applied as splines between the panels. Thus, the wall surface can be broken up into vertical or horizontal panels, squares, or rectangular designs. When paneling, you should



(A) OUTSIDE CORNER (B) INSIDE CORNER

Fig. 5. Method of Finishing Outside and Inside Corners for Plywood Wall Covering

always remember that panels applied horizontally make a room look longer and wider but make the ceiling appear rather lower than it is. Where joints run vertically, an effect of higher ceilings is given to the room.

The outside corner in a room can be given a simple and effective treatment by finishing it with a quarter-round molding, as shown at (*A*), Fig. 5, while a cove molding will finish an inside corner, as shown at (*B*), Fig. 5.

Structural Insulation Board Interior Finish. Interior-finish products made of structural insulating board include building board, plank, and tileboard. Various vertical and horizontal designs, or a combination of vertical and horizontal designs, can be made by skilful preparation and application of building board or plank. Different methods which may be used in applying insulation board are illustrated at (*A*), (*B*), (*C*), (*D*), (*E*), and (*F*), Fig. 6. For interior-finish purposes, the proper application of insulating board is important. The manufacturers of the various products furnish instructions which should be carefully followed to obtain the best results. However, the following information giving details of application will serve as a general guide.

Beveling and Grooving. By means of special tools which have been developed for the purpose, the large building boards can be readily

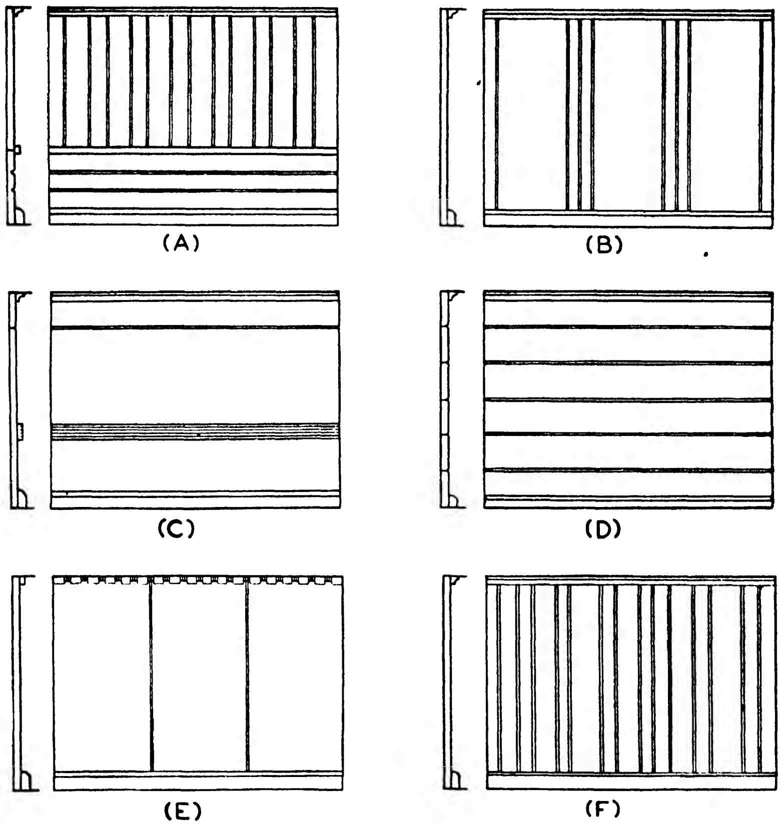


Fig. 6. Decorative Wall Designs for Structural Insulating Board Used as Interior Finish

beveled, grooved, or lapped, as shown in Fig. 7. The cut for a clean square edge is shown at (*A*), Fig. 7. The cut for two beveled edges is shown at (*B*), Fig. 7. The cut for a shiplap joint is shown at (*C*), Fig. 7. The cuts for beveling and grooving from a square edge are shown at (*D*) and (*E*), Fig. 7. The cut for a miter joint with a groove is shown at (*F*), Fig. 7. A supplementary tool or knife should be used for freehand carving where the beveling and grooving tool becomes unwieldy.

Applied to Framing or Furring. Insulation-Board products may be applied by nailing the boards to framing members or to furring strips, or by cementing the pieces into continuous surfaces. When attached to a nailing base the framing should correspond with the size or type of product used, but in no case should the framing be installed on greater than 16-inch centers. Furring strips for plank should be placed at right angles to the plank on 9-inch centers up to a height of 3 feet, and 12- or 16-inch centers above this height. It is especially important that the framing or furring for tileboard units should conform exactly

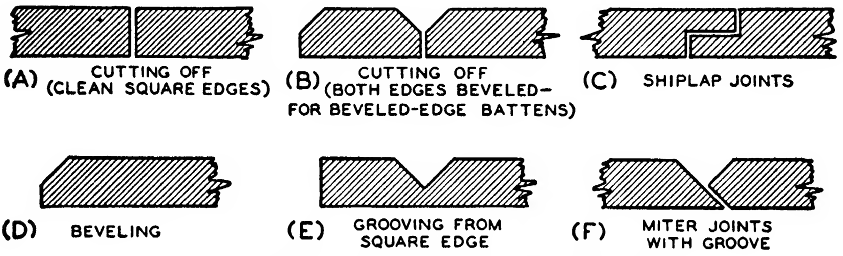


Fig. 7. Cuts Made with the Stanley Fiber-Board Cutter

to the size of the units used. Headers or board backings are recommended for use behind chair rails and all other heavy moldings.

Exposed Nailing. Where the nails are to be exposed, finishing nails, brads, or cadmium-plated insulation-board nails should be used. For ½-inch thick insulating boards use 1¼-inch nails and for 1-inch boards use 1¾-inch nails. Drive the nails at an angle, setting them below the surface and tapping down the fibers over the surface. Nails may be driven in the beaded groove of a plank. Where nails are to be covered with panel strips or molding, use 1½-inch nails for ½-inch boards, and 2-inch nails for 1-inch boards.[1]

Concealed Nailing. Some manufacturers have developed special clip systems and interlocking joints for installing tileboard, or panels, and other interior-finish products. The object of these clips is to eliminate exposed nailing.

[1] Walter E. Durbahn, *Fundamentals of Carpentry, Vol. I—Tools, Materials, Practice* (Chicago: American Technical Society, 1947), VI, Tables II and III.

Tileboard over Smooth Surfaces. Insulating tileboard may be applied to solid plaster, smooth wood, plaster board, and other continuous surfaces by means of special adhesives now available for this purpose. However, for the best results supplementary nailing is recommended, where possible. Apply the adhesive to the tileboard in spots about the size of a walnut. One spot should be placed in each corner of the piece of tileboard with additional spots where needed on larger sizes

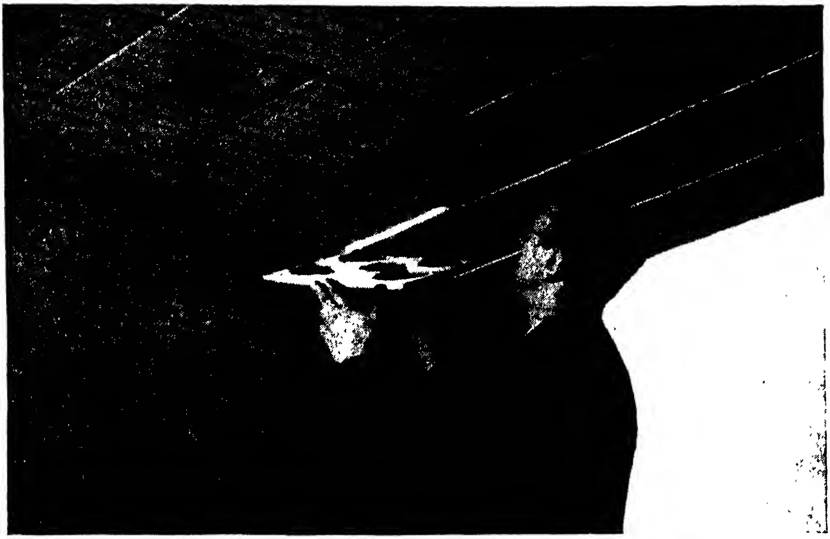


Fig. 8. Method of Applying Adhesive to Several Spots on Tile

of tile, as shown in Fig. 8. The application of the adhesive can be simplified by the use of a homemade tool similar to the one illustrated in Fig. 9. This tool is made of a piece of 1-inch or 1¼-inch brass pipe about 14 inches long. The cutout portion of the pipe is filled with the adhesive, and little balls of the adhesive can then be cut off with a putty knife and applied to the piece of tile. If desired, the adhesive may be applied over the entire surface which is to be bonded. It is particularly important that a sufficient amount of adhesive be applied, especially in the case of rough surfaces, for which a heavy-bodied adhesive is preferable. An intimate bond can be obtained by sliding or pushing the different units of the tile in place, using a sidewise pressure against the surface to be finished.

Various ceiling designs can be developed with tile insulating board, as illustrated in Fig. 10. A diagonal-square design is shown at (*A*), Fig. 10. A design, in which two different sizes of squares are used, is shown at (*B*), Fig. 10. A twin-rectangle design is shown at (*C*), Fig. 10. The ashlar and herringbone designs are shown at (*D*) and (*E*), Fig. 10. A combination of a square and rectangle design known as the *basket weave* is shown at (*F*), Fig. 10. Designs for ceilings can be further enriched by the use of different colored tile for borders or inserts with moldings made out of the same material. In developing an attractive tile ceiling, success depends to a great extent upon the planned layout and the placing of the first row of tile. Work should be started from the center of the ceiling by snapping a chalk line which will serve as a guide line. This will insure a balanced design around the edges.

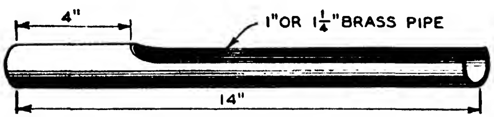


Fig. 9. Homemade Tool for Handling Adhesive

Sheetrock Used for Wall Covering. Sheetrock is a fire-resistant wallboard. It is made of gypsum, which is molded while in a plastic condition between two sheets of tough protective paper. The long edges are reinforced and protected by the same material with which the board is sheathed.

Sheetrock with square edges is made in thicknesses of ¼, ⅜, and ½ inch, in widths of 32 and 48 inches, with lengths of 4, 5, 6, 7, 8, 9, 10, 11, and 12 feet. The widths fit standard 16-inch centering of studs and joists. The varying lengths make sheetrock especially adaptable to the average ceiling heights.

The recessed-edge sheetrock is like the square-edged, except that the thickness along the folded edge is slightly decreased in the recessed edge. This permits the application of material for covering the joints for producing a smooth solid unit of wall or ceiling covering, which can be painted or otherwise decorated.

Sheetrock is also manufactured with a wood-grain finish on one side. This finish gives the face surface of the board the appearance of wood, such as walnut, knotty pine, or Douglas fir. This wood-finish effect is produced by an engraving and printing process which gives the graining and coloring of a genuine wood surface. When the joints of these boards are covered with wood molding a paneled effect is produced.

Application of Sheetrock. The framework to which the sheetrock is applied should be spaced 16 inches on center (O.C.). Headers of 2x4

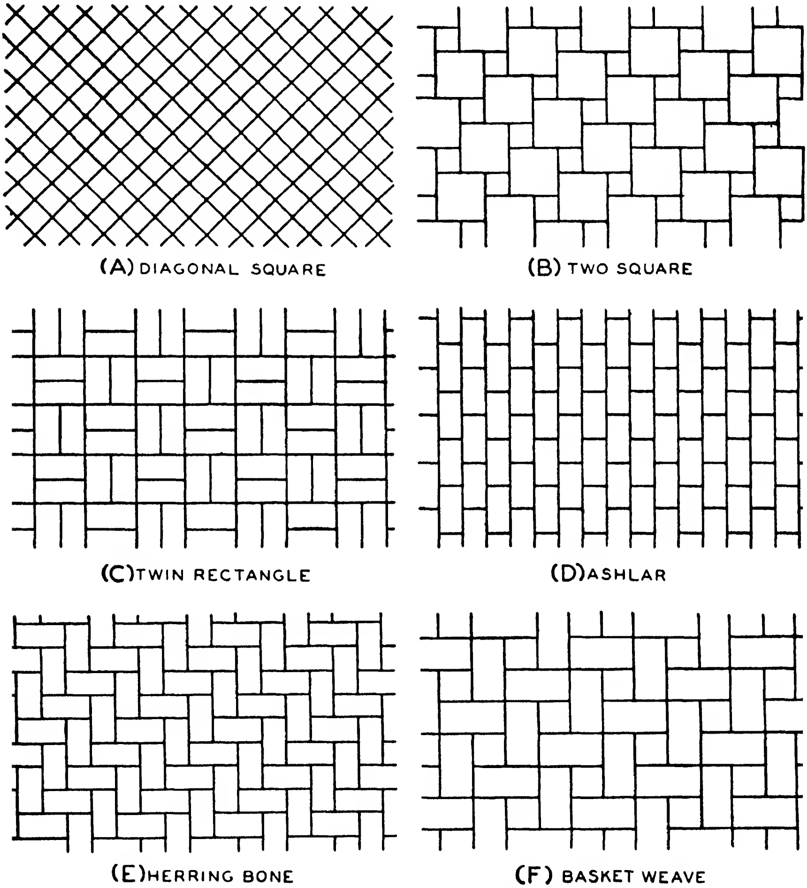


Fig. 10. Ceiling Designs for Insulating Tileboard Panels

material should be provided on ceilings to take all end joints of the sheetrock and, where required, to form a nailing base for the wood beams, cornice, and other framing members. Such headers should also be provided on walls for substantial nailing for baseboards, wainscoting caps, and other similar interior woodwork trim.

The sheetrock is laid out and cut with a saw or scored with a knife by placing it back down on a pair of sawhorses, as shown in Fig. 11. A support should be placed near the cutting edge to hold it rigid during the cutting process. Cuts, which are to be covered with trim, may be made with a knife or chisel and a straightedge. Immediately after a cut is made, the edge, which has been cut, should be slightly beveled on the face side with coarse sandpaper.

When fastening sheetrock to a wood frame, the 3-penny (3d) cement-coated common nail with a flat head should be used. When applying

Fig. 11. Workman Scoring Sheetrock Board for Cutting or Breaking
Courtesy of United States Gypsum Company, Chicago, Ill.

sheetrock over old plaster, 6-penny (6d) nails should be used. The nails should be spaced 3 inches apart and 3/8 of an inch from the edge of the board. On intermediate supports nails should be spaced 6 inches apart on ceilings and 9 inches apart on walls. All nails should be driven straight and slightly below the surface without breaking the protective paper covering. Do not set the nails. Wood-finish sheetrock should be nailed with 4-penny (4d) finish nails driven at a 45-degree angle.

On walls or ceilings which are to be painted, or otherwise decorated, the joints should be treated with either a 2-inch perforated metal strip, a woven-cloth fabric, or a fabricated, beveled, and perforated fiber tape. The latter is especially designed for sheetrock with recessed edges. These tapes should be cemented in place with a cement furnished

Fig. 12. Applying Tape and Cement over Joints of Sheetrock
Courtesy of United States Gypsum Company, Chicago, Ill.

by the manufacturer. The joints should first be covered with the cement, and then the tape pressed into place and smoothed down with a semiflexible scraping knife, as shown in Fig. 12. Four steps, in applying tape and cement over joints of sheetrock, are illustrated in Fig. 12.

Fig. 13. Wall Covering of Wood Boards
Courtesy of Western Pine Association, Portland, Ore.

At (1) is shown the joint before it is reinforced; (2) shows how the tape is applied over the joint; (3) shows how the cement is worked into the joint with a scraping knife; and at (4) a workman is smoothing and leveling the surface after the cement has been worked into the joint.

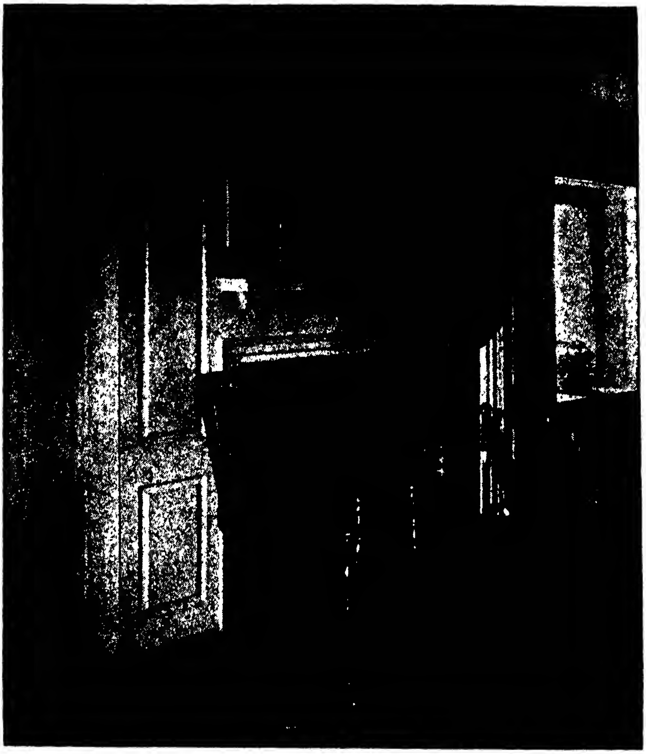


Fig. 14. Wall Covering of Raised-Wood Paneling
Courtesy of Western Pine Association, Portland, Ore.

Wood Wall Covering. Wood produces an interesting wall covering, giving the effect of stability and warmth. There are two types of wood wall covering—boards with molded edges, as illustrated in Fig. 13, and the raised or plain panels shown in Fig. 14. Boards with molded edges are used extensively in recreation rooms, although they can be used in any room of a house, and often are so used. Since the raised or plain woodwork is more expensive millwork, it is used principally in the most important rooms of a house. Knotty pine or pecky cypress are the most commonly used woods for this type of wall covering. Black walnut, butternut, oak, and chestnut are used on more elaborate panel installations. Boards of random widths, 4, 6, 8, and 10 inches, with molded edges are illustrated in Fig. 15. When applied vertically these boards give the appearance of added height to a room. Different types of molded edges, of random width boards, are illustrated at (*A*), (*B*), and (*C*), Fig. 15. These boards can also be applied horizon-

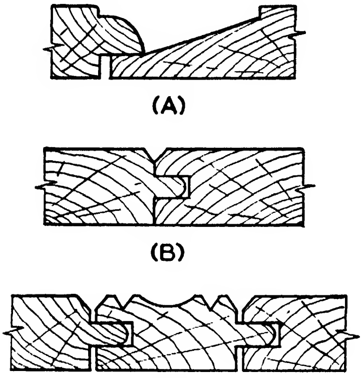


Fig. 15. Types of Molded Edges on Wall-Covering Boards

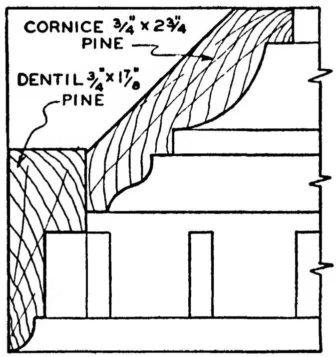


Fig. 16. Dentil Type of Cornice Moldings

tally, or a combination of vertical and horizontal application can be used if desired. The cornice molding near the ceiling may be a simple bed or crown molding, or it may be a more elaborate dentil type of cornice, as shown in Fig. 16.

The wood used in wood wall covering usually is selected because of its desirable color, the number and kind of knots, and its grain. The edges are molded and the surface is sanded to produce a good finish. A less expensive, knotty, pine-board wall covering can be obtained by using a select No. 2 white pine shiplap, with the edges beveled slightly, as shown at (*B*), Fig. 15.

Application of a Wood Wall Covering. When wallboards are applied vertically, headers must be placed between studs near the top and bottom of the wall, as shown in Fig. 17, with 24- or 30-inch spacing between the headers. When the boards are placed horizontally no headers are required. Wood panels can be applied directly to the stud frame, but on high-class work the walls are cross furred or even rough plastered to produce a true and solid backing for the panels. Masonry walls must be furred, as illustrated in Fig. 17, before wood-wall covering can be applied.

INTERIOR TRIM

The various trim members used in finishing the interior of a building are the casings around the doors and windows, the baseboard

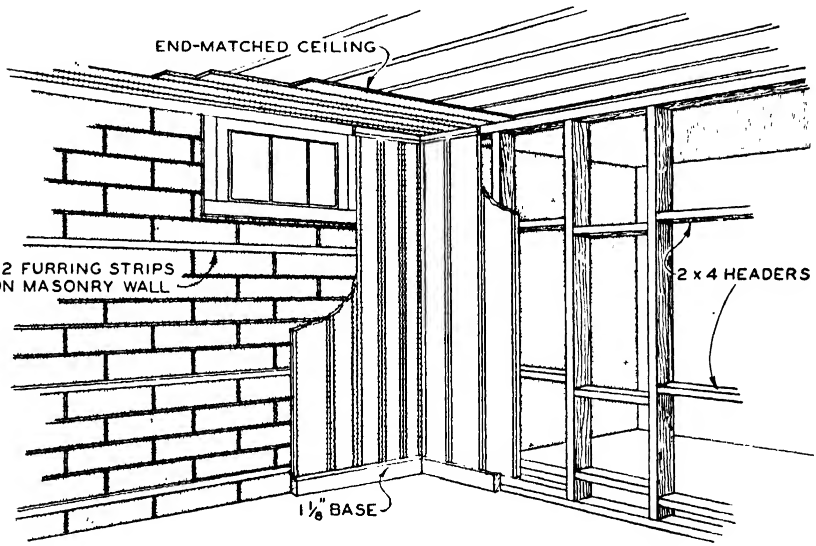


Fig. 17. Walls Prepared for Vertical Boards

with its base mold and shoe mold, the picture mold, chair rail, cornice mold, and panel mold. There should be a definite architectural relation in the design of all these members to that of the doors, windows, and the general architecture of the building. Therefore, it is well to make a careful study of all these details before selecting material for the interior trim. When an architect is not employed to help make this selection of trim material, a great deal of help can be obtained from the manufacturers of interior-trim materials.

Many varieties of wood are used for interior trim, such as birch, oak, mahogany, walnut, butternut, chestnut, white and yellow pine, magnolia, gum, tupelo, and other available woods. When the trim is to be painted a close-grain wood, such as birch, magnolia, tupelo, gum, or pine is desirable. The harder woods free from pitch, such as birch or magnolia, will provide a better paint surface than the softer woods such as pine.

Types of Casings. Four types of casings generally used to trim windows and doors are illustrated in Fig. 18. The simplest of these is the square-cut type, where the side casing butts up against the head casing as shown at (*A*), Fig. 18. In the corner-block type both head and side casing butt against the corner block as shown at (*B*), Fig. 18. The backband trim is used on flat casings butted against each other as shown at (*C*), Fig. 18; or on more elaborate molded casings which

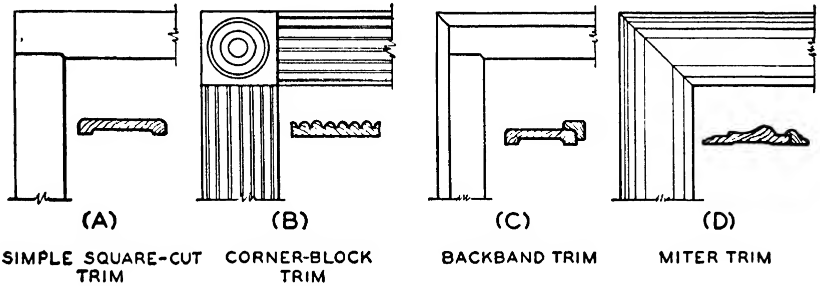


Fig. 18. Types of Trim for Interior Finish

are mitered as shown at (*D*), Fig. 18. The mitered casing frequently is cut and fitted at the mill, and is brought to the job assembled ready to nail to the door or window opening. This is known as *cabinet trim.* The miter joints of cabinet trim are held together with clamp nails and glue, or with wood splines and glue. When joints are fitted on the job, the casings are only glued and nailed.

The cap trim shown at (*A*), Fig. 19, is a modification of the simple-cut trim. It is used on both windows and doors. The mitered trim is shown at (*A*), Fig. 20. The plinth block used at the bottom of door casings is illustrated at (*B*), Figs. 19 and 20. The plinth block is made of thicker material than the casings. The baseboard is butted against the plinth block.

In addition to the casings, the window trim consists of the window stool and apron, illustrated at (*A*), Fig. 21. Double-hung windows must also have a stop to hold the window in place. A window stop is illustrated at (*B*), Fig. 21. The door stop, though of the same design, usually is wider than the window stop.

The Base. The trim member which is fitted against the wall on top of the finished floor is known as the *base*. It is usually made up of two members, the baseboard and the base shoe as shown at (*A*), Fig. 22. Frequently, however, a third member is added. This is illustrated at

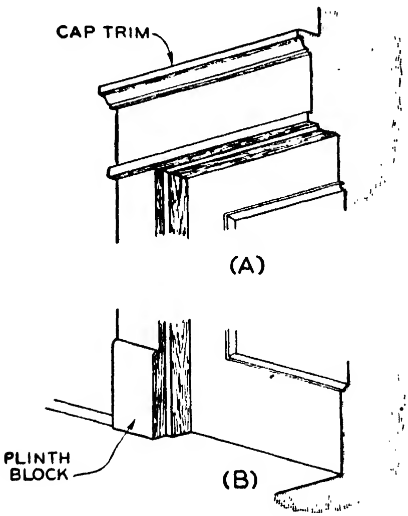


Fig. 19. Cap Trim, Modification of Square-Cut Type

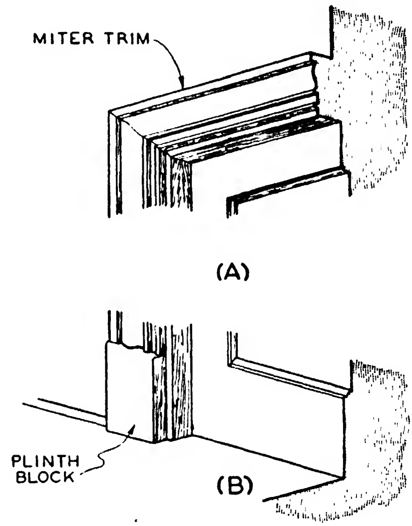


Fig. 20. Mitered Trim and Plinth-Block Type of Door Casing

(*B*), Fig. 22. It is called the *base-cap molding* and fits on top of the baseboard.

Miscellaneous Trim Members. The picture mold shown at (*A*), Fig. 23, is placed against the wall near the ceiling, usually up against the ceiling, although some prefer to lower it to 12 or 16 inches below the ceiling. The cornice mold shown at (*B*), Fig. 23, usually is a large cove mold fitted and nailed against both the wall and ceiling of a room. The cornice mold of a room sometimes becomes an extremely elaborate affair made up of several members and is sometimes especially ornamental, as illustrated in Fig. 16. The chair rail shown at (*C*), Fig. 23, may be placed on the wall at any one of various heights, such as the height of the back of a chair or 48 inches up from the floor. The chair rail provides a base for fastening various fixtures. The panel

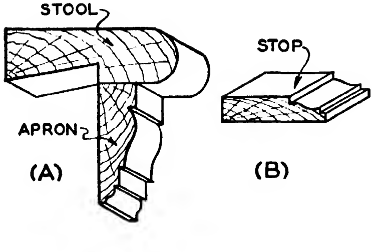


Fig. 21. (*A*) Window Stool and Apron; (*B*) Window and Door Stop

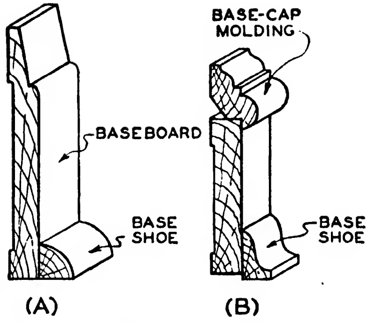


Fig. 22. Base Trim: (*A*) Shoe; (*B*) Cap Molding

mold shown at (*D*), Fig. 23, is used to divide wall spaces into panels which may be horizontal, as well as vertical. Shelves in closets rest on cleats, illustrated at (*E*), Fig. 23. The use of such cleats makes it easy to remove the shelves if desired.

The casings and stops of the doors and windows, as well as the stools and aprons, are sometimes delivered to a job cut to rough lengths. In such a case it is a good plan to assort, select, and place the various members at each opening; or to group them so the correct lengths may be quickly located when trimming an opening. If the material for these members come in random lengths, it is advisable to cut them to the rough lengths, and then assort them. This practice will help you find the proper lengths for the various openings, and will also give you the best service out of the material delivered. All base members and other moldings always come in random lengths. The

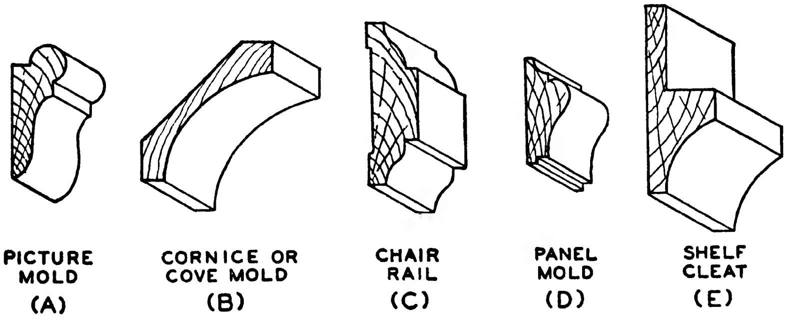


Fig. 23. Miscellaneous Trim Members

longest pieces should be reserved for the longest distances to be trimmed to avoid unsightly patching and piecing of trim.

WINDOWS

Window Trim or Finish. The fitting of sash and the trimming of windows usually is done before the finished floor is laid. In cold weather

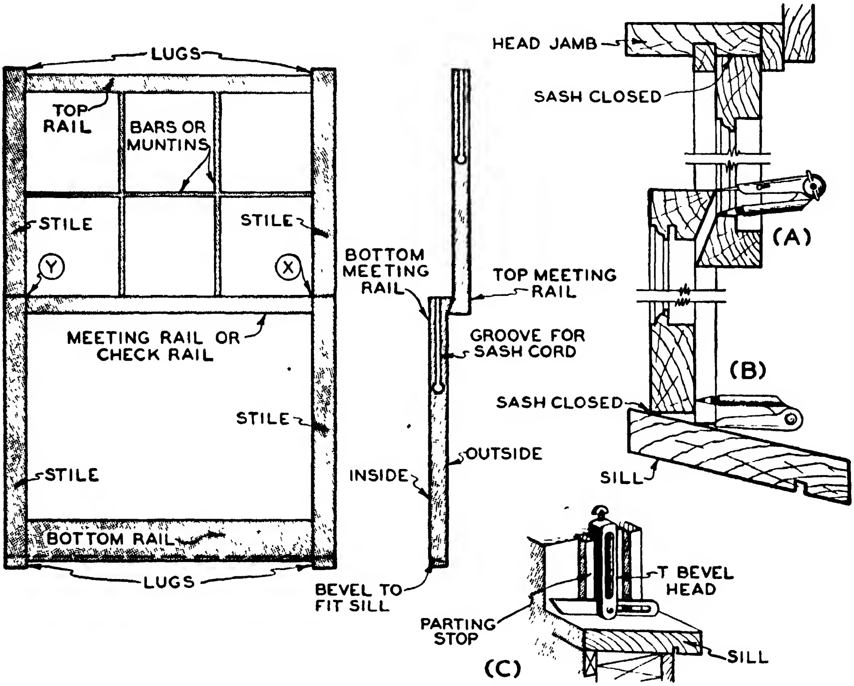


Fig. 24. Method of Fitting a Double-Hung Sash

the sash usually is fitted to close the building so heat can be applied before and during the plastering process. However, in cold weather a better plan is to apply some such material as muslin or Cell-O-Glass to window openings during the plastering period. Such material should be left on the window openings until the building is thoroughly dried out. The excessive amount of moisture caused by wet plaster will damage the sash, causing it to swell. The swelling will soil the sash and raise the grain of the wood.

Fitting and Hanging Double-Hung Sash. In outside walls, windows and doors must be properly fitted, to prevent a great loss of heat and an infiltration of cold air. The windows and doors should have a 1/16-inch clearance on each side. This will insure easy movement, but will also provide a reasonably close fit.

PROCEDURE

1. Check the jambs of the window opening to see if they are straight and square. Remove one parting stop, illustrated in Fig. 24, from one side of the window frame.

2. Take the top sash, square a line across the stiles in line with the top rail and cut off the lugs.

3. With a jack plane, joint the top and sides of the top sash, allowing 1/16-inch clearance on each side. Chamfer the arrises (edges) slightly with a plane. Mark and cut out the meeting rail to fit around the parting stop.

4. Place the sash into the frame opening, replace the parting stop and raise it up tightly on each side, holding it in place while fitting the bottom sash.

5. Take the bottom sash and cut off the lugs in the same way as on the top sash. Joint the sides to fit the frame with a 1/16-inch clearance on the sides.

6. Place the bottom sash into the frame opening. With a rule, measure the distance shown at *(A)*, Fig. 24, which is the distance between the top of the bottom meeting rail to the top of the top meeting rail. Take this measurement and check it at *(X)* and *(Y)*, Fig. 24. Adjust the bottom sash until *(X)* and *(Y)* check the same.

Note: In fitting sash, it must always be remembered that the two meeting rails must be flush when finished. Sometimes the frame is not square, and adjustments must be made on the top rail as well as on the bottom rail.

7. Set the dividers to the distance shown at *(A)*, Fig. 24, and scribe the outside of the bottom rail of the bottom sash shown at *(B)*, Fig. 24. *Scribing* is the drawing of a line parallel with an established surface with a pair of dividers or scribers.

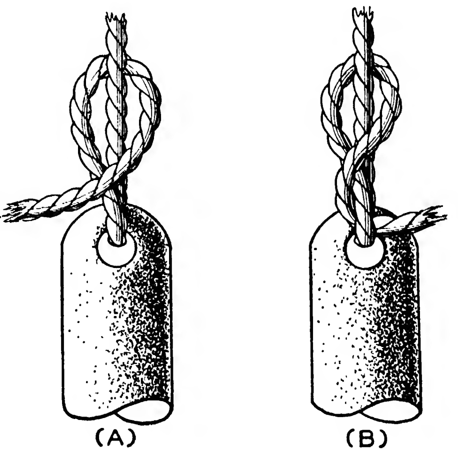


Fig. 25. Type of Knot Used for Tying Sash Cord to Weights

Note: If possible scribe on the outside; this is easily done if the window is near the ground or if the glass has not been set. When scribing on the outside of the bottom rail of the bottom sash is impossible, scribe on the inside of the bottom rail of the sash.

8. Remove the sash, set the **T** bevel to the angle of the sill with the head of the **T** bevel against the parting stop shown at *(C)*, Fig. 24. Lay out the bevel on the bottom rail and plane to the line. Care should be exercised in planing this bevel so the meeting rails will be flush on the top surface and the outside of the bottom rail will be tight against the top of the sill. Mark and cut the meeting rail of the bottom sash for the parting stop.

9. Remove both sashes. Run the sash cord over the pulleys and into the pulley pockets on each side of the frame. Tie the weights to one end of the cord and knot, the other end to fit into the sash. To determine the proper length for the sash cord, tie the weight to the cord, using the type of knot shown in Fig. 25, and pull the weight up against the pulley. Place the sash on the sill, holding the cord along the edge of the sash and cut the cord off about 4 inches below the hole in the edge of the sash. Knot the end of the cord and place the knot in this hole.

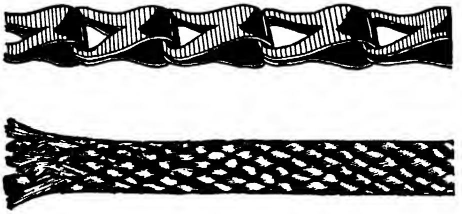


Fig. 26. Chain and Sash Cord Used for Hanging Sash

Note: Proper weights for sash can be determined by weighing each sash, and then dividing the result by two. This will give the size of the weight to be used on each side. If possible, make the weights for the top sash ½ pound heavier, to hold the upper sash up in place. Millwork catalogues give the weights of the sash for the full opening, for both single- and double-strength glass. The figure given must be divided by four to give the size of the weight for each side of each sash.

Sash Balances. Either a sash cord or chain, similar to those shown in Fig. 26, tied to a cast-iron weight can be used to balance a double-hung sash. Where windows are large and heavy, lead, because of its greater weight, is used in place of cast iron.

There are several patent sash-balance devices on the market, which make use of springs or friction for balancing the sash. The chief claim made for such devices is that they do not require a pulley pocket on the frame, thus permitting good nailing for narrow casings. A spring sash balance, which takes the place of the pulley on the frame, is shown in Fig. 27. A steel strap with a loop on the end is fastened to a spring in the balance case which will hold the sash in the desired position. The sash balance shown at (*A*), Fig. 28, has a spiral spring in a tube, with a twisted accelerated

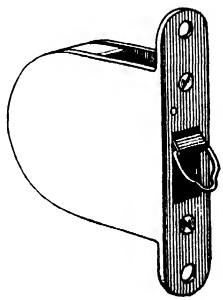


Fig. 27. Spring Sash Balance

rod which puts a tension on the spring and holds the sash in any position desired. This sash balance in place is shown at (*B*), Fig. 28.

Trimming a Double-Hung Window. Before beginning to trim the opening for a window, you should make sure that all necessary members for the opening have been selected and placed conveniently near the opening. When mitered joints are used, the various trim members

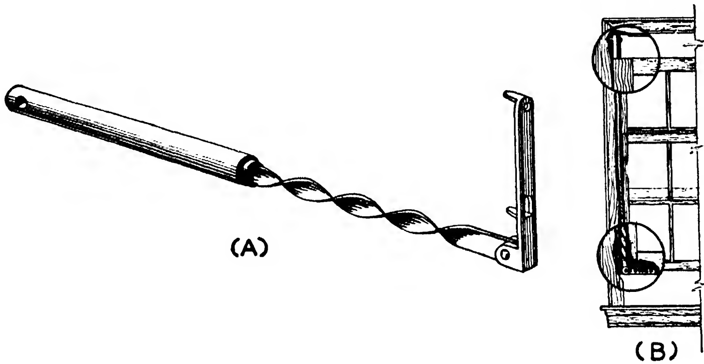


Fig. 28. Unique Sash Balance with Spiral Spring

may be fitted in place, as shown in the illustration, Fig. 29. When the trim calls for butt joints, the members are fitted together in the order indicated by numbers in Fig. 30.

PROCEDURE

1. Set a pair of scribers to the width of the rabbet on the window stool, as shown at *(A),* Fig. 31.

2. Place the window stool against the opening at the height it will be when fitted. With a square held in the position shown at *(C),* Fig. 31, draw the lines *(X)* and *(Y),* Fig. 31. Scribe the lines *(m)* and *(n)* on top of the stool, holding the scribers against the wall, as shown at *(B),* Fig. 31.

3. Carefully saw along these lines and remove the wood from the corners of the stool.

Note: When making a finish cut on the trim, always cut on the waste side of the cutting line, leaving part of the line; this will insure a snug fit against the casing.

4. Raise the lower sash and place the stool in its correct position. Bring the sash down and mark on the stool along the edge of the sash. Plane to this line and fit the stool with a 1/16-inch clearance between the stool and the sash.

5. When finished, the stool should project a distance shown as (*Y*), Fig. 32, beyond the side of the casing. The distance (*Y*) should equal the distance

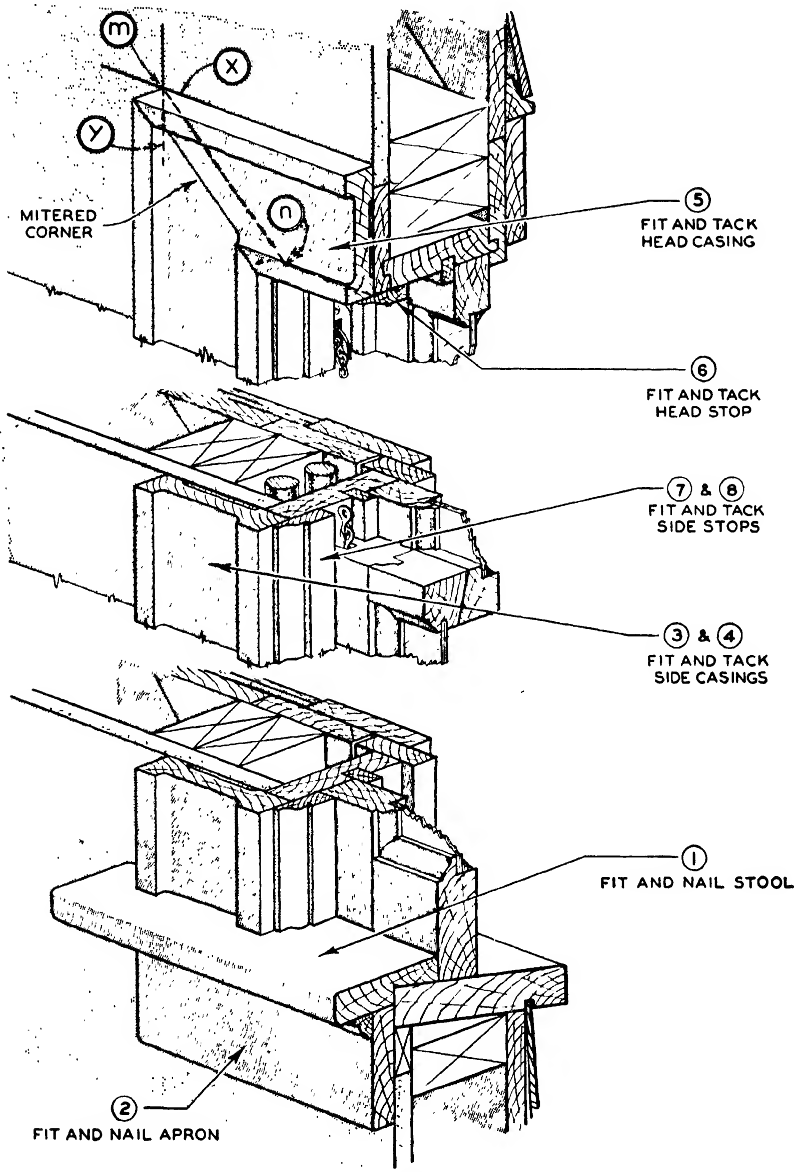


Fig. 29. Method of Fitting and Nailing Mitered Trim for Double-Hung Window

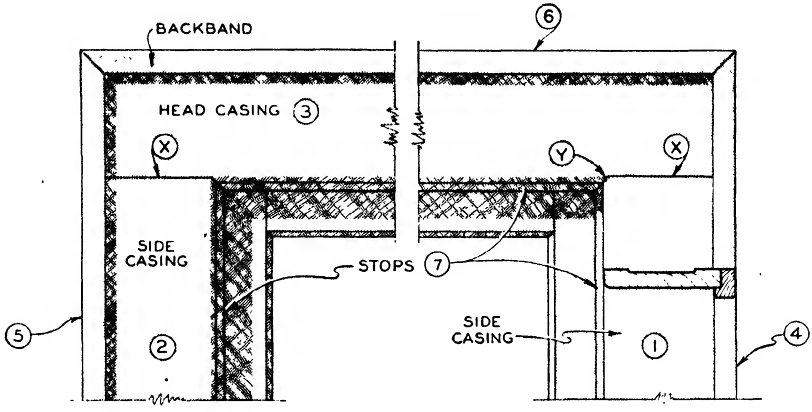


Fig. 30. Method of Fitting and Nailing Square-Cut Trim with Backband

(X), which is the distance the edge of the stool extends beyond the face of the casing, as shown in Fig. 32. Cut the stool to the correct length and return the ends.

Note: The term *return* means the continuation in a different direction, usually at a right angle, of the face of a building or any member, such as a

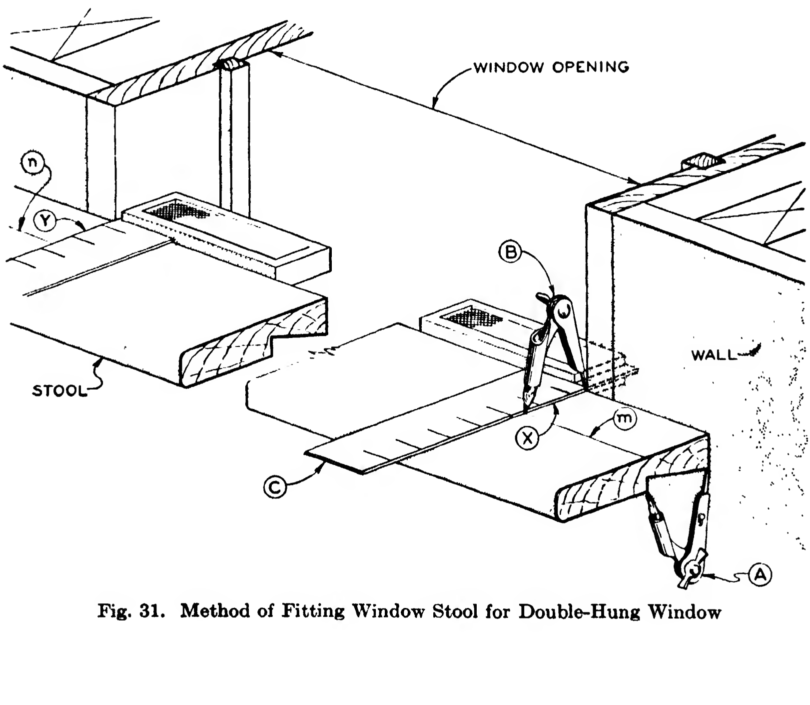


Fig. 31. Method of Fitting Window Stool for Double-Hung Window

molding or other trim member; also, the shaping the edges of trim members. When the edges of the stool are molded and extremely complicated, it is advisable to miter the return.

6. Carefully sandpaper the surface of the stool, also the ends and edges, before nailing it into place. The position of the stool, when in position, is shown at *(1),* Fig. 29.

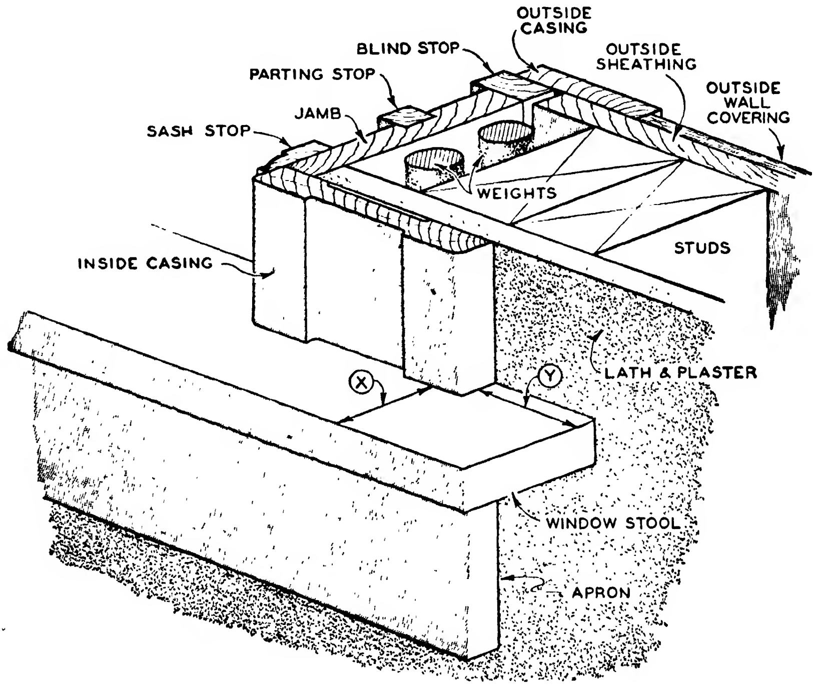


Fig. 32. Relation of Window Stool to Casings

7. Bed the stool in white lead.

Note: When nailing the trim, unless the wood is unusually soft, always drill holes for the nails first, to prevent the splitting of the wood.

8. Fitting the apron under the stool.

a) Mark the position of the side casing on the stool. The distance from the outside of one casing to the outside of the other casing will give the length of the apron. In other words, the ends of the apron are in line with the outside edge of the casings.

b) With a small piece of apron material, draw a pattern for the return of the apron on one end, as shown at *(A),* Fig. 33. Measure the length from the point *(1)* and draw the return on the other end in the same way.

Note: To draw returns on trim which is extremely irregular, good results can be obtained by coping the marking pieces to fit the surface of the apron.

c) Then cut out with a coping saw, and sandpaper the return piece.

9. Carefully fit the apron to the bottom of the stool, as shown at *(2),* Fig. 29.

10. Level the stool by placing the square against the sash. Hold the stool in position by propping it up with two laths, one on each end.

11. Nail the apron in position under the stool with 8-penny (8d) finish nails by nailing into the solid header of the rough opening, as shown at *(2),* Fig. 29.

12. Prop up the apron and nail the stool to the apron with three 8-penny finish nails.

13. Place the head casing *(5),* Fig. 29, in the proper position, flush with the inside of the jamb, if the trim design calls for it, and draw a short line *(X)* on the plaster along the outside of the casing.

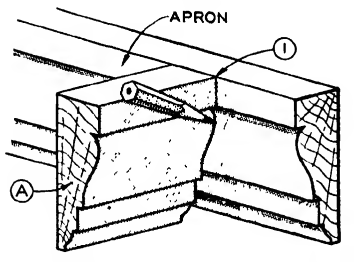


Fig. 33. Layout for Return of Window Trim on Apron

14. Place the side casing *(3),* Fig. 29, in its proper position and draw line *(Y)* to cross the line *(X)*. The intersection of these two lines at *(m)* shows where the corner of the casing will come.

15. Fit the side casing *(3)* to the stool and place it in position. Transfer the points (*m*) and (*n*), Fig. 29, to the casing. Connect these points with a line on the face of the casing. Cut the miter to the line and with a block plane dress down to the line, making the surface of the cut true, smooth, and square with the face of the casing. Fit and prepare side casing *(4)* in the same way.

Note: In the drawing, Fig. 29, only one side of the window construction is shown. The opposite side is constructed in the same way. Casing *(4)* is opposite casing *(3)*.

16. Mark and cut the head casing *(5)* in the same way as the side casing, leaving it a little longer for fitting. A skilled trimmer probably would not use this method of laying out the miter cuts if the frame were square. He would mark the longest or shortest point of the miter cut, draw a 45-degree line and cut on the line, then fit the cut by dressing it with a block plane.

17. Tack the two side casings *(3)* and *(4),* Fig. 29, into place, using 4-penny (4d) finish nails to fasten the casings to the jambs, and 8-penny (8d) finish nails to fasten the outside of the casings to the wall. Make sure that the 8-penny (8d) nails will pass into the studs. Dress the cuts of the head casing with the block plane and fit this casing into position, then nail it into place.

18. Drive all the nails home and set them with a nail set. Sandpaper the high points on the joints.

19. Cut and fit the top window stop (*6*), Fig. 29, in the opening, using square end cuts. Raise the bottom sash and nail the stop with 4-penny (4d) finish nails, allowing a 1/16-inch clearance between it and the sash. Fit the bottom of the side stops *(7)* and *(8),* Fig. 29, to the stool. Cut them to the correct length and cope them to fit against the head stop. Nail the side stops with 4-penny (4d) finish nails so the sash will have easy movement.

Square-Cut Trim. In casing openings where the trim is not molded, it is not necessary to miter the corners. Square cuts are made and the head casing (*3*), Fig. 30, run through and fit on top of the side casings (*1*) and (*2*), Fig. 30, as shown at (*X*). When the head casing on square-cut trim has a rounded edge, it becomes necessary to fit the side casing up into the head casing past the rounded edge, mitering

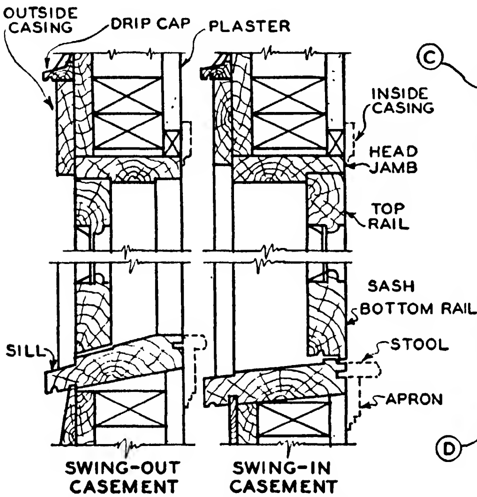


Fig. 34. Section through Casement Sash and Jambs

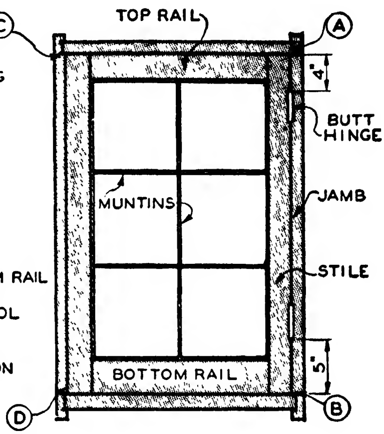


Fig. 35. Method of Fitting and Hanging Casement Sash

the corners at (*Y*). The corners of the backband pieces (*4*), (*5*), and (*6*) must be mitered.

Fitting and Hanging Casement Sash. There are two types of casement sash—the swing-out casement and the swing-in casement, as shown in the sectional view, Fig. 34. Both types have advantages and disadvantages. The swing-out casement is more watertight and windtight than the swing-in casement. If screens and storm windows are used, they must be fitted on the inside. This will require an operator to open and close the swing-out type of casement. The following procedure may be followed for fitting the casement sash.

PROCEDURE

1. With a straightedge, check the sides of the jamb for trueness from *(A)* to *(B)* and from *(C)* to *(D)*, as shown in Fig. 35.

2. Plane the edges or sides of the sash to fit into the frame at *(AC)* and

(BD), allowing 1/16-inch clearance on each side. The lock side or edge of the sash must be beveled like a door.

3. Cut the lugs on the top of the sash and plane the top rail to fit to the top jamb.

4. Measure and lay out the required length of the sash and plane the bottom rail, allowing 1/16-inch clearance on top and bottom.

Note: The bottom rail on out-swinging casements has a bevel to fit the sill. Therefore, length measurements must be taken to the longest point in the frame. The bottom rail on in-swinging casements is rabbeted with a rabbet plane or circular saw to fit over the sill.

5. Lay out and mortise the sash and frame for the butt hinges. The location and number of hinges on casements vary according to the length of the sash; for casements 4 feet in length, or longer, three hinges are recommended. The top hinge should be set about 4 inches from the top of the sash, the bottom hinge should be set about 5 inches from the bottom of the sash, and the third hinge should be located midway between the other two hinges.

Trimming a Casement Window. On an out-swinging casement, the stool is sometimes rabbeted the same as the stool of the double-hung window. When this is done, then the procedure for trimming the casement window will be the same as for trimming a double-hung window, except that window stops will not be required. Frequently the stool has a tongue and groove for fitting into the sill of the casement frame on both out-swinging and in-swinging casements; or the stool may have a square edge to fit against the sill. In any case, the stool must be fitted against the wall. The procedure of fitting and nailing all other members is the same as that of the double-hung window.

FLOORS

Laying Finished Floor. Wood for finished floor is selected because of its durability to withstand wear and for its appearance. In this country the woods most commonly used for finish flooring include oak, both plain and quarter-sawn, maple, birch, fir, and yellow pine. Finish-flooring material is always matched; that is, the boards have a tongue and groove to produce a tight and smooth floor.

Hardwood flooring comes in 13/16-inch and 3/8-inch thicknesses, in 1½-inch, 2-inch, 2¼-inch, and 3¼-inch face widths. It is bundled in lengths ranging from 2 feet to 16 feet. Oak flooring also is made in random widths of 4 inches, 6 inches, and 8 inches to give a Colonial-floor effect. The 13/16-inch plain-sawn 2¼-inch face of a clear grade red oak is used quite generally in ordinary residential work.

Formerly, maple was used extensively for kitchen floors. However, today, most kitchen floors are covered with linoleum which requires only a plain-sawn 4-inch fir flooring underneath. Maple still is used extensively for finished floors in public buildings. A good serviceable floor at lower cost can be made from either the 4-inch vertical-grain fir or the yellow pine.

Another type of wood floor, now gaining in favor with builders and contractors, is the hardwood squares of oak, maple, and elm laid in a mastic, a quick-drying cement. These squares are 9 inches or 12 inches in size, and are made up of several pieces of 2¼-inch face flooring glued together. The squares are laid so that the direction of the boards will alternate with each square.

Before any finished floor is laid, it is necessary for the rough floor to be thoroughly cleaned, all plaster removed, and the loose nails driven down. The rough floor usually is covered with a building paper before laying the finished floor. The paper will prevent dust from filtering through the floor and it will also help to keep the boards of the finished floor clean while they are being laid. Sometimes a heavy felt is used instead of paper. The use of felt has the advantage of sound insulation between stories of the building. Where furring strips are used under the finish floor, because of electric conduits, the paper should be laid first and the furring strips then nailed over the paper. The furring strips should be spaced 12 or 16 inches on center (O.C.), and be well nailed through the rough floor into the joist with 10-penny (10d) common nails to prevent the strips from working loose. When laying a finished floor directly on the rough floor, the boards of the finish floor should be laid so they will run in the opposite direction from the boards of the rough floor. Following this procedure will insure a smoother floor. When diagonal rough floor or furring strips are used, the finished flooring may be laid in either direction; that is, parallel or at right angles, to the rough floor.

PROCEDURE

1. Before the actual work of laying the floor is begun, a careful study of the floor plans should be made to determine the kind of flooring which is to be laid in the different rooms and the relations of the rooms to each other. First, select the *key room,* that is, the room which because of its size and importance determines the direction the boards of the finished floor should be laid. Then study the relation of the other rooms to the key room to see if the boards of the flooring in the key room will extend into any other room, Fig. 36.

2. Check the walls of the key room to see if the opposite sides are parallel to each other.

3. Establish a straight line, as *(L),* Fig. 36, by snapping a chalk line on the building paper on the rough floor. This line should be parallel to the longest wall of the key room, and should extend into the adjacent room.

Note: If, through an error in construction, the walls are not exactly parallel to each other, it will be necessary to adjust the line so the difference will be divided equally on both sides of the room.

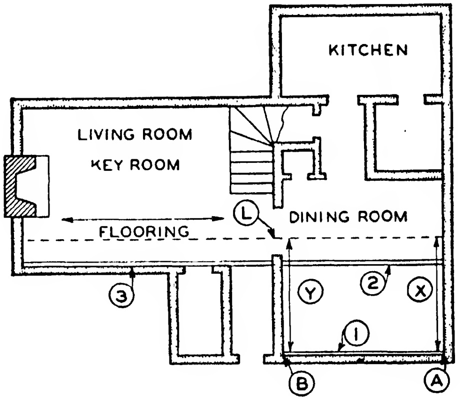


Fig. 36. Method of Starting Flooring Which Extends from One Room to Another

4. When laying the first flooring board shown at *(1),* Fig. 36, proceed as follows:

a) Select a long straight piece of flooring, the full length of the room if possible.

b) Place this piece of flooring in position, with the grooved edge toward the wall, flush with the finish plaster.

c) Face nail the board at *(A)* with an 8-penny (8d) finish nail, but *do not* drive the nail home.

d) With a stick, measure the distance *(X)* from the face of the first board to the chalk line (*L*). Transfer this distance to (*Y*), and set a nail at (*B*). The board *(1)* will then be parallel to the chalk line *(L),* and also will be parallel to the main wall in the key room.

e) Check the edge of the board *(1)* for straightness; this can be done with a straightedge, a line, or by sighting. Then face nail the board every 12

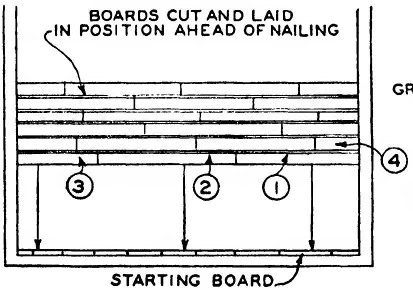


Fig. 37. Method Used in Laying Flooring

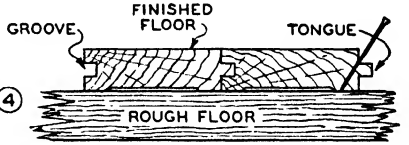


Fig. 38. Method of Nailing Finish Flooring

inches with 8-penny (8d) finish nails, nailing as near to the wall as possible. Set all nails with a nail set.

5. Continue to cut, fit, and nail the flooring until the board marked *(2)*, Fig. 36, has been reached, proceeding as follows:

a) First, cut and fit a number of boards (about 6 or 8), and lay them in order on the floor ahead of the nailing, as shown in Fig. 37. Use different lengths, matching them so they will reach from wall to wall. Never allow the joints in successive courses to come together. All joints should be broken after

Fig. 39. Three Men Laying Finish Flooring—One Cutting and Fitting, Two Nailing

every course. Begin with piece *(1)*, Fig. 37, and follow with pieces *(2)* and *(3)*. The part which is cut off from *(3)* should be used for piece *(4)* of the next course, as shown in Fig. 37. If the foregoing instructions are followed, there will be no waste of flooring material.

b) Begin by first nailing piece *(1)*, using 8-penny (8d) nails. Face nail the first board and toenail all others, driving the boards up tight. Always drive the nails through the tongue of the board at an angle of about 50 degrees to the floor, as shown in Fig. 38.

c) While nailing, stand with your feet on the board to be nailed, as shown in Fig. 39. The man with the hammer is standing on the board he is nailing. If you will follow this method of procedure, you can hold the board in position while it is being nailed. By standing on your feet, you can deliver a straight blow with the hammer to the nail with an easy motion. A standing position also permits quick and easy body movements. When the head of the nail reaches the board, you should raise the handle of the hammer. This will permit the face of the hammer to strike the tongue of the board instead of the edge, when the nail is given the last blow.

6. When the finish floor has been laid up to the line *(2)*, Fig. 36, the starter board *(3)* in the key room should be laid. The front edge of this board should be the same distance from the chalk line *(L)* as the front edge of board *(2)*. This will insure the boards coming out right at the door opening where the flooring passes from one room to the next.

7. Continue laying the finish floor until the flooring is within 2 or 3 boards from the opposite wall of the room. Then cut and fit the last few boards to be laid. With a rabbet plane, open up the groove of each board. Place the boards in position and draw them together tightly with a pinch bar, then face nail them in place.

Note: In using the pinch bar, be sure to protect the plaster on the wall against bruises by placing a strong piece of board between the bar and the wall.

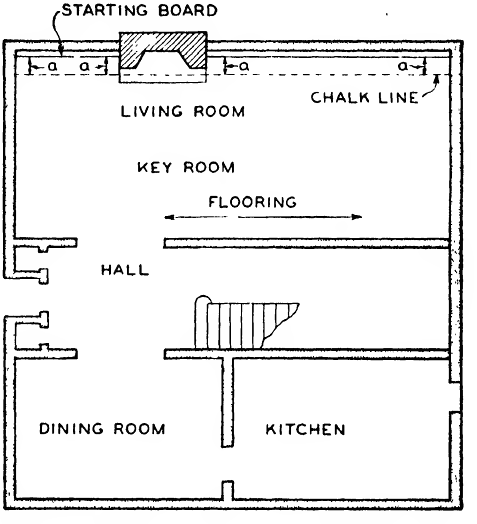


Fig. 40. Method of Starting Finish Floor in Room with Fireplace

8. Another type of room arrangement commonly used, in which the flooring boards do not extend from one room to another, is illustrated in Fig. 40. In this case, the starting board is in two sections because the chimney extends out into the living room on the side where the first board should be laid. Both ends of each starting board must be an equal distance *(a)* from the chalk line.

9. When there are no projections in the key room, and the finish flooring boards do not extend into any adjacent room, laying the finish floor becomes a simple matter. The starting board is nailed as close as possible to one of the two longest walls of the room, starting along one wall and running parallel to both walls.

DOORS

Setting Inside Door Jambs. That part of a doorway trim which forms the lining of the door opening is called the *door jamb.* The jambs, together with the casings, complete the unfinished wall around the door opening. To close the opening, the door is fitted and hung on these jambs. Inside door jambs usually are 7/8 of an inch in thickness, and of the same kind of wood as the interior trim. The width of the jambs should be 1/16 of an inch wider than the thickness of the wall.

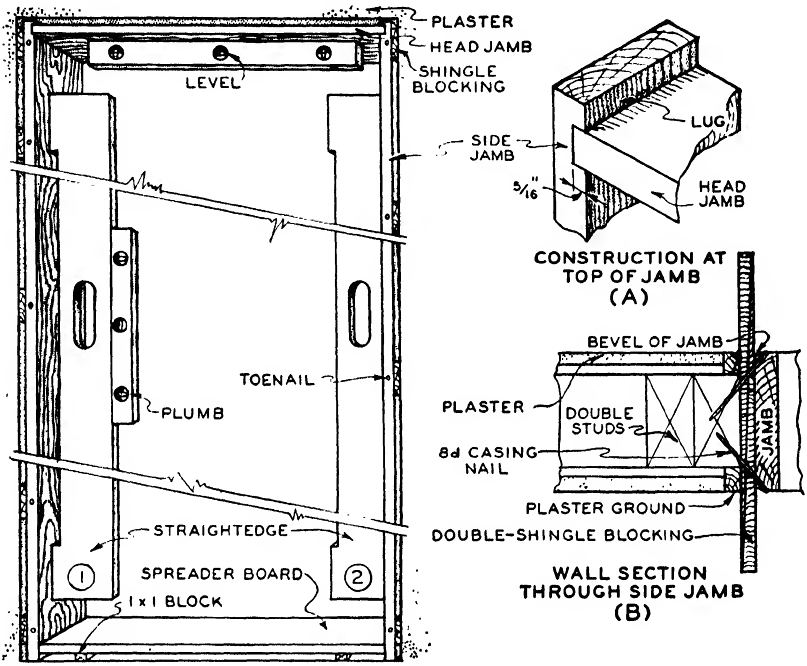


Fig. 41. Method of Setting Inside Door Jambs

The inside distance between the side jambs should be equal to the width of the door, but the height should be 1/2 inch more than the height of the door, to allow the door to swing freely. The head jamb should be housed into the side jambs as shown at (*A*), Fig. 41. The back edge of the side jambs should be slightly beveled as shown at (*B*), Fig. 41, so the edges of the casings will fit tightly against the jambs. Proceed as follows:

PROCEDURE

1. **Door jambs usually are delivered to the job with all parts fitted and sanded ready to assemble. It is advisable to check the width of the jambs** with the wall thickness; also, to check the length of both the head and side jamb with the door before the parts are assembled. Then the parts should be assembled by nailing them together with 8-penny (8d) casing or finish nails. Nail from the back through the housing into the head jamb. Cut off part of the lugs so the jambs will fit into the opening properly.

2. If the finish floor has been laid, place the jambs in position, and see that the head jamb is perfectly level. If the finish floor has not been laid, set the jambs on blocks equal in thickness to the finished floor and furring strips, if any. If the head jamb is not level, raise the lowest side jamb until the head jamb is level. Then scribe the longest side jamb and cut it off to fit the floor. This should bring the head jamb into a level position.

3. Take a piece of 1x6 and cut the ends square to fit snugly between the jambs at the head, thus forming a spreader which should be placed on the floor between the jambs at the bottom end.

4. Consult the working drawings to determine which way the door is to swing. Then mark the hinge jamb on the edge of the jamb to which the hinges are to be fitted.

5. The thickness of doors vary from 1⅜ inches to 2¼ inches. Therefore, find the thickness of the door which is to be hung in the opening. Gauge a faint pencil line ⅞ of an inch more than the thickness of the door from the edge of the jamb on which the door hinges. This line will be the *center line* for nailing. This line will later be covered by the door stop which will hide the nail holes.

6. Set the jambs as near as possible to the center of the opening, holding the jambs in place with double-shingle wedges on each side at the top, in line with the head jamb. Wedge the bottom in the same way.

7. Plumb the hinge jamb with a straightedge and level, holding the straightedge as shown at *(1)*, Fig. 41. Check the edge of the jamb with the plaster line. Then fasten the jamb with an 8-penny (8d) casing nail at the top and bottom. Place each nail back ½ inch from the pencil line. *Do not* drive the nails home until the other jamb has been adjusted and secured. Before nailing the second jamb, the shingle wedges should be brought up tightly against the second jamb at the top and bottom.

8. Complete the blocking by placing three more wedge blocks back of each jamb. On the hinge jamb, the blocks are placed with one block in the middle and the other two at the hinge location, which is 7 inches down from the top and 11 inches up from the bottom of the jamb. On the lock side, one block should be placed 36 inches up from the floor and the other two blocks should be placed midway between this block and the blocks above and below. Each jamb should be checked with the back of the straightedge as shown at *(2)*, Fig. 41, while placing the blocks and nailing the jambs in position. Each block should be fastened with two nails, staggering the nails ½ inch on each side of the pencil line.

9. Complete the nailing of the jambs by toenailing down the edges into each block, as shown at *(B)*, Fig. 41. The nails should be set back at least 5/16 of an inch from the face of the jamb, so they will be covered by the casings. Before nailing, always check with the straightedge for trueness. This practice will simplify fitting the door.

Trimming a Door Opening. A door opening is trimmed by fitting and applying the casings, backband, plinth blocks, and other parts shown in the illustration, Fig. 42. This trimming work is done after the jambs have been set and the floor laid, but before the fitting of the baseboards. To trim a door opening proceed as follows:

PROCEDURE

1. Select the necessary pieces of trim for the door opening and place these pieces conveniently near to the opening.

2. Gauge a light pencil line on the edge of the jamb $\frac{5}{16}$ of an inch back from the face as shown at *(A)*, Fig. 42. The inside edge of the casings and the plinth blocks should be set to this line.

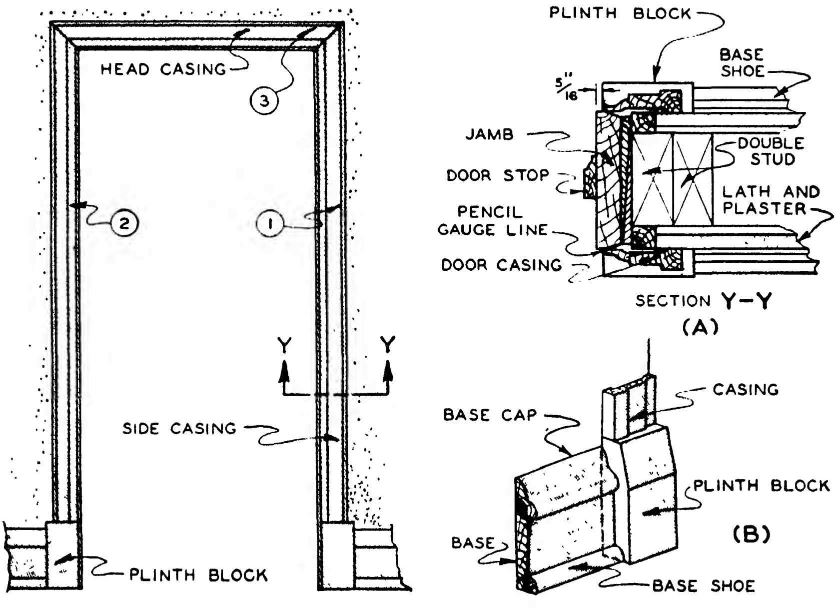


Fig. 42. Method of Trimming Door Opening

3. Fit the plinth blocks to the floor and to the gauge line on the jamb, and nail the blocks in place. The need for plinth blocks depends upon the thickness of the baseboard and base mold, also upon the general design of the interior trim. However, the chief purpose of plinth blocks is to provide a trim member thicker than the casing, against which the baseboard can be fitted as shown at *(B)*, Fig. 42. On casings with a backband or a backband design, the blocks may not be necessary.

4. Fit the bottom end of the side casings shown at *(1)* and *(2)*, Fig. 42, to the plinth blocks.

5. Lay out, cut, and fit the top of the side casings and both ends of the top casing in the same way as for window trim.

6. Nail the casings in place with 4-penny (4d) nails, nailing into the jambs. Along the outer edges, use 8-penny (8d) nails, nailing into the studs.

Note: Sometimes casings must be scribed and fitted to the plaster, if the plaster surfaces are uneven or rough. However, the painter usually is expected to fill any such openings between the plaster and casings.

7. Cut, fit, and tack the door stops in place. The stops should be tacked about 1/16 of an inch farther back from the edge of the jamb than the thickness of the door. After the door has been fitted and hung, the door stops are moved to the correct position and nailed in place.

Types of Doors. There are many different stock designs available on the market today. There are enough of these various designs to fill all the needs of the average housebuilder. A few of these stock designs are illustrated in Fig. 43. The outside doors for dwellings usually are 1¾ inches in thickness. If doors thicker than this are wanted, they must be custom built. Most slab or **V**-jointed doors come plain and the window ornamentation is cut in later to satisfy the customer's needs. Only one Colonial outside door is shown in Fig. 43. However, this is only one of many Colonial designs manufactured today. Cross-panel doors are available with either the flat or raised panel. The raised panel is a more expensive door, but it is also more attractive because of the extra lines provided by the moldings.

The outside doors illustrated in Fig. 43 include the plain-slab door shown at (*A*), the half-circle **V** jointed at (*B*), the Gothic-head **V** jointed at (*C*), the Colonial at (*D*), a one-light cross panel at (*E*), and an outside French door is shown at (*F*). The inside-door designs shown in Fig. 43 include the cross 5 panel shown at (*G*), a regular 4 panel at (*H*), a regular 5 panel at (*I*), a Colonial 6 panel at (*J*), a Colonial 8 panel at (*K*), and an inside French door is shown at (*L*). A vertical 2-panel door is shown at (*M*), a vertical 3 panel at (*N*), an insert panel at (*O*), a craftsman panel at (*P*), a regular 2 panel at (*Q*), and a reverse 2 panel at (*R*).

Doors are either solid or veneered. As a rule hardwood doors are veneered. Outside veneered doors have from ¼ of an inch to ⅜ of an inch of veneer on the surface. The veneer is glued and held in place with water-resistant glue. Inside veneered doors have 1/16 of an inch to ⅛ of an inch of veneer on the surface. The core in the veneered door is made up of short pine blocks, 2 inches or less in width.

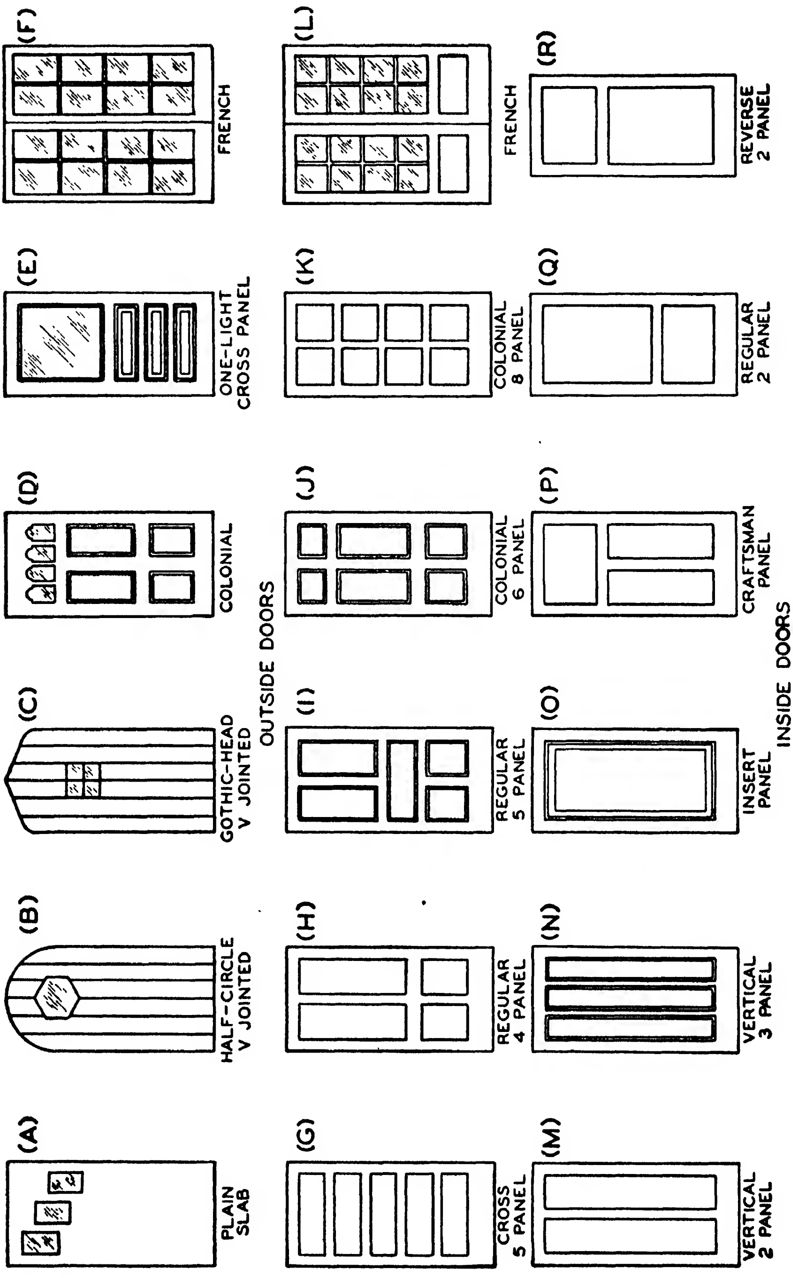


Fig. 43. Designs of Outside and Inside Doors

A $\frac{1}{16}$-inch cross banding is glued over the core. Then the hardwood face veneer is glued on the surface. The edges of these doors are faced with the same kind of hardwood as the veneer. The construction of the stiles on the solid-wood panel door is shown at (*A*), Fig. 44. The rails and stiles of panel doors are fastened together with dowels as shown at

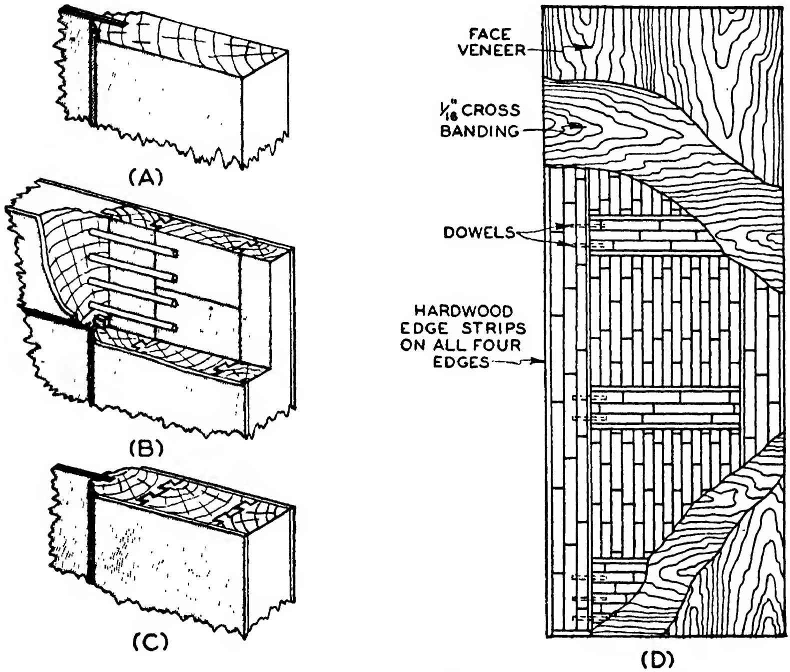


Fig. 44. Stiles, Rails, and Core of Modern Door Construction

(*B*), Fig. 44. The core of the stiles of a panel-veneer door is shown at (*C*), Fig. 44. Slab doors have an elaborate system of softwood blocks in the core as shown at (*D*), Fig. 44.

In recent years a new type of door, Fig. 45, has appeared on the market. It is commonly known as the *hollow core door*. This door is light in weight and lends itself to various treatments, such as sound proofing, temperature insulation, and fire resistance. The construction of such a door is illustrated in Fig. 45. Vent openings, or exits for ventilation and as an equalizer for temperature and humidity, are shown at (*A*). Each cell of the core is thus ventilated. Wide top and bottom rails of sufficient width to permit cutting down 2 inches in height, to be cut equally from top and bottom, are shown at (*B*). The edge strips can be faced with hardwood to match faces, as shown at (*C*). A grid core of woven wood, mortised and framed together for strength and to insure against swelling, shrinking, or sagging, is shown at (*D*). Standard grid-mesh sizes are 1x2, 2x2, 2x4, or 4x4 inches, the size used depending upon the architectural requirements. The lock area, measuring 4⅝ inches by 20 inches on both edges of the door, insures ample lock space no matter how the door is hung, as shown at (*E*). A woven-wood core overlaid with plywood (usually 3 ply), with two sides, is shown at (*F*). The veneer may be of any kind of wood desired.

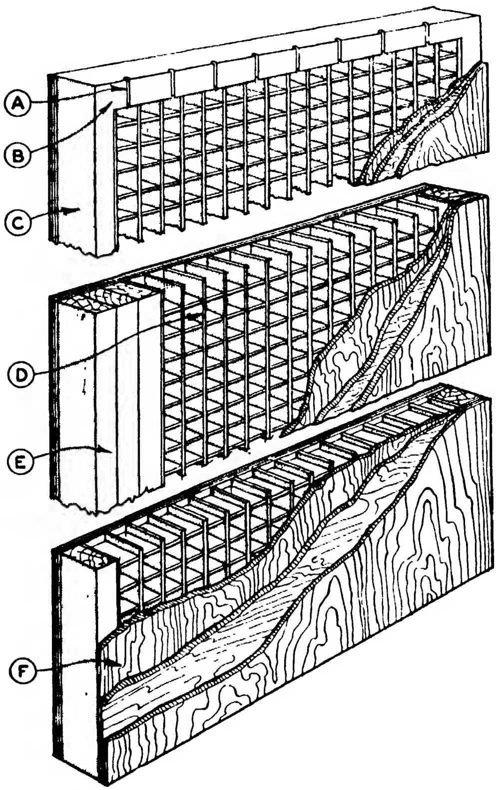


Fig. 45. Hollow Core for Door Construction

Fitting and Hanging a Door. There are three methods commonly used in hanging doors: (1) by side hinges on the edge or side of the door; (2) by pivot hinges on the top and bottom of the door near one edge; (3) and the roll-away, or sliding, method with the door on a track.

Side Hinge. Several kinds of side hinges can be used, such as the *strap,* the *tee,* and the *butt.* The first two are inexpensive surface hinges. Butt hinges are commonly intended to be mortised into the edge of the door, although a few styles are made to be applied to the side or surface. These are known as *surface butts.* Another type is the half-surface butt which is mortised into the jamb and fastened to the surface of the door. A fourth type is the invisible hinge commonly

(*A*) *Keep this distance sufficient to prevent splitting*

(*B*) *Set back enough to prevent splitting when chiseling*

(*C*) *Width of the gain*

(*D*) *Maximum clearance when door is open*

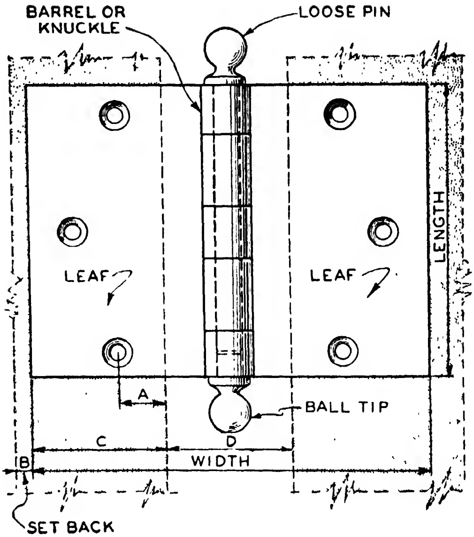


Fig. 46. Loose-Pin Butt Mortise Hinge

SPECIFICATIONS FOR LOOSE-PIN BUTT HINGE FOR WOOD DOORS

Size and Type of Doors*			Length of Butt Hinge Inches
Thickness Inches	Type of Door	Width Inches	
¾ or ⅞	Cupboard doors up to.	24	2½
⅞ to 1⅛	Screen doors up to.	36	3
1⅛ to 1⅜	Doors up to.	32	3½
1⅛ to 1⅜	Doors over.	32 to 37	4
1⁹⁄₁₆, 1¾, or 1⅞	Doors up to.	32	4½
1⁹⁄₁₆, 1¾, or 1⅞	Doors over.	32 to 37	5
1⁹⁄₁₆, 1¾, or 1⅞	Doors over.	37 to 43	5 Extra heavy
1⁹⁄₁₆, 1¾, or 1⅞	Doors over.	43 to 50	6 Extra heavy
2, 2¼, or 2½	Doors up to.	43	5 Extra heavy
2, 2¼, or 2½	Doors over.	43 to 50	6 Extra heavy

*Doors larger than 5 feet should have three butt hinges, one for each 2½ feet of height.

known as the *soss hinge* which is mortised into the edge of the door and the jamb. This hinge is not visible when the door is closed. In addition to these butt hinges there is also the single and double-acting spring butt. This type is seldom used today, as the pivot hinge has replaced it.

The round central portion of the butt hinge, shown in Fig. 46, is known as the *knuckle*. It is ordinarily divided into five sections. It is then called a *five-knuckle butt hinge*. The flat parts of such a hinge are known as the *leaves* or *flaps*. The two flaps are held together

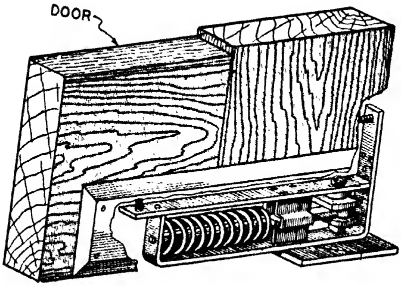


Fig. 47. Pivot-Spring Hinge for Double-Acting Type Door

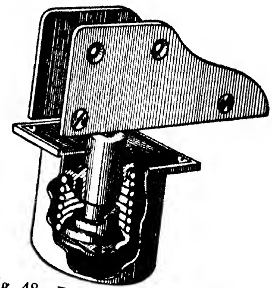


Fig. 48. Pivot for Double-Acting Mortise Floor Hinge

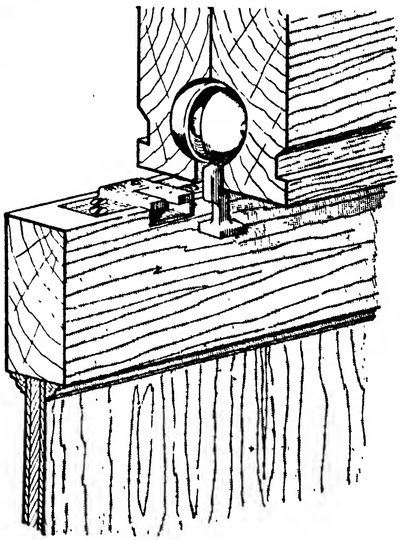
by a pin running through the knuckles. Door butts usually are made so the pin may be taken out, and are then known as *loose-pin butts*. When the pins are not removable the butts are called *fast joints*. The thickness and width of the door determine the size of the butt hinge required. Specifications for loose-pin butt hinges are given in connection with Fig. 46.

Pivot Hinge. The pivot hinge shown in Fig. 47 is a double-acting spring hinge. It is cut into the heel of the door and rests on top of the floor. The top pivot of the door consists of a pin on a plate which is mortised into the head jamb of the frame and a socket which is mortised into the top edge of the door. In modern homes the door between the kitchen and dining room is often hung with this type of hinge.

Another type of double-acting spring hinge of the pivot style is shown in Fig. 48. This type of hinge has a spring inclosed in a heavy cast-iron case that is set into the floor. This style of pivot hinge can also be obtained with a checking device known as a *checking floor-spring hinge*. Some of the more expensive styles have a liquid controlled checking device which regulates the action of the door. This type of hinge is used principally in commercial buildings where traffic is heavy.

Sliding Doors or Roll-Away Type. The sliding door, hung from a track and operating on rollers, was once extremely popular for

(A)



(B)

Fig. 49. Sav-A-Space Roll-Away Door with Cross Section Showing Grooved Header, Roller, and Plate

use in the home. However, it has lost its popularity in recent years because a double wall must be built to accommodate the track and rollers for this type of door. To meet the present-day needs, a *Sav-A-Space* sliding door has been introduced by the Fir Door Institute. This type of door requires only the regular 2x4 wall thickness. The Sav-A-Space door is a complete sliding-door unit with a track and rollers built into one package, as shown in Fig. 49. The frame unit is set into the wall opening and covered with the regular interior wall finish. Any door, with a thickness of 1⅜ inches, can be hung to the rollers, to match the interior trim. The frame for this type of sliding door, set up complete with the door hung and finish hardware installed, is shown at (*A*), Fig. 49. When this door is placed in the wall any type of interior trim can be applied over the spreaders. A cross-section drawing, (*B*), Fig. 49, shows a grooved header, roller, and plate of this type of door. A lug on a roller slides on a hanger plate fastened to the door.

Fitting the Doors. A door must be handled with care to prevent damage to it before it is hung. When delivered to the job, the doors should either be stacked carefully on the floor or set against the wall. If the doors are set against the wall, special care must be taken to prevent warping of the doors and to make sure the interior wall surface is not damaged in any way. Before attempting to fit and hang a door, the following preliminary precautions should be observed.

1. Consult the working drawings and building specifications regarding the type of door required for any particular opening, the hardware specified, and the direction the door is to swing.
2. Mark the door jamb which is to receive the hinges.
3. Check the size of the door with the opening size.
4. If possible, assemble all necessary tools and the equipment required while fitting the door, on the fitting side of the opening. Beside the usual small tools, such as the plane, saw, hammer, and chisel, it will be necessary to have a pair of sawhorses and a door jack placed conveniently near the door opening. For occasional door hanging, a small portable vise clamped to the end of a sawhorse is especially convenient for holding a door while it is being planed. However, when a number of doors are to be hung, the carpenter prefers a regular door jack.

Doors must be carefully fitted to the jambs with ample clearance to insure free movement of the door. To fit a door, proceed as follows:

PROCEDURE

1. **Place the door lengthwise on a pair of sawhorses.**

2. **Square a line across the stiles and cut off the lugs in line with the top and bottom rail.**

3. **Mark the hinge stile on the door and fit the door against the hinge jamb, planing the edge if necessary to conform to the shape of the jamb.**

Note: **The hinge edge usually should be square, although a slight bevel at the back has an advantage.**

4. **Measure the width of the opening (distance between the jambs) at the top and bottom with an extension rule, or two sticks to take the place of an extension rule, and transfer the dimensions to the door lying on the** sawhorses. Draw a cutting line on the door, making the door ⅛ of an inch narrower than the width of the opening.

Note: A well-fitted door should fit to the shape of the door opening and have a clearance of 1/16 of an inch on each side and on top. The bottom clearance should be from ⅜ to ½ inch, unless a threshold is used, in which case a 1/16-inch clearance should be allowed between the door and the threshold. The threshold should be fitted in place after the door has been hung.

5. Plane the second edge of the door to the cutting line.

Note: To insure uniform clearance, check the jamb for straightness before planing off the entire amount to be removed.

6. Place the door in the opening, check the fit and insert a wedge as shown at *(X)*, Fig. 50, in place. Scribe the top edge of the door to the top jamb. *(Scribing* means drawing a line parallel with an existing surface.) The scribing can be done with a pair of dividers or a regular scriber. This operation is unnecessary when both the door and jambs are square.

7. Plane the top edge of the door to fit the top jamb.

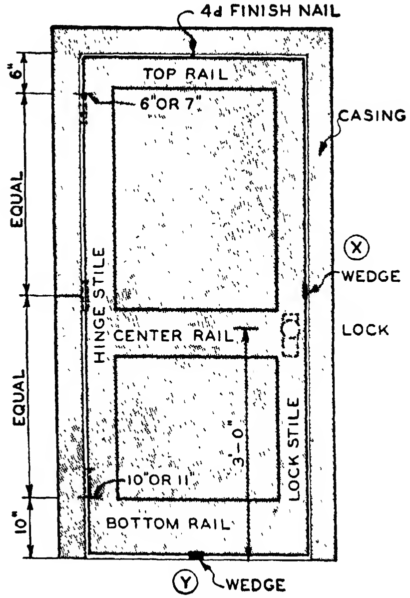


Fig. 50. Location of Hardware on a Door

8. Bevel the lock edge of the door. The side-hinge door forms an arc as it swings, and the lock side must be beveled so the point on the door shown at *(A)*, Fig. 51, will clear the edge of the jamb shown at the point *(B)*, Fig. 51. The amount of bevel required will depend upon the thickness and width of the door and the width of the hinge. This bevel can be obtained by drawing a diagonal line on the top edge of the door from one corner to the theoretical pin center of the hinge. The bevel line (*AB*), Fig. 51, is at a right angle to the line *(AX)*, Fig. 51. Set the **T** bevel to the line *(AB)* and the side of the door to find the correct angle of the bevel.

9. Remove the sharp edges of the door with the plane and sandpaper all edges until they are smooth.

Note: Edges of hardwood doors sometimes are hard to plane smooth and free from checks due to cross grain. A well-sharpened scraper will help to smooth such edges.

Hanging a Door. The size and weight of the door will determine the length of the hinge you should use. (See information given with Fig. 46.) The width of the hinge and the amount of the setback will depend upon the thickness of the trim shown in Fig. 52. Sufficient clearance must be allowed to prevent binding of the door against the trim as the door swings back against the wall. To hang a door proceed as follows:

PROCEDURE

1. Place the door in the door opening, then force the door against the hinge jamb with a wedge shown at *(X)*, Fig. 50. Place a 4-penny (4d) finish nail on top of the door and force the door up against the nail with a wedge shown at *(Y)*, Fig. 50.

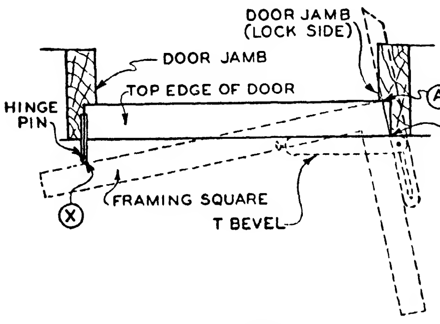


Fig. 51. Beveled Lock Stile of Door

2. Mark the hinge location on both the jamb and the door stile with a knife or sharp pencil and make a cross mark to indicate the side of the line the hinge should be gained.

Note: The hinge location may vary according to the decision of the architect or the foreman on the job. However, in general practice, a definite proportion usually is followed. If the top of the hinge is 7 inches down from the top of the door, then the bottom of the lowest hinge should be 11 inches up from the floor. Some carpenters prefer to use the figures 6 and 10, as shown in the illustration, Fig. 50. When there are three hinges, these figures generally are used. The third hinge should be centered between the top and the bottom hinges, as shown in Fig. 50.

3. Scribe the bottom of the door to the floor before removing the door. If a threshold is used, measure the thickness of the threshold and add to this

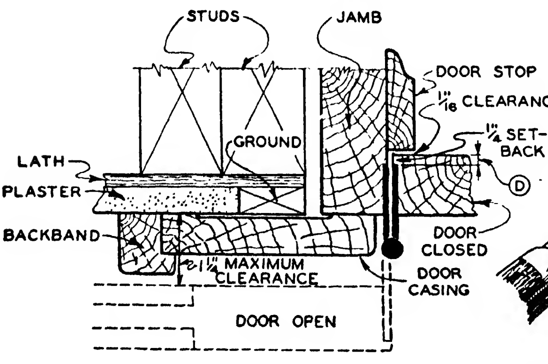


Fig. 52. Method of Hanging Door for Clearing Casing When Swung Wide Open

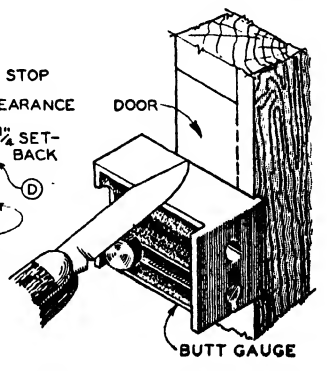


Fig. 53. Knife and Gauge Used for Squaring Lines for Width of Gain

figure 1/16 of an inch for clearance. If no threshold is to be used, then a 3/8-inch to 1/2-inch clearance is required.

4. Place the door in a door jack and with a knife and a butt gauge mark the width of the hinge on the edge of the door. Square the lines across the edge of the door with the butt gauge, as shown in Fig. 53.

Note: The detail of the gain for the jamb is shown at *(A)*, Fig. 54, and the detail for the door is shown at *(B)*, Fig. 54.

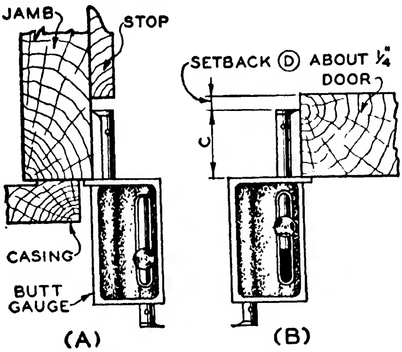


Fig. 54. Width of Gain Determined by Width of Hinge and Clearance Required

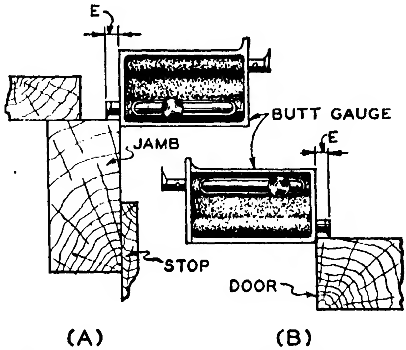


Fig. 55. Method of Setting the Butt Gauge for Depth of Gain

5. Set the butt gauge to the width of the gain as shown at (*B*), Fig. 54. This width will be determined by the casing clearance required and the width of the hinge as shown in Fig. 52. Gauge the width of the gain on the door as at (*B*), Fig. 54.

Note: The depth of the gain on the jamb is shown at *(A)*, Fig. 55, and the depth of the gain on the door is shown at *(B)*, Fig. 55.

6. Gauge the depth of the gain for the hinge as shown at *(B)*, Fig. 55.

Note: The depth *(E)*, Fig. 56, will depend upon the construction of the hinge. Butts for large doors are swaged as at *(A)*, Fig. 56; small butts for cupboard doors are straight and the gauge is set slightly less than half the thickness of the barrel shown at *(B)*, Fig. 56.

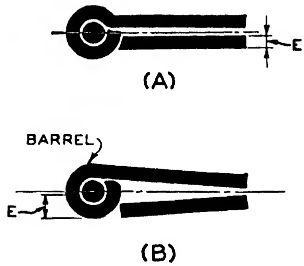


Fig. 56. Depth of Gain Depends upon Hinge: (*A*) Swaged Hinge; (*B*) Straight Hinge

7. The gain layout is shown at (*A*), Fig. 57. With a sharp chisel notch the two ends of the gain, as shown at *(B)*, Fig. 57, by setting the chisel with its bevel toward the gain. Then score the rest of the gain and clean it out by paring with a chisel. See (*C*), Fig 57.

8. Place the hinge in the gain so the loose pin will be up when the door is in position. Drive the screws toward the back of the hinge holes so the hinge will be drawn tightly into the gain against the setback shown at *(D)*, Fig. 52.

9. Lay out and mortise the gain into the jamb as shown at *(A)*, Fig. 54, the same as in the door. Pull out the loose pin and screw the free leaf of the hinge into place on the jamb with two screws.

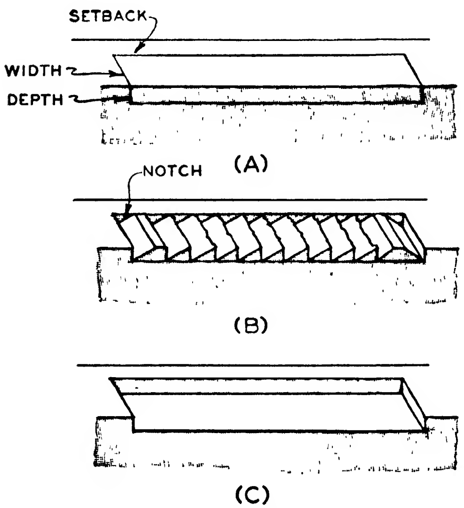


Fig. 57. Making Gain for Hinge: (*A*) Gain Laid Out; (*B*) Gain Notched and Scored; (*C*) Gain Cleaned Out by Paring with Chisel

10. Hang the door in place on the hinges and check the door for proper clearance, which should be 1/16 of an inch on each side.

Note: If the door has more than 1/16 of an inch clearance along the hinge jamb, the gain should be deepened slightly. If the door binds against the jamb, place a strip of cardboard behind the butt in the gain. Then drive all screws in place securely.

11. Adjust the door stops. The stop on the hinge jamb should have 1/16 of an inch clearance between it and the door. The stop on the lock side should hold the door flush with the outside edge of the jamb. The top stop should be held in line with the side stops. Nail the door stops securely with 4-penny (4d) finish nails.

Mortise Locks. Although there are several types of door locks, the instructions given in this text for the installation of locks is confined to the ordinary mortise lock. Special locks, such as those used on front doors, have installation directions enclosed in the package with the lock.

Rules for Installing Door Locks

Right-Handed or Left-Handed Doors or Casements. Locks are not always made so they can be reversed or changed to suit doors hinged on either the right-hand or left-hand side, or for doors opening in or out. Therefore, chiefly for the purpose of buying door hardware, it is necessary for the carpenter or builder to have some knowledge of the standard rules regarding locks intended for right-hand or left-hand doors or casements.

1. Whether a door is to be right-handed or left-handed is always determined from the *outside*.

2. The *outside* of a door is the street side of an entrance door and

the corridor side of a room door. The *outside* of a communicating door, that is from one room to another, is the side from which the butts or hinges are not visible when the door is closed. The *outside* of a closet, cupboard, or bookcase door is the room side, thus reversing the rule which applies to other doors.

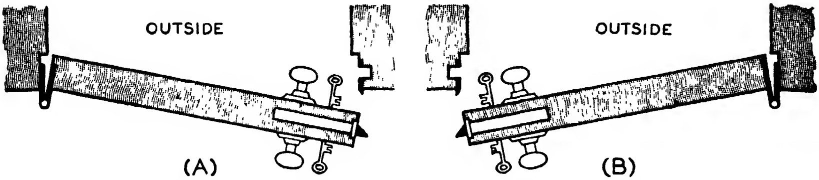


Fig. 58. Hand of Door and Locks When Opening from You

3. When you stand *outside* a door, if the butts are on your right it is a right-handed door; if the butts are on your left it is a left-handed door. If, when standing outside, the door opens from you, or inward, it will require a lock with a regular bevel bolt and the lock is described as either *right-handed* or *left-handed,* depending upon whether the butts are to your right or left. A lock with a regular bevel, for a right-handed door, is shown at (*A*), Fig. 58. A lock with a regular bevel, for a left-handed door, is shown at (*B*), Fig. 58. If, when standing outside the door, it opens toward you or outward, the door will require a lock with a reverse bolt and the lock is described as a *right-handed* or *left-handed lock,* depending upon whether the butts

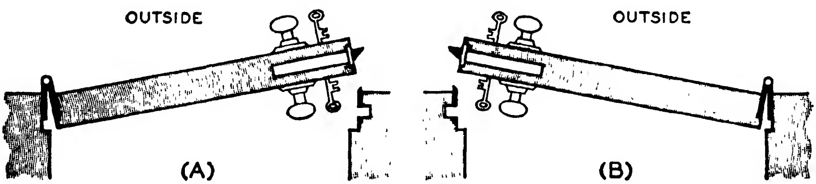


Fig. 59. Hand of Door and Locks When Opening Toward You

are to your right or left. A right-handed lock with a reverse bolt is shown at (*A*), Fig. 59. A left-handed lock with a reverse bolt is shown at (*B*), Fig. 59.

Installing the Mortise Lock. The various parts of the ordinary mortise lock as illustrated in Fig. 60 are: the *strike plate* shown at (*A*); the *face of the lock* and the *bit key* shown at (*B*); the *spindle* for the knob shown at (*C*); the *escutcheon,* or plate for the keyhole, shown at (*D*); the *rose* for holding the knob shown at (*E*); the *rose and escutcheon combination plate* shown at (*F*).

More elaborate mortise locks are made with cylinder locks on one or both sides, with a handle on one side and a knob on the other side,

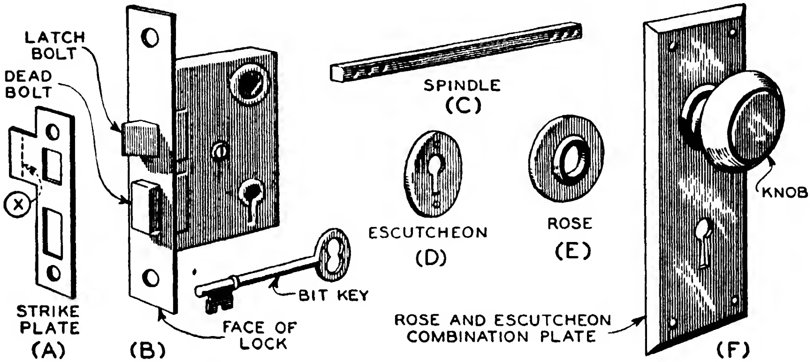


Fig. 60. Various Parts of Ordinary Mortise Lock

or with handles on both sides. However, this type of lock is used principally on front or outside doors. To install the ordinary mortise lock, proceed as follows:

PROCEDURE

1. Unpack the package containing the lock and examine each part in order to become familiar with the installation requirements. (Take care not to lose any of the parts or the screws.)

2. Open the door to a convenient working location and block it with two wedges under the front edge as shown in Fig. 61.

3. Measure up 36 inches from the floor, the usual knob height, and square a line for the lock spindle from the edge of the door, as shown at *(A)*, Fig. 61.

4. Place the lock on the side of the door with the face of the lock flush with the edge of the door and the spindle-hole center on the line *(A)*, Fig. 61. Mark the spindle location and the center of the keyhole. Also mark, near the edge of the door, the location of the top and bottom of the lock as shown at *(B)*, Fig. 62.

5. Square the top and bottom lines indicated as *(B)*, Fig. 62, across the edge of the door and gauge a center line between them, as shown at (*C*), Fig. 62. (A deep gauge line here will help to center the auger bit.)

6. Bore a ¾-inch hole for the spindle and another for the key.

Note: Continue to bore the hole until the screw of the bit shows on the opposite side of the door, then bore back from that side of the door. This will avoid splitting the wood. When small escutcheons are furnished, it is advisable to bore two small holes for the key and clean out these holes with a pocket knife instead of boring a ¾-inch hole. This will insure coverage of the hole by the escutcheon.

7. Select an auger bit 1/16 of an inch larger than the thickness of the mortise lock and bore holes into the edge of the door, as shown at *(1)* and *(2)*, Fig. 62. Then continue to bore a series of holes, one overlapping the other, to avoid excessive chiseling.

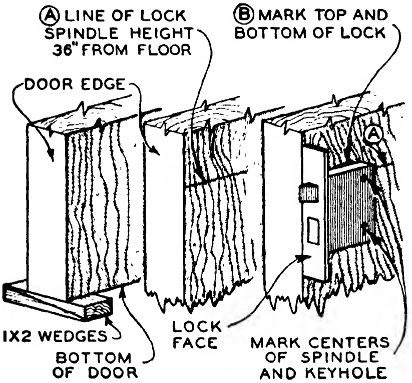


Fig. 61. Mortise Lock Layout: Wedging the Door; Laying Out Spindle Height; Locating Spindle and Keyhole

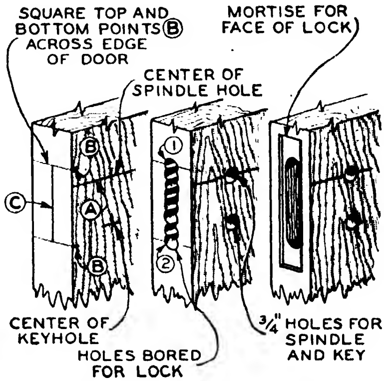


Fig. 62. Making Mortise for Lock: Gauging Center Line; Boring Holes for Mortise; Mortise for Lock Face

Note: In boring these holes, sight both sides of the door to avoid coming out on the side of the door with the bit.

8. Clean out the mortise with a chisel and try the lock.

9. Insert the lock with the face pressed tightly against the edge of the door. Line up the lock with the spindle and keyhole, then draw a line with a knife around the edge of the lock face.

10. Remove the lock and chisel out the mortise to the depth of the thickness of the lock face, as shown in Fig. 62.

11. Replace the lock and fasten it with screws.

12. Assemble the rose, escutcheon, spindle, and knob on the door and fasten them in place with screws. Adjust the knob and tighten the setscrew in the knob.

Note: A careful check should be made to see that the spindle is straight in the lock and the knob is free in the rose to insure freedom of action. The rose and escutcheon must be in line vertically for the sake of appearance, if for no other reason.

13. Remove the wedge from under the door, and partly close the door. Mark the top and bottom location of the latch bolt on the door jamb with a pencil.

14. Mark the relation of the strike plate to the lock by holding the plate against the face of the lock; also hold the plate against the side of the latch bolt and draw a line as shown at *(X)*, Fig. 60, along the edge of the door with a knife.

Fig. 63. A Well-Designed and Carefully Built Stair
Courtesy Ralph Stoetzel, Architect

15. Mark the location of the strike plate on the jamb with a knife, holding the plate so the line *(X)* is in line with the edge of the jamb and the latch-bolt marks on the jamb center in the strike-plate hole.

16. Remove the strike plate and chisel out the mortise to a depth equal to the thickness of the strike plate. Screw the plate in place.

17. Chisel out the wood to a depth of ½ or ⅝ of an inch through the strike-plate openings, to allow the latch and dead bolts to enter strike plate.

STAIR CONSTRUCTION

The staircase, when carefully designed and built, adds dignity and charm to a home, Fig. 63. The quality of craftsmanship displayed reflects the character of the entire interior of the building. Therefore, since stairways usually are located near the main entrance, the importance of the stairs, whether in a home or public building, must be given careful consideration in order to create a feeling of well-being as one enters the building.

In general, stairwork is considered a special field of carpentry; hence, stairs usually are built in a stair shop which often is a part of a regular mill. However, not all stairs are built in a shop. Stairs usually built by the carpenter on the job include the porch, basement, and any stairs on the outside of buildings, or less important stairs within a building. Therefore, it is important for every carpenter to have the necessary information regarding the general principles involved, as well as knowledge of the layout and construction, for at least the ordinary stairs.

Types of Stairs. The staircase in a building is one means whereby one may travel from the level of one floor to another. The ease with which a stairway can be traveled depends upon the proper proportioning of the riser and tread of each step and the number of steps in one series or flight. The design of the building and its space limitations will control the type of staircase suitable for the layout to meet the travel requirements.

Straight-Flight Stairs. A stairway commonly known as a *straight-flight stairs,* shown in Fig. 64, is the simplest to build, but not necessarily the most desirable. The layout of a building does not always permit the use of a straight-flight stairway. A staircase with a long flight, consisting of more than fifteen steps, is tiring because it affords no opportunity for a pause in ascent. For this reason a landing should be introduced somewhere in the flight, usually at the halfway point, as shown in Fig. 65.

Landings also have another function, that of changing the direction of the stairs, as shown in Fig. 66. The staircase returning on itself, as shown in Fig. 67, is economical in space, especially when there are a number of floor levels to be connected.

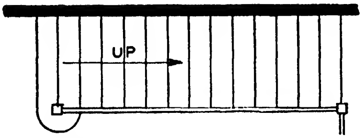


Fig. 64. Straight-Flight Stair

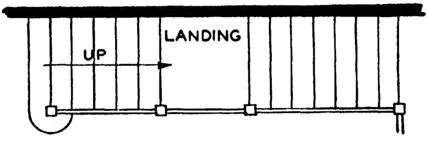


Fig. 65. Straight-Flight Stair with Landing

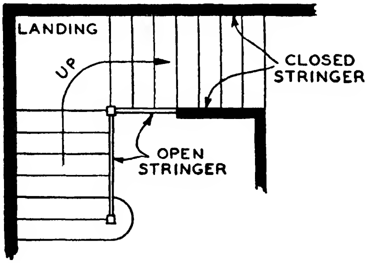


Fig. 66. A 90-Degree Change Stair with Landing

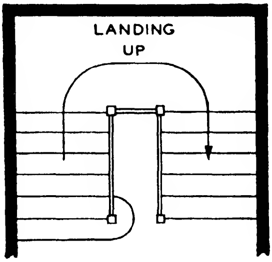


Fig. 67. Stair with Open Newel Returning on Itself

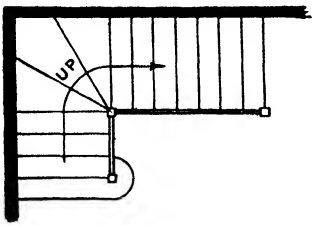


Fig. 68. The 90-Degree Change Stair with Winders

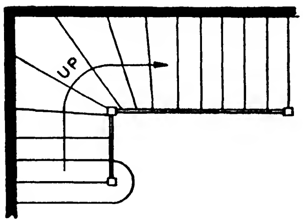


Fig. 69. The 90-Degree Change Stair with Spaced Winders

Winder Stairs. Space limitations frequently demand a staircase with winders to bring about a change in direction. The three-winder stairway frequently used, illustrated in Fig. 68, is dangerous because the treads come to a point, causing them to become too narrow in width as compared with the width of the regular tread at the line of travel. This hazard can be partially overcome by using a greater number of winders, as shown in Fig. 69, and laying them out so they do not come to a point. The width of the tread at the line of travel in such winders is more nearly the same as the width of the tread of the regular step.

Geometrical Stairs. The most complicated and most expensive stairways are those that are curved, commonly known as the *geometrical stairway*, Fig. 70. The geometrical stairway is a winding stairway, but it is so designed that the tread at the line of travel of all steps is the same width. These staircases may be circular as shown at (*A*), or elliptical as at (*B*), Fig. 70, and often are designed with landings to insure ease of ascending.

Safety Precautions in Stairway Building. Statistics compiled by the National Safety Council show that stairways are the cause of the greatest number of accidents in the home. These accidents can be at-

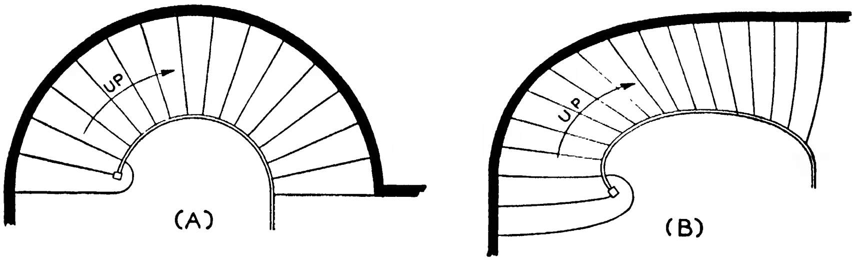


Fig. 70. Two Types of Geometrical Stairs: (*A*) Circular Stair; (*B*) Elliptical Stair

tributed to various factors, some, of course, are beyond the control of those who design and build the stairways, because of the action of the individual who travels them. However, there are far too many accidents, due directly to faulty construction, which the carpenter can and must control, thereby making a worthwhile contribution toward accident prevention.

The Safety Engineering Department of the National Workmen's Compensation Service Bureau has set up the following standards as suggestions to stairway builders to help remove some of the causes responsible for many accidents.

1. Stairways should be free from winders.

2. The dimensions of landings should be equal to or greater than the width of stairways between handrails (or handrail and wall).

3. Landings should be level and free from intermediate steps between the main up flight and the main down flight.

4. All treads should be equal and all risers should be equal in any one flight.

5. The sum of one tread and one riser, exclusive of the nosing, should not be more than 18 inches nor less than 17 inches.

6. The nosing should not exceed 1¾ inches.

7. All stairways should be equipped with permanent and substantial handrails 36 inches in height from the center of the tread.

8. All handrails should have rounded corners and a surface that is smooth and free from splinters.

9. The angle of the stairways with the horizontal should not be more than fifty degrees nor less than twenty degrees.

10. Stair treads should be slip proof, firmly secured and with no protruding bolts, screws, or nails.

Relation of Treads and Risers. Stairs can be built at any angle from 20 degrees to 50 degrees, Fig. 71. However, when the angle is between

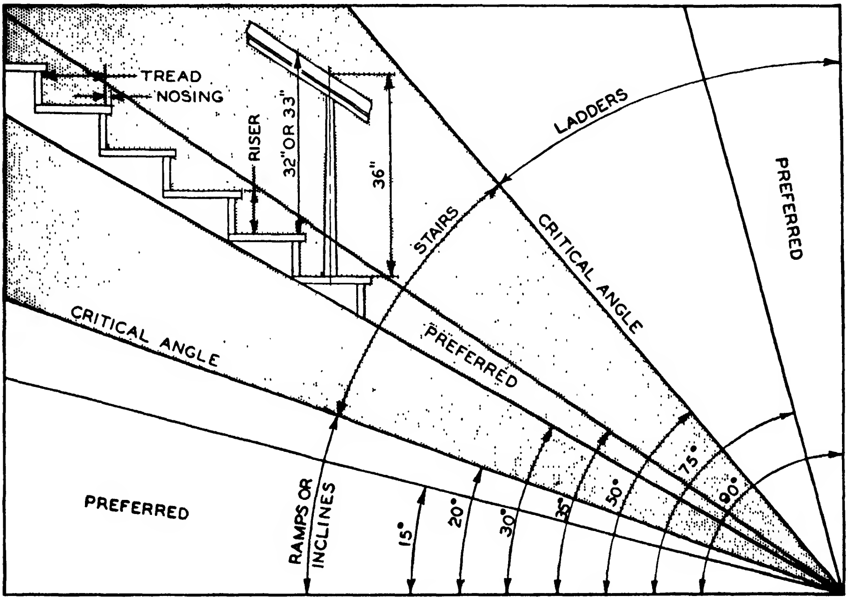


Fig. 71. Preferred and Critical Angles for Stairs, Ladders, Ramps, and Inclines
Safety Department of National Workmen's Compensation Service Bureau

30 and 35 degrees, greater safety can be insured. Therefore, such a size angle is preferred. The relation between the risers and treads is especially important to insure safety and ease in travel. The proper relationship between these members establishes the distance of the step or man's stride in ascending and descending, and must be kept within certain limits. The accepted rule for this relation is that *the sum of one tread and one riser should equal from 17 to 18 inches.* How this relationship is maintained for the various angles from 22 degrees to 50 degrees is shown in Fig. 72. The height of the riser increases and the

width of the tread decreases as the stairway becomes steeper. The main staircase for a house should have risers as near as possible to 7 inches. However, this dimension may vary from 6½ to 7½ inches. The tread should be about 10½ inches wide, not including the *nosing*. This width may vary from 10 to 11 inches. These dimensions for risers and treads are preferred, but cannot always be adhered to strictly. However, the carpenter should aim to get as near as possible to these proportions to insure a good safe stair.

ANGLES, RISERS, AND TREADS FOR STAIRS*
(Tread+Riser=17½ Inches)

Angle with Horizontal		Riser in Inches	Tread in Inches	
Degrees	Minutes			
22	00	5	12½	
23	14	5¼	12¼	
24	38	5½	12	
26	00	5¾	11¾	
27	33	6	11½	
29	03	6¼	11¼	
30	35	6½	11	
32	08	6¾	10¾	Preferred
33	41	7	10½	
35	16	7¼	10¼	
36	52	7½	10	
38	29	7¾	9¾	
40	08	8	9½	
41	44	8¼	9¼	
43	22	8½	9	
45	00	8¾	8¾	
46	38	9	8½	
48	16	9¼	8¼	
49	54	9½	8	

*Safety standards developed by Safety Department of National Workmen's Compensation Service Bureau.

Fig. 72. Relation of Riser to Tread for Various Angles of Stairs

Headroom. The space above the stair, called *headroom,* is measured vertically from the top of the tread at the face of the riser up to the under side of the stair above or the end of the wellhole. (See Fig. 83.) This headroom should be about 7 feet in the ordinary house. Greater headroom should be provided in public or semipublic buildings. The headroom is important not only to allow a man to travel up or down the stairs without bumping his head, but also to permit the moving of furniture up or down the stairway.

Handrails. Handrails should be provided on one or both sides of a stairs. The height of handrails should be 32 or 33 inches from the edge of the nosing to the top of the rail, as shown in Fig. 71.

Stair Widths. The width of staircases is determined by the necessity for two people to be able to pass comfortably on the stairs, and the fact that furniture will, at some time or another, have to be carried up or down. One person can with reasonable comfort use a stair two feet

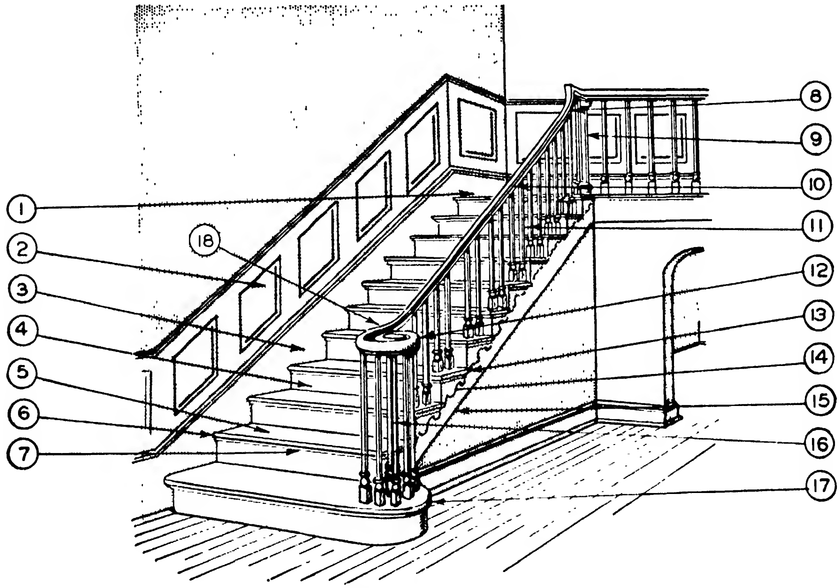


Fig. 73. Various Parts of a Staircase

1. Landing
2. Raised-panel dado
3. Closed stringer
4. Riser
5. Tread
6. Tread housing
7. Cove molding under nosing
8. Goose neck
9. Landing newel post
10. Handrail
11. Baluster
12. Volute
13. End nosing
14. Bracket
15. Open stringer
16. Starting newel post
17. Bull-nose starting step
18. Concave easement

wide, but if two people are to be able to pass on the stairs, the width must be at least three or three and one-half feet.

The width of stairs necessary for the passage of furniture depends upon the shape of the stairs and the kind of furniture which it is reasonable to expect will have to be taken up or down the stairs. The straight-flight stairway permits the movement of objects more easily than does the winder or platform type of stairs. When winding or platform stairways are open on one side, including open-well stairways, they will afford a better chance for moving large pieces of furniture, because such objects usually can be raised over the handrails and newel posts unless the articles are extremely heavy.

The main staircase of a building, when carefully designed and built, presents not only a pleasing appearance, but also requires con-

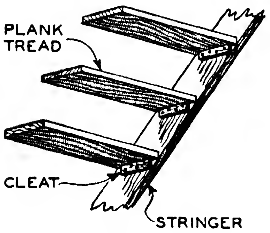


Fig. 74. Stringer with Nailed Cleats

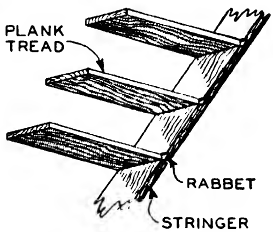


Fig. 75. Rabbeted Stair Stringer

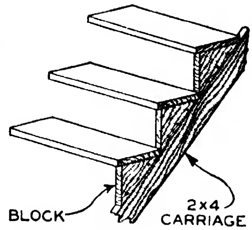


Fig. 76. Stair Blocks Nailed to Carriage

siderable skill in erecting and assembling of the many different parts. Of the different parts of a staircase, such as the one shown in Fig. 73, there are at least two parts—*the treads and the stringers,* which are common to all stairways regardless of how simple or complicated they may be.

Types of Stringers. The terms *stringers, strings, horses, springing trees,* and *carriages* are applied to the supporting members of the stairs and are synonymous terms. The *carriage* most often assumes the simple

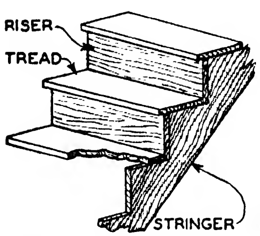


Fig. 77. Cutout Stringer; a Type Commonly Used on Porch, Basement, or Attic Stairs

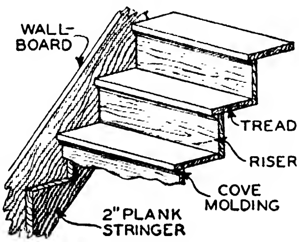


Fig. 78. Cutout Stringer with Wallboard Used against a Plaster Wall on Attic or Basement Stairs

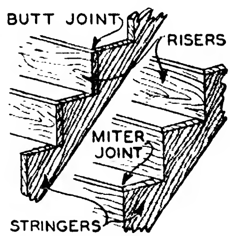


Fig. 79. Risers May Be Butted and Nailed against Cutout Stringer or Mitered and Nailed

form of a straight 2x4 to which blocks are nailed for the treads and risers. The carriages may form the framework for lath and plaster for the under side of the stairs, the stair soffit.

The simplest type of *stringer,* illustrated in Fig. 74, is just a plank with cleats nailed to the sides, on which the treads rest. The stringers may be rabbeted as shown in Fig. 75, which is a more sturdy type of construction. However, this method is seldom used today.

The blocks nailed to the carriage, as shown in Fig. 76, are triangular in shape. The two sides of the triangle which are at right angles to each other are equal to the riser and tread of the stairway.

Cutout Stringer. The type of stringer commonly used on porch, basement, and attic stairs is the *cutout stringer* illustrated in Fig. 77.

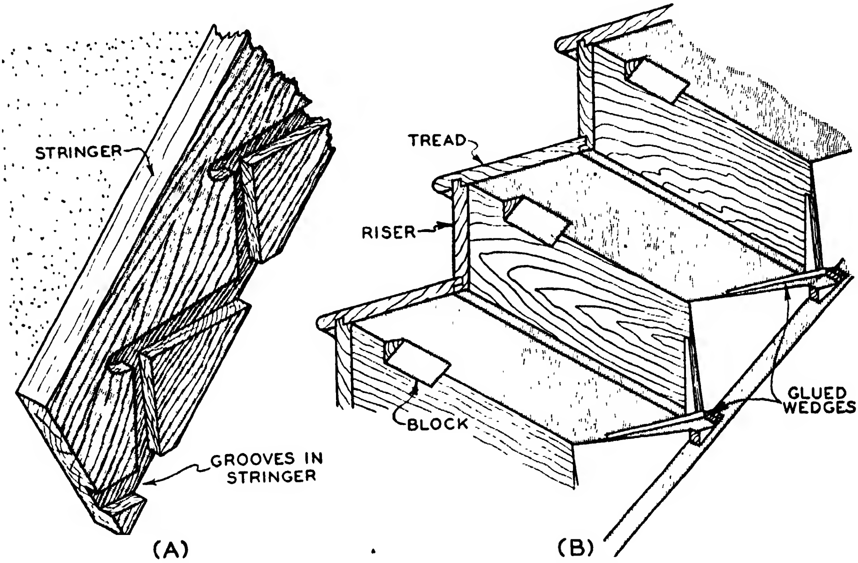


Fig. 80. Housed Stair Showing (*A*) Housed Stringer and (*B*) Assembled Stair

When this type of stringer is used against a plastered wall on attic or basement stairs, a wallboard is first nailed against the wall and the stringer is nailed against the wallboard, as shown in Fig. 78. The riser on open cutout stringers can be butted against the stringer, or mitered to produce a more finished appearance, as in Fig. 79. In case of a butted riser, allowance must be made for the thickness of the riser. This allowance becomes important when there are horizontal limitations.

Housed Stringer. The best type of stair is formed with a housed stringer as illustrated at (*A*), Fig. 80. In this case the stringers are rabbeted with tapered grooves into which the treads and risers fit. In assembling the housed stairway, the risers and treads are cut to the correct length, placed into the grooves and fastened in place with glued wedges driven into the tapered grooves under the treads and against the back side of the risers, as shown at (*B*), Fig. 80. Several blocks glued along the middle of the steps hold the treads and risers together as shown at (*B*), Fig. 80. In the best construction of housed stairways the risers are rabbeted into the treads, then glued and nailed, as shown in Fig. 81. The rabbeting produces a stairway which will not squeak nor allow dust and dirt to sift through the joints.

Stair Treads. The treads for the main stairs of a dwelling are commonly made of hardwood, either birch or oak, 1⅛ to 1¼ inches in

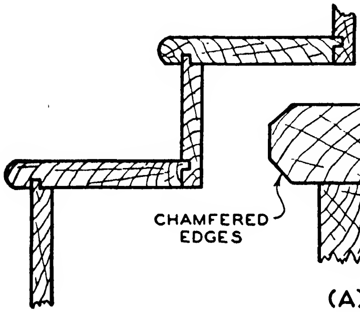


Fig. 81. Tread and Riser Rabbeted into Each Other

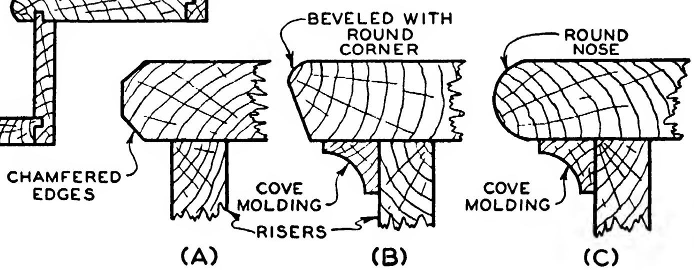


Fig. 82. Three Types of Nosing Commonly Used on Stair Tread

thickness, while the attic stairs frequently have treads 1 inch in thickness. When basement stairs are built on the job, the treads usually are made from a 2x12. When a 2x12 is used for the treads on porch or other outside steps, it is advisable to bore several holes in the treads to allow water to run off quickly. A better plan is to use several 2x4's slightly spaced to prevent the water from standing on the treads.

The *nosing,* that part of the tread which extends beyond the riser, can be finished in several different ways as illustrated in Fig. 82. A square finish with the sharp edges taken off, or chamfered, with a plane is shown at (*A*); a beveled finish with a rounded corner is shown at (*B*), and a round nose is shown at (*C*). A more finished appearance can be produced by nailing a ¾-inch cove molding under the nosing, as shown at (*B*) and (*C*), Fig. 82.

Calculations Necessary for a Straight-Flight Stair Layout. To help bring about a better understanding of how to go about laying out a stair stringer, let us consider laying out a stair which must have a total rise of 8 feet 4 inches. The wellhole, already established, is 11 feet 3 inches, as shown in Fig. 83.

Before any stringer can be laid out a study must be made of the plans, or stair location, to determine the type of stair required, such as straight-flight, platform, winders, or others. Also, the limitations or restrictions must be considered; that is, obstacles which demand certain changes in the stair layout due to door openings near the bottom or windows along the stair flight. Frequently such restrictions will only

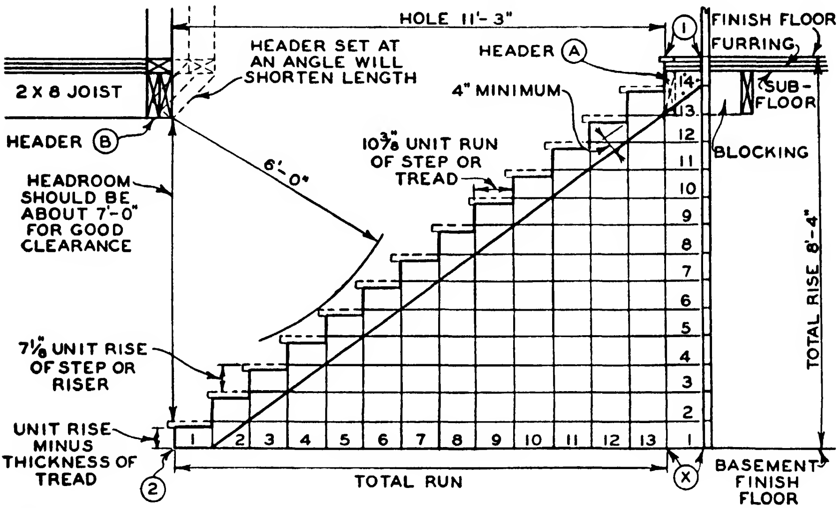


Fig. 83. Straight-Flight Stair, Showing Relation of Riser to Tread, Total Rise to Total Run, and Desirable Headroom

determine the place where the stairs will start at the bottom, and this might necessitate the shortening of the total run of the stair, thus changing the standard proportions between the riser and the tread by narrowing the tread. In other words, this study of the stair location will give an overview of the stair requirements which are necessary before the stairs can be laid out.

Space will not permit going into a detailed discussion regarding all the situations which may develop and the problems involved in building various types of stairs. However, when the principles involved in the layout of a simple stair with no restrictions are thoroughly understood, then the problems in most variations can be solved satisfactorily. As an illustration let us consider the straight-flight stairs shown in Fig. 83.

PROCEDURE

1. Take a story pole (any piece of lumber, 1x2 preferred) and set it on the finished floor in the wellhole on the basement floor. Mark the location of the finished floor above, or first floor, as shown at *(1)*, Fig. 83. The distance *(1–X)* will be the total rise of the stair, in this case 8 feet 4 inches.

Note: If the finished floor has not been laid when the measurement is taken, a block of wood should be placed on the rough floor above to establish the line of the finished floor, or allowance can be made for the thickness of the finished floor.

2. Set a pair of dividers to 7 inches (a permissible unit rise per step) and step off the total rise on the story pole, dividing the distance *(1–X)* into equal parts. If upon the first trial you find there is a remainder, adjust the dividers to another number and try again. If the remainder is less than 3½ inches set the dividers to a number larger than 7 inches. If the remainder is more than 3½ inches, set the dividers to a number smaller than 7. Continue adjusting the dividers and stepping off the distance on the story pole, until the last unit is the same as all of the others. This number then will be the unit rise per step.

The unit rise per step can also be obtained by dividing the total rise in inches by 7 to find the number of risers (drop the fraction if any), then divide the total rise by the number found, to obtain the exact unit rise per step. For example, when the total rise from finished floor to finished floor is 8 feet 4 inches (100 inches), divide 100 by 7, which gives 14²⁄₇. Then 100 divided by 14 (fraction dropped) equals 7.143 or 1⅛ inches, which will be the exact unit rise per step (for 14 risers) for a total rise of 8 feet 4 inches.

3. The standard width of the tread is obtained by subtracting the unit rise from 17½, as the sum of the riser and the tread should equal between 17 and 18 inches. In our problem, the unit rise was found to be 7⅛ inches. Then subtracting 7⅛ inches from 17½ inches gives 10⅜ inches. Therefore, 10⅜ inches is the width of the tread, or the unit run per step, as shown in Fig. 83. Consulting the safety standards given in Fig. 72, you will find that a unit rise of 7⅛ inches with a tread width of 10⅜ inches will fall within the preferred group of sizes for angles, risers, and treads, and is considered ideal for stair construction. Basement stairs are the cause of many home accidents. Therefore, these stairs should be designed so as to come within the preferred angle the same as the main stairs of the house, if at all possible.

Note: In laying out the stair, the nosing of a step is not considered a part of the tread. Since the nosing is added for appearance only, it does not enter into stair calculation.

4. To find the total run of the stair, multiply the width of the tread by one less than the number of risers. The reason for this can be found by studying Fig. 83, which shows there is one less tread than the number of risers. In the foregoing problem, the width of the tread was found to be 10⅜ inches and the total number of risers 14. Therefore, subtracting 1 from 14 leaves 13, the number of treads; and 13 × 10⅜ gives 134⅞ inches, or 11 feet 2⅞ inches (3″), the total run of the stairs.

5. To find the starting point of the stairs, locate point *(X)*, Fig. 83, on the basement floor by plumbing down from the header *(A)* in the wellhole. Then lay out the total run of 11 feet 3 inches (2⅞") of the stair to locate the starting point as shown at *(2)*, Fig. 83.

6. The amount of the headroom of a stairs should be about 7 feet. The headroom can be determined by finding the amount of rise of the stair directly below the header of the wellhole. When the unit rise per step is added to the thickness of the floor above, together with the thickness of the joist, and this sum is subtracted from the total stair rise, the result will be equal to the headroom of the stairs. In our problem in Fig. 83 the stair is up one riser height, or 7⅛ inches, at the point directly below the header *(B)*, in the wellhole. The floor (and joist) thickness above, plus 7⅛ inches, equals 17 inches. Subtracting 17 inches from 100 inches leaves 83 inches, or almost 7 feet, which is adequate headroom for these stairs.

Note: If it is found that the headroom is insufficient, additional clearance can be gained by tipping the header in the wellhole at an angle, or moving it back a few inches.

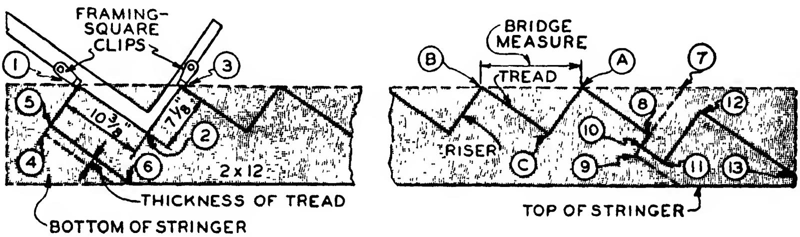


Fig. 84. Layout of a Stair Stringer

Laying Out a Stair Stringer. Such calculations as those just explained are necessary before a stair stringer can be laid out. In laying out the stair stringer illustrated in Fig. 83, the following method can be used.

PROCEDURE

1. Select a straight piece of 2x12 of the correct length and lay it on a pair of sawhorses.

Note: The required length can be found by taking the unit rise per step (7⅛") on the tongue of the framing square, and the unit run per step, or tread (10⅜"), on the blade. Lay the square on the edge of any straight stick to these measurements and draw the lines *(AC)* and *(CB)*, Fig. 84. The distance *(AB)* will be the bridge measure per step. Multiply this bridge measure (12¾") by the number of risers (14). The result will be 14 feet 10 inches, the approximate length required for this stair stringer.

2. Begin at the bottom of the stringer, lay the square in the position shown in Fig. 84 (use framing-square clips if available). Take the unit rise (7⅛") on the tongue and the unit run, or tread (10⅜"), on the blade. Draw the lines *(1–2)* and *(2–3)*.

3. Reverse the square and draw the lines *(1–4)* at right angles to *(1–2)*. The length of the line *(1–4)* is equal to the unit rise of the step (7⅛″). Shorten the rise of the first step from the bottom an amount equal to the thickness of the tread to be used. Draw the cutting line *(5–6)* parallel to *(1–2)*.

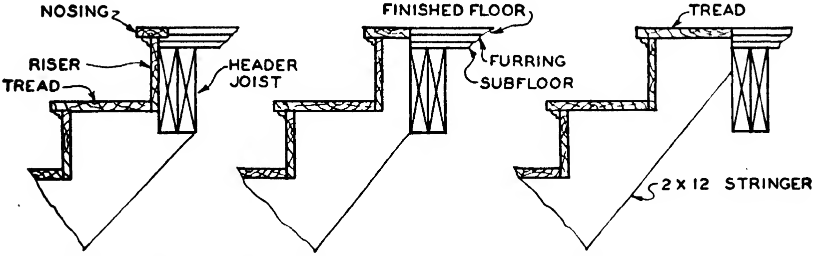


Fig. 85. Methods Used to Secure Adequate Support of Stair Stringer at Top

4. Continue to lay out from point (*3*), along the edge of the 2x12, the balance of the steps required for the stair. Great accuracy is required in laying out the steps. Therefore, use a sharp pencil or knife and make the lines meet at the edge of the 2x12.

5. When the point *(7)* at the top of the stringer has been reached, extend the line *(7–8)* to point *(9)*, making *(7–9)* equal to the thickness of the first floor above (joist and flooring), at the wellhole.

6. The thickness of a tread was removed from the first riser at the bottom of the stringer; this will drop the stringer. Then this tread thickness *(9–10)* must be allowed at the top, if the stringer is to fit up tightly against the joist header of the first floor.

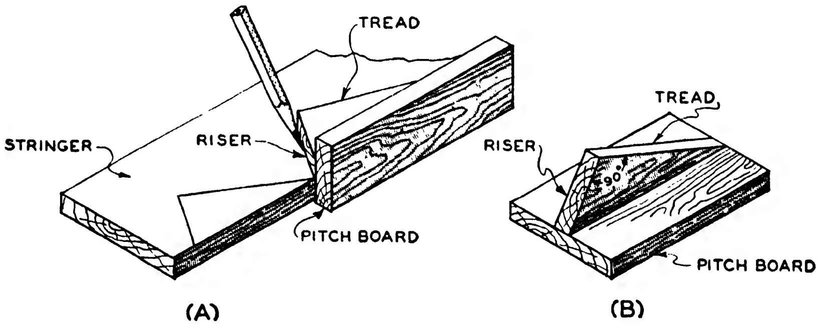


Fig. 86. Pitch Board Used to Layout a Stair Stringer

7. Greater nailing support of the stringer at the top can be obtained by fitting the stringer around the header joist. Therefore, draw lines *(10–11)*, thickness of joist, also *(11–12)*, height of joist, and *(12–13)*, top cut of the stringer.

Other methods used to secure the stair stringer at the top are illustrated in Fig. 85.

8. A *pitch board* may be used instead of a framing square in laying out the treads and risers of a stair stringer.

The pitch board shown in Fig. 86 is made of 1-inch material. The exact size of the tread and riser of the step must be used when making the pitch board shown at *(A)*. All edges should be planed smooth and square with the surface. The pitch board shown at *(B)* is made out of a 1x4, the length being equal to the bridge measure of the step.

Winder Stairs. At best *winding stairs* are dangerous to travel, because the treads are narrow on one end and this frequently causes accidents. A platform or landing is always more desirable when a change in direction of a stair is required. However, space does not always permit a landing and the carpenter may be compelled to use winders.

Three-Winder Stair. An easy and advisable way to build any winder stair is to first draw a full-size layout on the floor, showing size and shape of the treads, length of risers, together with all angle cuts of both treads and risers. Risers are to be nailed against stringer, butt jointed. The following method may be safely used when building winders.

PROCEDURE

1. Draw a square *(1–2–4–6)* equal in width to that of the stair as shown in Fig. 87. The dotted lines show the thickness and location of the outside stringers.

2. With *(1–2)* as a radius, draw an arc connecting *(2)* and *(6)*.

3. Divide this arc into three equal parts (*2–3′*), (*3′–5′*), and (*5′–6′*) and through these points draw the riser lines *(1–3)* and *(1–5)*. The thickness of the risers is shown by dotted lines.

4. The width of the treads at their narrowest point is obtained by drawing the full-size newel post in position.

5. The angle of the cuts for the stringer cutouts is obtained by laying the framing square on the layout as at *(A)*. The framing square held as at *(B)* will give the angle cut for the risers.

Layout of Stringer for Winders. The winder stringer is in two parts (*a–4*) and (*c–e*), Fig. 87. The layout of each part is different and both stringers have a different angle of rise from that of the main stair as shown in Fig. 88.

The layout of the stringer is made along the edge of the stick with the framing square, in the same way as shown in Fig. 84. The rise per step is the same as that of the main stair, but the run of each tread must be taken from the full-size layout, Fig. 87. Therefore (*a–b*), (*b–4*), (*c–d*), and (*d–e*), in Fig. 88, are the same as in Fig. 87.

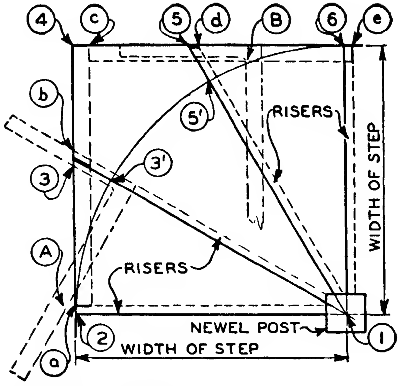


Fig. 87. Full-Sized Layout of Winders Is Simple Method of Finding Dimensions and Angles

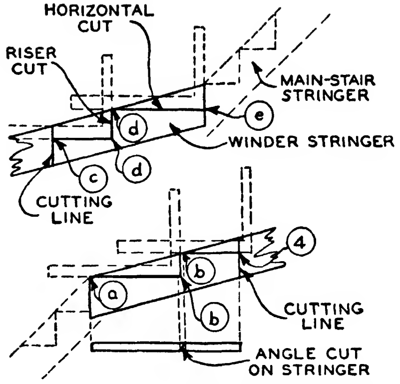


Fig. 88. Stringer of Winders Has Different Angle from That of Main Stairs but the Rise per Tread Is the Same

The angle cut for the riser on the stringer should not be laid out until the horizontal cut for the tread has been made on the stringers. The angles for these cuts are taken from the full-size layout by laying the square as shown at (*A*), Fig. 87.

The treads of winders should be laid out to the exact shape and size according to the full-size layout, except that 1¼ inches must be added to the width of the tread at the front for nosing.

Riser lengths and angle cuts are also obtained from the layout; their heights are the same as the risers of the main stair.

The newel post should be routed out to receive the risers and treads; blocks can be nailed against the newel post to hold the treads and risers; however, this method is inferior workmanship.

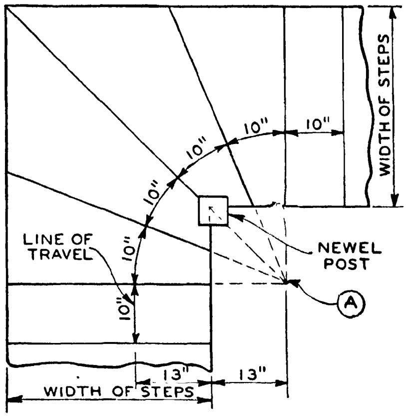


Fig. 89. Four-Winder Quarter-Turn Stair Insures Greater Degree of Safety Because Treads Are of More Uniform Width than Three Winders

Winder Stair of Greater Safety. Greater safety can be insured when winders are designed as shown in Fig. 89. A more uniform width of tread is obtained by using four instead of three winders and by converging the risers at a point (*A*) outside of the stair. This procedure will widen the winders at the narrow point and will reduce the width at the widest point of the tread.

The width of these treads at the line of travel will become the same as the regular tread. Therefore, it is necessary to determine the line of travel before laying out the winders. The distance that the line of travel is from the newel post depends a great deal upon the general conditions of the stair. A skilful designer will take various factors into account, such as location of the handrail, and the fact that many people have a tendency to cut corners seeking the shortest path to travel. In other words, there is no fixed distance for this line of travel for all stairs. However, 13 inches probably will serve as a pretty good average. For some stairs the line of travel will be 12 inches and on other stairs the line of travel will be 14 inches, depending upon conditions.

INSTALLING CABINETS

The cabinets of a home or building are becoming more and more a part of the so-called prefabricated type, a type which is made at a mill or cabinet shop and delivered to the job complete, where the cabinets are then installed by the carpenter. This installation work requires a high degree of skill not only to install the cabinets plumb and level, as well as to fit them tightly against the wall or other cabinet work, but also to avoid damage. The following method of installing cabinets may be used.

PROCEDURE

1. Set the cabinet in place on the floor and into the corner of the room where it is to be installed.

2. Level the top both ways as shown at *(1)* and *(2)*, Fig. 90. If the floor should not be level, it will be necessary to use wedges, as shown, to bring the cabinet to a level position. After the top has been leveled, plumb the sides as shown at *(3)* and *(4)*, Fig. 90. If the cabinet has been carefully built so that all faces are square, then the sides will be plumb when the top is level. Failure to check for plumbness will demand adjustment in the position of the cabinet where it is least noticed.

3. Scribe the bottom edge of the cabinet to the floor. This is done by setting the scribers *(A)*, Fig. 90, to the widest space, and then drawing the pencil line *(a)* with the scribers parallel with the floor.

4. Turn the cabinet over on its side or back and remove the excess amount of wood to the lines just scribed. Any amount more than one-fourth inch is more quickly removed with a saw. However, the plane is commonly used for this job.

5. Again place the cabinet into the position where it is to be installed, pushing it tightly against the walls and level the top a second time as a check.

6. Set a pair of scribers *(B)*, Fig. 90, to the widest opening between the back of the cabinet and the wall, then scribe a line *(b)* along the end and the top of the cabinet.

Note: Cabinets should be designed with excess material along the edges of the outside faces by setting the back and the side of the cabinet from ½ to ¾ inch back from the edges, as shown in Fig. 90.

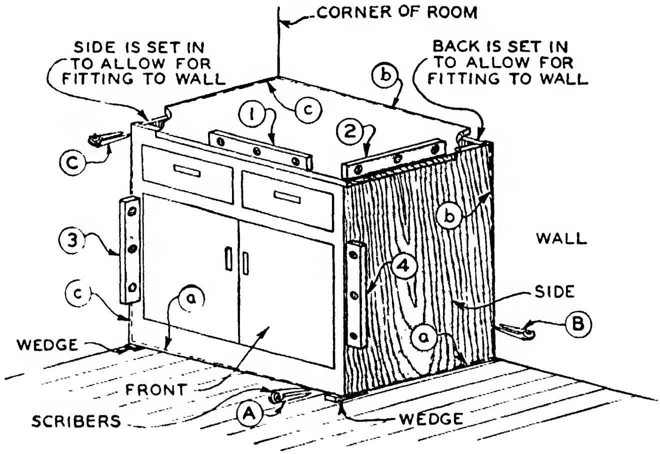


Fig. 90. Method of Fitting and Installing a Cabinet

7. Set the scribers (*C*) to the widest opening along the front edge and scribe the lines *(c)* along the front and the top.

8. Remove the excess wood with either saw or plane to the lines just scribed, undercutting slightly to insure a tight fit on the face side.

9. Place the cabinet back into position and check all edges for a good fit and improve the cuts if necessary.

10. Fasten the cabinet into place by toenailing the sides into the floor, while the top is toenailed into studs of the wall.

INTERIOR MOLDING

The baseboards, shoe molding, chair rail, and other molding trim are more or less continuous trim members extending around a room. These are among the last of the trim members to be put into place because they usually have to be fitted against other work, such as door casings, stairs, and cabinets. These trim members present the problem of joining in the corners of the room so that the joints will be tightly closed and all members of the moldings properly aligned. Either the miter or the coped joint is used for joining such trim members, depending upon the nature of the corner in which the joint is to be made.

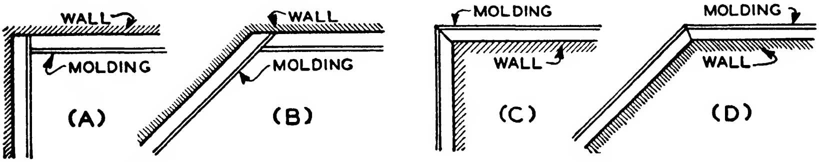


Fig. 91. Methods of Applying Molding in Internal and External Corners of Room

The internal corners, as shown at (*A*) and (*B*), Fig. 91, formed by the side walls of a room, require coped joints. The coped joint is better for interior corners because it will not open while nailing the trim into place against the wall and if the wood on such joints should shrink, the opening will not be nearly so noticeable. External corners such as (*C*) and (*D*), Fig. 91, formed by chimneys or any other corners projecting out into a room, should have the trim members mitered because the miter corner does not show the end grain of the wood.

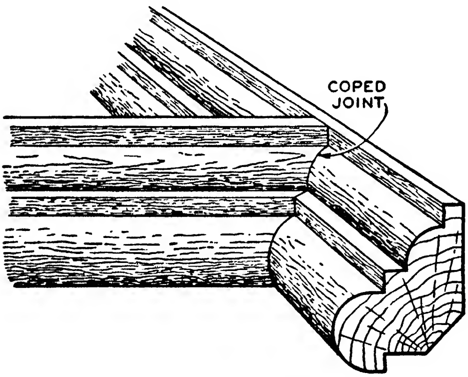


Fig. 92. Coped Joint on Molding

Coped Joints. Coping consists of shaping the ends of a molding or board so that it will fit with a butt joint against an adjacent member as shown in Fig. 92. The coped joint is used in fitting moldings on internal or inside corners. To cut a coped joint proceed as follows.

PROCEDURE

1. Place the piece of molding in a miter box in the same position that it will be when in place against the wall or other surface, as shown in Fig. 93. The vertical side of the molding when in place should be against the back of the miter box. A 45-degree miter will give the correct outline on the face of the molding for a right angle or 90-degree corner. The outline or profile formed by this miter cut is the cutting line which is to be followed with the coping saw to get the correct cut in making a coped joint.

Note: The angle of the miter must always be one-half of the angle of the corner to which the moldings are to be fitted.

2. Place the molding on a sawhorse with the vertical side down (the side which was against the side of the miter box), Fig. 94.

With a coping saw follow closely on the waste side of the cutting line

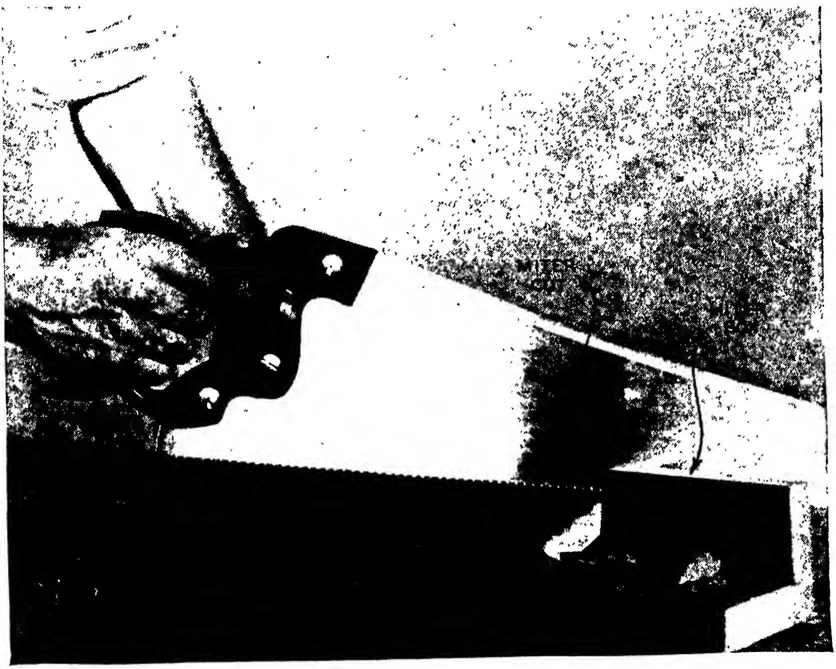


Fig. 93. Miter Cut Will Give Profile or Cutting Line for a Coped Joint

formed by the miter cut, holding the saw as illustrated, the teeth of the saw pointing down.

Note: The coped end should be slightly undercut. This will permit the front edge to fit up tightly while the back edge is free.

3. Try the joint against the other member which is nailed in place. If necessary, improve the cut by trimming it with a jackknife.

4. The coping line for wide boards usually is scribed with a pair of scribers or dividers instead of mitering to get a profile.

Miter Joints. The angle of the cut on the molding or board for a miter joint is equal to one-half of the angle of the corner around which the molding is to be fitted. The angle of the miter cut for a square corner is 45 degrees, which can easily be laid out by holding the framing square along the edge of the straight stick to any two identical figures, such as 5 and 5 on the edge of the square, as shown in Fig. 95.

The miter of any angle can be laid out by taking a **T** bevel and adjusting it to the angle of the corner. If this angle is then transferred to a board, as shown in Fig. 96, bisect this angle with a framing square, and locate the points (*B*) and (*C*) at equal distances from the center of the angle, as (*O*), Fig. 97. Take any two identical figures, as 5 and 5 on the framing square, and hold them on the points (*B*) and (*C*) and mark point (*D*). Draw the line (*OD*), which is the bisector of the angle (*BOC*). Then, all that remains to be done is to lay out the angle (*DOC*), the miter cut, on a miter box in which the moldings are to be cut or mitered. This can be done with either the framing square or the **T** bevel.

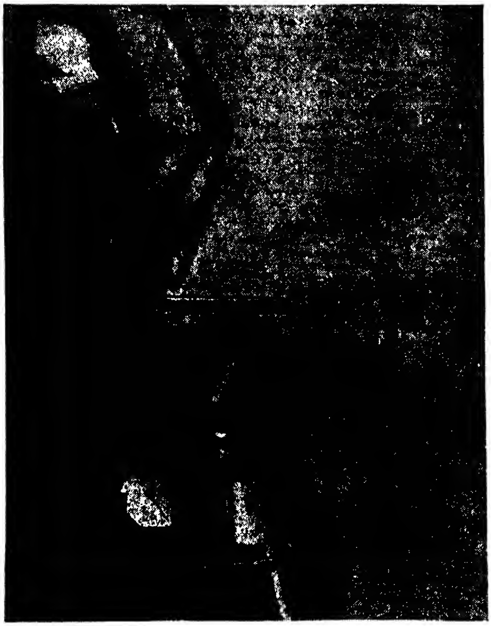


Fig. 94. Coping Saw Used to Follow Profile of Miter Cut to Make Coped Joint

Fitting Baseboards. A trim member usually is provided at the junction of the wall and the floor, called the *base*. This base may consist

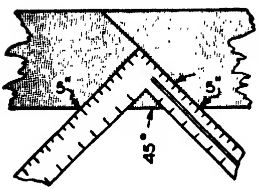


Fig. 95. Forty-Five Degree Angle Laid Out with Framing Square

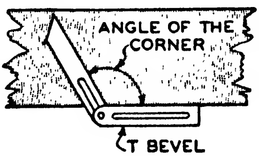


Fig. 96. Transferring an Angle through the Use of a **T** Bevel

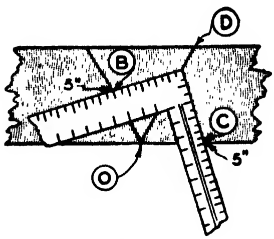


Fig. 97. Bisecting an Angle by Using a Carpenter's Framing Square

of only one board, as shown at (*A*), Fig. 22, or it may have several members, as at (*B*), Fig. 22, made up of the baseboard, base shoe, and base-cap molding. The baseboard is nailed against the wall and fitted with a butt or coped joint for internal corners, and mitered on external corners, as shown at (*C*) and (*D*), Fig. 91. When fitting baseboards, the following method may be used.

PROCEDURE

1. Clean out the corners of the room. Drive in any nails protruding on the grounds and sweep the floor clean along the edges, where the base is to be fitted in place.

2. Locate all wall studs and mark them on the floor with a light pencil mark.

3. Square both ends of a piece of baseboard to the correct length and fit it into place along the longest wall of the room. A tight fit can be insured by

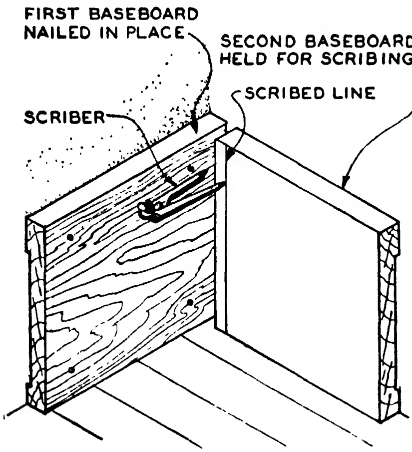


Fig. 98. Scribing Piece of Baseboard in a Corner for a Butt Joint

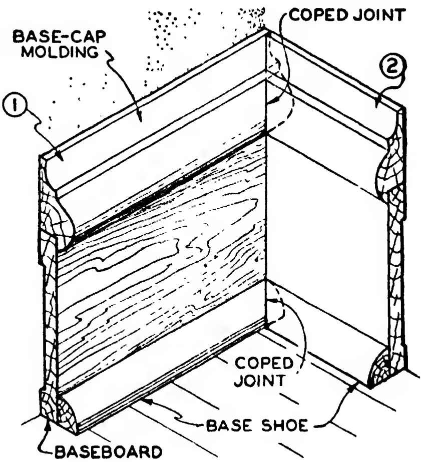


Fig. 99. Base-Cap Molding and Base Shoe Are Coped on Internal Corners

cutting the board from 1/16 to 1/8 of an inch longer than the length of the wall, and springing the board into place against the wall. However, care must be exercised not to break the plaster in the corners. Nail the board in place with two 6-penny (6d) finish nails to each stud, holding the board down tightly against the floor.

Note: Sometimes two or more pieces of baseboard are required for the length of a wall; if this is the case, the joints should be made on a stud where each of the boards can be securely nailed and the surface block sanded.

4. Select a second piece of baseboard of the approximate length of the adjacent wall, hold it in position and scribe the end against the first board as shown in Fig. 98.

5. Cut along the scribed line, undercutting slightly to insure a tight fit on the surface.

6. Cut the second piece to the correct wall length, measuring from the face of the first baseboard to the plastered wall in the other corner. Then nail the second piece in place.

7. The baseboards should be fitted against door casings or plinth blocks in the same way as siding is fitted against window and door casings, as shown in Fig. 66, Chapter V.

8. The base-cap molding should be fitted and nailed after the baseboard has been placed in position. The first piece of cap molding shown at *(1)*, Fig. 99, should be cut square on both ends and fitted tightly into the corners in the same way as the first piece of baseboard was fitted into place.

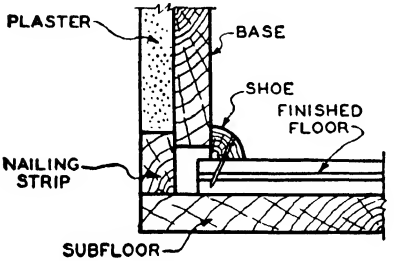


Fig. 100. Base Shoe Nailed to Floor Tight against Baseboard to Hold Shoe in Place When Floor Settles

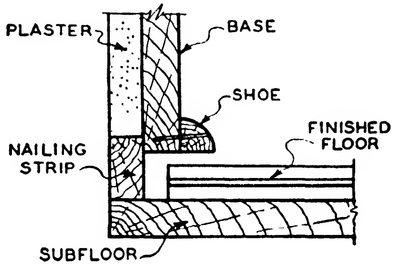


Fig. 101. Base Shoe When Nailed to Baseboard Will Create an Opening When Floor Settles

9. One end of the second piece of cap molding shown at *(2)*, Fig. 99, should be coped to fit against the first piece *(1)*. The other end of the second piece *(2)* should be cut square so it will fit into the opposite corner.

10. Continue to fit and nail all cap moldings in place, nailing diagonally downward to draw the piece against the baseboard and wall.

11. The base shoe, also known as *carpet strip* or *quarter round,* is cut and fitted in the same way as the cap molding. The base shoe should be nailed with 4-penny (4d) finish nails into the floor, as shown in Fig. 100, so it will stay in place on the floor in case the floor joist should shrink. If the base shoe is nailed against the baseboard, as shown in Fig. 101, a pocket will be created where dirt and dust will collect if the floor settles.

12. The mitered corners on the wide baseboards for external corners should be laid out on the board when it is in position, as shown in Fig. 102. Follow the method illustrated at *(A)* and *(B)*, Fig. 102. This procedure will take care of any irregularities of the walls or floor and will help to insure a satisfactory joint.

INTERIOR TRIM OF *THE HOUSE OF THE BOOK*

Work of applying the interior trimming of *The House* should not start until after another thorough study has been made of the interior plans and details shown on the blueprints at the back of the book.

The specifications pertaining to this work and given in the Appendix should also be read over again. Such a study will enable the carpenter to plan his work more effectively and also become more familiar with the kind of materials which are to be used, and the place where each trim member is to go; also the order in which all materials should be delivered to the job. In addition, such planning will help to prevent

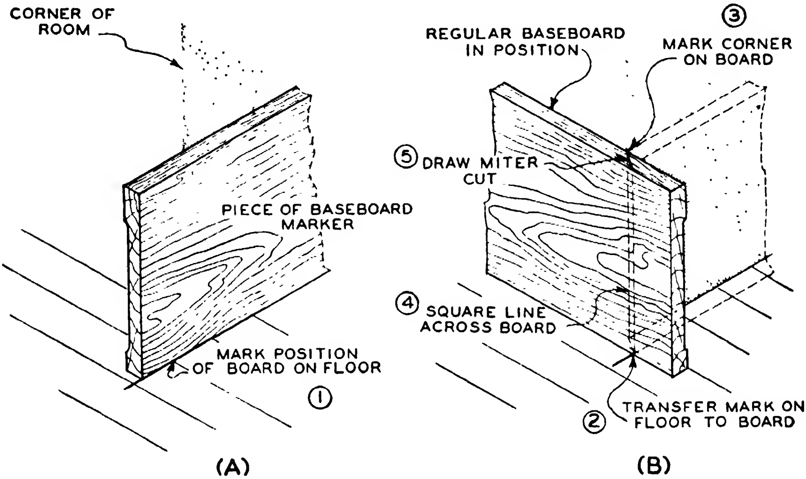


Fig. 102. Easy Method of Laying Out a Miter Cut for Baseboard on External Corner

the making of mistakes and will avoid confusion and unnecessary handling of materials.

Note: No trim should be applied until the plaster has dried and the house as a whole has been thoroughly dried out, either by natural or artificial means (heating plant).

Order of Procedure for Trimming *The House.* The usual order in trimming a house may be varied to some extent. However, it is advisable to apply as much of the trim as possible before laying the finished floor. The following order is recommended.

1. Fit the sash (cold-weather construction demands the fitting of the sash before plastering unless other means such as muslin is used to close the window openings).

2. Trim all windows, fitting and nailing stool, apron, casings, and stops.

3. Apply knotty-pine wall covering and cove molding in the living room and entry, except on the stair wall. Set the mantel for the fireplace in position.

4. Lay the finished floor throughout the house. Sand the floor to make it ready for the painter. The painter should stain, fill, and apply one coat of protection (either shellac, varnish, wax, or other suitable material), after which the carpenter should cover the entire floor with a tough paper to protect the finished floor.

5. Set the door jambs.

6. Trim all door openings.

7. Hang all doors and fit hardware on doors and windows.

8. Erect the stairs and apply knotty-pine wall covering on stair wall in entry.

9. Set kitchen cabinets.

10. Fit base, base-cap molding, base shoe, and picture molding.

11. Trim closets (closets should be left until the last, as odds and ends of material or trim members partly damaged can then be used).

12. Apply hardware after the painters have completed their work.

Schedule for Delivery of Interior Trim and Materials. No material should be scheduled for delivery until shortly before it is needed, to avoid confusion and to keep the floor as clear as possible for work.

1. The first delivery should consist of all sash, doors and window casings, window stools and apron, window and door stops, knotty pine for the living room and entry walls, together with the cornice moldings.

2. The flooring should not be delivered until after the furring strips and paper have been laid. However, several days before the flooring is to be nailed in place it should be delivered to the job and be piled loosely in the various rooms, so it will have a little time to become adjusted to the atmospheric conditions of the rooms.

3. Doors, door jambs, stairs, and cabinets should not be delivered until the floors have been laid, finished, and covered.

4. Only a small part of the hardware is needed before the doors are hung. Immediately after the hardware is delivered, it is advisable to provide a closet with a door and lock where the hardware can be safely locked up in order to avoid losses.

5. Base trim, picture molding, shelving, and shelf cleats are materials which are delivered in long lengths and are the last of the trim

members to be fitted. Therefore, it is best not to have this material around until most of the other work is out of the way.

Distribution of Trim Materials. Door and window casings, window stools and aprons, also the stops, are frequently delivered to the job in long pieces. When this is done, a list of rough lengths required should be made, allowing from ½ to 1 inch for fitting. It is advisable to select these long pieces carefully and to plan the cutting of them so as to avoid waste of material, and also to insure obtaining all of the required pieces.

Door casings and stops will not be used until the floor has been laid. Therefore, such pieces should be carefully stacked in an out-of-the-way place until needed. All sash, as well as window trim, should be selected and placed at each opening ready for fitting before work is begun.

Fitting of Sash and Trimming of Windows. All the sash for the entire house, except the basement, are double-hung sash. These sash are to be fitted and hung according to procedure previously explained, and illustrated in Fig. 24.

The basement sash which are to be of steel construction will be delivered to the job with the frame fitted and hung.

The window casings are to be of one piece. Since there are several molding features, it will be necessary to miter the corners. Instructions and methods of procedure for trimming window openings have been given previously, and are illustrated in Fig. 24.

However, the trimming of the living-room windows must wait until the knotty-pine wall covering has been nailed into place.

Living-Room and Entry Wall Covering. The knotty-pine boards for the living-room walls are to be applied vertically. This will demand cross headers at the top and bottom of the wall and at every two-foot interval between the top and bottom. Since headers, at least on the outside walls, cannot be nailed in place at the time of framing because of the insulation, these headers frequently are left out until the inside finish is ready to be installed.

The placing of these wallboards is started in one corner of the room, toenailing each board (driving the nails at an angle into the edge of the board, so they will not be visible). All boards must be driven tightly against each other and held in place with nails. Three different widths of boards are used. These are 4, 6, and 8 inches and should be applied in a staggered order. No definite order or sequence should ever be followed. If the boards are installed in the same order or sequence, the wall will appear uninteresting because of its uniformity. Full-length boards which extend from the ceiling to the floor are desirable for this purpose, as shown in Fig. 1.

The cornice cove molding should be fitted and nailed into place after the walls have been covered. The molding is fitted at the corners with a coped joint, as explained previously and illustrated in Fig. 91.

Fireplace Mantel. The mantel for the fireplace will be delivered to the job prefabricated, and consequently will only require trimming at the bottom on each side to level it and to fit it to the hearth, and to insure a uniform 6-inch exposure of brick at the top and sides. See detail of fireplace shown with the east-elevation drawing (blueprints).

Place the mantel in position against the wall, with the top level and the sides plumb over the fireplace, with equal brick exposure on each side. Measure the brick exposure at the top; this will be slightly wider than the brick exposure on the sides, since an allowance was made in the height of the mantel for fitting it to the hearth. The difference between the top and side exposure should be scribed or laid out on the bottom of the mantel, then cut to fit it to the hearth. If this is done carefully, the brick exposure at the top and sides of the mantel will be uniform. Nail the mantel in place with finish nails against the knotty-pine wallboards. Reset the cove molding so it will fit tightly against the brick around the opening.

Laying the Finished Floor. It is advisable to lay the finished floor lengthwise in a room and have it run in the same direction in all rooms of each floor. This will avoid unnecessary joining of boards at door openings and the somewhat undesirable feature of showing change of flooring direction at this point.

The flooring on the first floor of *The House* should run north and south, which will be lengthwise in the living room and dining room. It is also desirable to have the floors run in this same direction in all of the other rooms, even though it will be crosswise in the entry. The flooring on the second floor should run east and west because of the long east-and-west hallway.

The rough floor should be given a thorough cleaning and all loose boards should be nailed down well. Paper must be laid over the rough floor and one-inch furring strips laid parallel with, and on, the joist. The furring strips must be nailed thoroughly with 10-penny (10d) coated nails to prevent them from working loose and causing a squeaky floor. Furring strips must be 7/8 of an inch in thickness for the kitchen and bathrooms, to allow for the linoleum which will cover these floors; all others should be a full inch in thickness.

The laying of the flooring on the first floor should start at the west wall in the living room, and at either the east or west wall of any of the rooms on the second floor. The hardwood floor should stop in the center of the doorway in such doors as those of the kitchen and bathrooms, since the floors of these rooms will be covered with linoleum. For the method of procedure for this work see explanation and previous description, together with the illustration, Fig. 36.

After the operation of laying the floor has been completed, the floor must be smoothed with either a hand scraper or a sanding machine. However, sanding is most commonly used today. It is advisable to hand sand the floor after the machine work, to insure a good smooth and well-finished surface which will take the stain and filler uniformly without clouding.

A good craft paper should be laid over the floor after the painter has treated it. This paper should be held in place with lath along the edges and held down with 2-penny (2d) lath nails, three nails to a lath.

Door Openings. All door openings can be trimmed by setting the door jambs, then fitting and nailing the casings. See previous instructions given for trimming door openings, and illustration, Fig. 41. The doors can then be fitted and hung, and the locks fitted as previously explained and illustrated in Figs. 50 to 60.

Kitchen Cabinets. For details of the kitchen cabinets, see east-elevation drawings. The cabinets for the kitchen will be delivered to the job in three sections, the long lower part and the two corner sections. The setting of the long lower section can be simplified if the top can be removed. The front can then be scribed and fitted to the side walls. After the lower part of the cabinet has been fitted and nailed into place, the top should then be fitted and fastened onto the lower part. For the method of procedure for doing this work, see the instructions given previously for installing cabinets. Also see Fig. 90.

The kitchen sink, which when installed will become a part of the lower section of the kitchen cabinet, must be fitted into the top by the carpenter. This work will require a carefully prepared layout to center the sink with the window and to meet the requirements for plumbing. The edge of the sinkhole must be rabbeted to recess the rim of the sink to make it come flush with the counter top of the cabinet. The plumber will make all necessary pipe connections after the sink has been placed in the proper position.

The face and one side of the cabinets above the counters must be scribed and fitted against the plastered walls of the kitchen and up to the plaster drop above the cabinets. These cabinets must be held in place and carefully secured by screws through the back of the cabinet into the wall studs.

Basement Stairs. The basement stairs for *The House* are to be built on the job, with 2x12 stringers, 2x9 treads, and mitered risers one inch in thickness. To lay out the stringers for this straight-flight stairs, follow the method previously explained and illustrated in Fig. 84. The only special problem which will be encountered in connection with the building of these stairs will be in providing for the required headroom at the base of the stairs.

Before the stringers are laid out, a careful study must be made of the location and plan of the basement stairs shown on the basement-floor plans of the blueprints at the back of the book. Such a study will show that the length of the wellhole must be restricted to 9 feet 4 inches because of the steel **I** beam under the partition between the living room and dining room of the first floor. Therefore, it is necessary to shorten the total run of the stairs as much as possible to allow ample headroom at the bottom of the stairs. Also, study the sectional view (*B–B*) of the blueprints to determine the allowance which must be made for the thickness of the first floor and the joist.

In our problem, the total rise of the stairs from the finished basement floor to the finished first floor above is 8 feet, or 96 inches, as shown on the sectional view (*B–B*) of the blueprints. The unit rise of the stairs per step can be found by either one of the two methods previously explained. The simplest method is to divide the total rise in inches by 7 (a permissible riser height). Dividing 96 by 7 gives 13$\frac{5}{7}$ (drop the fraction). Then there are 13 risers in this stair. The unit rise per step will be somewhat more than 7 or about 7.384, or 7⅜ inches.

The total run of the basement stair for *The House* cannot exceed the length of the wellhole, which is 9 feet 4 inches. In fact the total run of the stairs should be slightly less to allow the minimum headroom at the bottom of the stairs. Therefore, the width of each of the 12 treads (one less than the total number of risers) should not exceed 9 inches, making a total run of 108 inches, or four inches less than the wellhole opening.

The 9-inch tread plus the 7⅜-inch rise will equal only 16⅜ inches instead of 17½ inches as previously described as the ideal relationship between tread and riser for a good stair.

This, then, is an example of a situation where the architect or the builder must deviate from the best practice in order to meet certain fixed and unchangeable conditions.

Main Stairs. The parts for the main stairs will be delivered to the job prefabricated, but not fitted and assembled. It will still remain for the carpenter to cut, fit, assemble, and fasten the various parts of these stairs into place. The full-size layout used by the millman in prefabricating the housed stair will be a great help to the carpenter when he erects these stairs. The various sections of the stair stringers and the newel posts must be fitted and placed in the proper relation to one another. Therefore, no part should be permanently nailed into place until all parts have been temporarily fitted and tacked, then checked to make sure the treads will be level and fit correctly into their respective places. The following method of procedure may be used when erecting these stairs.

PROCEDURE

1. Remove the temporary stairs and clear the wellhole, making it ready for the erection of the permanent stairs.

Note: The temporary stair usually is erected with space between the stairs and the wall so the plasterers can apply plaster to the wall above and below the stair in one piece. The erection of a housed stair can be greatly simplified if the under side is lathed and plastered after the stair has been placed in position.

2. Place the bull-nose starting step in correct position, level it, and scribe it to the floor, then cut and fit it into place. For detail of stairs see north-elevation drawing (blueprints).

3. Fit the short winder stringer into place against wall (*A*), Fig. 103, by cutting the bottom end to fit the floor and the top end to fit against wall *(B)*,

103. The riser height of the stringer at *(1)* must be equal to the height of the starting step, as shown in detail *(X)*, Fig. 103, and the cut at the top must be a distance of *(4)* to *(5)* from the front of the riser of *step four.* Tack the stringer in place so the top of the tread will be level.

4. The stringer along wall (*B*) will be in two sections, a short section for the winder steps *four*, *five,* and *six,* and a longer section to take the balance of

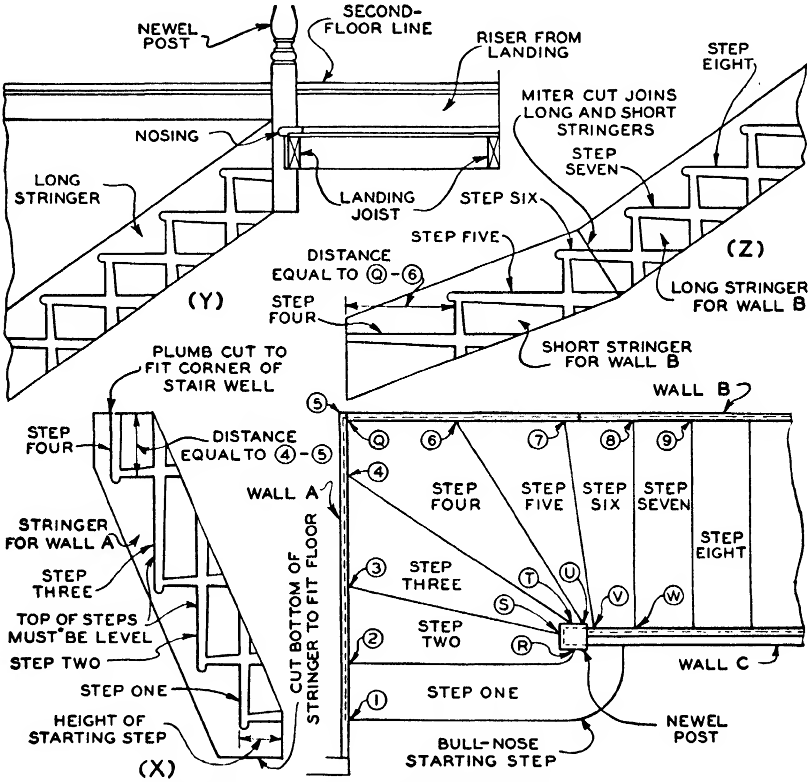


Fig. 103. Method of Erecting Housed Stair of *The House of the Book*

the steps up to the landing near the second floor. At this point, the stringer must fit against the second-floor newel post, as shown in detail *(Y)*, Fig. 103.

The short stringer must be fitted against the stringer on wall *(A)* so the distance *(Q)* to *(6)* will check with the width of the tread and the top of the treads will be level. The miter cut at the top of the short section shown in detail *(Z)* must join up with the bottom cut of the long section so the top edge of both sections will line up correctly in their respective positions. This stringer must also be cut so step *six* will have the correct tread width according to the full-size layout. Cut, fit, and tack the short and long sections in place on wall *(B)*. The top end of the long section must be fitted against the second-floor newel post as indicated in detail *(Y)*, Fig. 103.

5. Cut off the newel post on the first floor at the bottom so it will rest on the floor, and the lower housing in the newel will line up with the tread of the starting step. The housing at *(R)* and *(S)* will then be level with points *(2)* and *(3)* of the wall stringer. Fit and fasten the newel post against wall *(C)*.

Note: The lower section of the newel post, that part below the turning, should be boxed so it will fit over the frame of wall *(C)*, allowing enough room for the knotty-pine wall finish under it. The top of this boxed newel is later cut off to correct height and the turned section fitted into it.

6. Lay out the top and bottom cut of the stringer for wall *(C)* so it will fit against the newel post at the bottom and the stair landing at the top. This stringer must be set so points *(U)* and *(V)* will be level with points *(6)* and *(7)*. The point *(W)* must be directly across from point *(8)*; in other words, the riser line *(8–W)* must be at right angles with both wall stringers *(B)* and *(C)*.

7. Fit the tread of the starting step into the housing of the newel post and into the housing of the wall stringer. Fasten the tread into place by toenailing it to the floor and with wedges glued into the housing of the wall stringer.

8. Cut the riser for step *two* to the correct length, slide the riser into place. The top of each riser must fit up against the tread of the step above it. Therefore, no riser should be secured in place until the tread immediately above it has been fitted and secured in place with wedges and glue.

9. Cut and fit the tread for step *two* and fasten the tread in place with wedges and glue. The exact shape of this tread is taken from the full-sized layout. Fasten the riser of step *two* in place with wedges, then glue and nail the lower edge of the riser to the tread of step *one*.

10. Continue in this same manner for all steps until the top of the stair has been reached. A piece of nosing will finish up the step at the landing and at the second-floor level. This nosing must be placed so the top will be flush with the finished floor.

11. Cut the turned section of the newel post and fit it into place.

12. Cut the handrail and fit it into place. The bottom end of this handrail will fit against the newel post and the top end of the handrail will fit against the 4-inch beam on the under side of the wellhole.

13. Cut the balusters and fit them in place. The bottom of these balusters on wall *(C)* will rest on a board with molded edges covering up the top of wall *(C)*, the stringer and the knotty-pine wall covering. The two balusters at the top of the stair must be of special turning as they are shorter than the regular balusters.

14. The handrail on the second floor is fastened to the newel post on one end and to the wall on the other end. The balusters are cut, fitted, and spaced along this handrail according to the plan shown on the drawings or blueprints.

Base and Picture Moldings. The trim members known as *base* and *picture moldings* are the last to be cut and fitted into place when trimming the interior of *The House*. All rooms and closets of this house are to receive base molding, while only the dining room and the bedroom on the first floor are to receive picture molding.

The important rooms of *The House,* such as the living room and the dining room, should be given first consideration in fitting these trim members so the longest and best pieces will be used in these rooms. Bedrooms and closets are finished last. In these rooms the shorter and slightly damaged pieces can be worked in to good advantage.

The method of fitting the base and picture molding has been carefully explained in detail previously, and illustrated in Fig. 91. This same procedure can be followed when fitting these moldings for *The House.*

CHECKING ON YOUR KNOWLEDGE

The following questions give you the opportunity to check up on yourself. If you have read the chapter carefully you should be able to answer the questions. If you have any difficulty, read the chapter over once more so that you have the information well in mind before you go on with your reading.

DO YOU KNOW

1. What kind of wall covering is to be used in the living room of *The House?*
2. What different methods may be used for finishing joints when plywood is used as a wall covering?
3. Of what material sheetrock is made? How it can be used for interior finish?
4. The names of ten varieties of wood that are suitable for interior finish?
5. The four types of casing generally used to trim windows and doors? Name three of these.
6. Whether or not lead is ever used for a sash balance weight? If so, when?
7. The difference between a double-hung window and a casement window?
8. What kind of wood should be selected for finish floors? Why?
9. What different pieces of trim are used in finishing a door opening?
10. What size doors are called for on the plans for *The House* for closets? If these doors are all the same size?
11. What is meant by a *Colonial* door? What special feature distinguishes this door from other doors?
12. How to hang a roll-away door? Where a pivot-hinged door is used in the modern home?
13. What determines the size and weight of the hinge to be used when hanging a door?
14. What feature of a house causes the majority of accidents in the home?
15. The meaning of the following terms used by the carpenter: *nosing, stringer, wellhole, straight-flight stair, winders, cove molding, base molding, headroom, pitch board,* and *balusters?*

16. What is the accepted size for the tread and riser of a stairs?

17. How to find the width of a stair tread when you know the length of the wellhole and the number of risers required?

18. Whether or not the cabinets for *The House* are built on the job?

19. What kind of covering is to be used on the kitchen and bathroom floors of *The House?*

20. Where picture and base moldings are to be used in *The House?*

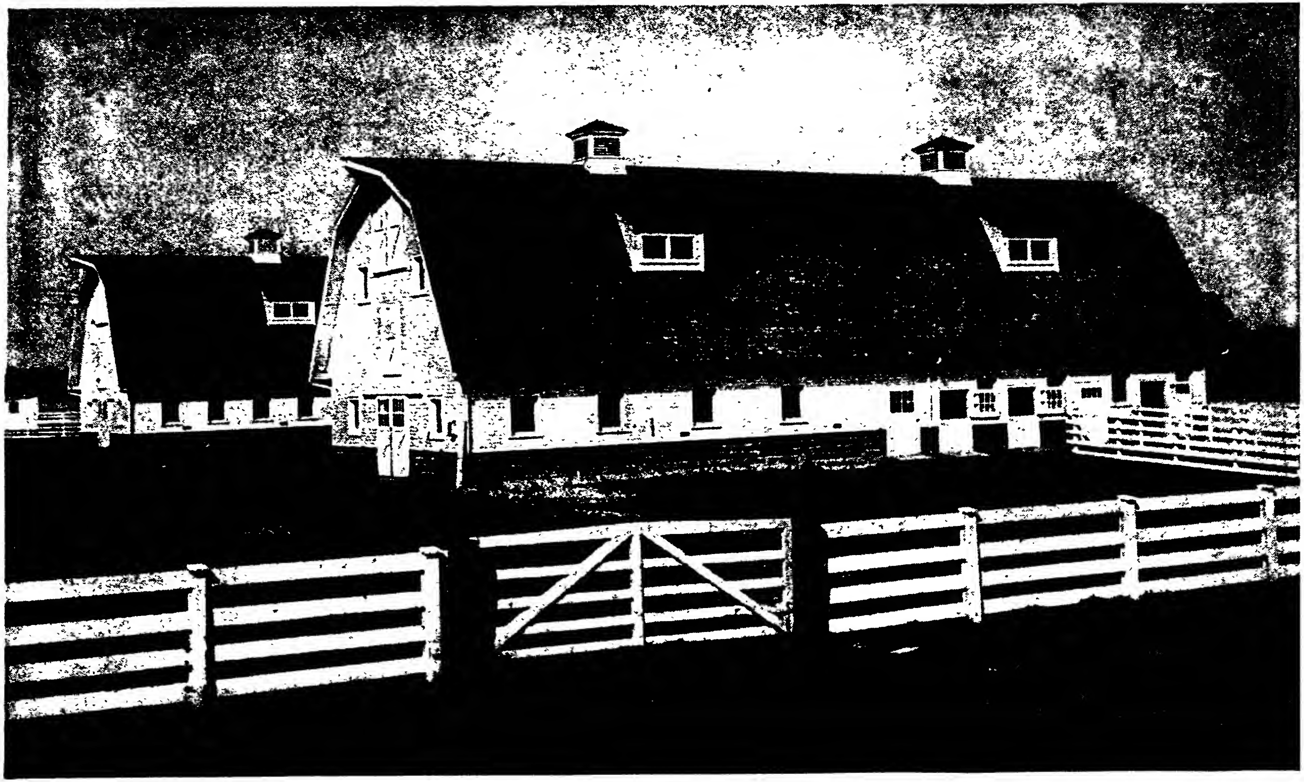
21. What construction feature determines the length of the wellhole for the basement stairs of *The House?*

22. What are the last interior trim members to be put in place?

23. Which rooms are the last to receive interior trim? What is the advantage in this procedure?

24. Why the living room and dining room of *The House* should be the first rooms to receive interior trim members?

25. What kind of stairs is used between the first and second floors of *The House?*



IN THE UPKEEP AND MAINTENANCE OF FARM BUILDINGS A KNOWLEDGE OF CARPENTRY IS INVALUABLE TO THE FARMER

Courtesy of American Builder

CHAPTER VII

Farm Buildings

QUESTIONS THIS CHAPTER WILL ANSWER

1. *When designing and constructing a barn, why is it important for the carpenter to understand the nature and effect of wind pressure?* 2. *What advantage does the gambrel-roof barn have over a gable-roof barn?* 3. *Can you name three farm buildings besides the house and barn?* 4. *What kind of material is used in the construction of small farm buildings?* 5. *What two types of hog houses are commonly used by farmers?*

INTRODUCTION TO CHAPTER VII

In this chapter you will learn many important facts about the construction of barns, hog houses, and poultry houses. Other small farm buildings also considered include sheepsheds, rabbit hutches, and granaries. Attention is called to the fact that the carpenter must understand the nature of wind pressure and the effect on buildings of different types of winds, such as the ordinary straight wind and the winds of hurricane proportions. It is likewise pointed out that among the common causes of farm-building failures are faulty foundations, insufficient anchorage of buildings, and poorly constructed joints. The responsibility of the carpenter in preventing these failures is stressed, since he must be able to anticipate and effectively prepare for the defeat of these destructive forces by learning how to build well.

You will further find in this chapter interesting as well as instructive discussions on the advantages of certain types of roofs for barns, sheds, and other farm buildings. Careful consideration is given also to the question of how to provide properly heated and ventilated shelters for livestock, in order to protect the health, not only of the horses and cattle, but also of the hogs, sheep, and hens.

You should give as careful attention to the study of this chapter as you did to the chapters dealing with the building of a home for a family. Since the wealth and income of the farmer depend largely upon the proper storage of his farm crops and the good physical condition of his flocks and herds, it is a common saying with farmers that "a good barn will build a good house."

CONSTRUCTION OF FARM BUILDINGS

Farm buildings comprise a large field of special construction. Any book on carpentry would be incomplete without some attention being given to the construction of barns, hog houses, sheepsheds, henhouses, implement sheds, and other important small farm buildings.

When erecting store buildings, warehouses, or other buildings necessary to carrying on his business, the city dweller relies in most cases upon the services of an architect, contractor, or a trained builder. However, the farmer usually does much of his own carpentry work, with the help of his neighbors and friends. Because of the nature of his work, the average farmer is by necessity something of a mechanic and usually can handle carpentry tools with reasonable skill. What he needs most is information concerning design and details, also training in the various methods of construction. Fortunately, such information usually is available through services provided by leading agricultural colleges, state universities, and the United States Department of Agriculture. There are also private organizations[1] and dealers in building materials that generously furnish information regarding the use of the supplies which they handle.

CAUSES OF FAILURES OF FARM BUILDINGS

Extensive investigations, study, and experiments[2] show that failures of barns and other farm structures to withstand violent winds usually may be attributed to one or more of the following causes: (1) misunderstanding of the nature and effect of wind pressure; (2) inadequate foundations; (3) insufficient anchorage of the frame to foundation; (4) lack of adequate bracing in the framework; and (5) weak joints.

Nature and Effect of Wind Pressure. In order to prevent the failure of barns and other farm buildings to withstand the pressure of violent winds, the builder should understand the nature of wind pressure and the effect such pressures exert upon frame structures. Three types of violent windstorms wreck buildings in the United States—the *cyclone,* the *tornado,* and the *hurricane.*

Cyclones. As storms of gigantic circular movements of air, *cyclones* pass across the United States as high- and low-pressure areas, usually traveling with a velocity of from 20 to 30 miles an hour. These wind-

[1] For example, Southern Pine Association, New Orleans, La., and the West Coast Lumbermen's Association, Seattle, Wash.

[2] *Design of Barns to Withstand Wind Loads,* Bulletin No. 42, published by the Kansas State College, Experiment Station, Manhattan, Kan. This is a full report of studies and experiments which furnished much basic data on wind loads.

storms, characterized by circular movements, often rotate at the rate of from 90 to 130 miles an hour. In the Northern Hemisphere these rotations move in a counterclockwise direction; in the Southern Hemisphere they move in a clockwise direction. The high-pressure currents of air in a cyclone rotate about a calm center of low atmospheric pressure. The diameters of these huge circular air movements usually vary from 50 to 900 miles. The cyclone and the hurricane both appear to be straight winds in any locality. Although the winds in a cyclone are not as strong as those of the violently whirling tornado, cyclonic winds are more widespread and do much greater total damage than the tornado. The term *cyclone* should not be applied, as it often is, to either the tornado or the twister.

Tornado. The *tornado* is an extremely violent revolving windstorm, normally occurring in association with cyclones. When fully developed, a tornado is accompanied by a funnel-shaped cloud. The funnel-shaped mass, depending from a black storm cloud above, tapering downward to the earth and advancing with a velocity of from 20 to 50 miles an hour, sometimes covers a distance of many miles as it travels over the land. Though in comparison with the diameter of the cyclone, the diameter of the funnel of a tornado is small, yet this type of storm, with its rapidly whirling air movements, is highly destructive wherever it strikes the earth. Its path may vary in width from a few feet to a mile or more. As the storm progresses it leaves behind a well-marked pathway strewn with wreckage. The tornado occurs in many localities, but is especially frequent in spring and early summer in the central Mississippi River Valley. The wind pressure in a tornado cloud is too violent to be measured and the barometric pressure falls so rapidly that wooden structures often are lifted from the ground and burst open by the pressure of the air confined within them.

Hurricanes. The *hurricanes* which occur along the southern and eastern coasts of our country are also large circular air movements of a cyclonic nature. These air movements create high-wind velocities near the center of the storm cloud and often do tremendous damage to many different kinds of structures, as well as to crops and forest trees. For example, consider the hurricane which struck Galveston in 1900; it was a cyclonic wind which blew steadily for 18 hours, reached a velocity of 135 miles an hour and resulted in the loss of 5000 lives and property damage estimated at more than $17,000,000. However, after the storm had passed, there were some buildings in Galveston that had withstood this terrific test of their construction. The builders of these structures had understood the nature and effect of wind pressure, and also realized the importance of providing for such emergencies.

When a straight wind is blowing directly against the side of a building, the wind pressure against that particular surface varies with the velocity of the wind. In addition to this pressure on the windward side there is also a negative pressure, or *suction pressure,* as it is commonly called, on the opposite side, also on the ends, and on most of the roof. The air pressure on a gambrel-roof barn, when the wind is blowing against one side, is shown in the illustration, Fig. 1. Note the direction and amount.

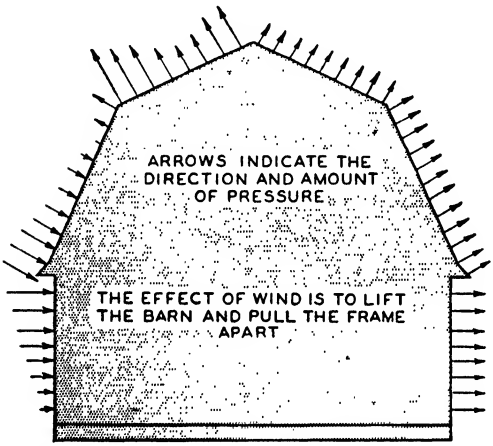


Fig. 1. Wind Pressure on a Gambrel-Roof Barn

In designing a building to withstand wind pressure we should, of course, consider, not only the pressure on the windward side but also the suction and the lifting pressure on much of the remaining surfaces of the building. In fact, the suction forces are greater in total amount than the wind forces which press in on the walls. In preceding chapters we have emphasized the ability of a building to stand up under loads, and most of the various members are designed to hold up the weights of the building or the load of materials stored in the building. When constructing barns and small buildings on the farm to withstand wind, we should lay equal or greater emphasis upon both the part that holds the building down to the foundation and that which holds the roof onto the walls. We might also give more attention to the shape of a building as it affects wind pressure. The building with streamlines such as circular roofs are less likely to be blown over and are still safe even with a lighter and cheaper construction.

WIND-RESISTANT CONSTRUCTION

An adequate foundation for anchoring a building securely to the ground is the starting point of all good wind-resistant construction. The second essential of good construction of a wooden building is anchoring the frame securely to the foundation. In wind-resistant construction,

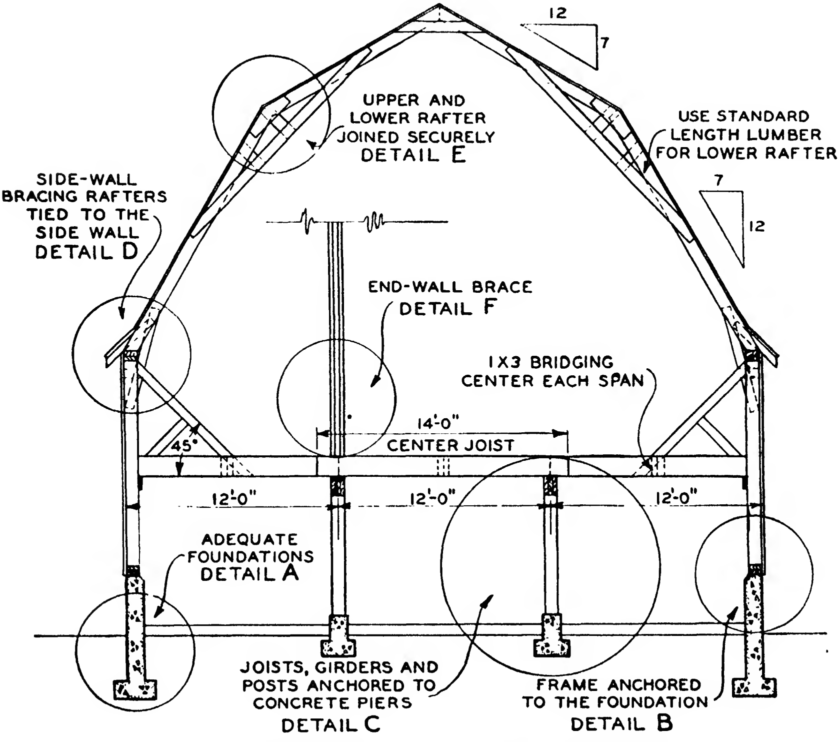


Fig. 2. Six Essentials of Wind-Resistant Construction

another important factor is anchoring the joists, girders, and posts to concrete piers, while a fourth essential is securely tying the roof rafters to the side walls. Bracing of end walls is a fifth important factor, and a sixth essential in good construction is proper fastening of broken joints, such as those of a gambrel roof. These six essentials of good wind-resistant construction are illustrated at (*A*), (*B*), (*C*), (*D*), (*E*), and (*F*), Fig. 2. Another essential, which may be called the seventh essential of good construction, is the method used in fastening joints

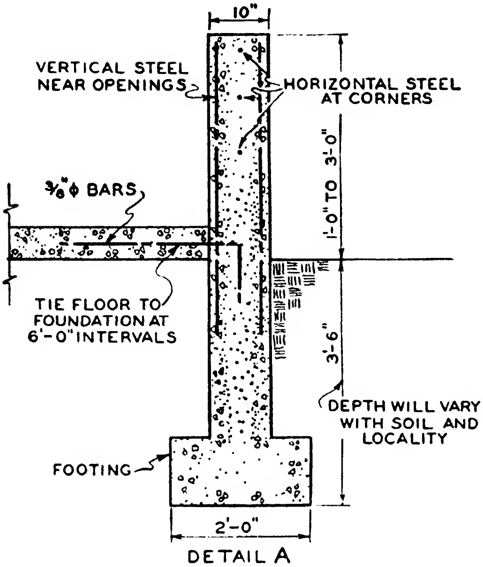


Fig. 3. Floor Tied to Foundation with Steel Rods

and materials together. A brief description in detail of each of the foregoing essentials is given in the following paragraphs.

1. Foundations. A good foundation is essential for any building, not only to carry the weight of the building but also to provide a place to anchor the building securely. In order to construct an adequate foundation for the structure to be erected upon it, the architect or the builder must first study the soil and weather conditions of that particular locality, then build a foundation suitable for that soil and climate, since soil stability is affected by weather conditions. For example, the problem of constructing a foundation for a building on a mesa in New Mexico

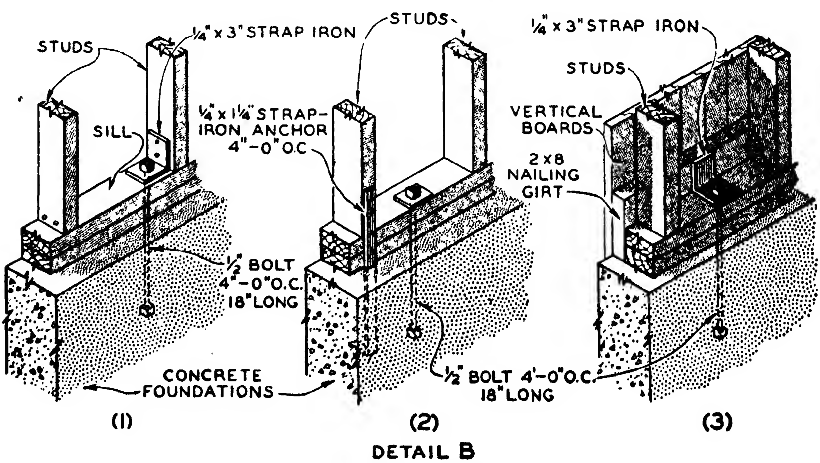


Fig. 4. Three Methods of Anchoring Walls to Foundations

is far different from that of constructing a foundation for a similar building in the Everglades of Florida. In the northern and central regions of the United States, foundations should go below the frost line, if at all possible, to prevent heaving by frost. To be satisfactory the footing must be wide enough to hold the weight of the building and its contents without settling. Steel rods in foundations are good investments and will prevent uneven settling and heaving. See (*A*), Fig. 2, and the detail drawing of this shown in Fig. 3. Note especially the steel rods. This type of construction will also hold foundations together at corners and will tie the walls and floors together. This often prevents cracks in the foundation at this point. Foundations also should be high enough to hold wooden framing members above the ground moisture.

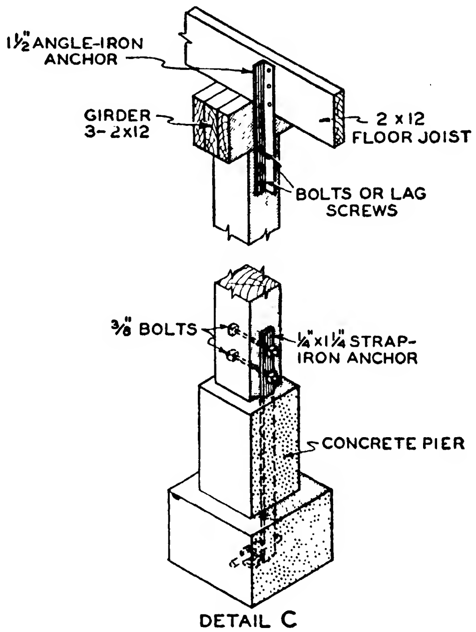


Fig. 5. Joists, Girders, and Posts Anchored to Concrete Piers

2. Wall Anchorage. All surveys of damage done by violent storms have shown that many buildings have been lifted off their foundations by wind. See (*B*), Fig. 2, and the detail drawing of this shown in Fig. 4. Note particularly the three different methods of anchoring buildings to foundations. The method illustrated at (*1*), Fig. 4, shows a heavy piece of strap iron, bent to a right angle, with one leg bolted to the foundation and the other leg bolted to the stud. This makes a simple and effective tie. Another method of using strap iron and bolts for tying the sill to the foundation is illustrated in (*2*), Fig. 4. The third method shown at (*3*), Fig. 4, is to nail vertical or diagonal sheathing directly to the sill which is then bolted to the foundation. This is also a good method.

3. Anchors for Joists, Girders, and Posts. A method of anchoring joists, girders, and posts to concrete piers is shown at (*C*), Fig. 2, and the detail drawing of this is shown in Fig. 5. Note the angle iron used to anchor the floor joist to the girder and to secure the girder to the post. Also note the use of strap iron and bolts to anchor the post to the concrete pier.

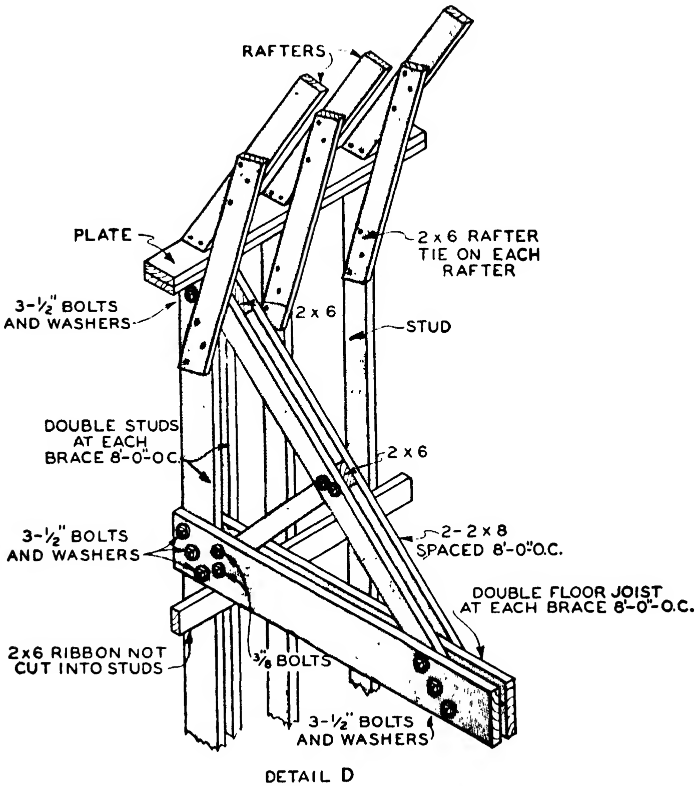


Fig. 6. Bracing Rafters Tied to Side Walls

4. Roof Anchorage. For tying side-wall bracing rafters to the side wall see (*D*), Fig. 2, and the detail drawing of this shown in Fig. 6. To anchor the roof to the walls the usual method of construction is to toenail the rafters to the rafter plate. However, a better method is the use of short pieces of 2x4 or 2x6 in addition to the toenailing. These pieces should be nailed to both rafters and studs as shown in Fig. 6, where 2x6 rafter ties are shown nailed to each stud. Another method of solving this problem is to make the rafter and stud of one continuous member, as, for example, in the laminated rafters of the gothic-roof barn.

5. Rafter Ties. Rafters must be securely tied together where they meet at the ridge or where the two rafters of the broken or gambrel roof join. Wind suction pulls upward and outward on both leeward rafters, thus tending to pull these rafters apart. See (*E*), Fig. 2, and the

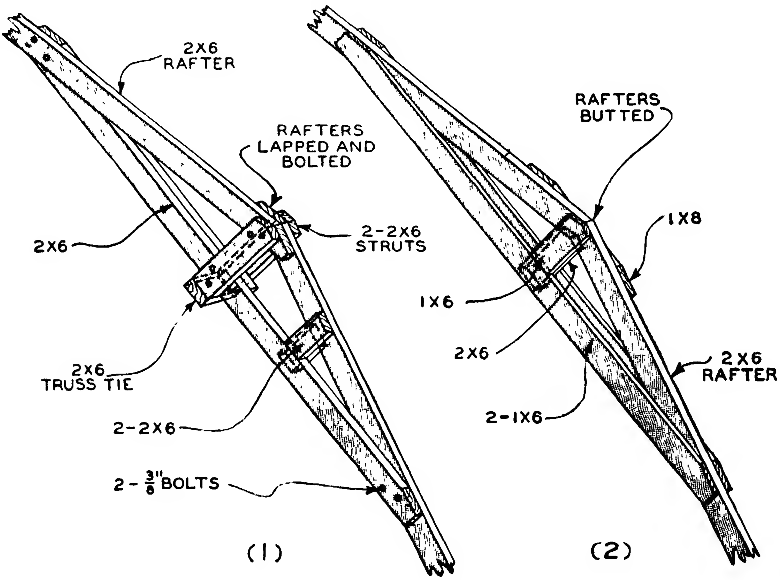


Fig. 7. Two Methods of Construction for Tying Rafters Together

detail drawing of this shown in Fig. 7. Note the two methods of construction. The better method (*1*), Fig. 7, shows the rafters lapped and bolted. Note also the truss tie and the struts. These tend to give stiffness to the member, increasing its wind resistance. The method shown at (*2*), Fig. 7, does not provide as great resistance to wind pressure since the rafters are butted instead of lapped. There are no truss ties and, instead of bolts, nails are used for fastening the materials together.

6. Braces for Side Walls and End Walls. Diagonal braces spaced 8 or 10 feet apart are needed to stiffen the frame against wind loads. In Fig. 6 side-wall braces are shown running down from the wall plates to the floor joist. These braces are necessary and should not be omitted. Such braces do not interfere seriously with the space in the haymow and they do greatly increase the rigidity of the entire barn against wind pressures. Note the 2x6 ribbon which helps in supporting the joists. The ribbon should not be cut into the studs because this will weaken the studs at a point where they are carrying an extra load and should never be weakened by cutting. Double studs and floor joists are recommended at the point where each diagonal brace is located. Where the interior arrangement of a barn includes cross partitions, these can be utilized to stiffen the walls by putting in diagonal braces extending down to the floor. See also (*F*), Fig. 2, and the detail drawing of this bracing which is shown in Fig. 8.

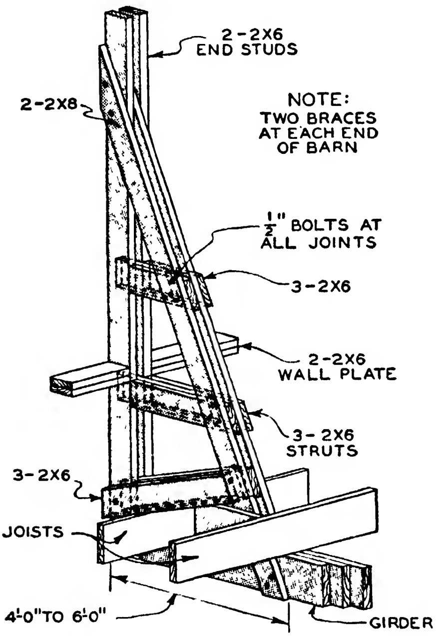


Fig. 8. Diagonal Braces Used to Stiffen Frame of Barn against Wind Pressure

The ends of the barn also need bracing against wind pressures and sometimes also to withstand hay pressure from the inside. A practical method is shown in Fig. 8. Note especially the two 2x8's extending from the double studs about 12 feet above the floor down to the rigid girder which supports the joists. A rigid end-wall brace is provided by the double or triple struts between the main members, all securely bolted together. Note especially the 2x6 struts which stiffen the brace, adding resistance to wind pressures. In the construction of barn roofs, braces are designed not only to stiffen the building to resist wind pressures but also to withstand hay pressure from within.

Fastening of Joints and Materials. A wood frame building is no stronger than its joints. Therefore, a seventh essential of good wind-resistant construction is the need for stiff joints between the framing members. Unfortunately for the good of barn frames, the nailed joints so commonly used are the weakest of all ordinarily used methods of joining structural lumber. Better results can be obtained by using one of the following methods of securing joints: (1) glued and nailed joints; (2) bolted joints; (3) glued and bolted joints; (4) split-ring connectors with bolts; and (5) toothed-ring connector with bolt.

All of the foregoing methods for joining materials have been explained previously in the chapter on "Wood Fastenings," *Fundamentals of Carpentry,* Volume I.

BARNS

Next to the house, the barn probably is the chief building on the average farm. In addition to housing the livestock, the barn usually provides space for a vast amount of feed for the stock. In planning for this important farm building several factors must be considered.

1. Floor Plan. The inside arrangement, or floor plan, of a barn must meet the requirements of the livestock which the building will shelter. These requirements will depend upon the kind, number, and size of the animals; the methods used for feeding the stock; and the method to be used in removing litter and such like. The size of a barn is determined largely by the extent of its use. See Table I for size of cow stalls commonly used.

TABLE I. DIMENSIONS OF COW STALLS*

Breed	Approximate Weight, Lbs.	Length of Stall	Width of Stall
Ayrshire	1,000	4 feet 8 inch.	3 feet 6 inch.
Brown Swiss	1,200	5 feet 0 inch.	3 feet 8 inch.
Guernsey	1,000	4 feet 8 inch.	3 feet 6 inch.
Holstein	1,200	5 feet 0 inch.	3 feet 8 inch.
Jersey	900	4 feet 6 inch.	3 feet 5 inch.
Shorthorn	1,400	5 feet 4 inch.	4 feet 0 inch.

Courtesy, Portland Cement Association.

*These are dimensions commonly employed for average size cows. Stall lengths for large cows may be increased three inches; for small cows, decreased three inches. Heifers require stalls about three feet wide and four feet long.

2. Storage Space. Provision for the storage of grain and hay, or other roughage, is governed to a great extent by the shape and construction of the roof. The gothic type of roof, although more expensive to build, naturally allows for more storage space because of its large unobstructed haymow.

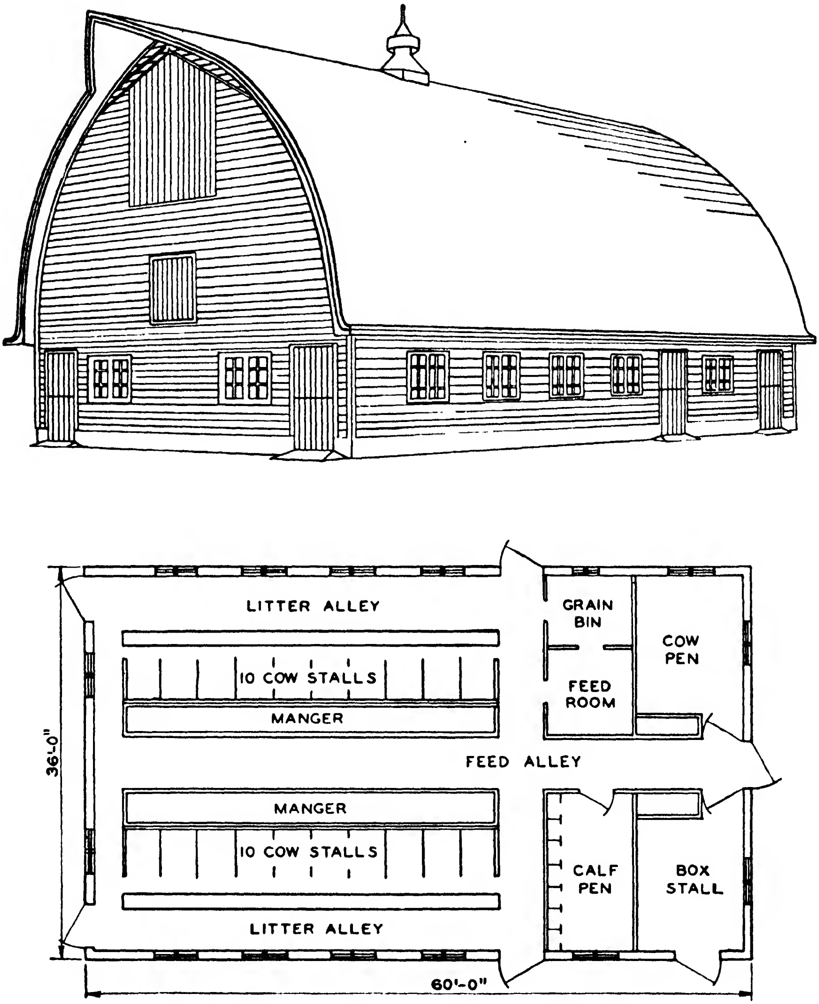


Fig. 9. Gothic-Roof Dairy Barn and Floor Plan

3. Architectural Design. Requirements of the outward appearance, or *architectural design,* of the barn must be given consideration also. The design must meet the practical needs of the owner, harmonize with the other farm buildings, and be structurally sound. The three types of barns considered in this chapter are those most common on American farms today. All three types are structurally sound and are

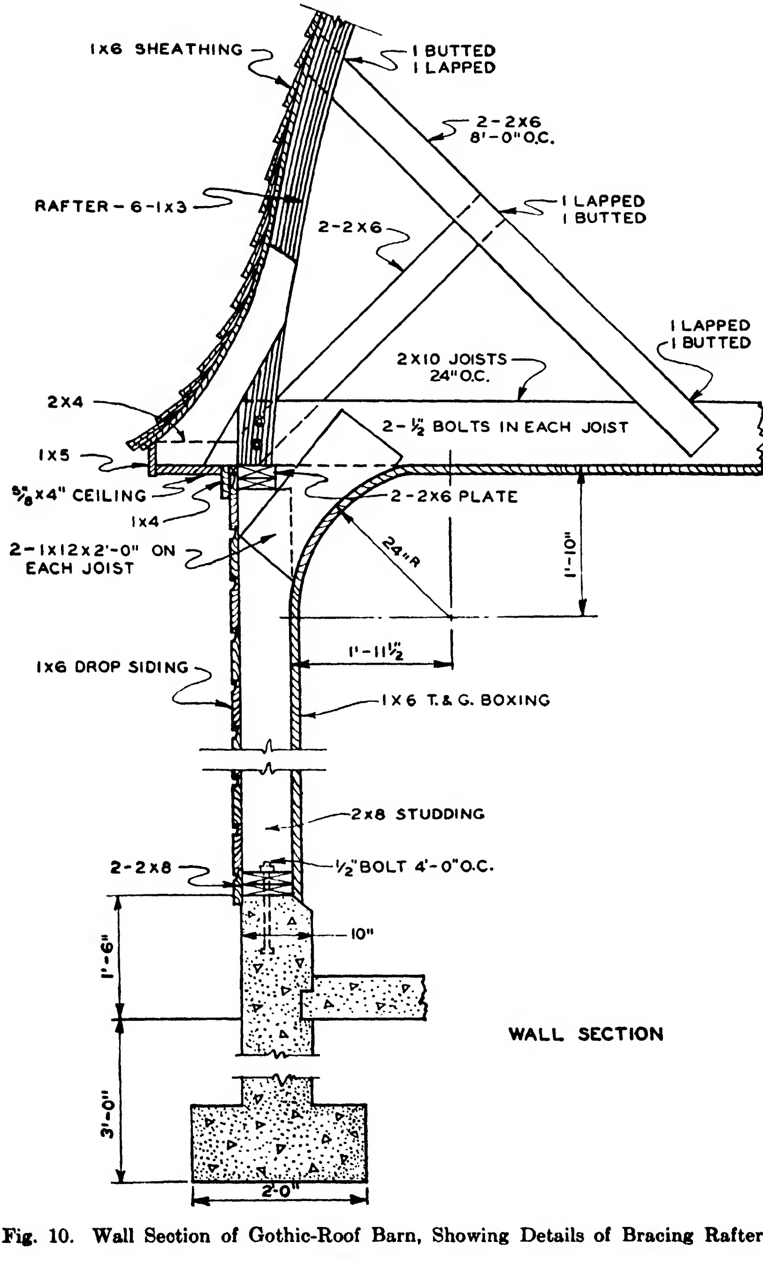


Fig. 10. Wall Section of Gothic-Roof Barn, Showing Details of Bracing Rafters

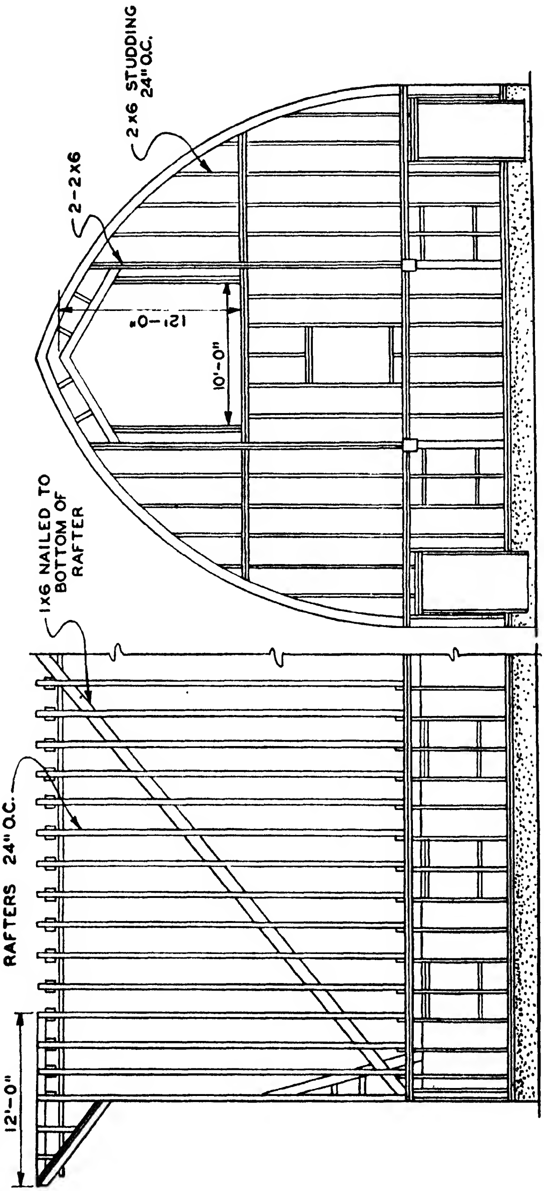


Fig. 11. Framing for Side Wall and End Wall of Gothic-Roof Barn

designed to resist wind pressures. The structural plans of these three types of buildings are intended for barns of 36 feet or less in width. Wider buildings require a different and more expensive roof design to carry the load of wind and hay pressure.

Gothic-Roof Barn. A modern design of dairy barn known as the *gothic-roof barn* is becoming extremely popular. It not only meets the

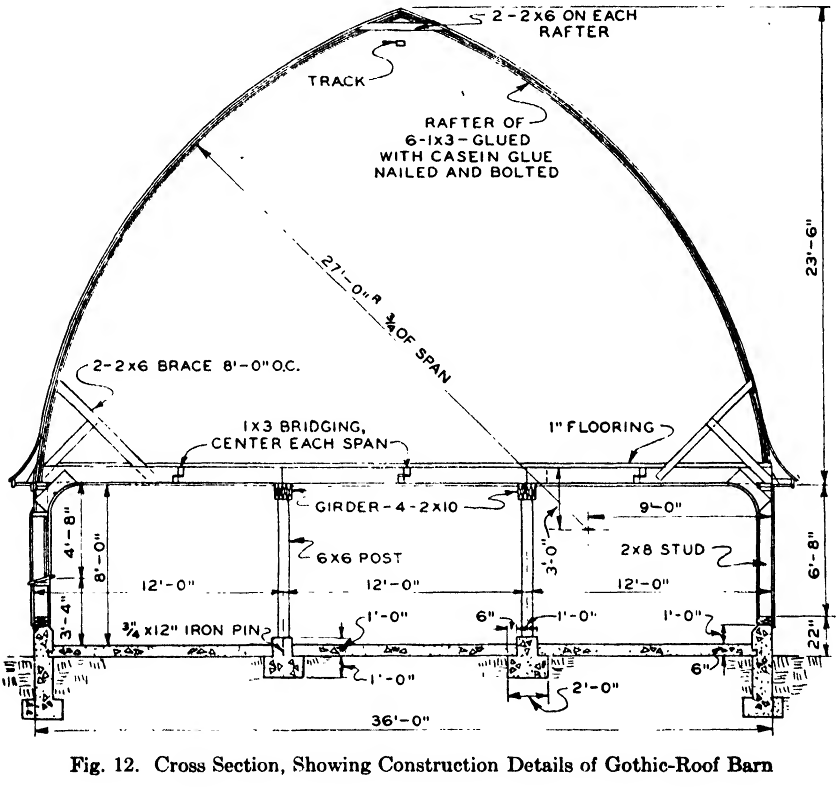


Fig. 12. Cross Section, Showing Construction Details of Gothic-Roof Barn

requirements for utility and good design but also withstands heavy wind loads. It provides comparatively large haymow space, free from obstructions, and permits of a variety of floor arrangements. The curved roof with its laminated rafters requires little bracing within, thus producing a mow with a hay capacity of 60 tons, Fig. 9. The kind and amount of materials required for building this barn are given in the following lists.

MATERIALS

FRAMING LUMBER	AMOUNT REQUIRED
Sills	384 lineal ft., 2x8
Studs, side wall	40 pieces, 14 ft. long, 2x8
Studs, end	8 pieces, 20 ft. long, 2x6
Studs, end	27 pieces, 14 ft. long, 2x6
Studs, end	24 pieces, 10 ft. long, 2x6
Studs, end	356 lineal ft., 2x6
Plates	504 lineal ft., 2x6
Floor joists	31 pieces, 14 ft. long, 2x10
Floor joists	62 pieces, 12 ft. long, 2x10
Girders	480 lineal ft., 2x10
Posts	12 pieces, 14 ft. long, 6x6
Joist braces	120 pieces, 2 ft. long, 1x12
Bridging	360 lineal ft., 1x3
Rafters	12,056 lineal ft., 1x3
Lookouts	186 lineal ft., 1x8
Lookout struts	62 lineal ft., 2x4
Cornice struts	80 lineal ft., 2x2
Collar beams	30 pieces, 10 ft. long, 2x6
Side-wall braces	12 pieces, 12 ft. long, 2x6
Side-wall braces	6 pieces, 14 ft. long, 2x6
Side-wall diagonal braces	173 lineal ft., 1x6
End-wall braces	8 pieces, 12 ft. long, 2x8
End-wall braces	108 lineal ft., 2x6
Hay beam	1 piece, 12 ft. long, 4x8
Sheathing roof	2,890 ft., B.M., 1x6
Mow flooring	2,520 ft., B.M., T. and G., 1x6
Inside boxing	3,000 ft., B.M., T. and G., 1x6 (omitted in mild climates)

FINISH LUMBER	AMOUNT REQUIRED
Verge	124 lineal ft., 1x5
Frieze	124 lineal ft., 1x6
Molding	124 lineal ft., ½″x1¼″
Cornice trim (fascia)	124 lineal ft., 1x4
Cornice ceiling	310 ft., B.M., ⅝″x4″ ceiling
Doors	388 bd. ft., T. and G., 1x6
Door battens	288 lineal ft., 1x8 boards
Door battens	146 lineal ft., 1x6
Door Trim	158 lineal ft., 1x4
Track planks	2 pieces, 12 ft. long, 1x10
Shingles	40 squares (4½ inches to weather)
Drop siding	2,610 ft., B.M., 1x6 drop siding
Windows	33–6 light, 9x10 barn sash
Window trim	330 lineal ft., 1x4
Window trim	232 lineal ft., 1x6
Window trim	42 lineal ft., 1x2
Window sills	60 lineal ft., 2x12

(*Continued on page 377*)

MATERIALS—*Continued*

Corner boards	4 pieces, 14 ft. long, 1x4
Drip cap	100 lineal ft.

HARDWARE AND MISCELLANEOUS MATERIALS

58 pieces	26 gauge wind shield
68 lineal ft.	24 gauge, galvanized iron, ridge roll
56—3/8"x7"	Bolts—end braces
8—3/8"x9"	Bolts—end braces
128—1/2"x5"	Bolts—joists to rafters
48—1/2"x15"	Bolts—foundation
48 pieces 1/4"x1 1/4"x10"........	Strap iron
496—1/4"x5 1/2"	Bolts—rafters
66 lineal ft.	Hay carrier track
20 lineal ft.	Door track
1 only	24" Barn ventilator
32 cu. yds. of concrete	

The various construction details for this barn are shown in Figs. 10–15, and need little additional explanation. A sectional view of the wall is shown in Fig. 10; the side-wall framing and end-wall framing is shown in Fig. 11; the laminated rafters, glued, nailed, and bolted in place, are illustrated in Fig. 12; the frieze sawed to fit curve is shown in Fig. 13; the detail of a wind brace is shown in Fig. 14; a detail of a sill, metal windshield, and a drip cap are shown in Fig. 15; and Fig. 16 shows the detail of a laminated rafter layout. Cold-mixed waterproof glues are recommended for the rafter bents which are made out of six 1x3's nailed and bolted together as shown in Fig. 12 and detail (*A*), Fig. 16. Rafters for the gothic roof are laid out on the floor of the mow in a form as illustrated in Fig. 16.

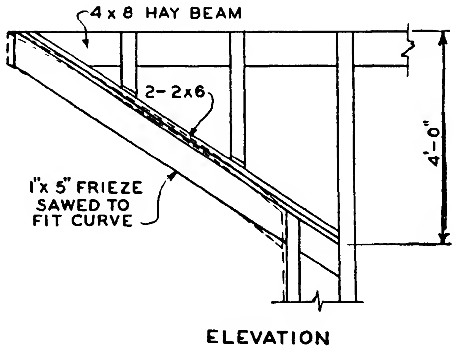


Fig. 13. Detail of a Hay Beam

The Gambrel-Roof Barn. A gambrel-roof barn adapted to general utility purposes is illustrated in Fig. 17. This sturdy, well-designed gambrel-roof barn is of the braced-rafter type. It meets all the requirements of many small farms and can be built at comparatively low cost. Short lengths of lumber can be used and no large or heavy timbers are required. When built accord-

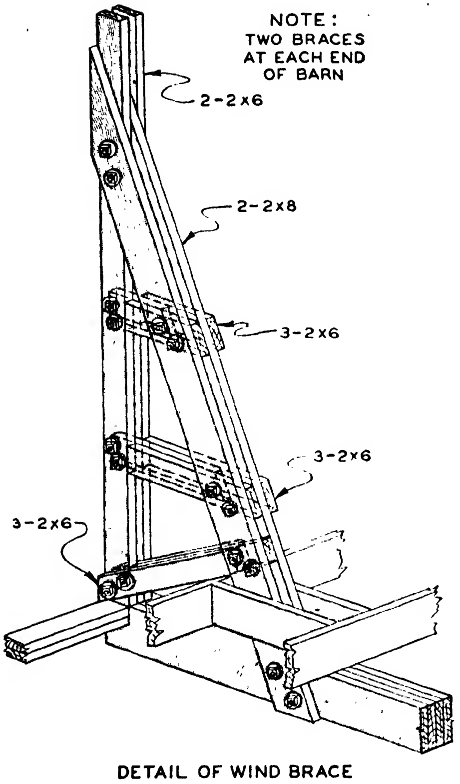


Fig. 14. Detail of Wind Brace on End of Barn Showing Sizes of Lumber Used for Braces and Location of Bolts

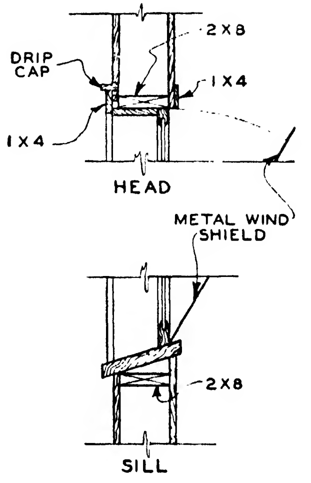


Fig. 15. Detail of Barn Window, Showing Drip Cap, Metal Wind Shields, and Sill

ing to the plans given in this text, this type of barn is easy to construct. It is a durable serviceable structure and will prove to be satisfactory under all normal conditions.

The suggested floor plan shows a compact arrangement of stalls for six cows and three horses, also one box stall and grain bins. Other arrangements can be planned to provide for cows only, for horses only, or for various combinations of cows and horses. This design can be used equally as well on a barn of larger size up to 36 feet in width. However, adapting this roof design to a wider barn will demand longer rafters and larger braces. The sizes of these members must be kept to the same

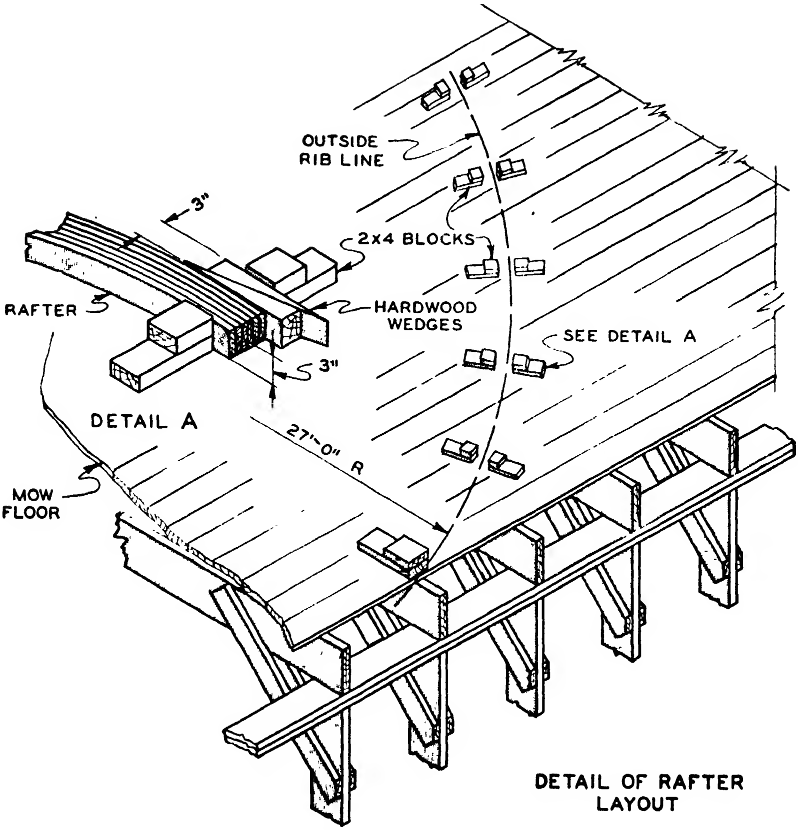


Fig. 16. Detail of Layout for Rafter Bents of Gothic-Roof Barn

proportions as those shown in the cross-section drawing (Fig. 21). The haymow in this 24x32-foot barn has a hay capacity of 15 tons of loose hay.

The framing for the side and end walls are shown in Figs. 18 and 19. The 2x4 lookouts at the eaves are nailed to each rafter at an angle great enough to carry the roof water away from the sides of the barn, Fig. 20. The rafter bents, Fig. 21, are laid out on the floor of the haymow, as shown in the detail drawing, Fig. 22. Point (*A*) represents the peak of the roof. The line (*AB*) equals 12 feet. The line (*BC*) equals 12 feet (½ the width of the barn). The line (*AD*) equals 8 feet, the length of the upper-slope rafter. The line (*DC*) equals 10 feet, the

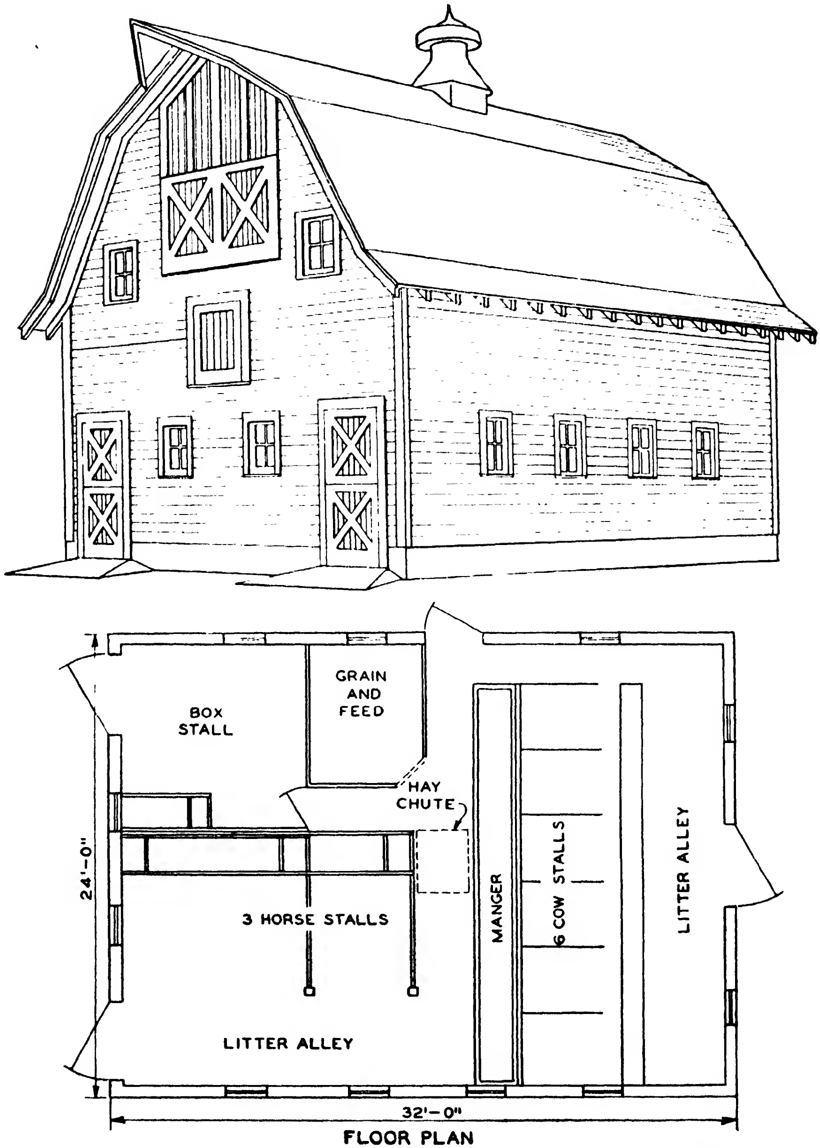


Fig. 17. Gambrel-Roof Barn and Floor Plan, for Cows and Horses

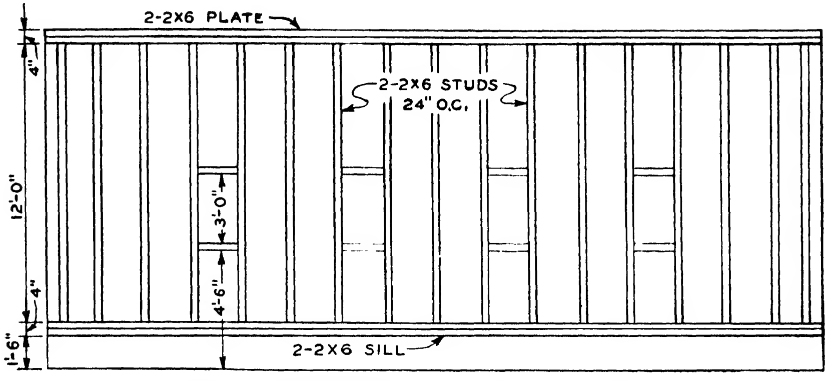


Fig. 18. Side-Wall Framing for Gambrel-Roof Barn

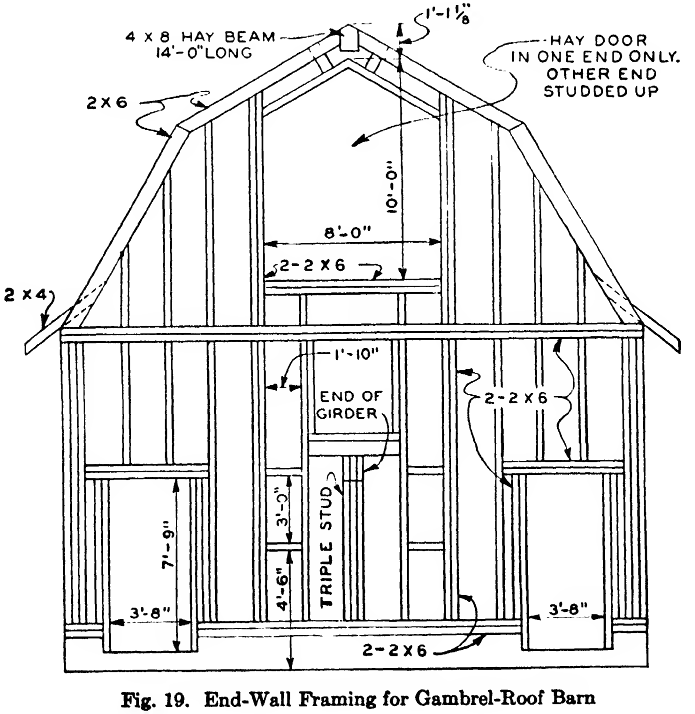


Fig. 19. End-Wall Framing for Gambrel-Roof Barn

length of the lower-slope rafter. The upper and lower rafters are held in place on the floor by 2x4 blocks, as shown in Fig. 22. Note that when laying out the rafter bents, each rafter forms the third side of a right triangle. The rafters of these bents are held together at the joint (*D*) with braces, as shown at (*E*), Fig. 2. The rafters may be nailed together securely or be lapped and bolted, as shown at (*1*), Fig. 7.

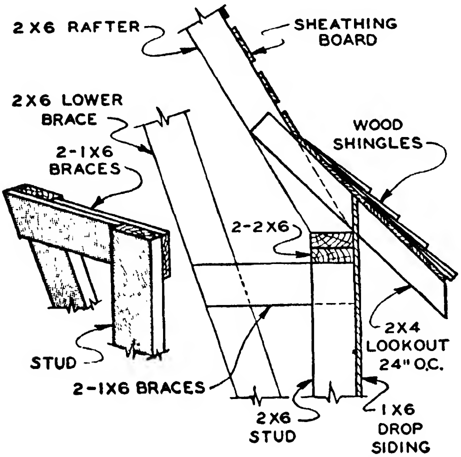


Fig. 20. Detail at Eaves, Showing Lookout and Lower Brace

The kind and amount of materials required for this barn may be estimated approximately by referring to Figs. 18–21.

The Gable-Roof Barn. A *gable-roof barn* is more economical to build than either the gothic or gambrel-roof type. The gable-roof barn shown in Fig. 23 has a high loft with a mow capacity of 15 tons of loose hay. The long rafters of the gable roof, as shown in Fig. 24*(A)*, require a support near the middle to carry the weight of the roof. Note the purlin, consisting of three 2x8's which serve this purpose, shown in Fig. 24*(B)*. The purlin makes it possible to use two pieces of rafter 16 feet and 12 feet in length. These two pieces are cheaper to buy than one stick 28 feet in length. The detail of the ends of the barn framing are shown in Fig. 25. Other details not given here are similar to those for the other two barns previously described.

SMALL BUILDINGS

Other buildings on the farm almost as important as the barn are those that house the machinery, workshop, and small animals, including sheep, hogs, and poultry. Because of the size of these buildings, which are usually small, the farmer is apt to build them himself.

Gable Implement Shed and Workshop. A practical machine shed with a workshop and space for two cars is illustrated in Fig. 26. The construction is simple. Trusses carry the weight of the roof, permitting large floor space without supporting posts. The absence of such posts allows for free movement of machinery. The simple truss construction and other details are illustrated in Fig. 27.

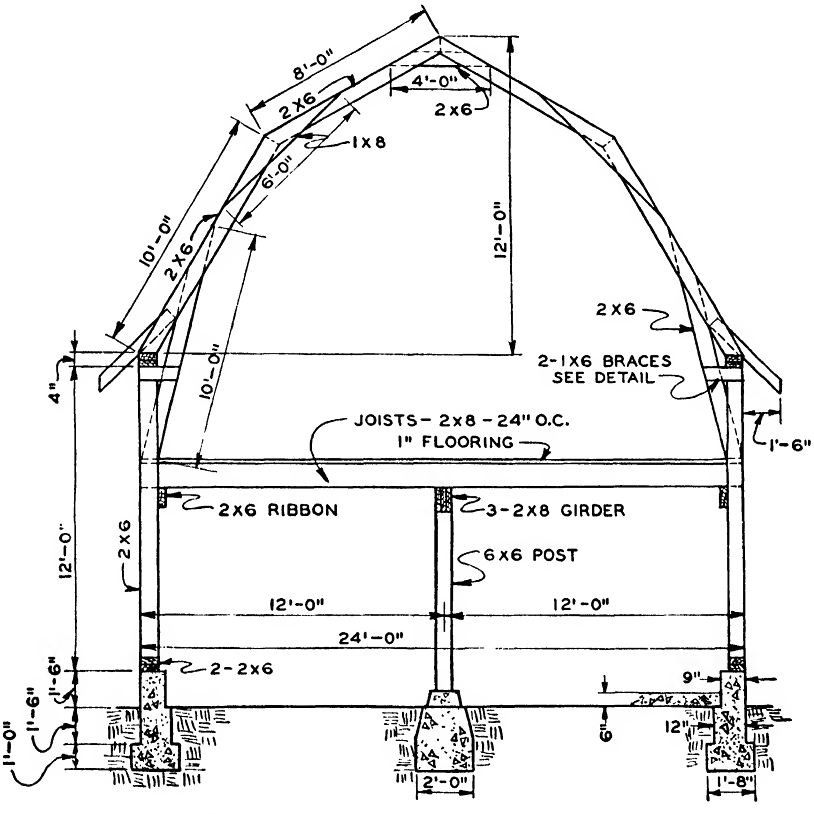


Fig. 21. Cross Section of a Gambrel-Roof Barn

Hangar-Type Implement Shed. Designed to give a large unobstructed floor space with its unbroken curved roof extending almost to the ground, the *hangar-type implement shed* resists strong winds effectively. This type of implement shed is illustrated in Fig. 28. The rafter bents, constructed like those of the gothic-roof barn, are curved ribs made out of six 1x2's glued and nailed or bolted together, as shown in Fig. 29. The rafter bents extend from the foundation to the ridge of the roof with the upper straight portion supported by a truss of simple design, as shown in Fig. 30. Wood shingles cover the curved walls and roof. For the various pieces of equipment usually housed in an implement shed see Table II.[3]

TABLE II. DIMENSIONS OF VARIOUS FARM EQUIPMENT ITEMS

	Feet		Feet
Automobile	7x16	Hay loader	10x12
Binder	8x15	Manure spreader	7x12
Corn binder	7x10	Mower	5x 8
Corn cultivator (one row)	5x 6	Potato digger	5x 8
Corn cultivator (two row)	6x10	Rake	6x12
Corn planter	6x 6	Side-delivery rake	8x12
Disc harrow	5x 9	Silage cutter	7x 8
Gang plow	6x 8	Sulky plow	5x 7
Grain drill	6x12	Tedder	6x10
Harrow	4x 6	Tractor	7x14
		Wagon	7x14

Hog Houses. There are two types of hog houses in common use among farmers. These are the *community hog house* and the *portable hog house.* The community hog house is sometimes spoken of as a *central hog house* and the portable type is sometimes referred to as an *individual hog house.* Each type has its particular advantages,

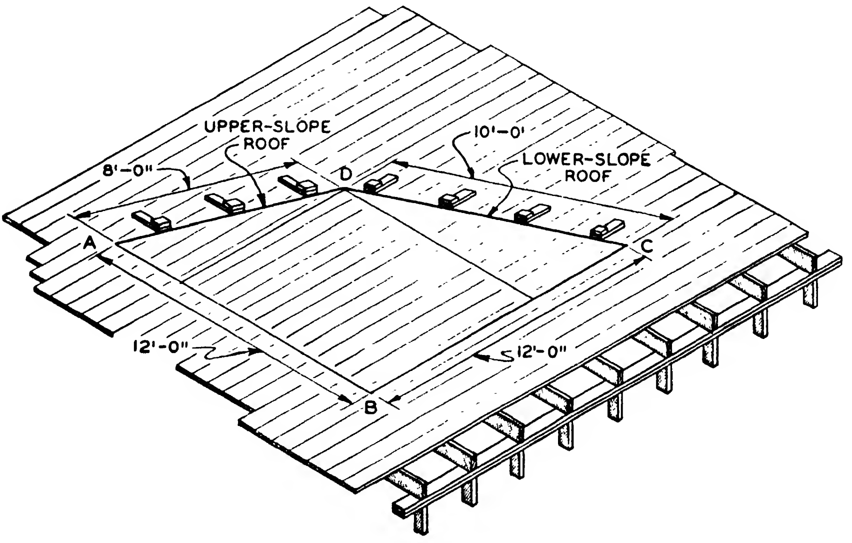
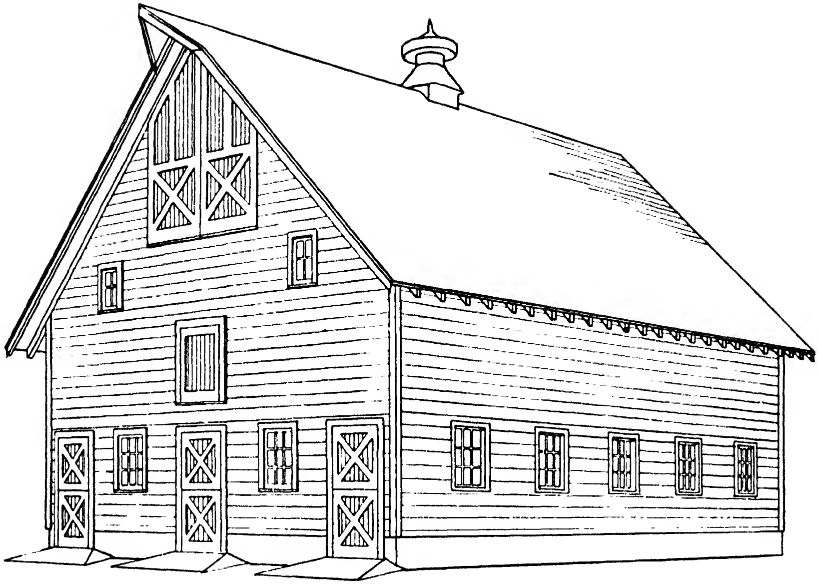


Fig. 22. Detail Drawing of Layout for Rafter Bents for Gambrel-Roof Barn

[3] Figures given in Tables II and III were provided by the Portland Cement Association.



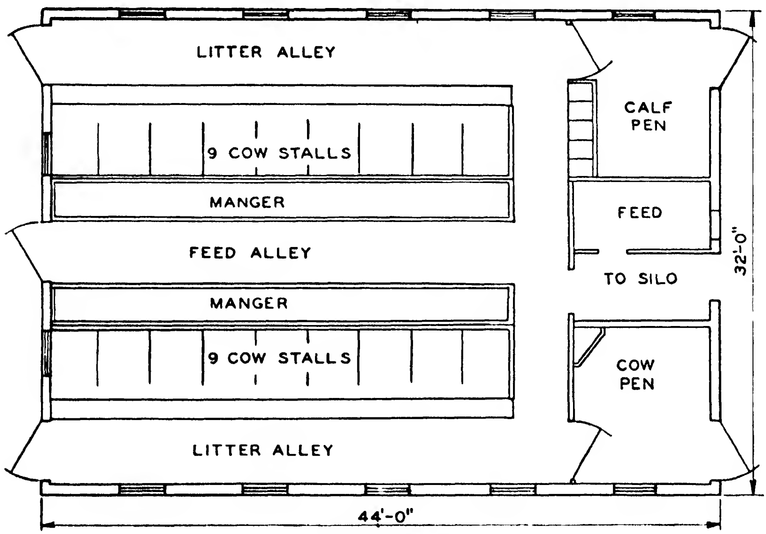


Fig. 23. High-Loft Gable Barn with Floor Plan

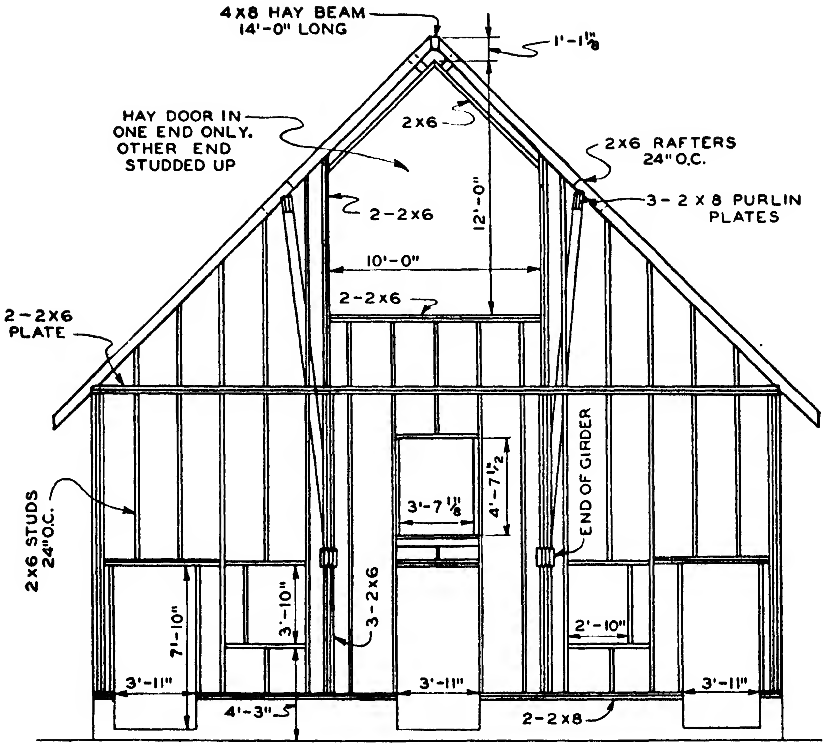


Fig. 24 (*A*). End-Wall Framing for Gable-Roof Barn

though swine authorities usually recognize the greater possibilities for health in the portable hog house, which can be kept clean more easily than the community hog house. However, the community type has

TABLE III. SIZES OF FLOORS FOR HOG HOUSES

Number of Hogs	Minimum Sq. Ft. Floor Required
15	150
30	300
60	600
120	1200
150	1500

the advantage of requiring less time to care for farrowing sows, since the water supply, feed storage, and equipment can be conveniently located. Also, this type of house can be kept warmer than the portable type, a highly desirable feature when sows farrow during the cold

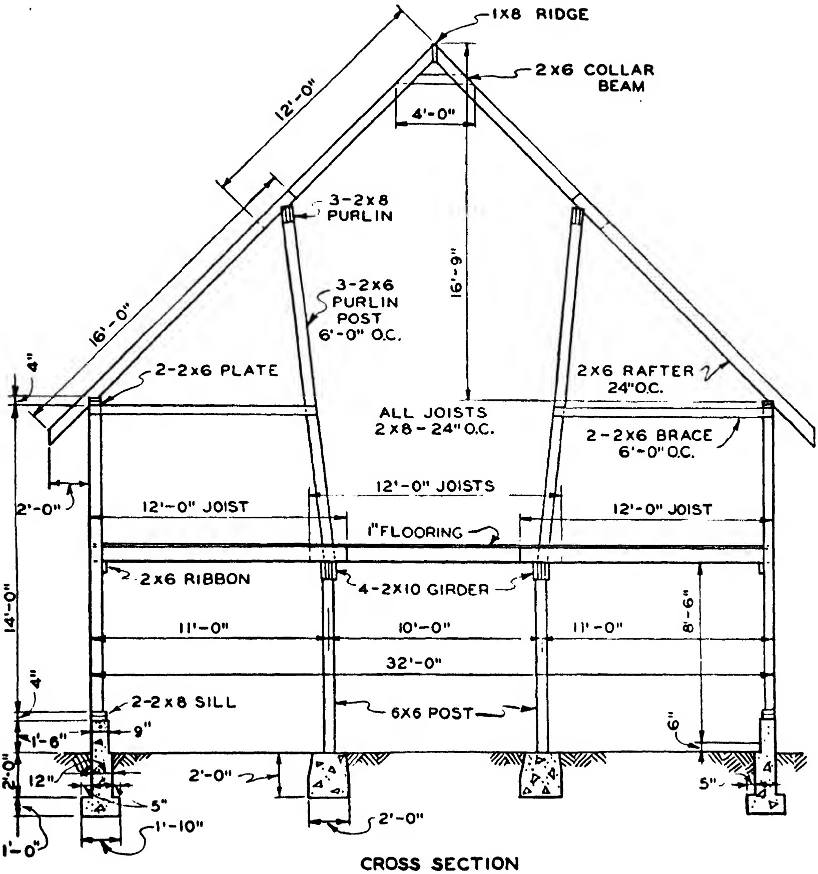


Fig. 24 (*B*). Cross Section of Gable-Roof Barn, Showing Purlin and Purlin Posts

months of late winter and early spring. If the farmer prefers the community hog house, it should be located where it will have proper soil drainage and be protected in cold climates by a windbreak. The windbreak may be provided by natural conditions; for example, building the hog house on the leeward side of a hill. Such a location also affords good drainage. Trees and shrubbery provide a suitable windbreak, or this may be afforded by other and larger farm buildings. If the community hog house is designed with a feeding alley between two rows of pens and with removable or hinged partitions between adjoining pens,

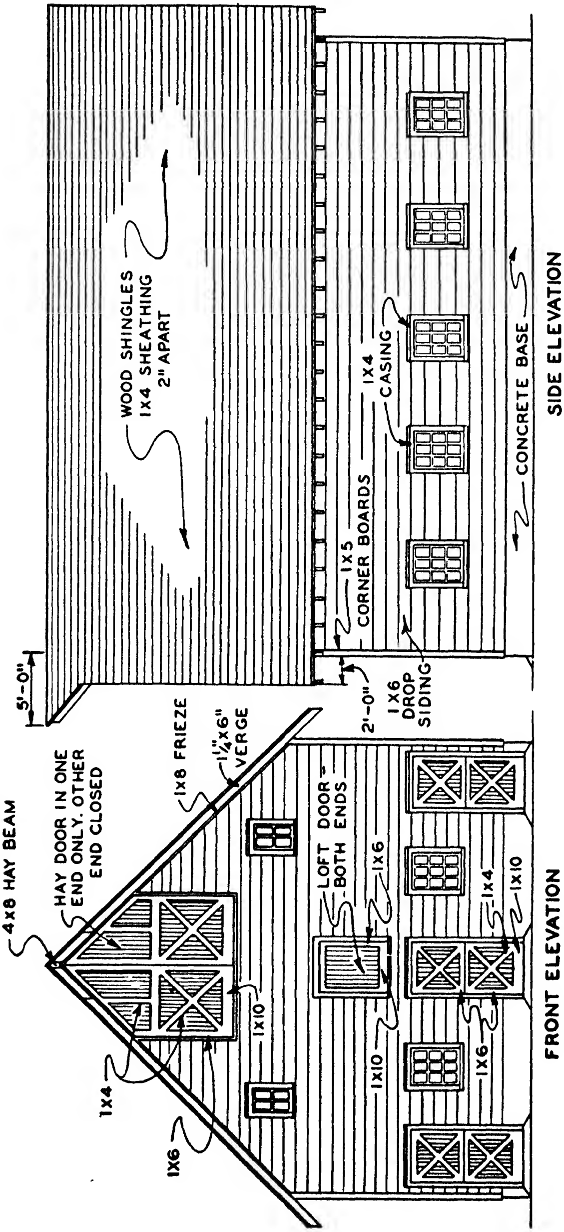


Fig. 25. Front and Side Elevation of Gable-Roof Barn

the house can be used for sheltering and fattening hogs when it is not needed for sows and their litters of pigs. A guide for building the proper size of hog house to suit the housing needs of hogs on the average farm is given in Table III.

1. Community Hog House. Two types of community hog houses are shown here, the *gable-roof hog house* and the *half-monitor hog*

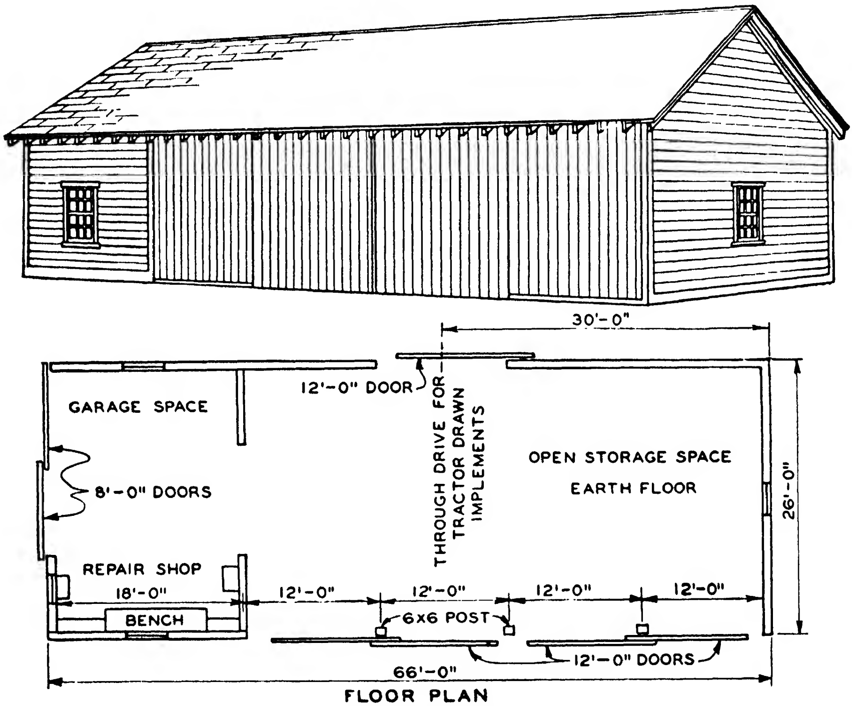


Fig. 26. Implement Shed and Workshop with Floor Plan

house, Figs. 31 and 32. Both types are designed especially for simplifying the handling and proper care of hogs. Concrete footings, foundations, and floors are recommended for community hog houses.

a) Footings, Walls, and Sills. Footings should be from 6 to 8 inches in depth, from 12 to 16 inches in width, and should be placed below frost line The walls of the community hog house should be low, to insure warmth for the sows and their litters of pigs. Studdings of 2x4's spaced 24 inches on center (O.C.) are suggested. Double construction is especially advisable to give warmth and strength to the building.

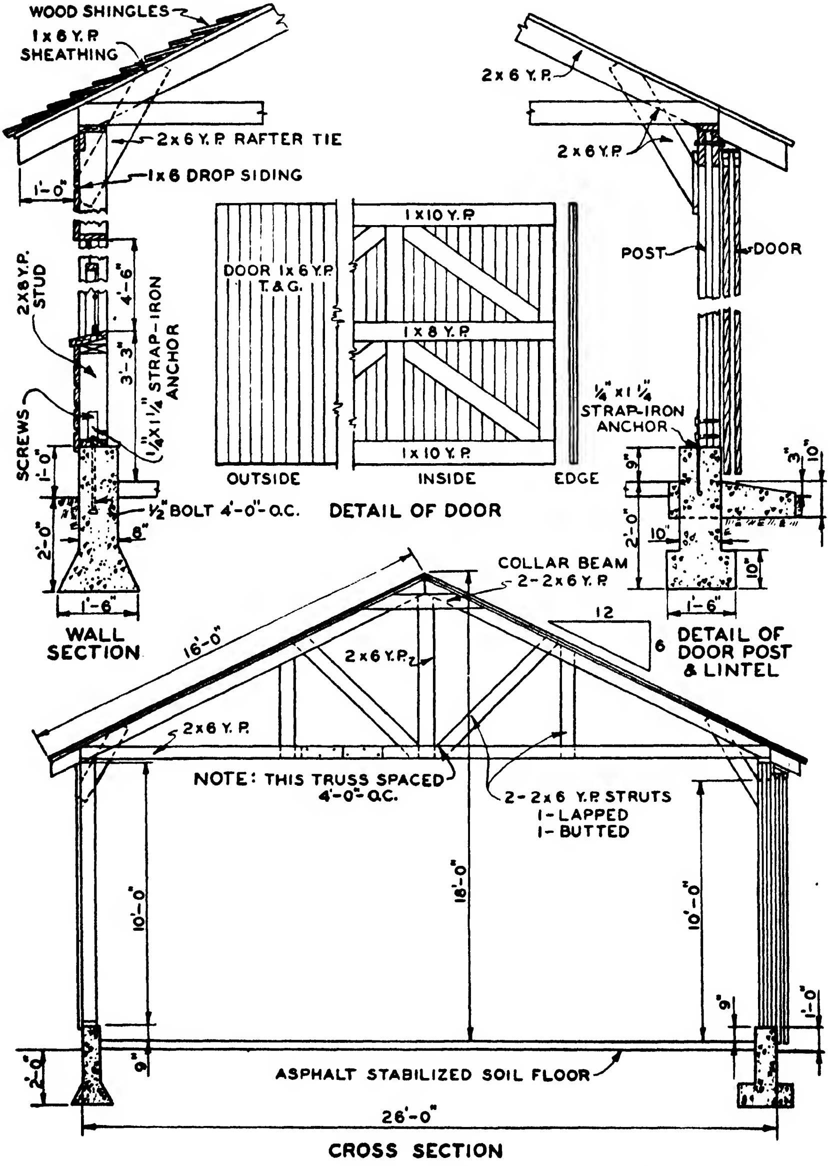


Fig. 27. Cross Section of Workshop, Showing Detail Construction

MATERIALS FOR GABLE IMPLEMENT SHED AND WORKSHOP (Figs. 26 and 27)

FRAMING LUMBER	AMOUNT REQUIRED
Sills	96 lineal ft., 2x6
Studs	75 pieces, 10 ft. long, 2x6
Studs, gable	92 lineal ft., 2x6
Posts	12 pieces, 10 ft. long, 2x6
Plates	254 lineal ft., 2x6
Lintels	10 pieces, 12 ft. long, 2x8
Lintels	2 pieces, 16 ft. long, 2x8
Lintels	76 lineal ft., 2x6
Rafters	68 pieces, 16 ft. long, 2x6
Rafter trusses	15 pieces, 16 ft. long, 2x6
Rafter trusses	15 pieces, 10 ft. long, 2x6
Struts on trusses	760 lineal ft., 2x6
Collar beams	22 pieces, 12 ft. long, 2x6
Rafter ties	12 pieces, 12 ft. long, 2x6
Sheathing	1,640 ft. B.M., 1x6
Cornice lookout	lineal ft., 2x2

FINISH LUMBER	AMOUNT REQUIRED
Windows	4 6-light, 10x12 D.S.
Window jambs	4 pieces, 12 ft. long, 1x6
Window sills	1 piece, 12 ft. long, 2x8
Window stop	96 lineal ft., 1x2
Window parting stop	48 lineal ft., ½"x¾"
Inside casing	4 pieces, 14 ft. long, 1x4
Outside trim	4 pieces, 14 ft. long, 1x4
Corner boards	8 pieces, 10 ft. long, 1x4
Doors	886 ft., B.M., T. and G., 1x6
Door battens	10 pieces, 12 ft. long, 1x10
Door battens	2 pieces, 16 ft. long, 1x10
Door battens	18 pieces, 12 ft. long, 1x8
Verge boards, rake	4 pieces, 16 ft. long, 1x4
Frieze, rake	4 pieces, 16 ft. long, 1x4
Molding, rake	54 lineal ft., ½"x1¼"
Drip cap	16 lineal ft.
Shingles	22 squares (4½" to weather)
Drop siding	1,630 ft., B.M., 1x6

HARDWARE AND MISCELLANEOUS MATERIALS

Rolling-door hangers	7 sets
Rolling-door track	152 ft.
Foundations	30 —½-inch bolts, 16" long
Strap-iron ties	30 pieces, ¼"x1¼"x10"
Strap iron	4 pieces, ¼"x1¼"x18"
Galvanized-iron ridge roll	68 lineal ft.
Concrete	15 cubic yards

Either Douglas fir or hemlock is the best wood to use for studding, since both of these woods are strong, stiff, light in weight, easy to work, and comparatively inexpensive. For exterior wall covering, 6-inch drop siding is suggested. Western red cedar is desirable for sills, as it is

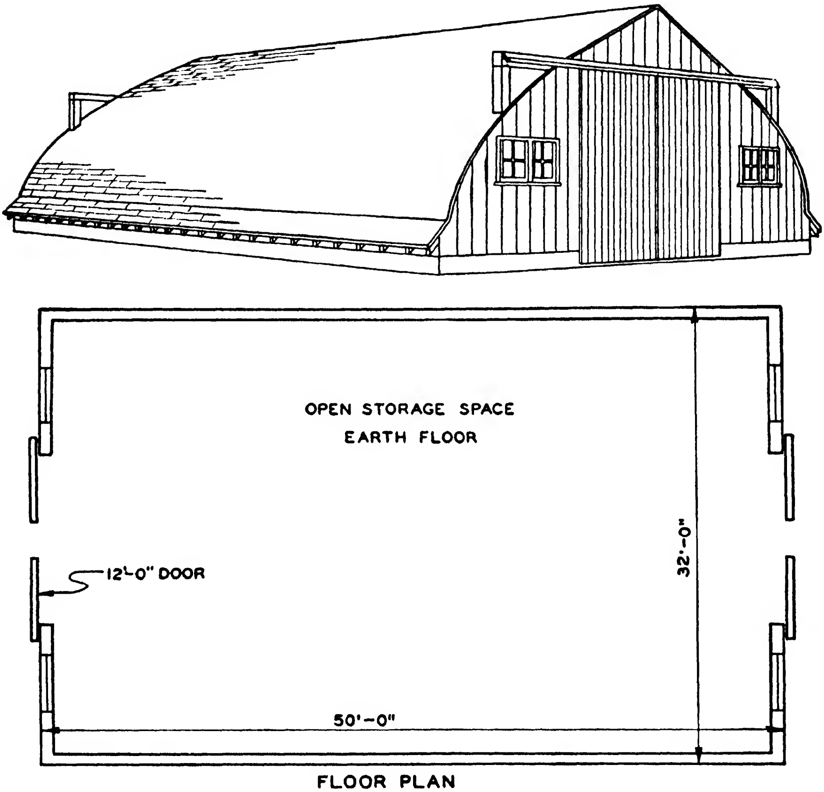


Fig. 28. Hangar-Type Implement Shed with Floor Plan

practically immune to decay because its fibers are saturated with a natural preservative which is resistant to decay-producing fungi. This wood is close-grained, highly resinous, and resists water. Cedarwood also has high durability even under unfavorable conditions, such as contact with moist soil or exposure to weather. It does not require painting, since it will stand up under exposure of the severest kind without auxiliary preservatives. Its advantage for use in hog-house construction is obvious, since red cedar, on account of its natural odor, is repellent to vermin and insects.

b) *Roof.* For the roof of the hog house it is advisable to use 2x4 rafters spaced 24 inches on center and covered with either 1x4 or 1x6

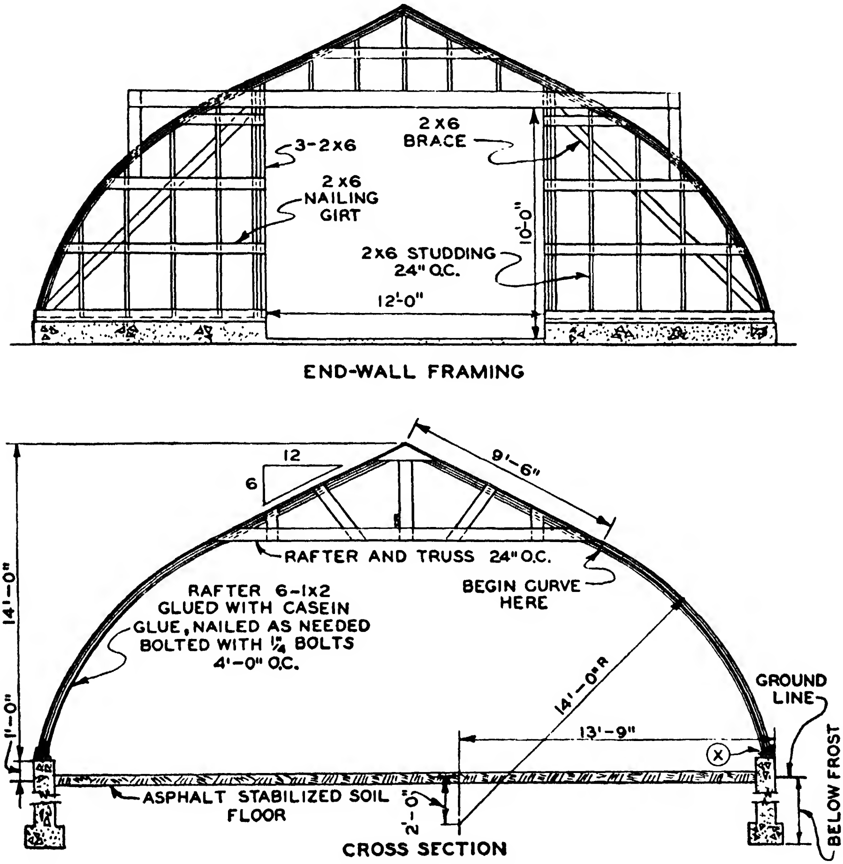


Fig. 29. Cross Section of Hangar-Type Implement Shed, Showing Detail Construction and End-Wall Framing

Douglas-fir sheathing. Red-cedar shingles should be laid 4½ or 5 inches to the weather over the sheathing. This will provide a roof that helps keep the hog house warm in winter, and will also provide protection from heat for the hogs during the summer. Care should be taken in selection of nails. These should be of high quality, such as hot-dipped

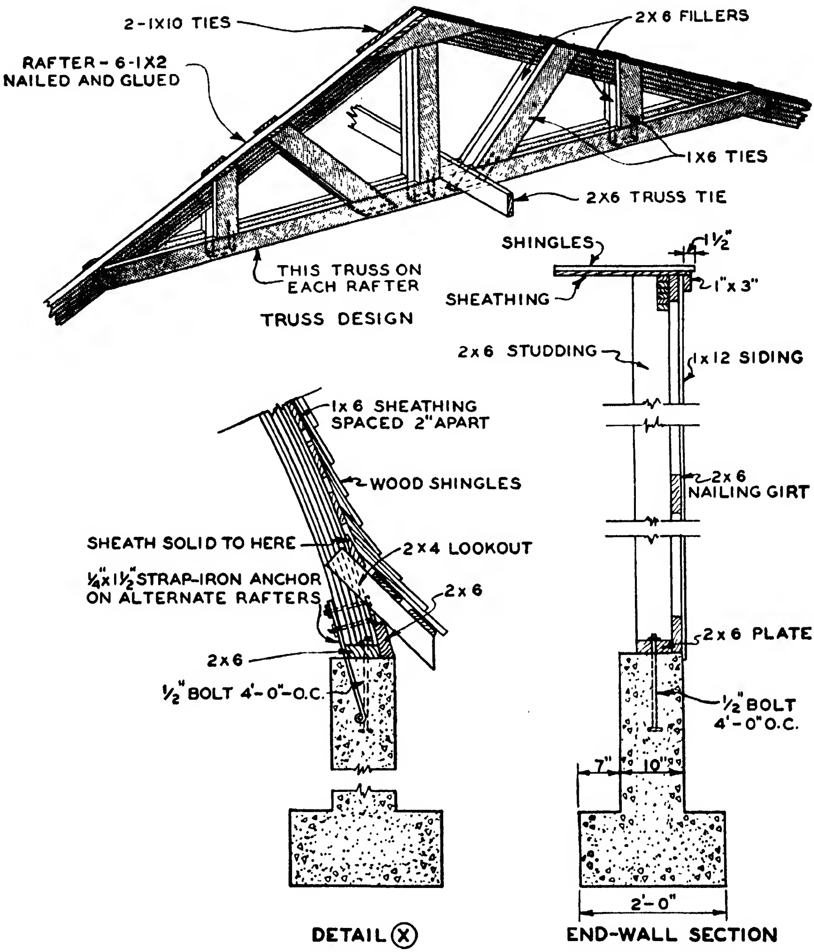


Fig. 30. End-Wall Section of Hangar-Type Implement Shed with Detail Construction Shown at (*X*), and Truss Design

zinc-coated nails or copper nails. Steel nails are not recommended because they rust easily.

c) *Windows.* The size and location of windows in a community hog house are especially important and should be given careful consideration. The greatest amount of floor space possible should be flooded with the sun's rays at farrowing time. The height of the windows

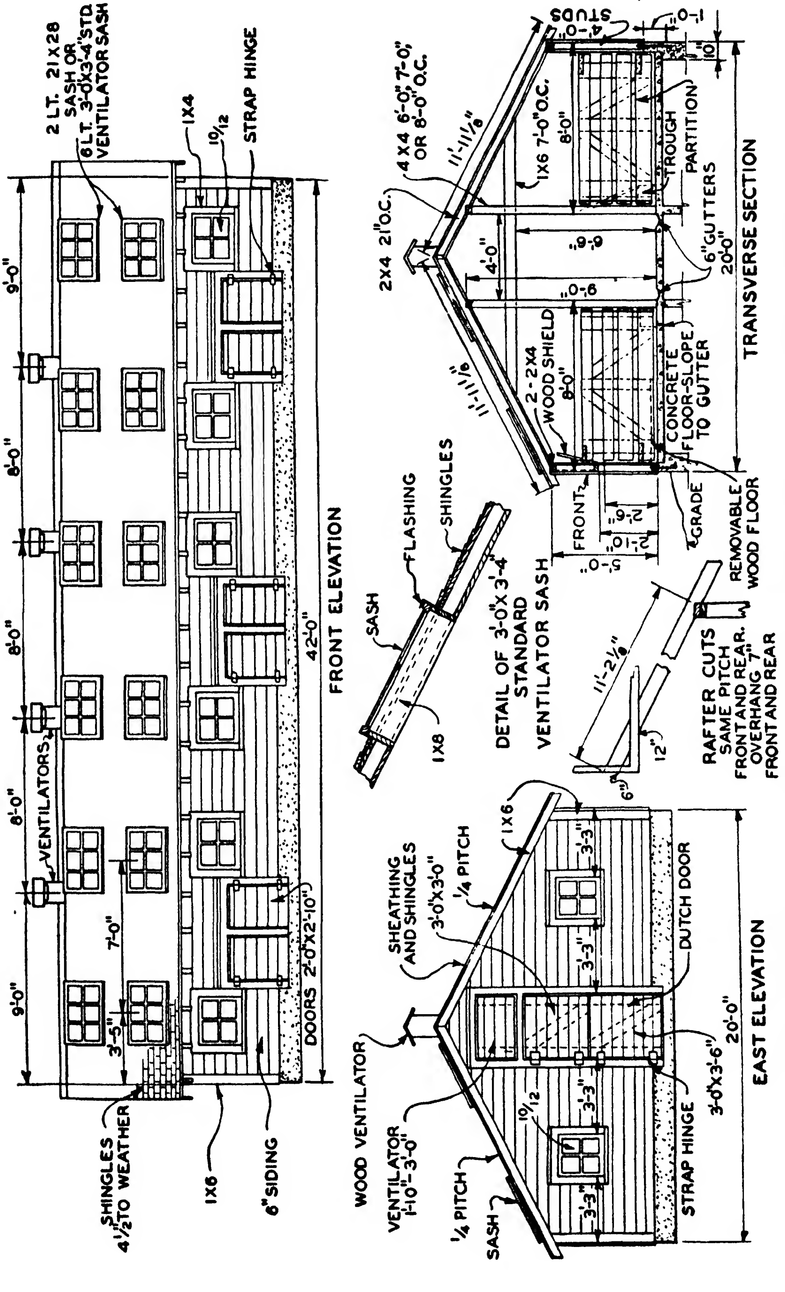


Fig. 31. Gable-Type Hog House, Showing Front and East Elevation, Also Transverse Section

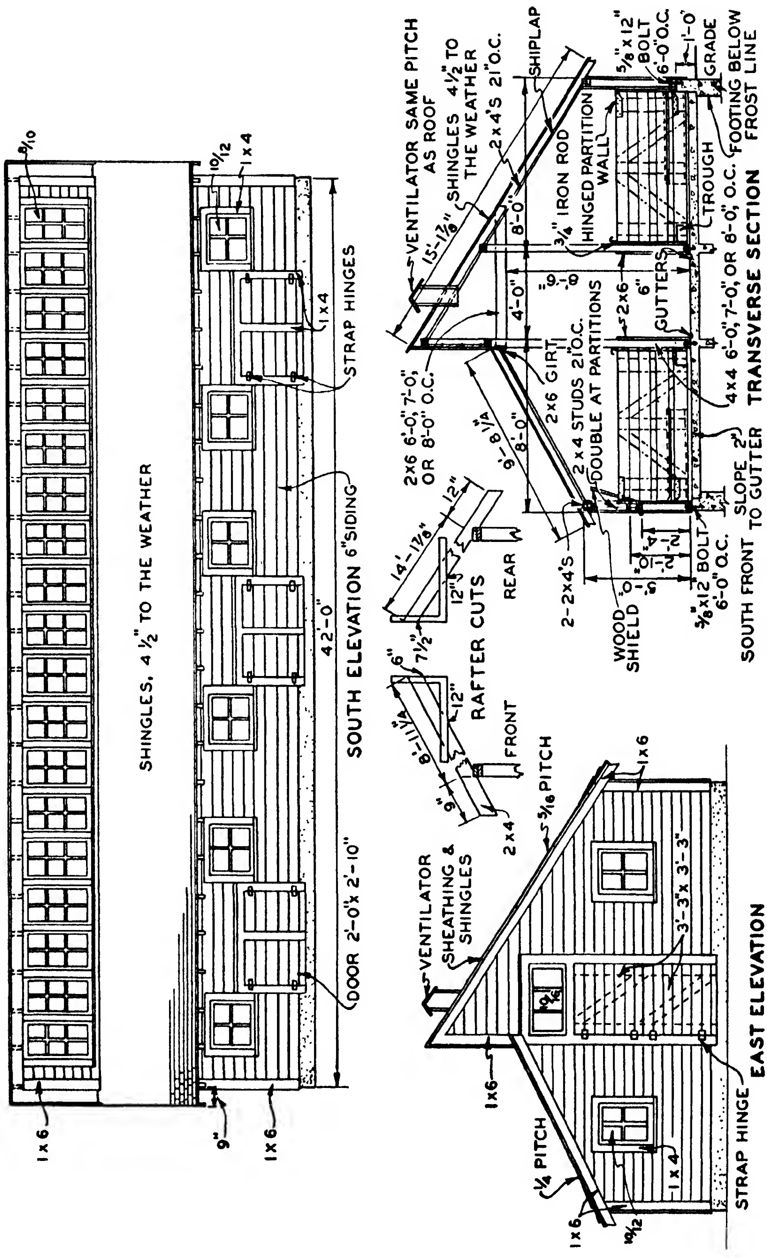


Fig. 32. Half-Monitor Hog House, Showing South and East Elevation, Also Transverse Section

should be determined according to their location and upon the time of year the sows are to farrow, also upon the width of the pens and the width of the feeding alleys. For ventilation purposes, the roof windows should be hinged at the top and fitted with rods so they can be opened by a person standing on the floor of the building. Roof windows should be located so as to give maximum light to the farrowing pens. If the hog house is located on an east-and-west axis, barn-sash windows with four 10x12-inch lights may be used in the south half of the house. Similar windows may be placed also in the end walls.

Each hog house has many windows as shown in the illustrations. These numerous windows permit the penetration of sunlight to every corner of the building. Conventional grouping of the windows, as shown in the drawings, may be changed to suit the needs of the individual owner. Construction details, as well as recommended materials, are given in the drawings, Figs. 31 and 32.

d) *Pens.* The most common pen sizes are 6x8, 7x8, and 8x8 feet. Each pen should contain from 50 to 60 square feet of space. Partitions between pens should be removable to make possible the throwing of pens together for feeding or other purposes when not needed for litters of pigs. Fenders around the inside walls of the pens are advisable since this precaution saves many pigs from being crushed at farrowing time. These guardrails, or fenders, are made of 2x4's placed 8 inches above the floor, with the inner edges 8 inches from the walls to which they are fastened.

2. Portable Hog Houses. There are many types of portable hog houses, but all types are mounted on runners or skids to permit easy transfer from one lot or pasture to another. When necessary to be cleaned, the house can be moved to a new location safely removed from infected rubbish. Thus housed, a brood sow and her litter of pigs are not so liable to be disturbed by other animals nor exposed to contagious diseases. Consequently, the lives of more pigs are saved. The portable type is an advantage to the renter because it affords him the opportunity to provide his own hog house and to take it with him when he moves.

Many desirable features are incorporated in the portable multiple hog house, making it usable all the year round, Fig. 33. The straw loft insures dry pens for use at farrowing time in spring and fall. The

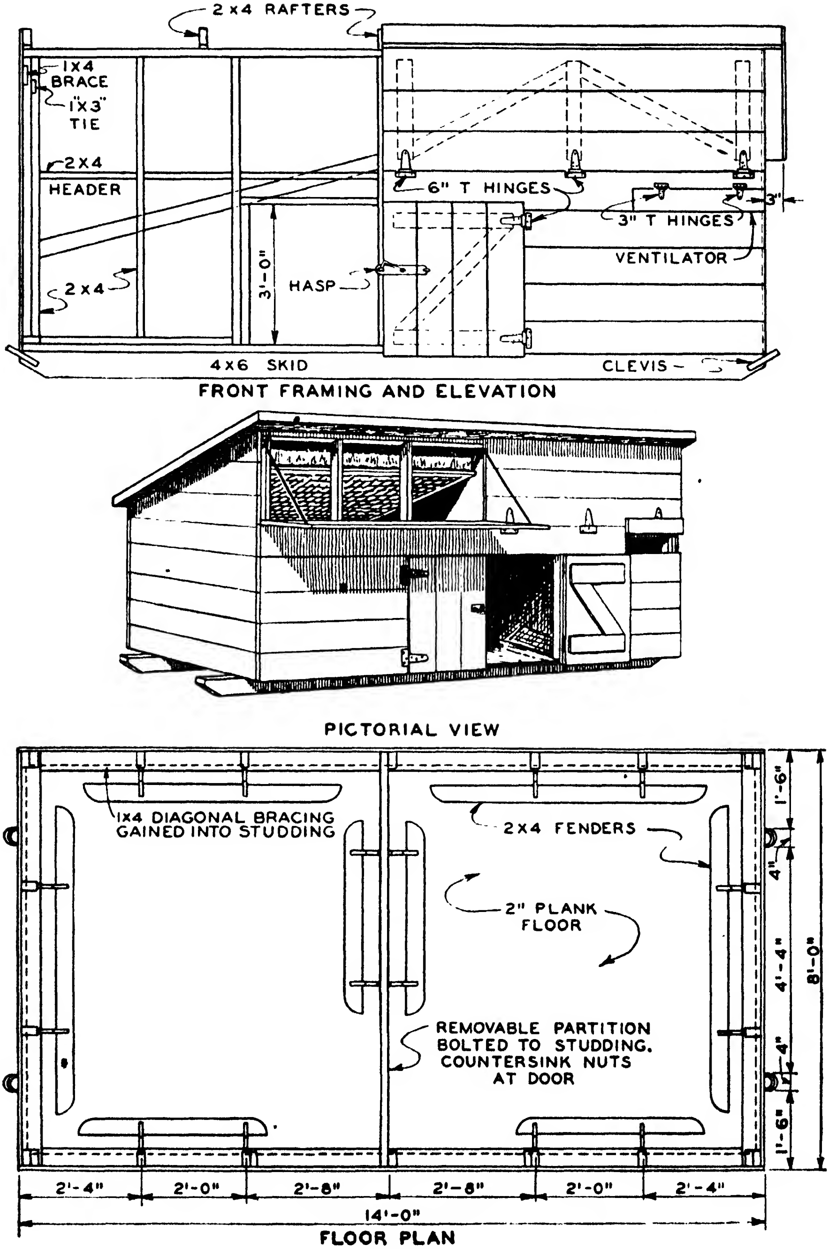


Fig. 33. Portable Hog House and Floor Plan

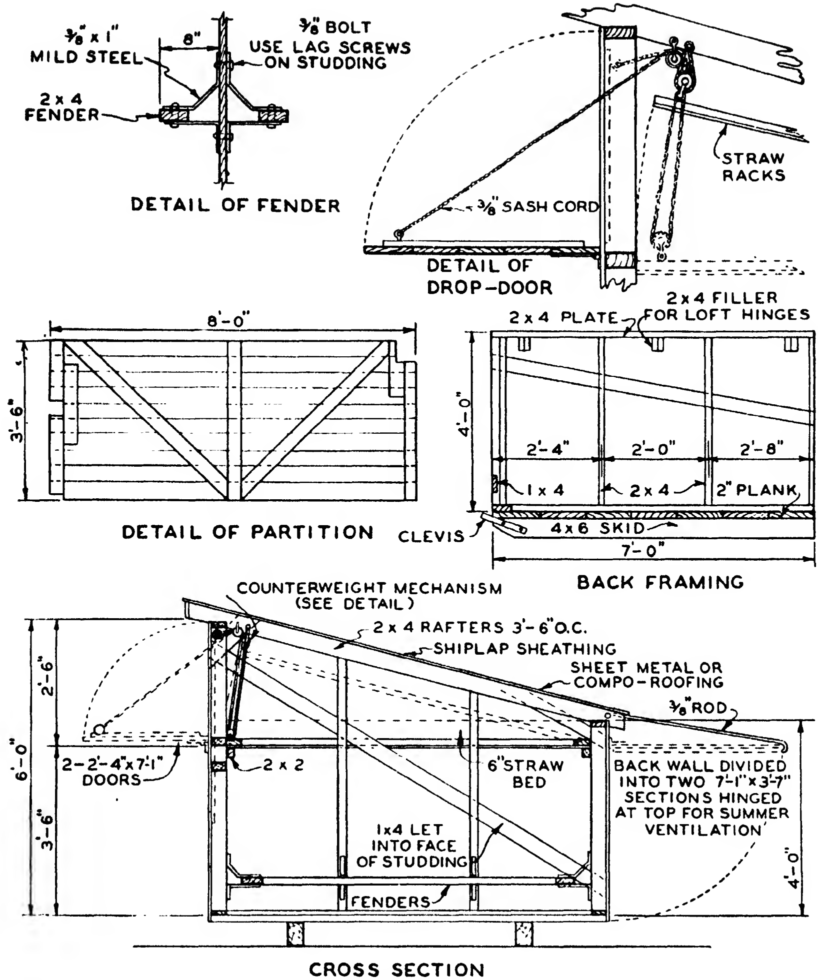


Fig. 34. Cross Section of Portable Hog House, Showing Details of Construction, Including Fender, Drop-Door, Partition, and Back Framing

small doors in front may be opened for ventilation in cold weather. The straw racks are hinged at the rear and counterbalanced by the large doors in front. The racks can be raised out of the way by opening the front doors. For summer use, the partition and fenders may be removed and, when shade is needed, the rear wall sections, which are hinged at the top, can be raised. This feature allows thorough

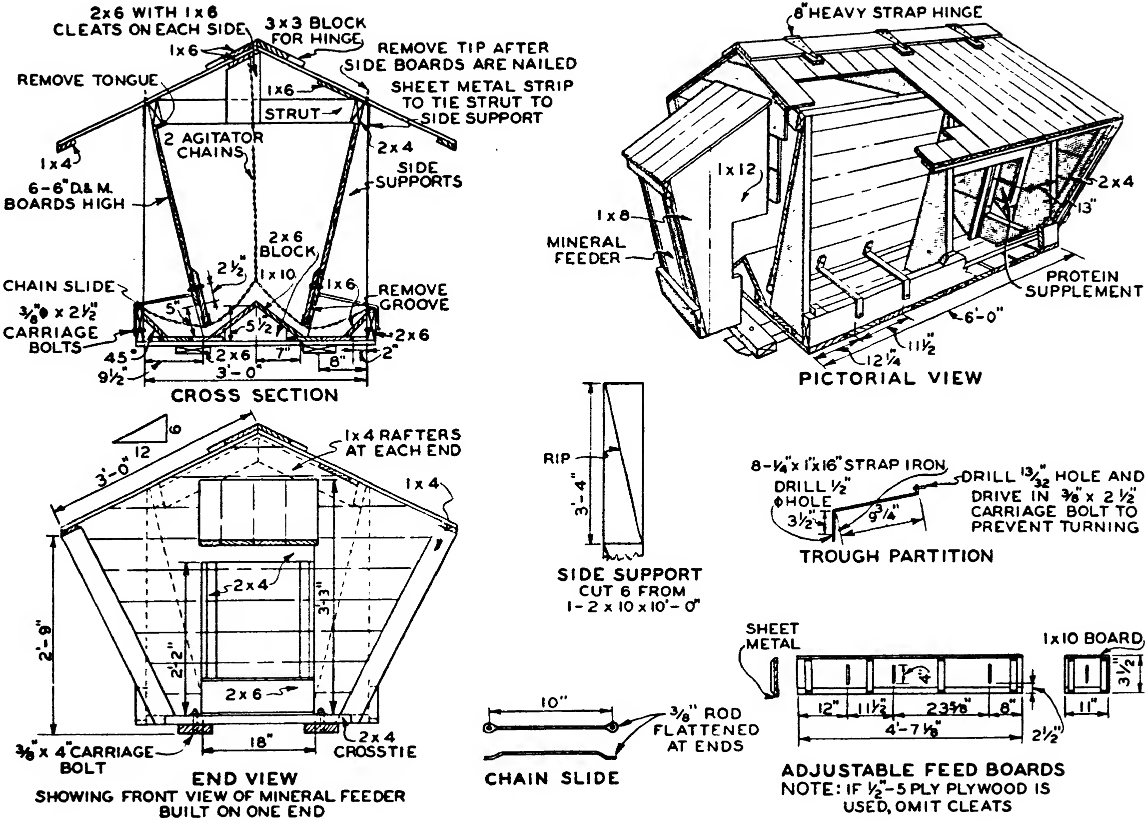


Fig. 35. Outdoor Self-Feeder for Hogs, Showing Cross Section, End View, and Pictorial View

circulation. Furthermore, it makes interior cleaning and disinfecting much easier. Being portable the house can be moved from place to place with little trouble. For these and other reasons portable hog houses should be a part of the equipment of every modern hog farm. Construction details are given in Figs. 33 and 34.

Self-Feeder for Hogs. Many hog raisers prefer the outdoor self-feeder, illustrated in Fig. 35. This type of feeder, with its overhanging roof, is designed to give protection to the feed, keeping rain out of the troughs. If the feeder is to be placed directly on the ground, and not on a feeder floor, 4x4 skids are better than 2x6 skids. For large sows, the feeder must be placed on cross blocks, so the eaves will be high enough to clear the sow's back. Finely ground feed mixtures have a tendency to pack and arch or bridge over in the bin. When there is no whole grain or corn in the feed mixture the use of an agitator chain, similar to the one shown in the drawing, will keep the feed moving downward, preventing arching. A feeder 6 feet long holds 32 bushels of feed. This capacity can be increased or decreased by lengthening or shortening the feeder.

Poultry Buildings. A poultry house that is nearly square in shape not only provides more comfort for laying hens but is also more economical to build. One of the most common and expensive mistakes made by poultry raisers is the crowding of their flocks. Poultry authorities recommend a full three square feet per bird for leghorns and four square feet per bird for heavier breeds. When the ceiling of a henhouse is high enough to permit the caretaker to stand erect and walk about comfortably, it is high enough to meet the requirements of his flock.

A house where hens can live and eat comfortably provides the kind of quarters where they make the best use of good breeding and good feeding, rewarding the owner with a steady and sizable return on his investment. To avoid sudden changes in temperature, the henhouse should be insulated. A poultry house designed for rigorous climates is shown in Figs. 36 and 37. This building has a straw loft providing good ventilation which helps to insure a dry atmosphere, a highly desirable feature for obtaining the best results from laying hens. This type of poultry house, or one similar in construction, will meet the requirements of the average poultry raiser. Both hens and pullets, as

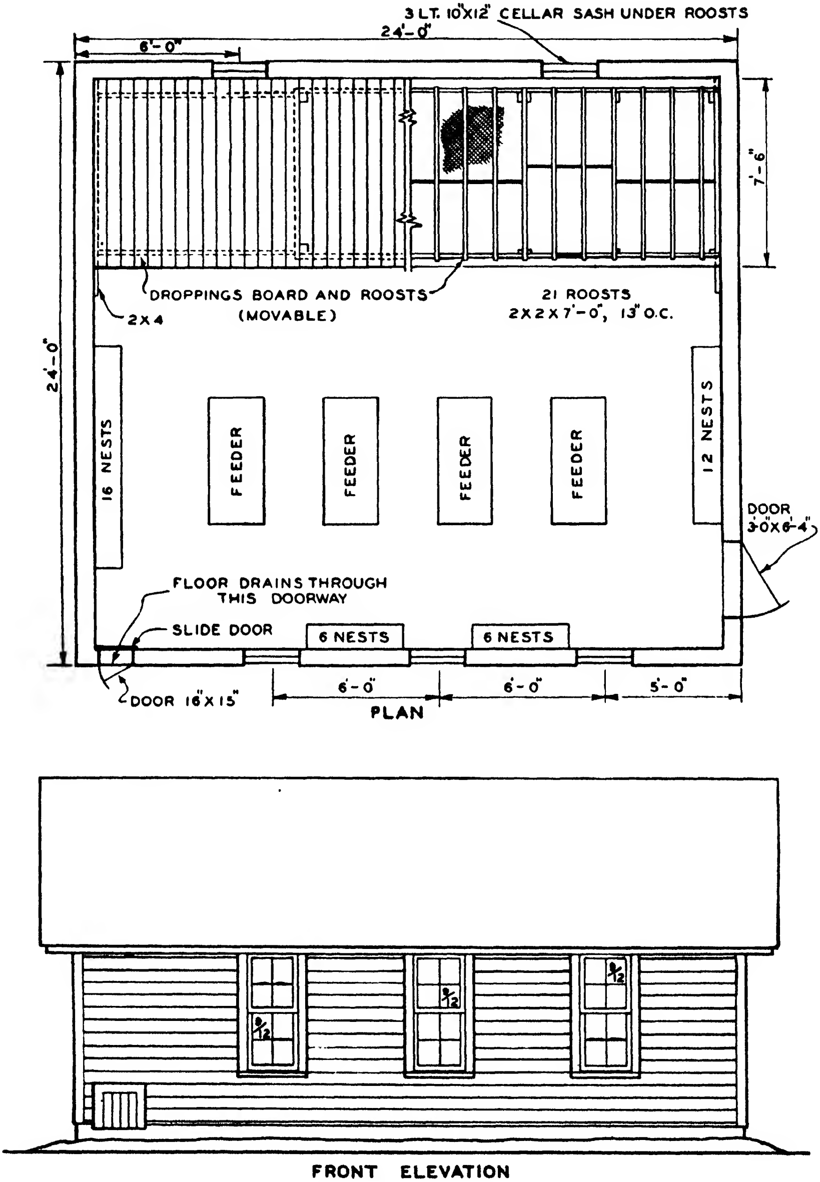


Fig. 36. Poultry House, Showing Front Elevation and Floor Plan

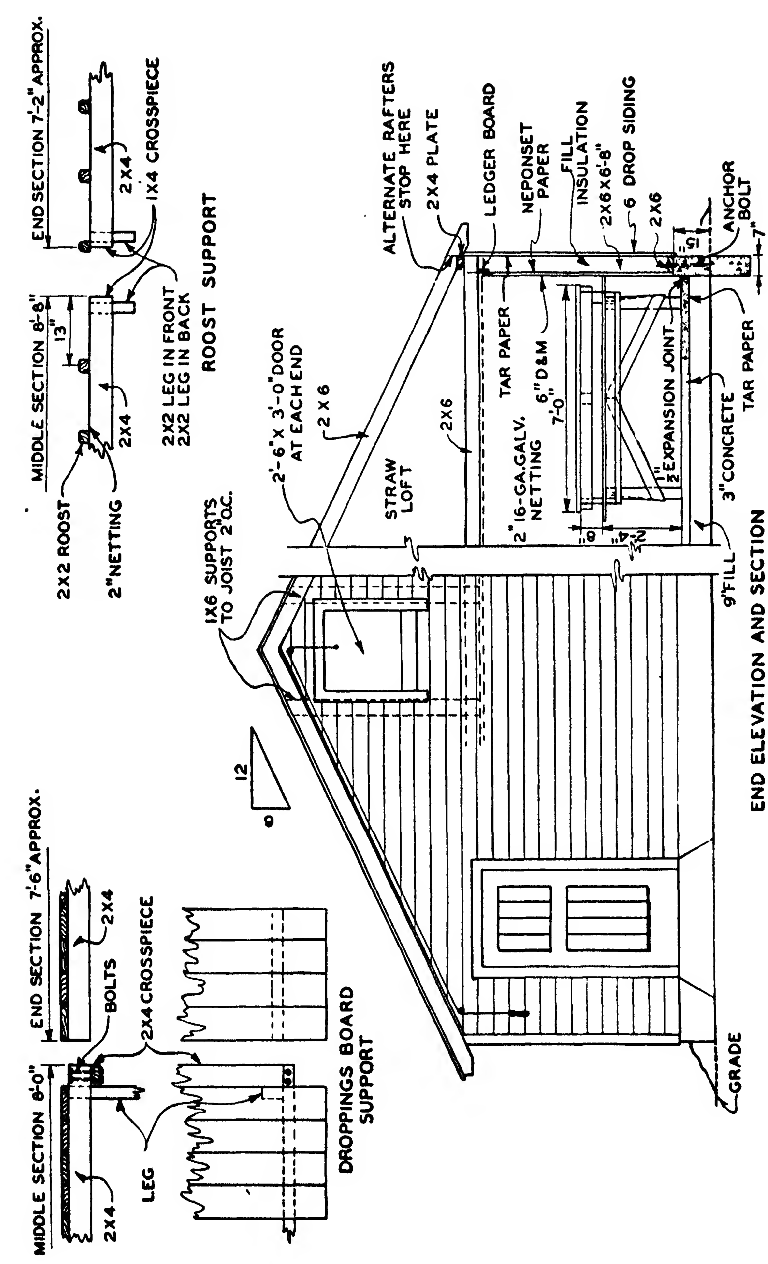


Fig. 37. Poultry House, Showing End Elevation and Detail of Construction

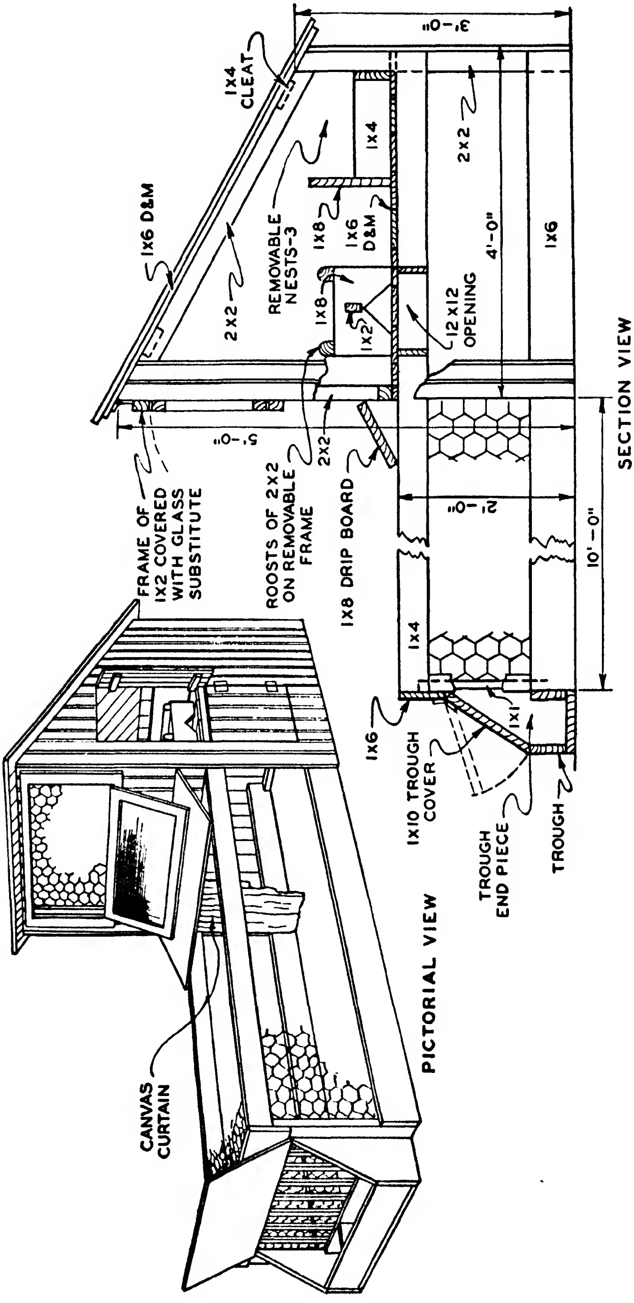


Fig. 38 (*A*). Back-Yard Laying House, Showing Pictorial View and Cross-Section View

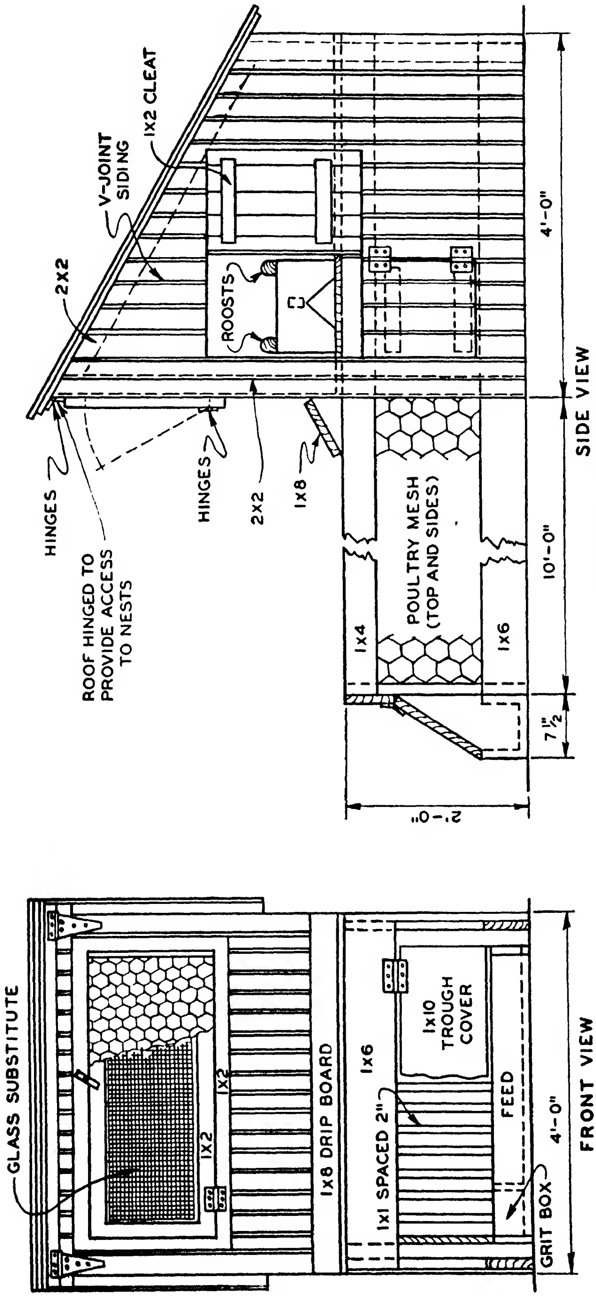


Fig. 38 (*B*). Detail Construction of Back-Yard Laying House

well as heavy and lightweight breeds, lay better when kept in separate pens. The house plan should be arranged so that it can be divided easily into separate pens where such a combination is desired.

Furnishing the Henhouse. Furnishings for the house should be arranged for the comfort of the chickens and the convenience of the caretaker. The roosts should be placed along the entire length of the rear wall. This arrangement keeps the birds out of drafts and provides open working space in front. No more than 7 to 8 inches of roost space should be allowed per hen, as this amount is sufficient; more than this is a waste of floor space. The nests should be grouped together in double-deck formation at the front and ends of the house; allowing one nest for every five hens will meet the needs of a laying flock.

Back-Yard Laying House. The small poultry house such as the one illustrated in Fig. 38 will accommodate 12 laying hens which should furnish the average family with an ample supply of eggs. This structure being portable can be moved about easily. The hens may be fed mash in the covered trough on the end of the runway. By using the upper half of the double door, roosts and nests may be removed for cleaning without permitting the hens to escape. The sloping hinged roof, serving as a door, provides access to the nests. In areas where the ground is apt to become damp or wet at short intervals, the portable henhouse can be placed on an elevated platform and kept there until the soil is dry enough to allow the hens to exercise in the runway with safety.

Poultry Self-Feeders. Various types of metal poultry feeders are available on the market. The three types shown here can be constructed by the poultry raiser in his workshop to meet his particular needs.

1. Indoor Self-Feeder. An indoor feed hopper such as the one shown in Fig. 39 saves time when caring for poultry. The dressed and matched lumber used in its construction insures a feedbox tight enough to hold finely ground grain. If desired the hopper may be partitioned to provide for several different kinds of feed. The hinged top is built on a steep slope to discourage the hens from trying to roost on it.

2. Poultry Mash Feeder. Standard equipment of every poultry raiser includes mash feeders such as the one illustrated in Fig. 40. Mash can be fed better in an open feeder, but when feeding whole grain cafeteria style, about twice as much space should be allowed

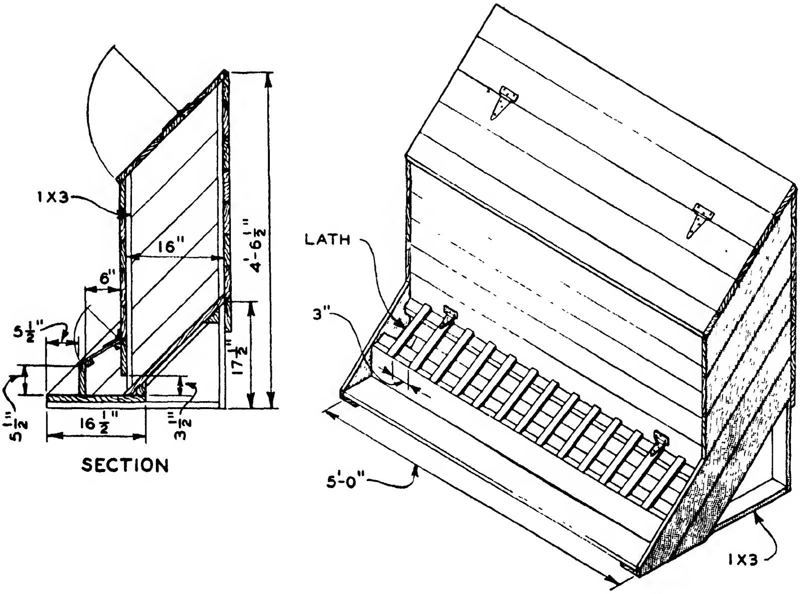


Fig. 39. Indoor Self-Feeder, Showing Perspective and Sectional Views

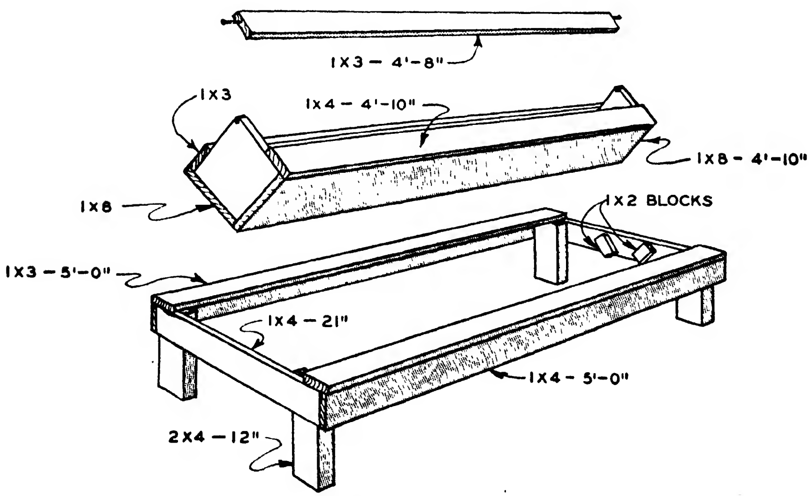


Fig. 40. Poultry Mash Feeder, Showing Trough, Stand, and Revolving Board

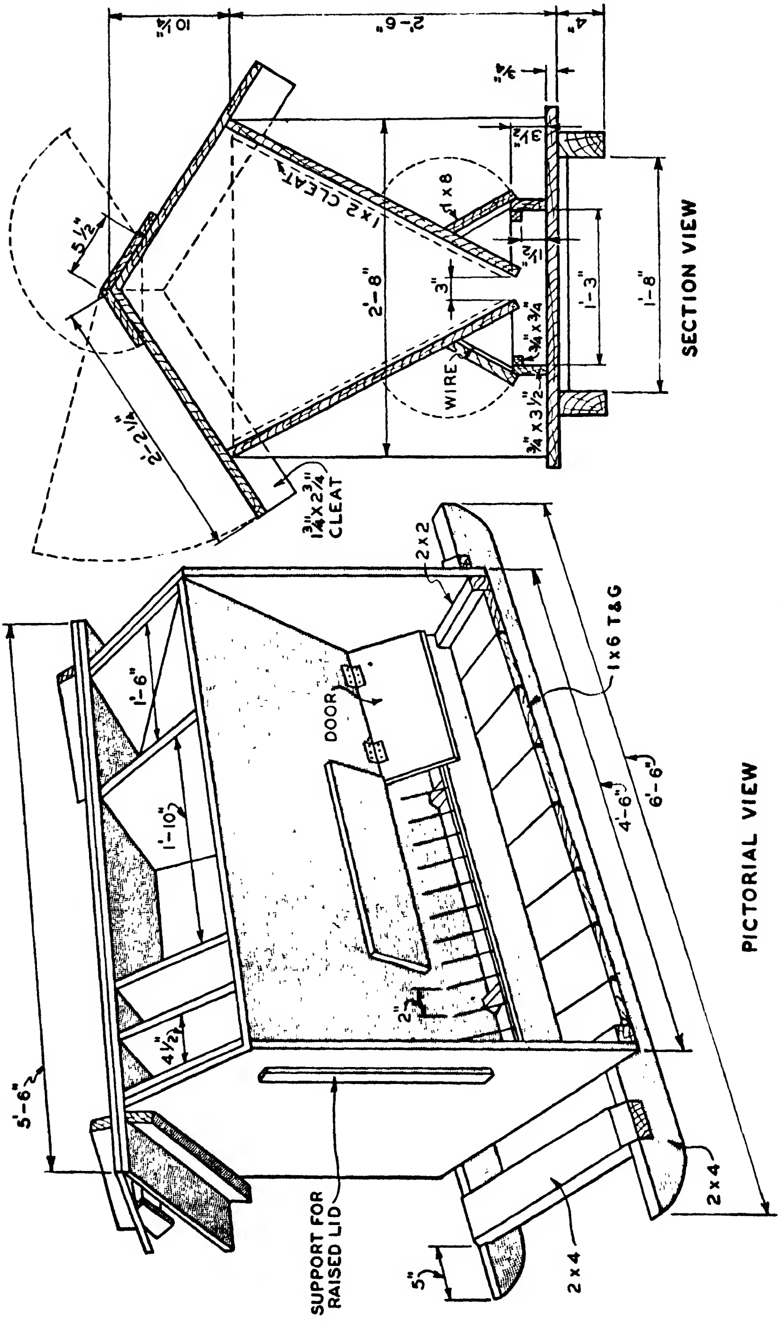


Fig. 41. Outdoor Range Feeder, Showing Pictorial and Sectional Views

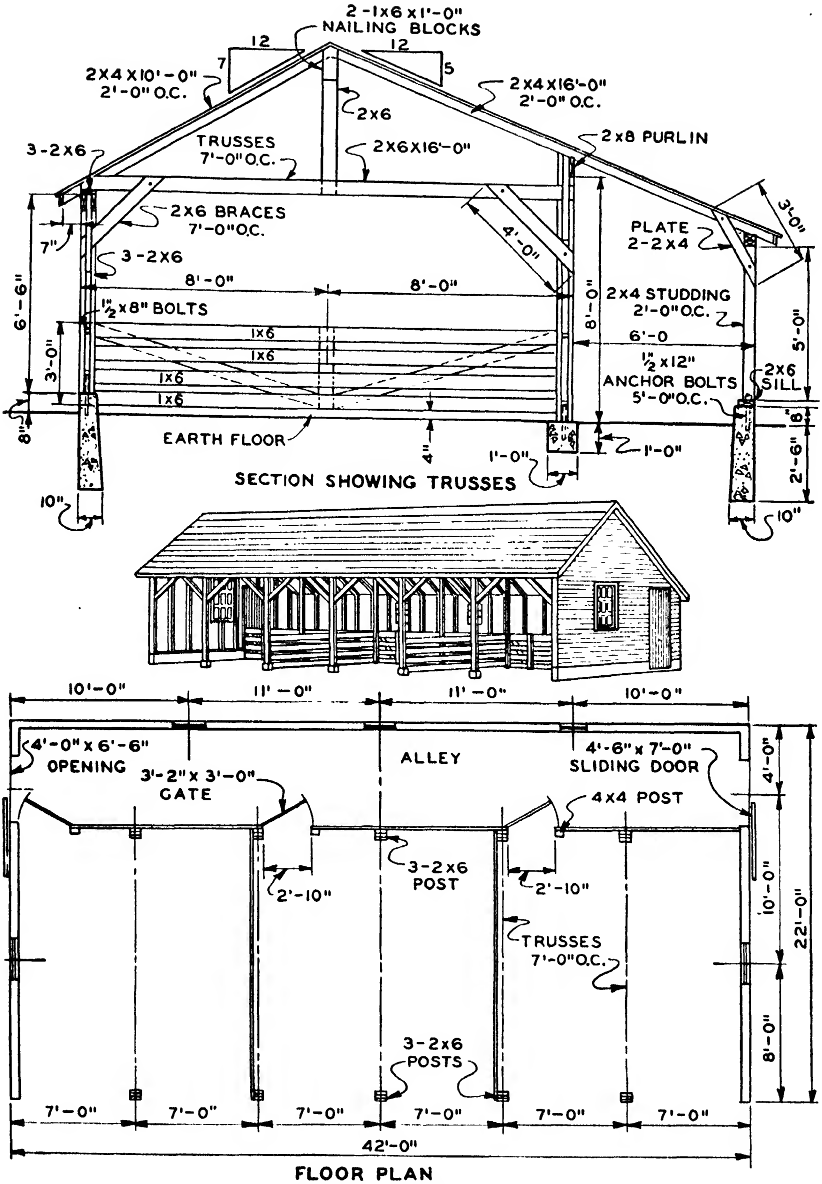


Fig. 42. Open-Front Sheepshed, Showing Floor Plan and Detail Construction

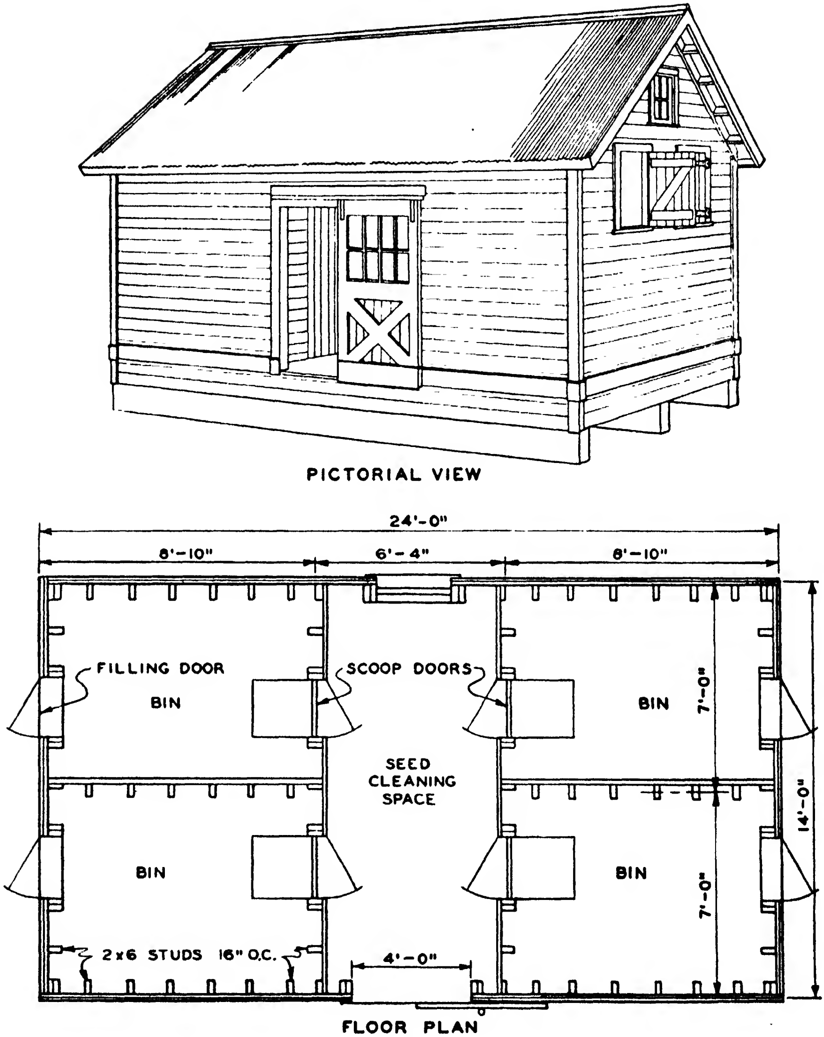


Fig. 43 (*A*). Four-Bin Granary, Showing Perspective View and Floor Plan

as in the other types of feeders. This feeder will accommodate fifty hens feeding on mash and using both sides. The trough can be taken out and cleaned. The revolving board at the top tends to discourage the hens from roosting on the feeder. Care should be taken to place the nails off center as indicated in the illustration.

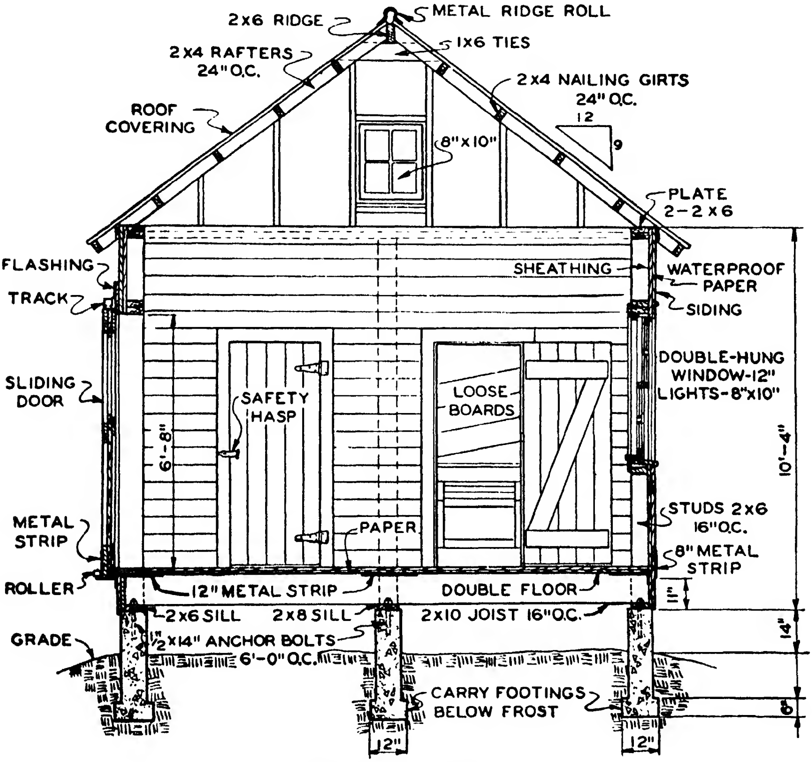


Fig. 43 (*B*). End-Wall of Four-Bin Granary, Showing Details of Construction

3. Outdoor Range Feeder. A portable feed hopper recommended for outdoor feeding is shown in Fig. 41. This feed hopper requires a watertight cover which extends over the trough far enough to keep the feed dry during rainy weather. The sides, sloping inward from the top, force the feed into the trough at the bottom. The skids underneath make it easy to move the feeder to various locations.

Open-Front Sheepshed. The requirements of the average sheep raiser are fulfilled by the open-front sheepshed with its combination roof, as illustrated in Fig. 42. The principal requirements of a sheepshed are dryness, good ventilation, freedom from drafts, and good

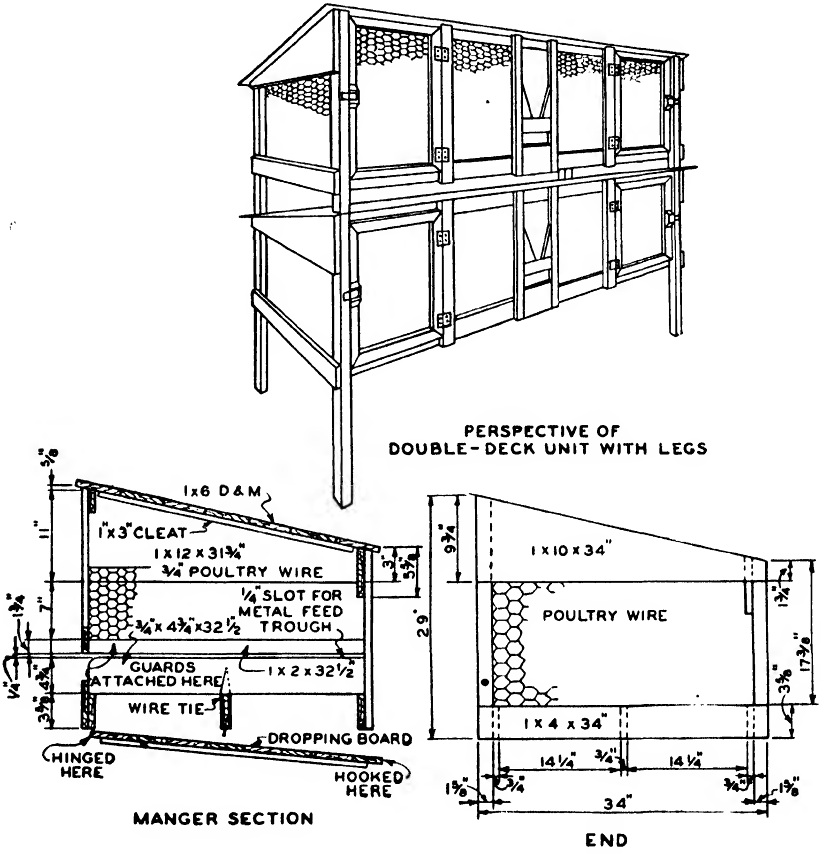


Fig. 44. Rabbit Hutch, Showing Perspective View, Manger Section, and Details of Construction

lighting. A building with an open front to the south makes a satisfactory sheepshed for mild climates. The size of the shed shown here provides shelter and feeding accommodations for a herd of 40 to 45 sheep. Locating a shed next to a larger building or windbreak will give the sheep additional shelter. To prevent surface water from

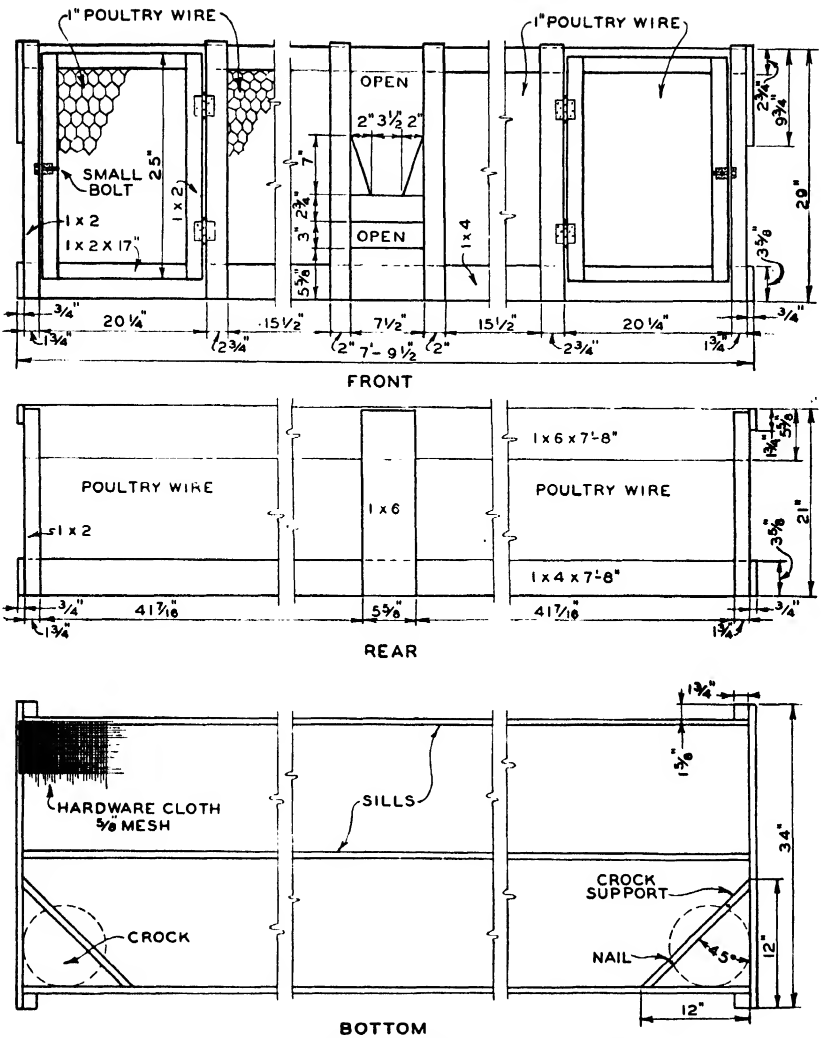


Fig. 45. Floor Plan of Rabbit Hutch, Also Front and Rear Views

draining into the building, the earth floor and foundation should be about 6 inches higher than the surrounding ground.

Granary. A stationary granary of frame construction, adequately braced to withstand the pressure of grain on its outside walls, is illustrated in Fig. 43. This type of granary is suitable for the farmer who has only a few thousand bushels of grain to store. The cross walls stiffen the building and provide four bins, which may be filled through the outside doors. Each bin will hold from 450 to 480 bushels of grain, and in emergency about 780 bushels may be stored in the space intended for cleaning seed. The grain is shoveled into the bins through the small outside doors of each bin. The bottom of each of three small doors is about 6 feet above the floor of the granary. Space for grinding and mixing feed can be provided by increasing the length of the building to widen the alley. Although the drawing shows the use of corrugated metal for roofing, wood shingles (or prepared roofing) may be used instead of the metal roofing. The average farmer will be able to erect this sturdily designed granary without experiencing serious difficulties.

Rabbit Hutch. In all parts of our country, rabbits are raised for food and fur. However, their value in supplementing the family meat supply, or in adding to the farm income, is much greater in some sections than in others. The hutch shown in Fig. 44 can be used for commercial or home-use rabbit raising. This type of hutch permits good circulation of air and is sanitary. Designed for attachment to the hutch is the self-feeder shown in Fig. 45. This type of feeder is a valuable aid in caring for the rabbits.

CHECKING ON YOUR KNOWLEDGE

If you have read this chapter carefully, you should be able to answer the following questions. If you have any difficulty, you should read the chapter again, so that you will have the information well in mind.

DO YOU KNOW

1. The most common causes of failures of farm buildings?
2. Why it is important for the carpenter to understand the nature and effect of wind pressure on buildings?
3. Six essentials of good wind-resistant construction discussed in this chapter?
4. What type of roof construction is most resistant to wind pressure?
5. The names of three types of barn-roof construction in common use today?
6. The names of five important small farm buildings considered in this chapter?
7. What three types of poultry feeders are in common use by poultry raisers at the present time?

8. The names of two types of hog houses in common use on American farms today?

9. What advantage each type of hog house, discussed in this chapter, has? Which type is usually recognized by swine authorities as having the greater possibilities?

10. The chief requirements of a satisfactory sheepshed?

THE APPRENTICE CARPENTER MUST LEARN THE CORRECT STANCE IN LAYING FINISH FLOORING

Courtesy of American Builder

THE INSTALLATION OF THE FINE LACEWOOD, OAK, AND PRIMAVERA CARSTENITE PANELING OF THIS LIVING ROOM SHOWS OUTSTANDING CRAFTSMANSHIP

Courtesy of American Builder

APPENDIX

SPECIFICATIONS FOR THE HOUSE OF THE BOOK

1. WORK REQUIRED. The contractor shall furnish and erect all woodwork mentioned in the building specifications or indicated on the drawings, including all framing and finishing woodwork both outside and inside. He is to co-operate with, and do any necessary carpentry required by, other trades for completing their work.

No finish woodwork or finish flooring is to be put in place or stored in the building until the plastering is finished and thoroughly dry.

2. DIMENSION LUMBER. Unless otherwise specified, all dimension lumber shall be No. 1 yellow pine or fir, thoroughly seasoned. All lumber shall be straight and free from any defects that would weaken the stick.

3. WOOD JOISTS. Joists shall be framed properly with a clearance of 2 inches around the chimney masonry, except where 8 inches of masonry is used outside the flue lining, in which case the framing may be built flush with the chimney masonry. The 2-inch space thus formed shall be filled with fire-resistant material to form a fire stop. Framing necessary around stair wells and other similar places shall be of trimmers and headers, consisting of double joists well spiked together.

The cutting of floor joists to facilitate the installation of piping and duct work will be permitted, with the following limitations:

a) The top or bottom edges of joists may be notched not to exceed 1/6 of the joist depth. Notching the top or bottom edge of joists will not be permitted in the middle third of any joist span.

b) If cutting of a floor joist more than 1/6 of its depth is found necessary, a header the full depth of the joist shall be cut in to support the end of the joist.

c) Where location of pipes necessitates their passing through the joists, holes shall be drilled to receive the pipes. The diameter of the holes shall not be more than 1/2 inch greater than the outside diameter of the pipe and in no case shall the diameter of the holes be greater than 2½ inches. The edge of the holes shall not be located nearer than 2 inches from the top or bottom edge of the joist.

No stud shall be cut more than half its depth to receive piping and duct work. If more depth is required, the partition studs shall be increased accordingly. Where the running of pipes and ducts necessitates the cutting of plates, proper provision shall be made for tying together and supporting all structural members affected by such cutting.

4. ROOF. The wood-shingled roof is to be sheathed with No. 2, 6-inch boards laid with 1-inch spacing between boards. The sheathing for the metal roof to be 6-inch D & M (dressed and matched).

5. EXTERIOR WALL COVERING. All exterior sheathing is to be covered with one layer of asphalt waterproof building paper before finished material is applied. Paper is to be placed horizontally with at least 2-inch lap.

a) Exterior walls, where indicated, to be covered with the best grade of clear vertical grain Royal (4/2" 24") shingles laid 10 inches to the weather.

Note: A double starting row shall be used in shingle installation.

b) Exterior walls on the small dormers, porch ends, to be clear cypress shiplap.

c) All exterior trim, including roof cornice, porch, and bay window, shall be clear white pine or cypress, carefully fitted and thoroughly nailed.

6. ROOF COVERING. Roof covering to be the best-grade vertical grain clear shingles (5/2" 16") where shingles are indicated. These shingles to be laid 5 inches to the weather, except on the porch roof, where they are to be laid 4½ inches to the weather, double coursing,all first courses.

7. INSULATION. Furnish and install wall thickness 3½-inch rock-wool blanket in all ceilings and roof as indicated and 1-inch balsam-wool blanket in all exterior walls. The insulation to be inclosed in a vapor-proof paper covering with a spacer flange on the 1-inch blanket. All insulation to be installed according to manufacturers' instructions.

8. PARTITIONS. All studding partitions and outside walls shall be constructed as shown of 2x4's or 2x6's, with plates well spiked. All studs to be spaced 16 inches O.C. (on center). Cut 1x4 ribbons into studdings for supporting joists. Double studding around all openings, at all corners, and properly trussed across all openings. Corners for all rooms should be framed solid for lath or other interior finish.

9. WOOD FLOORS. Subfloors. Joists shall be floored with No. 2, 8-inch sheathing laid close and double-nailed at each joist, straight on the first floor, diagonally on second floor.

Finished wood floors shall be hardwood as noted in the finish schedule and shall be laid on furring strips. Between all finish wood floors and subfloors, provide single layers of building paper or deadening felt.

All flooring to be well drawn together, joints broken and sanded, ready to receive finish as specified in painting instructions.

10. WEATHERSTRIPS. Furnish and install spring bronze weatherstrips, for all windows and exterior doors, complete with interlocking sills for all exterior doors.

11. CALKING. All exterior doors and window frames set in masonry and all other intersections of wood and masonry shall be calked with an approved standard brand of calking paste.

12. WOOD DOOR AND WINDOW FRAMES. The parts of the frames exposed outside shall be made of strictly clear white pine or cypress. Pulley stiles to be ⅞ of an inch in thickness and to have pockets for access to weights. Frame to be complete with blind stop, beads, sills, casings, and pulleys, as shown in drawings.

13. WOOD SASH. All exterior sash shall be 1⅜ inches thick unless otherwise indicated, made of kiln-dried white pine or cypress. All shall be mortised and tenoned and divided as shown on drawings. Basement windows to be steel sash.

14. STAIRS. Basement stairs to have ⅞-inch mitered yellow-pine risers and 1⅝-inch treads, well supported on 2x12 stringers, 16 inches O.C., all as detailed on drawings. The main stairway shall be housed, properly glued, wedged, and blocked; the risers to be of white pine and the treads of oak. This stairway shall have not less than 6 feet 8 inches

continuous clear head room measured vertically from the front edge of the tread to a line parallel to the stair run.

15. DOORS. All doors to be sandpapered, scraped, and hand smoothed. For sizes, thickness, and design, see drawings. Interior doors in finished rooms to be veneered on both sides to match trim of room.

16. CLOSETS. In all closets the trim and base shall be ⅝ of an inch in thickness without moldings; each closet to have 12-inch shelves and hook strips. Include ¾-inch gas pipe across back for hangers.

17. CUPBOARDS AND CASES. Build as shown and indicated, with 1⅛-inch flush doors and ⅞-inch adjustable shelves. All cupboards and other cases in the kitchen to have a birch face; cabinets in the rest of the house the same as the trim in the room.

18. MEDICINE CABINETS. Built-in toilet and bathroom medicine cabinets of steel.

19. PICTURE MOLD. Picture mold to be furnished and applied for the dining room and bedroom on the first floor as detailed and material is to match the woodwork of the room.

20. CASINGS. All casings shall be detailed.

21. THRESHOLDS. Where two different kinds of flooring join, cover the joint with a neat threshold.

22. SCREENS. Furnish and fit for all exterior windows and doors full screens, frames 1⅛-inch thick of white pine or cypress with mortise-and-tenon joints. All netting shall be best copper wire applied with tacks and covered with molding.

23. STORM SASH AND DOORS. Furnish and fit for all exterior windows and doors, storm sash and doors, 1⅛-inch thick, glazed with D.S.A. (double strength grade A) glass. Doors to match entrance doors of house.

24. CORNICE. Furnish and install wood cornice in rooms as detailed on drawings.

25. WOOD BASE. Furnish and install wood base in all rooms as detailed on drawings.

26. FIREPLACE MANTEL. Furnish and install as detailed, fireplace mantel and shelf.

27. ROUGH AND FINISH HARDWARE. Furnish all necessary rough hardware, such as nails, wall ties, sash weights, sash cord, and other builders' hardware, to complete the job.

a) Finish Hardware. All finish hardware, such as locks, butts, door checks, and similar finish hardware, except as otherwise specified, will be purchased by the owner and delivered to the building, where the contractor shall receipt for it and properly install it.

b) Contractor shall include in his bid an allowance of $100.00 for finish hardware which owner will select and deliver to the building. Saving in this shall revert to owner, any extra cost to be borne by him. Contractor shall replace, at his own expense, any hardware that is lost or damaged.

SCHEDULE FOR WOOD TRIM AND FLOORING

BASEMENT. Wood trim around doors to be yellow pine.

FIRST FLOOR. Wood trim, Grade B, or better, white pine, except the kitchen and bathroom, where it is to be select birch. Living room and entry walls to be covered with shiplap-molded knotty pine placed vertically; boards are to be 4-, 6-, and 8-inch widths. Flooring material to be Grade A, 2¼-inch, straight-grain red oak in all rooms and hall except the kitchen and bathroom, which are to be in 4-inch flat-grain fir flooring. All flooring to be machine-sanded to a smooth finish ready for stain and filler. Kitchen and bathroom floors to be covered either by linoleum or asphalt tile which will be installed by owner.

SECOND FLOOR. Wood trim, Grade B, or better, white pine, except bathroom, which is to be select birch. All floors to be $2\frac{1}{4}$-inch straight-grain red oak except bathroom, which is to be 4-inch flat-grain fir flooring.

Note: In addition to their primary purpose, specifications have other important uses, such as preventing disputes between the owner and general contractor and subcontractor. In this text we are interested only in the specifications pertaining to the carpentry work for *The House of the Book.*

ANSWERS TO QUESTIONS ON *THE HOUSE OF THE BOOK*

Blueprint Reading and Specifications

When you check your answers to the questions on blueprint reading and specifications for *The House of the Book,* with the following correct answers, draw a line through any of your answers which are wrong. If there are two or more parts to a question, mark each part separately. If you have answered one part correctly, cross out only that part of your answer which is wrong.

1. A picture of the building as it will appear when completed. Also, a picture of the division of the different floors into rooms.

2. By means of blueprints, that is, architectural drawings and written specifications.

3. (*a*) Four. (*b*) *South; East; North;* and *West.*

4. The floor plans.

5. (*a*) In the basement. (*b*) The width of the recreation room (omitting the recess for the bay window) is 10 feet; the length is 25 feet and 11 inches. (*c*) Two.

6. Concrete blocks.

7. (*a*) Concrete. (*b*) Four inches. See sectional view *B–B.*

8. (*a*) Five. (*b*) Steel sash. See Specifications, No. 13.

9. The thickness of the outside foundation wall on the south and west of the main section is 12 inches. All other outside foundation walls are 10 inches thick. See basement-floor plan. *Note:* The thickness of the porch foundation is 8 inches.

10. All footings are 8 inches thick. Under the 12-inch walls the footings are 2 feet in width, under the 10-inch walls the footings are 18 inches in width. See sectional views *A–A and B–B.*

11. The wall sections shown in detail are: *A–A* through the south window of the living room; and *B–B* through the north window of the living room.

12. (*a*) Stone veneer on main section, shingles on addition. (*b*) Wood shingles. (*c*) Shiplap.

13. (*a*) One. (*b*) There are two flues on the second floor, but only one in the basement. (*c*) Terra cotta. (*d*) No, the chimney is of stone. The interior of the fireplace is of fire brick.

14. Wood shingles.

15. (*a*) Standing seam metal roof. (*b*) Wood shingles. See Specifications, No. 6. (*c*) Metal roofing.

16. (*a*) Specifications for the exterior front door (*A*) call for size 3′0″x 6′8″, with a thickness of 1¾″. (*b*) Specifications for west exterior door indicated as (*B*) call for size 3′0″x6′8″, with a thickness of 1¾″. (*c*) Specifications for north exterior door indicated as (*D*) call for size 2′8″x6′8″, with a thickness of 1¾″. (*d*) Closet doors (*G*) are 2′0″x6′8″, with a thickness of 1⅜″. (*e*) Closet doors (*H*) are size 2′0″x5′10″, with a thickness of 1⅜″. See Door Schedule.

17. (*a*) Two. (*b*) Five feet.

18. Spring bronze with interlocking sills. See Specifications, No. 10.

19. Clear white pine or cypress.

20. Birch. See Specifications, No. 17.

21. (*a*) The addition dimensions are 14′0″x12′0″. (*b*) One. (*c*) Two.

22. Twenty.

23. (*a*) Three. (*b*) Specifications call for size 2′4″x3′10″. (*c*) Twelve lights for each of these windows are called for in the specifications.

24. The ceiling height for the first-floor rooms is 8′1″.

25. (*a*) There are two inside stairways. (*b*) One outside.

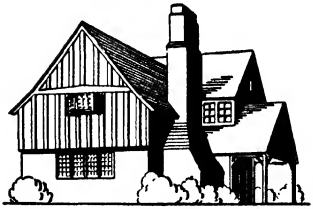
When you have finished checking your answers with the correct answers given here, add up the number of answers you had wrong, if any, then find your score. Each complete question rates 4 per cent. If the question is divided into four parts and you had three correct and only one wrong, give yourself credit for 3 per cent. If your score is 25 per cent or less, you should study this chapter again.

Right__

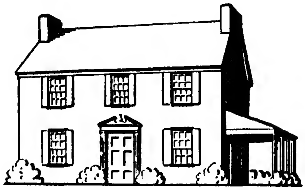
Wrong____

Score_____

VARIOUS TYPES OF HOUSE CONSTRUCTION



(1)



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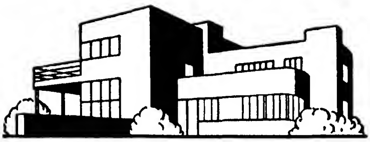

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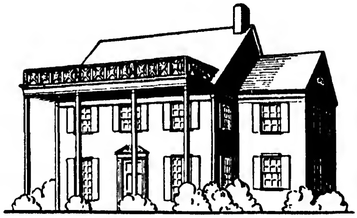

(4)

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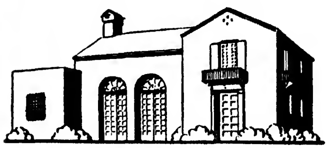


(8)

1. The style of architecture shown here is known as Elizabethan or English half-timbered type. Except for the half-timber work, this house might also be classed as of Tudor style.

2. This house belongs to the Georgian type. The distinguishing features are the symmetrical arrangement of windows and the classical detail of the entrance doorway.

3. Because of the angular appearance of the principal parts and the absence of decorative details this style of architecture is known as Modernistic.

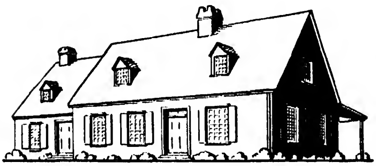
4. A Southern-Colonial type of architecture often seen in the South. The two-story columns are typical.

(9)

(10)

(11)

(12)



(13)

5. A Dutch-Colonial style distinguished by the double-sloped main roof with gable ends.

6. A house of the New England type. Distinguishing features are the symmetrical arrangement of windows and doors, simplicity of detail, and the use of clapboards.

7. The Monterey style with low-pitched roof and a long balcony.

8. Mediterranean style of architecture, distinguished especially by low-pitched roofs, plain walls, iron balconies and grilles, and decorative chimney cap.

9. French Provincial or Norman French. The round tower with the steep conical roof gives it a French appearance, otherwise it might be classed as Old English or Elizabethan.

10. Early English type; special features are high-pitched roof with eaves at the first-floor level, detail of the entrance porch, and by its lack of symmetry.

11. A Formal French or French Provincial style, with a mansard roof, dormer windows with curved roofs, and outward curve of the roof at the eaves.

12. Tudor style; chief features are prominent gables and chimney, absence of formality and symmetry, and high brick chimney pots and the gables.

13. Cape-Cod style distinguished by windows of Colonial type and an air of simplicity about the entire design.

TYPES OF ROOF TRUSSES

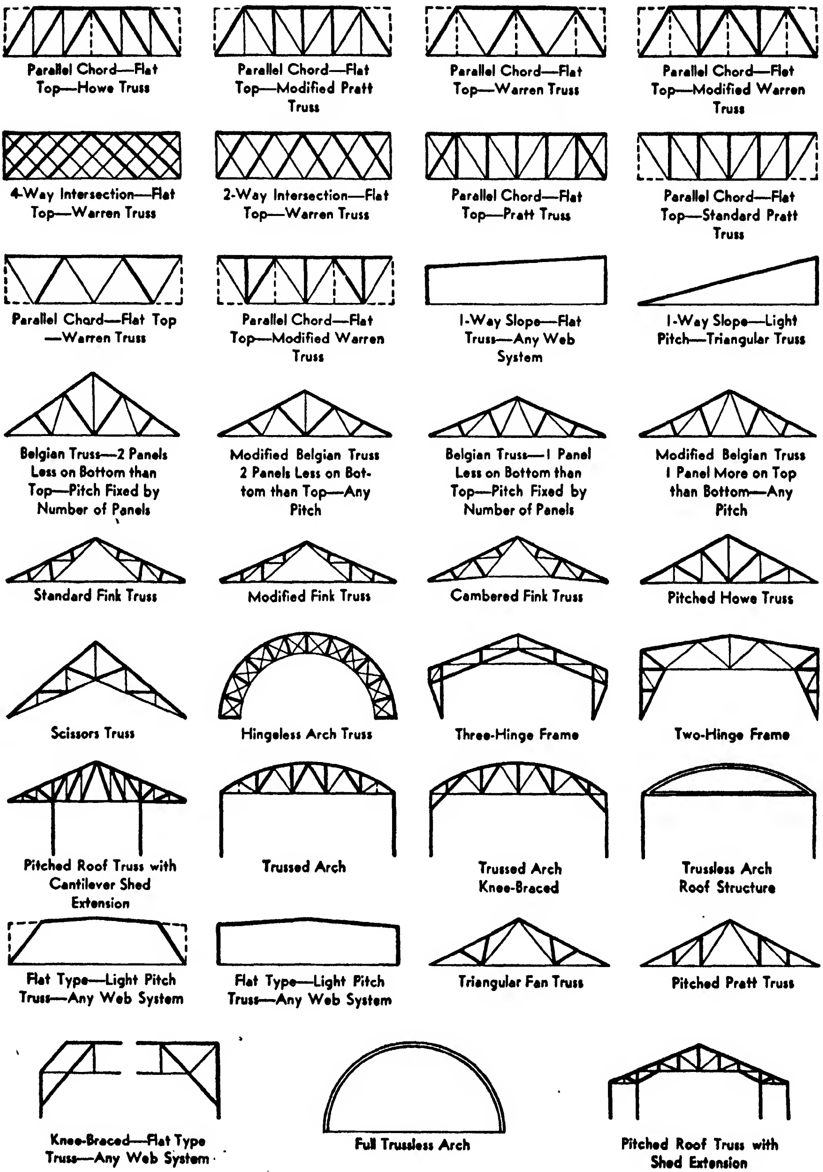


TABLE I. MINIMUM LIVE LOADS ALLOWABLE FOR USE IN DESIGN OF BUILDINGS*

HUMAN OCCUPANCY	POUNDS PER SQUARE FOOT
Dwellings	40
Hospital rooms and wards	40
Hotel guest rooms and lobbies	40
Tenements	40
Office buildings†	50
School rooms	50
Corridors in hospitals, hotels, schools	100
Assembly rooms with fixed seats	50
Grandstands	100
Theater stages	100
Gymnasiums	100
Stairways and fire escapes	100
INDUSTRIAL OR COMMERCIAL OCCUPANCY	
Storage purposes (general)	250
Storage purposes (special)	100
Manufacturing (light)	75
Printing plants	100
Wholesale stores (light merchandise)	100
Retail storerooms (light merchandise)	75
Stables	75
Garages, all types of vehicles	100
Garages, passenger cars only	80
Sidewalks‡	250
Roofs, up to slope of 4 inches per foot	30
Roofs, slope of 4 inches to 12 inches per foot	20
Roofs, slope of over 12 inches per foot, wind force of 20 pounds per square foot acting normal to surface	

*Report of Building Code Committee, Bureau of Standards.
†A 2000-pound load upon any space 2½ feet square shall be used if it produces greater stresses.
‡A concentrated load of 800 pounds shall be used if it produces greater stresses.

Table II. Permissible Reductions in Live Loads*

	Per Cent
Carrying one floor	0
Carrying two floors	10
Carrying three floors	20
Carrying four floors	30
Carrying five floors	40
Carrying six floors	45
Carrying seven floors	50

*Except on buildings for storage purposes, the above reductions in live loads are permissible in designing all columns, piers or walls, foundations, trusses, and girders.

Table III. Maximum Span of Rafters Determined by Bending*

Lumber Sizes	Spacing of Rafters on Center	Maximum Allowable Lengths between Supports					
		Southern Pine Douglas Fir $f = 1{,}400$ lbs.		Western Hemlock $f = 1{,}100$ lbs.		Spruce $f = 1{,}000$ lbs.	
		Ft.	In.	Ft.	In.	Ft.	In.
2x4	12	8	10	8	5	8	1
	16	7	8	7	4	7	0
	24	6	4	6	0	5	9
2x6	12	13	6	12	11	12	4
	16	11	10	11	4	10	9
	24	9	9	9	4	9	11
2x8	12	17	10	17	1	16	3
	16	15	7	14	11	14	3
	24	12	11	12	4	11	9
2x10	12	22	4	21	4	20	4
	16	19	7	18	9	17	10
	24	16	3	15	6	14	10

*Materials: #1 Dimension lumber.
Dead load: Weight of roof joist or rafters.
Weight of roof sheathing (2.5 pounds per square foot).
Weight of roof covering (2.5 pounds per square foot).
Live load: Thirty pounds per square foot of roof surface considered as acting normal to surface.
f = allowable stress in extreme fiber in bending.

TABLE IV. MAXIMUM SPAN OF JOISTS LIMITED BY DEFLECTION*

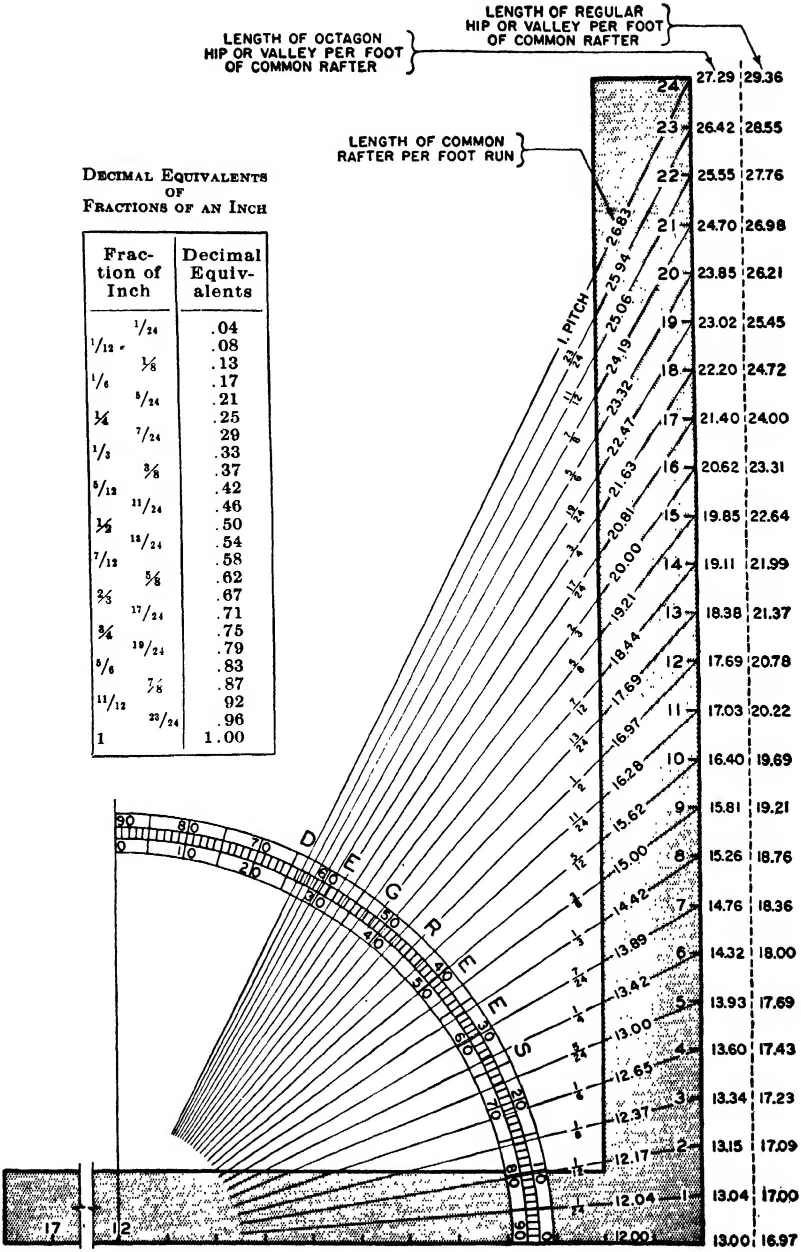
Size of Joist	Joist Spacing Center to Center	Live Loads													
		40 Pounds		50 Pounds		60 Pounds		70 Pounds		80 Pounds		90 Pounds		100 Pounds	
	Inches	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
2x8	12	13	3	12	7	12	0	11	6	11	2	10	9	10	6
	16	12	2	11	6	11	0	10	6	10	2	9	10	9	7
2x10	12	16	8	15	10	15	2	14	7	14	1	13	7	13	3
	16	15	4	14	6	13	10	13	4	12	10	12	5	12	1
2x12	12	20	1	19	1	18	3	17	7	17	0	16	5	16	0
	16	18	6	17	7	16	9	16	1	15	6	15	0	14	7
2x14	12	23	6	22	4	21	4	20	7	19	10	19	3	18	8
	16	21	8	20	6	19	8	18	10	18	1	17	7	17	1
2x16	12	26	10	25	6	24	5	23	6	22	9	22	0	21	5
	16	24	9	23	6	22	6	21	7	20	10	20	2	19	7
3x8	12	15	4	14	7	14	0	13	5	13	0	12	7	12	3
	16	14	2	13	5	12	10	12	4	11	11	11	6	11	2
3x10	12	19	4	18	4	17	7	16	11	16	4	15	10	15	5
	16	17	10	16	11	16	2	15	6	15	0	14	6	14	1
3x12	12	23	2	22	1	21	2	20	4	19	8	19	1	18	7
	16	21	6	20	5	19	6	18	9	18	1	17	6	17	0
3x14	12	27	0	25	9	24	8	23	9	23	3	22	4	21	9
	16	25	1	23	3	22	10	21	11	21	2	20	6	20	0
3x16	12	30	9	29	4	28	2	27	2	26	3	25	6	24	10
	16	28	8	27	3	26	1	25	2	24	3	23	6	22	10
4x8	12	16	11	16	1	15	5	14	10	14	4	13	11	13	6
	16	15	8	14	10	14	3	13	8	13	2	12	9	12	5
4x10	12	21	2	20	2	19	4	18	8	18	1	17	6	17	0
	16	19	8	18	9	17	11	17	3	16	7	16	1	15	8
4x12	12	25	5	24	3	23	3	22	5	21	9	21	1	20	6
	16	23	8	22	6	21	7	20	9	20	1	19	5	18	11

Courtesy, Southern Pine Association

*Based on modulus of elasticity 1,600,000 pounds per square inch, the live load given plus a dead oad of 15 pounds plus weight of joist per square foot. Deflection limited to $^1/_{30}$ of 1 inch per foot of span.

Note: In using Table IV to check the possibility of substituting one size joist for another, it should be kept in mind that a factor of safety has been applied in both the stress value assigned and in the floor load. For this reason, a certain amount of tolerance is permissible. For example, 3x12 joists spaced 16 inches on center are limited to a span of 20 feet 5 inches for a 50-pound load. It would be entirely reasonable to use this size joist with the same spacing for a 20-foot 6-inch or 20-foot 7-inch span.

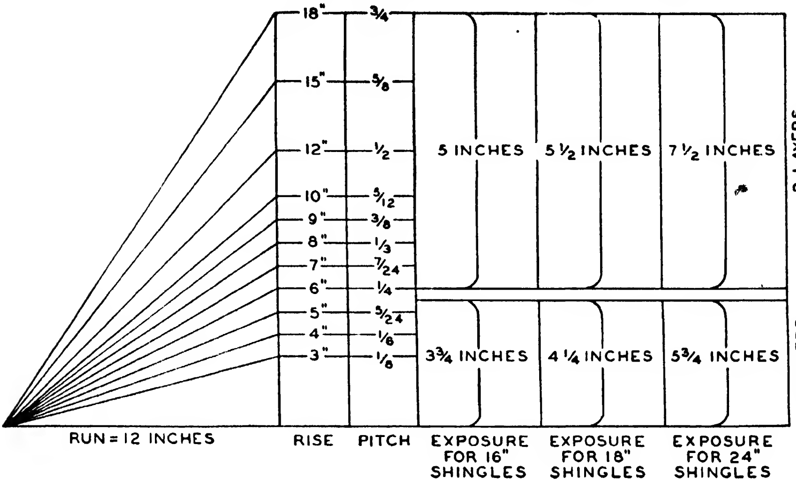
Table V. Roof Pitches and Degrees



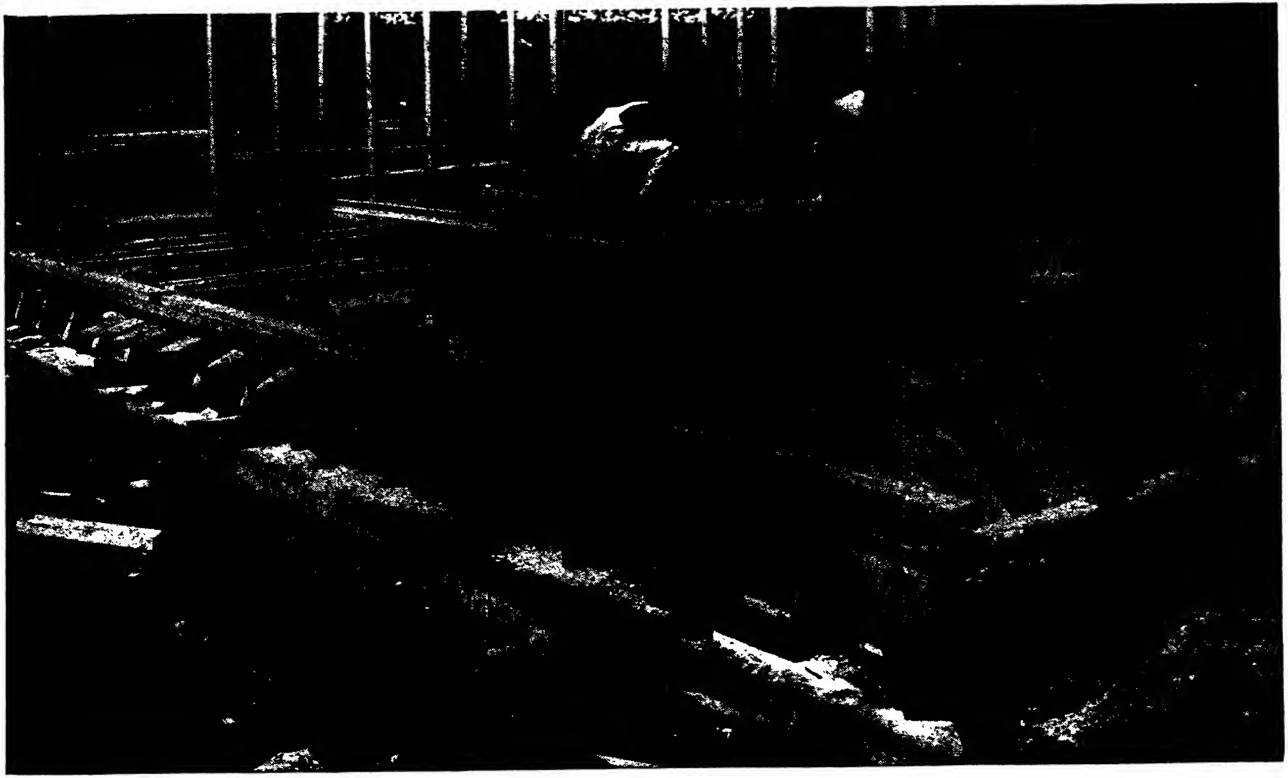
Decimal Equivalents of Fractions of an Inch

Fraction of Inch	Decimal Equivalents
1/24	.04
1/12	.08
1/8	.13
1/6	.17
5/24	.21
1/4	.25
7/24	29
1/3	.33
3/8	.37
5/12	.42
11/24	.46
1/2	.50
13/24	.54
7/12	.58
5/8	.62
2/3	.67
17/24	.71
3/4	.75
19/24	.79
5/6	.83
7/8	.87
11/12	92
23/24	.96
1	1.00

Table VI. Shingle Exposure for Various Roof Pitches



Note: This diagram shows at a glance the weather exposure to be used for various roof pitches. For example, if a roof has a rise of 8 inches in a run of 12 inches, it can be seen that this is ⅓ pitch and that an exposure of either 5 inches, 5½ inches, or 7½ inches should be employed, depending upon the length of the shingles used.



DIAGONAL LAYING OF ROUGH FLOORING MEANS GREATER STRUCTURAL STRENGTH AND IS A STANDARD PRACTICE AMONG CARPENTERS

Courtesy of American Builder

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